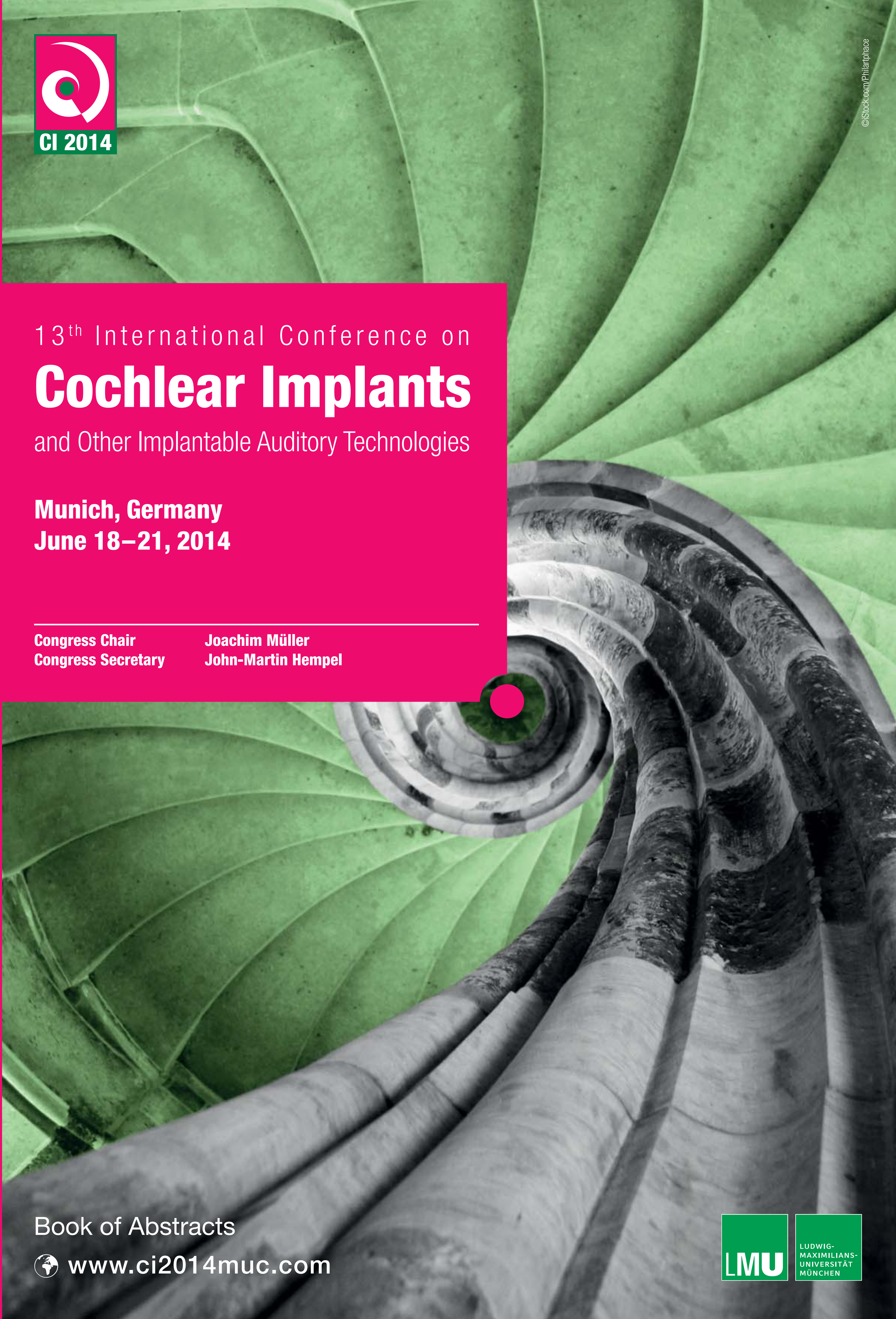

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13th International Conference on

Cochlear Implants

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VIDEO PRESENTATIONS

VS1 Video session

VS1-1

Endomeatal approach (ema) partially ossified cochlea

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Introduction: Cochlear ossification is a challenge for CI surgery, due to the difficulty of electrode array insertion. Surgery through anatomical natural orifices (external auditory canal and round window) avoids facial nerve (FN) and internal carotid artery (ICA) risks

Objective: The objective of this original technique: endomeatal double cochleostomy with standard electrode array is to approach in a safe manner ossified cochleas, where usual anatomical landmarks are unclear.

Material and method: Technique was developed in temporal bone Lab and then applied in 4 patients. EMA allows access to all the turns of the cochlea from base to apex. The advantage lies mainly in that the middle and inner ear access is addressed in front of the posterior wall instead of coming behind it, overcoming those limitations. This technique allows to start drilling in an endomeatal manner the basal cochlear turn from the round window until the cochlear lumen is reached, (4,5mm +/–). Second cochleostomy is performed in the middle turn, which controls the correct positioning of electrode array, during insertion, and if it is not possible a reverse insertion from middle turn cochleostomy to basal turn direction, can be attempted. The video case presented is a partial cochlear ossification, with vestibular scale fibrosis post stapedectomy and partial ossification of the scale tympani by otoespongiosis, confirmed by CT and MRI.

Results: Functional outcome of patients with partial ossification is correct, and the implant has proven its stability over time, with a higher evolutionary track than five years. No healing or extrusion problems.

Discussion: EMA is a technique of choice in cases where other approaches, due to the anatomical characteristics are not feasible and allows the CI without risk to the facial nerve, and internal carotid artery.

Learning outcome: Surgical techniques must be simplified. Cochlear implant surgery through natural anatomical orifices gives the chance to positionate de electrode array in a safer manner, although further experience is required.

VS1-2

Partial deafness treatment - 6 surgical steps

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The authors depict main steps in surgical treatment of various malformations of the middle ear using various types of electrodes in cochlear implant systems. The film presents the manner of matching electrodes depending on the state of preoperative residual hearing at low frequencies, which must be preserved. The film presents a surgical procedure created and implemented by Professor Henryk Skarzynski.

VS1-3

Complications of cochlear implant surgery: Report on 100 sequential cases

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Cochlear implant for the hard of hearing has become a wide spread practice to rehabilitate subjects with severe to profound sensory neural hearing loss. Children still represent the most commonly implanted patients. In spite of the technical advancements both in the devices, surgical techniques and availability of facial nerve monitor and anesthetic techniques, the literature is full of reports on complications of this surgery as well as methods to avoid its occurrence. Herein we report on 100 sequential cochlear implant cases, analyze the results and compare it to those reported in English published literature. Also we discuss our techniques as regards prevention and avoidance of these complications.

VS1-4

Approaches to manage facial nerve obscuring round window visualization

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With more and more patients with residual hearing being operated, attention has focused on the round window which helps in more precise, atraumatic placement of electrodes. Even the most vociferous critics of round window insertion seem to be relenting now, with overwhelming scientific evidence pointing towards the benefits of the procedure. Cochlear implant manufacturers too are designing electrodes meant for round window insertion.

One of the most difficult aspects of round window insertion is the visualization, which can be glaringly easy at times but frustratingly difficult sometimes. The key to proper visualization of the round window is adequate skeletonisation of the facial nerve and thinning of the posterior canal wall inferior the two tympanomastoid suture line. With this technique, sometimes aided by drilling anterior to the facial nerve on the stapedius muscle. This last technique is not generally recommended though because post-operative ESRT may be affected by drilling on the stapedial muscle though data on this is lacking.

A structured approach towards the facial nerve exposure will thus improve the visualization of the round window without damaging critical structures like the chorda tympani nerve and the posterior canal without sacrificing on time taken for surgery.

VS1-5

Baha attract implantation - surgical procedure

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The authors present a technique of BAHA Attract implantation basing on bone conduction. The film illustrates the implantation of the inner part in the case of both congenital malformations of the external ear and earlier reconstructions of auricle. It also shows various methods of proceedings when the access to the implanted inner part is limited.

VS1-6

Bonebridge implantation - surgical procedure

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The film presents the surgical procedure of a Bonebridge implantation in chosen cases of congenital malformations in the middle ear with a limited space, applied in the World Hearing Center of the Institute of Physiology and Pathology of Hearing, Warsaw, Poland. The Bonebridge bone conductive implant is used in patients with conductive and mixed hearing loss in chronic otitis media, congenital ear deformations and other conditions where conventional reconstructive surgery techniques are not effective or cannot be performed.

Applied technique must include preoperative CT scan in order to assess the possibility to implant the device, because limited space in mastoid is a contraindication to implantation. Limited skin incision is performed, then making the hole in the temporal bone between posterior wall of the external auditory canal, dura and sigmoid sinus. After that using the diamond cylinder one should refine internal walls of the hole. In the next step it is necessary to make two hollows for the screws to fix the implant to the temporal bone very tightly. This should be done with a specially designed screwdriver with a force limitation system. The last step is to close the wound.

The obtained results are very good. There were no extrusion of the device, healing of the wound was perfect in all cases and implant worked properly.

VS1-7

Direct stimulation of the round window with Vibrant Soundbridge - surgical procedure

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The authors present a surgical procedure of using a Vibrant Soundbridge middle ear implant for direct stimulation of the round window membrane. Indications for this procedure are mainly situations when a patient has already undergone radical surgeries or changeovers. The film presents surgical steps created and used by Professor Henryk Skarzynski in 2006.

VS1-8

Middle ear implantation procedure with CODACS - surgical procedure

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The authors discuss a surgical procedure of using a CODACS middle ear implant. The film presents subsequent steps in CODACS implementation, actual indications and results of surgical treatment.

VS1-9

Implantation of a Vibrant Soundbridge device in congenital malformations of the middle ear - surgical procedure

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The authors outline several case studies of Soundbridge implantation in both complex malformations of the external and middle ear and isolated malformations of the middle ear. The film presents various methods of FMT fixation (Floating Mass Transducer) depending on the condition of malformations of both the tympanic cavity and conductive apparatus in the middle ear.

ORAL PRESENTATIONS

KN2 Middle ear implants

KN2-1

Incidence of indications for active middle ear implants

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More than 10.000 preoperative Audiograms for all kind of ear surgery were analyzed, showing in which patients conventional surgery alone would not be able to achieve social hearing. In revision surgery and in malformation interventions the indication for an implantation of an avtive middle ear implant is highest.

KN2-2

Mechanical aspects of natural and reconstructed hearing

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To achieve good hearing results after surgical reconstruction is a most challenging task. For that it is helpful to know about the mathematical background of the complex mechanical processes in the middle ear and the cochlea.

First, the frequency dependent transfer behavior of sound through the middle ear to the basilar membrane in terms of natural frequencies and vibrational modes is discussed based on mechanical computer models. With such models the effects of diseases like otosclerosis or partial malleus head fixation can be studied. For the surgeon, they facilitate the appropriate choice of passive or active implants to reconstruct damaged hearing and allow the optimization of surgical procedures.

The sound transfer in a physiological intensity range can be described with linearized models whereas large quasistatic pressure variations or internal preloads must be treated by fully nonlinear descriptions. In case of reconstructions, such preloads can be intrinsic, e.g. due to implant coupling or scar tissue and may lead to a distorted sound transfer.

The reconstruction with various types of passive prostheses is considered. They may differ in material, the points of attachment and in the mechanical principle of coupling them to the natural structures. Particularly, the vibrational behavior and the principle how the implant is attached to the bones or membranes determines the quality of sound transfer as well as the handling and safety of application. Different coupling principles like plastic crimping, elastic clips or shape memory alloys are discussed concerning contact forces, application forces and damping of the interface layers.

Active implants offer an amplification of sound and therefore feed-back effects may occur. The implants are classified according to their driving principle (piezoelectric or magnetic coils) and the fixation of the actuator´s base (free floating or skull coupled). Again, the coupling interface between actuator and ossicles or round window membrane plays the crucial role for the sound transfer. The particular properties and advantages of the different configurations are discussed.

Introducing a CI-electrode into the inner ear will change the hydrodynamics of inner ear fluid. Important issues of the altered travelling waves of the basilar membrane are the surgical modifications at the round window, the creation of a third window, the stiffness of the oval window and the vibrational behavior of the electrode itself. These facts become important when a combined stimulation is in focus, e.g. natural excitation of lower frequencies utilizing a residual hearing and an additional electrical stimulation of the higher frequencies.

Appropriate measures are addressed to asses a reconstruction. For a detailed judgment, the entire system of natural ear with particular disease and the implant with actuator, amplifier and microphone has to be taken into account. Here, the mechanical aspects are considered from the clinical point of view.

KN2-3

Middle ear implants in Japan- 20 year's experiences at University of Miyazaki

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Indications of recent middle ear implants (MEI) have been extended to include conductive or mixed hearing-loss patients with previously operated middle ears. Similar attempts had first been made using the Rion MEI, which was clinically available as an advanced medical technology in Japan between 1993 and 2005. The multicenter clinical trial of the vibrant sound bridge (VSB) has recently been done in Japan with favorable shot-term results. We herewith present our experiences with two kinds of MEIs implanted in a total of 12 patients, who had suffered mixed hearing loss and whose condition would not lend itself to surgical correction.

The Rion MEIs were implanted between 1994 and 2000 in 6 patients with preoperative hearing levels ranged from 66 to 77 dB. The better hearing ear was chosen for implantation in 3 patients. Five of them had had radical mastoidectomy and one had previous canal-wall up cholesteatoma surgery. Four patients with a dry mastoid cavity were implanted in one stage with closure of the external ear canal, whereas one patient having an infected cavity filled with active granulation tissue required a two-stage procedure for implantation. The round window vibroplaty technique was employed for VSB between 2012 and 2013 in 6 patients. Preoperative hearing levels ranged from 63 to 73 dB. Three of them had previous canal-wall up cholesteatoma surgery, two had radical mastoidectomy and one had atresia surgeries. Preparatory operation was done before implantation in 2 patients having a radical cavity with retroauricular opening.

The Rion MEI has been functioning well in four patients. All three patients implanted in a better hearing ear have regained socially useful hearing with the device without any recurrence of middle ear inflammation. One patient implanted in the worse hearing ear rather uses a conventional hearing aid on the other side of the ear with an additional use of the hearing device when needed. One device was removed 8 years postoperatively because of her acute deterioration of bone conduction. Short term results with the VSB are favorable for all patients in both audiological and otological aspects at present.

We could confirm significantly improved gain with either MEI, especially in the high frequencies, satisfying patients' demands with high quality sound at least one-year time after surgery. The Rion MEIs tolerated well for more than 15 years after closure of the external ear canal. Long time follow-up is necessary for cost-effectiveness assessment because hearing deterioration may become evident in some patients after satisfactory use of MEI for several years.

For long term success in MEIs for patients with severe middle ear diseases and potential eustachian tube dysfunction, careful control of middle ear space at implantation seems to be crucial in addition to technological advancements. Long term date with the Rion MEI help to plan MEI surgery with recent sophisticated devices such as VSB.

KN2-4

Clinical results with a direct acoustic cochlear implant

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Currently available conventional hearing aids normally do not provide sufficient benefit to patients with severe-to-profound mixed hearing losses (MHL). On the other hand, as the sensorineural hearing loss (SNHL) component is only from moderate degree, cochlear implants also may be a less than optimal alternative. The Codacs Direct Acoustic Cochlear Implant is a new implantable hearing system, which was developed for treatment of this specific patient group. This device is intended to stimulate the cochlea fluid directly by a conventional stapes piston that is attached to an actuator and vibrates the perilymph through the oval window.

Here we report clinical results from patients implanted at the Medical University of Hannover that were assessed 3 month (n = 18), one year (n = 9) and two years (n = 7) after activation. The audiological protocol included pre- and postoperative air conduction and bone conduction (BC) pure tone thresholds and speech intelligibility by headphone as well as in sound field. In patients wearing hearing aids pre-operatively, measurements in sound field were performed in unaided and in aided condition. The preoperative BC thresholds (0.5 - 6 kHz) were between 43 and 60 dB HL (mean 55 dB), with an additional air bone gap between 30 und 44 dB HL (mean 34 dB).

The comparison of pre- and postoperative BC thresholds showed on average no decrease in the inner ear function within two years after the implantation. Five month after the implantation, aided speech perception in quiet improved significantly from 26 % word recognition score with conventional hearing aids to 81 % with Codacs. Speech intelligibility in noise (OLSA, S_0N_0) was significantly better with Codacs (range 4.5 to -4.5 dB SNR, mean +0.1 dB SNR) than with hearing aids (range 12 to -1.5 dB SNR, mean +7.6 dB SNR).

These results indicate that Codacs is an effective and safe treatment for severe to profound mixed hearing loss.

KN2-8

Reliability of the otologics Carina® totally implantable active middle ear transducer: A retrospective study in 136 devices

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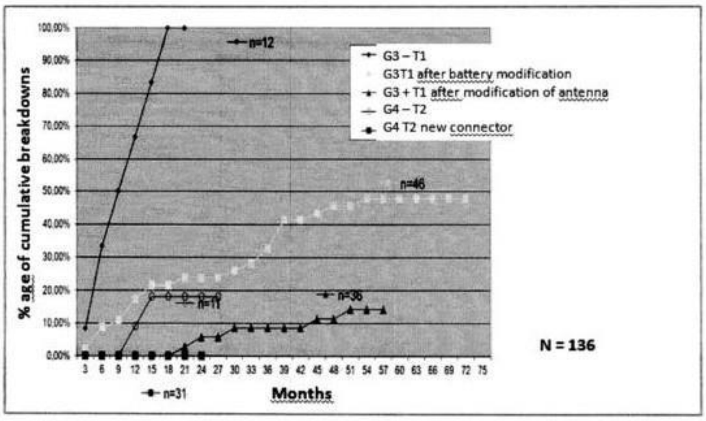
Design: Prospective, multicenter at 6 university tertiary referal centers.

Aim: To assess the reliability of the Otologic Carina® Active Middle Ear Implant (AMEI) as a function of different technological evolutions across time.

Population: 157 Carina® AMEI (Otologics®, Boulders, Colorado, USA) implanted during period of survey; 136 devices were included in the study. Bilateraly implanted patients were n=8. All implantees between September 2005 and July 2012 were included. Number of AMEIs' changings was n=26; 19 devices with lots of follow-up or no available data were excluded. This sample represents 86,6 % of all the Otologics Carina® AMEIs implanted in France during this period. Types of hearing losses were : perceptive n = 93, and conductive / Mixte : n = 30. 6 University tertieral referral centers in France participated (Lyon, Marseille, Clermont-Ferrand, Saint-Etienne, Bordeaux, Dijon); Types of AMEIs: Carina® G3 with transducer T1 (G3-T1) from September 2005 ; Carina® G3 with modified battery (G3T1) from October 2006; Carina® + : G3 with modified antenna and microphone (G3+T1) from April 2008; Carina® G4 with transducer T2 (G4-T2) from August 2010; Carina® G4 with transducer T2 and modified connector (G4T2) from December 2010

Methods: Survival rate of differents devices. This took count of technologic breakdowns. Other causes for explantation (medical problems, trauma) were analyzed.

Results: Figure displays the percentage of cumulative breakdowns. Over time according to different devices used.



[carina reliability]

Conclusions: We observed in an independent survey that the reliability of the Otologics Carina® AMEI improved dramatically over time according to technological changes.

KN2-9

Long-term results after application of the Esteem device

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Intro: The Esteem active middle ear implant is a fully-implantable device that may be proposed to subjects with sensorineural hearing loss of various degrees.

Methods: From 2007, 34 subjects have been implanted with an Esteem device at a tertiary University Hospital.

Results: An auditory improvement has been shown in around 80% of the subjects, with undeniable advantages also in quality of life. The implant has been explanted in three subjects for different reasons. in all the subjects, reconnection of the ossicular chain was achieved so as to allow them to wear a conventional hearing aids. Three subjects also displayed a temporary, delayed facial paralysis that recovered completely after 4 to 6 weeks. In some patients, hearing (bone conduction) deterioration was shown after the first years of use. The Esteem´s battery needed to be changed in a relatively shorter time than that reported by the Company.

Conclusion: The Esteem showed to provide good/excellent results in over 80% of the implanted subjects, with very low morbidity rate.

Learning outcome: The Esteem may be proposed to subjects with sensorineural hearing loss of different degree for improving the hearing disability and the quality of life.

KN2-16

Are middle ear implants superior to bone-conduction devices for patients with conductive/ mixed hearing loss?

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Introduction: Recently, we published our data on the maximum power output (MPO) of several kind of amplification options for patients with conductive and mixed hearing loss.[1] E.g. bone conduction works but it is not an effective means for sound transmission to the cochlea. Therefore, bone-conduction devices (BCD) require powerful amplifiers, nevertheless the MPO of the standard percutaneous BCD (e.g. Cochlear BP100 or Oticon Ponto) is limited, approximately 70 dB HL. Transcutaneous BCDs have even lower MPOs. For middle ear implants, with their actuator coupled to one of the cochlear windows, MPO was found to be 5 dB higher than that of the most powerful BCD (Baha Cordelle).[1] The Codacs device (Cochlear), developed for patients with otosclerosis, outperformed the other amplification options. Typically, its MPO exceeded 110 dB HL. The recently introduced active transcutaneous BCD (Bonebridge) has a MPO just below that of the standard percutaneous BCD.[2]

To deal with the relatively low MPO of most amplification options, many users with minor or a mild sensorineural hearing loss component chose for negative amplification, or, in other words, they chose a volume setting that compensated their air-bone gap only partially. Then the loudest input sound that could be processed without MPO related distortion equals the MPO value plus the attenuation (remaining air-bone gap).[3]

New results: Functional gain, defined as the bone-conduction thresholds minus the aided thresholds was calculated using data from relevant publications that could be traced using PubMed. Results were compared to the well validated NAL-NL norms. The calculations showed that (owing to the MPO limitations) Baha and Ponto devices showed functional gain values of about 15 dB below the NAL target gain. Transcutaneous BCDs showed an even 10 dB poorer result. Middle ear implants like the Vibrant Soundbridge and the Otologics devices, with their actuator coupled to one of the cochlear windows, showed functional gain values that are grossly comparable to those of percutaneous BCDs. Functional gain of the Codacs was closest to the NAL target gain.

Conclusion: Based on this audiological evaluation of published data, there are good arguments to choose percutaneous BCDs instead of transcutaneous BCDs. Excluding Codacs, published audiological data indicate that middle ear implants and percutaneous BCDs are competitive options for most patients with conductive or mixed hearing loss. As a consequence, other clinical data become decisive in the final choice.

References:

1. Zwartenkot et al., Otol Neurotol 2014, in press

2. Mertens et al., Otol Neurotol 2014, in press

3. Snik, ENT & Audiology News, 2014, in press

KN3 Binaural hearing

KN3-2

Congenital single-sided deafness affects aural preference and binaural processing

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Congenitally deaf cats (CDCs) have been used as an animal model of prelingual deafness (Kral and Sharma, 2012, Trends Neurosci). The present study investigates the effect of single-sided deafness, such as observed in CDCs that were implanted on one ear with a cochlear implant and chronically stimulated, or animals in the colony born with single-sided deafness on one ear and a normal hearing on the other ear. Microelectrode recordings were performed at the primary auditory cortex under stimulation at the hearing and deaf ear with bilateral cochlear implants. The contralateral aural preference normally observed in hearing controls was reduced in bilaterally deaf CDCs (Kral et al., 2009, J Neurosci). Single-sided animals showed a change of aural preference toward the hearing ear, whereas age of onset of asymmetric hearing before 3.5 months was critical for such a shift (Kral et al., 2013, Brain). With respect to morphology of LFPs, pronounced hemisphere-specific effects were observed (Kral et al., 2013, Front Syst Neurosci). Binaural interactions in multiunit recordings confirmed a reduced binaural interactions in unilaterally congenitally deaf cats specific to the hemisphere ipsilateral to the hearing ear. Increased occurrence of suppressive interactions was observed at the cortex ipsilateral to the hearing ear, whereas facilitatory interactions were reduced in both hemispheres. Finally, sensitivity for interaural time differences was substantially affected by single-sided deafness, with reduced sensitivity particularly at the ipsilateral hemisphere. The results suggest a specific adaptation process at the hemisphere ipsilateral to the hearing ear, involving mechanisms (likely down-regulated inhibition) not found at the contralateral hemisphere.

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KN3-4

Listening in acoustically adverse conditions: Models and algorithms

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To enable listening in acoustically adverse conditions is an important task of audio technology and a major challenge when the levels of noise and reverberation are high. The problem at large concerns the enhancement of human listening with and without hearing impairment (for example, intelligent microphones for recording purposes, hearing aids, and CIs) as well as the design of machine listening devices (for instance, robot audition, automatic speech-recognition and -dialogue systems). In this talk, we report on relevant work as performed at our Institute in Bochum.

First: Development of speech enhancement algorithms for the acoustic front ends of hearing instruments (work performed in the EU projects AUDIS and ICanHear). The size of typical devices, the power budget, and the admissible processing latency require a careful design of statistical models and processing schemes to achieve the required performance in real world applications.

Second: Development of a comprehensive functional model of binaural listening, including cognitive analysis and assignment of meaning. The system exploits expert knowledge in the application domains concerned and takes advantage of cross-modal cues for auditory stream segregation, scene analysis and disambiguation. The front end is a mobile robot with auditory, visual, haptic and propriozeptive sensors. Demonstration scenarios concern search-and-rescue tasks and the assessment of the perceptual quality of spatial-sound reproduction (work performed in the EU-project TWO!EARS).

KN4 Vestibular implant

KN4-1

Vestibular implant for restoring sensation of head movement - why it is needed and why it will work

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Profound bilateral vestibular deficiency (BVD) causes disabling oscillopsia, chronic disequilibrium, and postural instability, and there is no adequate treatment for individuals disabled by this loss despite optimal medical and rehabilitative intervention. Affected individuals suffer illusory drift of visual fields during head movement, chronic disequilibrium and postural instability caused by failure of vestibulo-ocular and vestibulo-spinal reflexes. Recent epidemiologic data from a national survey of United States adults reveal that more than 64K US adults (28/100K) suffer a constellation of symptoms consistent with chronic, profound bilateral loss of vestibular sensation. Affected individuals report reduction or cessation of driving due to their symptoms (44%), a high incidence of reduced participation in social activity (56%), a >24-fold increase in fall risk in comparison to the nationwide average (Ward et al., 2013). BVD individuals also report significantly reduced quality of life, increased health care expenses, and decreased productivity due to dizziness-related workplace absenteeism.

An implantable prosthesis that continuously and accurately emulates normal sensory transduction of head rotation could significantly and cost-effectively improve quality of life for these individuals. Progress toward such a device has accelerated over the past decade, and clinical feasibility trials of similar devices designed to deliver transient stimulation of the labyrinth have yielded promising results in humans. Achieving sufficient stimulation selectivity and intensity to accurately and chronically/continuously encode the full range of natural 3-dimensional head movements remains a key challenge. This lecture will provide an update on prosthetic vestibular stimulation research at the Johns Hopkins Vestibular NeuroEngineering Lab, including the neurophysiologic and anatomic basis of current prosthesis development efforts; comparison of different stimulation and encoding strategies; impact of vestibular implantation on hearing; directional plasticity and adaptive responses to chronic multichannel stimulation; correlation of vestibular electrically-evoked compound action potentials to eye movement responses, infrared laser stimulation; novel approaches to inhibiting undesired neuronal activity; and progress made through University-industry partnership toward a system for clinical application.

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KN4-2

Vestibular implant surgery: Progression and Pitfalls

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Intro: Until now, there are two options to implant a vestibular prosthesis: extralabyrinthine or intralabyrinthine. The extralabyrinthine approach (local anesthesia) comprises approaches to the posterior ampullary nerve and the lateral/superior ampullary nerve. With the intralabyrinthine approach (full anesthesia), electrodes are inserted in the ampullae of the semicircular canals. The Geneva-Maastricht group has used both techniques in humans to evaluate their feasibility, advantages and drawbacks.

Methods: Eleven patients were implanted with a modified cochlear implant providing vestibular electrodes (MED-EL®; Innsbruck, Austria). In five patients, the extralabyrinthine approach was used and in six patients the intralabyrinthine approach. Surgical experience and possible improvements were shared, combined with research from other groups.

Results and discussion: Both techniques are feasible in humans. The extralabyrinthine approach is likely to have less impact on hearing, while fixation of electrodes remains a challenge. The intralabyrinthine approach is easier to perform, but does not always preserve hearing and positioning of electrodes during surgery is more difficult. Future research should focus on optimization of electrode design to improve positioning and fixation of electrodes and to preserve hearing.

Conclusion: The extralabyrinthine and intralabyrinthine approaches are both useful for implanting a vestibular prosthesis. Electrode design needs to be improved to get a clinically useful and reliable device using these techniques.

Learning outcome: With the experience so far, both techniques can be used for implanting a vestibular prosthesis. A combination of both in the same patient could even be an option.

KN4-3

Artificial balance: restoration of the vestibulo-ocular reflex in humans with a prototype cochlear-vestibular implant

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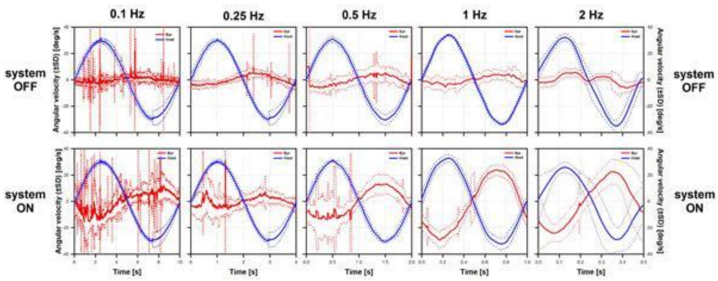
Intro: Patients with a bilateral vestibular loss (BVL) suffer from imbalance and oscillopsia. Consequently their quality of life is significantly impaired. Currently there is no effective treatment for bilateral vestibular deficits. The present study investigated whether it is possible to artificially restore the vestibulo-ocular reflex (VOR) using motion-modulated electrical stimulation.

Methods: Three patients received a modified cochlear implant providing vestibular electrodes (MED-EL®; Innsbruck, Austria). Subjects were submitted to 30°/s peak velocity, sinusoidal whole body rotations around the vertical axis in darkness, at frequencies of 0.1Hz up to 2Hz. Eye movements were recorded and the VOR gain was computed with the system OFF (e.g., without electrical stimulation) and with the system ON (e.g., while motion sensors were used to modulate the amplitude of stimulation currents delivered to the lateral ampullary nerve).

Results: Example VOR responses for one patient are presented in Fig. 1. As expected, in the system OFF conditions (upper row in Fig. 1) compensatory eye movements were practically absent and VOR gains were very low. In the system ON conditions (lower row in Fig. 1) clear VOR responses were observed and the VOR gain increased significantly, especially at frequencies >0.5Hz. The VOR gain also increased significantly as modulation strength (i.e., intensity of the stimulation) increased, reaching 57%-121% (mean 79%) of the median VOR gain measured for a group of 5 healthy subjects in the same experimental conditions.



[Figure 1]

Discussion: These results demonstrate that it is possible to evoke an artificial VOR in patients with a BVL of substantially different durations (from >50 years to 1 year) and of different etiologies. We also observed better artificial VOR responses at higher rotation frequencies. This closely resembles well known and documented dynamic characteristics of the normal VOR, with optimum performance in the 1Hz-2Hz frequency range, which is critical for important every-day activities such as walking.

Conclusion: The artificial restoration of the VOR observed in our group of implanted patients can be considered as substantial functional recovery. These results constitute a fundamental milestone, demonstrating that an artificial VOR can be successfully evoked in humans using electrical stimulation.

Learning outcome: These results allow us to envision for the first time clinically useful rehabilitation of this patient population.

RT1 Cochlear implants: a remarkable past and a brilliant future – the 'past presidents panel'

RT1-3

Cochlear implantation in infants below 12 months of age

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Intro: This study evaluates the safety and efficacy of cochlear implantation in deaf infants below 12 months of age.

Methods: With the wide application of newborn hearing screening programs, infants with deafness are being identified at birth. When a hearing aid trial fails, cochlear implantation is the only option to restore hearing. Mounting evidence suggests that age at implantation is a strong predictor of language outcomes. Using the minimally invasive surgical technique we have employed for neary two decades, a limited clinical trial was initiated in 2000 because this age limitation fell outside of FDA guidelines. The infants were assessed using the preferential listening paradigm to confirm that they could learn associations between speech sounds and objects. Sufficient time was allowed to pass to administer more traditional language measures.

Results: No surgical or anesthetic complications occurred in this group of infants. The pattern of listening skill development mirrored that seen in normal hearing infants. Long-term language assessments using the Peabody Picture Vocabulary test (PPVT) and other measures have demonstrated that many of the infants achieved age appropriate language skills.

Discussion: Very early access to sound maximizes the listening and language acquisition skills of deaf infants.

Conclusion: In experienced hands, the surgical procedure can be safely performed in very young, deaf infants and the outcomes can exceed those previously seen.

Learning outcome: Expansion of selection criteria continues to evolve.

RT1-4

Infants receiving a cochlear implant before nine months of age have no language delay

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Aim: The main objective of this study was to investigate whether prelingually deaf children who received a cochlear implant (CI) before nine months of age developed age-equivalent spoken language abilities to a greater extent than children who were operated on at a later stage. The study also examined the medical risk of intervention with CIs in very young children. In addition, the study aimed to describe a cohort of early implanted children without exclusions that are common in other studies.

Methods: The spoken language abilities of 137 prelingually deaf children, who received CI, were analyzed. The children were divided into five groups depending on their age at the time of the implantation: Age group 1: < 9 months (n= 20), Age group 2: 9-11 months (n= 31), Age group 3: 12-17 months (n=33), Age group 4: 18-23 months (n=30) and Age group 5: 24-29 months of age (n=23).

Language understanding, vocabulary, speech production and speech perception were assessed with language and hearing tests. The levels of the skills were tested at six month intervals after the CI operation. The children were followed-up for up to 11 years (mean 6.8 years).

Results: Children implanted before 9 months of age had no language delay and reached age equivalence results on all language measures. Children implanted at 9-11 months of age had an initial language delay in language understanding and in speech intelligibility, but caught up after 2- 3 years. The children implanted between 12-17 months did not close the gap on language understanding during pre-school age, but caught up on vocabulary at early school age. Children operated from 18 months and onwards did not close the gap compared to children in the youngest age group, in any language measures except for speech intelligibility.

No increase in complications was recorded when the youngest children who received implants were compared with those who were older when they received their implants.

Conclusion: Cochlear implantation before nine months of age reduce the spoken language delay, compared to children implanted at higher ages, and gives the majority of prelingually deaf children spoken language acquisition similar to that of their normal hearing peers.

RT1-6

Hybrid cochlear implants: Acoustic hearing stability and long-term results

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Multicenter clinical trials with Nucleus Hybrid Cochlear Implants have been on-going in the United States since 2000. This population of adults had residual low-frequency (LF) hearing no poorer than 60 dB HL through 500 Hz and severe high-frequency (HF) hearing loss above 2000 Hz.

Three different electrode configurations (Hybrid S8, S12, and L24) have been implanted in 164 subjects. The residual acoustic hearing, speech perception scores in quiet and noise, and spatial hearing have been obtained. A subset of this population has been followed for over 10 years.

The results demonstrated that immediate hearing preservation (at initial activation) was accomplished in 98% of the subjects. Over time (12 months) some hearing preservation was maintained in 92% of the group; however 27% of the subjects did not maintain functional LF acoustic hearing (< 85 dB HL PTA). The reasons for this outcome are likely multifactorial, and possible mechanisms will be discussed. However, the 10mm implants (S8 and S12) resulted in significantly less total or profound hearing loss (18%) compared to the Hybrid L24 (44%). An important finding is that preservation of functional hearing (thresholds better than 85 dB HL in the LF) enables subjects to take advantage of acoustic plus electric hearing in quiet and in noise. Interestingly, there does not appear to be a correlation between the amount of preservation of functional hearing and speech perception as long as acoustic hearing can be aided. Combined acoustic plus electric speech processing has enabled most of this group of subjects to gain improved word understanding in quiet compared to their preoperative hearing with bilateral hearing aids. Additionally, the combined acoustic plus electric hearing enabled some individuals to have improved signal to noise ratios of more than 9 dB SPL. Furthermore, preserving acoustic hearing in both ears allowed spatial hearing. Demographic factors such as etiology, duration of HF hearing loss and age at implantation have been found to be variables that can impact these results.

Long-term acoustic hearing can be maintained for more than 12 years, and monosyllabic word scores are unchanged over this time period. Finally, selection of electrode length and the risk/benefit will be important as individuals with more hearing request electric sound processing.

Listeners will have a better understanding of the longitudinal stability of acoustic hearing and speech perception performance in subjects implanted with a hybrid device.

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RT5 The beauty of the cochlea

RT5-1

Human cochlea and CI

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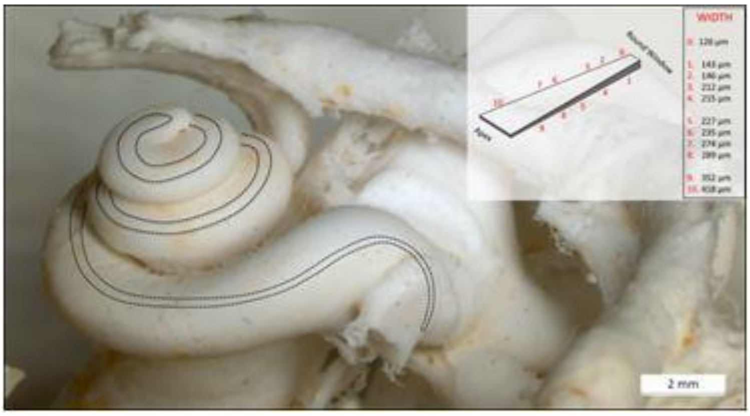
Novel techniques in CI have led to modifications to introduce electrode arrays into the cochlea. This has set new demands on surgeons' acquaintance with the cochlear anatomy. A brief presentation of the anatomy of the human cochlea with variations is given. We used micro-dissected, human macerated temporal bones, 324 plastic moulds, electron microscopy and immunohistochemistry of well-preserved human tissue obtained at surgery for life-threatening petro-clival meningioma. The complex “hook” region may challenge electrode insertion. The macromolecular organization of the basilar membrane was assessed and its dimensions evaluated using TEM and SEM. Width varied from 126 µm at the base to 418 µm in the apex. Thickness varied from 1.16 µm at the base to 0.55 µm in the apex. The results are appraised relative to various electrode array designs and insertion depths. The basilar membrane “proper” was found to consist of collagen II. The tympanic covering layer (TCL) expressed collagen IV. We speculate on the TCLs´ culpability for inflammation and fibrotic reactions around the electrode through a fibronectin/β-integrin trans-membrane receptor system. Per-operative anti-inflammatory drug-delivery may be essential to arrest these signal cascades in routine CI surgery.



[Graph]

RT5-3

Imaging of the membranous labyrinth in healthy and Meniere's disease ear

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Visualization of the membranous labyrinth will provide useful information on the inner ear condition and inner ear surgery. With 3DCT imaging, it is possible to use several CT window values (CTWVs) per image. Using this strategy we investigated to compare the anatomical narrows of the endolymphatic pathway of the membranous labyrinth of normal cases and Meniere's disease (MD) ears. The morphology of the membranous labyrinth between the vestibular cecum of the cochlea and the saccule were significantly different between healthy individuals and MD cases.

The present investigation first shows the usefulness of 3DCT imaging of the membranous labyrinth and will provide useful informations of the inner ear and preoperative assessment of the inner ear surgery including cochlear implant surgery.

RT5-10

The visible ear simulator 1.3 / 2.0: A virtual temporal bone microdissection training simulator

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The role of virtual simulators in training for ear surgery is growing as human temporal bones and scheduled tutor resources are becoming increasingly sparse. To increase training convenience many users may prefer a simulator interface in their own language and may benefit from an application with integrated user instructions.

The Visible Ear Simulator, VES 1.3 can be downloaded as freeware from the website http://ves.cg.alexandra.dk, installed on any PC with a GeForce GTX graphics card and tested with just a PC mouse.

Operation with a Phantom Omni©/ Geomagic Touch© haptic device of the high-fidelity simulator provides intuitive 3-D handling with force-feedback and drilling in real-time with a Chinese, English or German language interface and pdf manual. An integrated surgical tutor provides stepwise instructions through conventional images and brief texts during drilling. Metrics derived from the bony segment of the corresponding steps are used to color-code the volumes of bone to be removed directly on the 3-D model and to provide immediate feedback and final evaluations. The latest version accepts haptic devices with FireWire, Ethernet- or USB interface and coming versions will support French, Spanish, Portuguese, Russian and Japanese interface.

A VES version 2.0 including interactive deformable representations of the Dura, Sinus, Facial nerve, Drum and Skin is in Beta testing. Partnership projects are developing CT/MRI import functions for patient specific scenarios, and haptic simulation of CI electrode insertion and general device handling.

RT7 New indications

RT7-2

Cochlear implantation as hearing rehabilitation method in single-sided deafness after acoustic neuroma surgery with intracochlear placeholder insertion

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Introduction: Translabyrinthine acoustic neuroma surgery consecutively leads to single-sided deafness (SSD) if the hearing is normal on the contralateral ear. Subjectively and objectively, cochlear implantation (CI) is the most successful method of hearing rehabilitation in patients with SSD.

Methods: Sixteen patients who had undergone acoustic neuroma surgery between 2010 and 2013 were analyzed in a retrospective study. In all patients an intracochlear placeholder was inserted during acoustic neuroma surgery in order to prevent cochlear obliteration. One year after acoustic neuroma surgery, extensive counseling on hearing rehabilitation options including MRI follow up and testing of pseudo-stereophonic solutions were performed. Three patients received a CI. Audiological testing consisted of speech recognition in noise and localization measurements preoperatively as well as 12 months after first fitting of the CI. Subjective evaluation was administered using the SSQ questionnaire.

Results: Preservation of the cochlear nerve and insertion of an intracochlear placeholder could be achieved in all 16 patients during acoustic neuroma surgery. One year after acoustic neuroma surgery, 3 patients chose no therapy at all or another form of SSD hearing rehabilitation. Another 9 patients opted for a preoperative CI evaluation including promontory testing. In another 4 patients promontory testing has not yet been performed. Objective and subjective hearing rehabilitation results of the 3 CI patients after CI surgery are comparable to SSD patients receiving a CI due to other medical reasons.

Conclusion: The results confirm a binaural hearing benefit with cochlear implant, likewise in patients after acoustic neuroma surgery. Thus, SSD hearing rehabilitation with a CI should be recommended only to patients in whom the integrity of the cochlear nerve can be expected after acoustic neuroma surgery. Planning and counseling at an early stage, especially in translabyrinthine acoustic neuroma surgery, is essential, as an intracochlear placeholder is obligatory to allow electrode insertion and prevent obliteration.

Learning outcome: An intracochlear placeholder can prevent obliteration of the cochlea in patients after translabyrinthine acoustic neuroma surgery in order to have all rehabilitation options available in case of remaining integrity of the cochlear nerve.

RT7-4

Nucleus® cochlear implants for patients with severe tinnitus and asymmetric hearing loss

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Cochlear Implantation (CI) is an accepted treatment modality for severe to profound binaural sensorineural hearing loss and recently is also considered for restoring binaural hearing in patients with Asymmetric Hearing Loss (AHL) that have one ear with normal hearing or moderate loss and another ear indicated for CI. Studies have shown that CI can partly restore binaural hearing and additionally provide a relief of tinnitus these patients.

The primary objective of this Spanish Cochlear sponsored multi-center study is to investigate the efficacy of CI in adult patients with AHL with a hearing loss related severe tinnitus handicap, lasting < 3 years and recognized as score on THI > 58%, which is unresponsive to conventional tinnitus treatments.

Data are collected preoperatively and over a period of 12 Months after CI. Tinnitus data include: THI, Visual Analog Scale of tinnitus loudness (VAS) and a characterization of tinnitus. Hearing evaluation includes: audiometry, speech perception tests and hyperacusis evaluation. In addition Quality of life (HUI) and hearing (SSQ) is evaluated.

Currently 12 patients are enrolled in the study. Current VAS results suggest that patients find a relief of their tinnitus when the implant is active but less so when the implant is off. Preliminary results and implications for clinical practice will be presented.

RT7-6

Hearing preservation, hybrid stimulation, and speech understanding in an expanded indication study: Preliminary results

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Introduction: Significant advances in cochlear implant (CI) technology and surgical techniques have occurred since the initial approval of the multichannel device almost 20 years ago. Concomitant with these advances has been an improvement in speech understanding and subsequent expansion in indications for usage. Despite these changes, many patients who use hearing aids fall outside of current criteria yet demonstrate great difficulty hearing and communicating in real world situations. These patients usually score too high relative to the candidacy criteria on standard sentence recognition tests (HINT), but score poorly when given monosyllabic word tests (CNC) or more difficult sentence materials (AzBio). They also may have better hearing thresholds than allowed by current criteria. A multicenter clinical study has been initiated to study the effect of CIs in a population of patients who fall outside of current clinical criteria as set forth by the US Food and Drug Administration (FDA). That these patients have more hearing prior to surgery, hearing preservation and electric-acoustic (hybrid) stimulation are additional outcome measures. The objective of this investigational device exemption (IDE) clinical study is to evaluate the safety and efficacy of a standard length slim straight CI electrode array in a population of newly implanted adults with expanded indications for candidacy.

Methods: A prospective, multicenter, repeated-measure, single-arm, open label clinical trial is on-going. Inclusion criteria require moderate hearing loss through 1000 Hz sloping to severe above 3000 Hz in the ear to be implanted, with aided CNC word scores between 10 and 50% for the ear to be implanted; up to 70% contralaterally. Outcome measures include a comparison of pre and post-operative audiometric thresholds, CNC word recognition scores, and AzBio Sentence recognition scores in noise.

Preliminary Results: A majority of subjects experienced post-operative audiometric threshold shifts of less than 30dB, often resulting in the potential for hybrid stimulation. Early results reveal improvements in CNC and AzBio scores as early as 3 months following the initial activation of their device regardless of sound processor configuration (electric only or hybrid).

Discussion: Preliminary data indicate that adults with better hearing and speech scores than traditional candidacy criteria can benefit from CI. Moreover, aidable residual hearing can be preserved in many patients allowing for access to hybrid stimulation.

Conclusion: These results further support the expansion of current candidacy criteria to include patients with greater degrees of residual hearing.

RT8 Bilateral cochlear implants

RT8-2

The virtual reality as a tool for the investigation of the mobile and stationary localization with cochlear implant users

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Intro: The localization of sound sources based on acoustical features is limited with monaural hearing, as in unilateral cochlear implant (CI) users or single sided deaf listeners, in comparison with normal binaural hearing. In the clinical setup the localization is investigated in a stationary test setup where the subject points out the direction of motionless sound sources (stationary localization). Since most of these investigations covered the localization in quiet only the outcome of the localization under more realistic conditions like reverberated acoustics is unknown. Under these realistic conditions the relative movements between the listener and the sound source might additionally influence the localization abilities of the listener.

Methods: To measure the localization abilities under potentially more realistic but yet controlled conditions an alternative method of measurement is introduced which uses the opportunities of the virtual reality (VR). In the VR setup the stationary localization and the mobile localization can be investigated. In the mobile localization setup the participants of the study indicate the direction and the position of the invisible sound source in an acoustically and visually simulated room by moving themselves through the virtual room to the localized sound source. The required length of the path through the VR until the sound source has been found will be discussed as measure for the localization abilities.

The mobile and stationary localization were tested with bilaterally and unilaterally listening CI users to test the benefit of bilateral hearing. Rooms with different reverberation times were simulated in the VR to test how the localization of CI users is affected by reverberation.

Results: First localization results of unilateral and bilateral cochlear implant users will be presented. The results of a stationary localization test setup are compared to the results of mobile localization setup which were both implemented in the VR.

The mobile and the stationary localization revealed differences between the binaural and monaural hearing of CI users. In most CI listeners the localization was poorer in reverberated rooms. The localization abilities of CI users ranged from poor to near to normal.

Discussion: The results indicate that reverberation affects the localization in most CI but not all CI users. The factors which might influence the localization abilities of CI users will be discussed.

Conclusion: The measurement of the mobile localization in the VR is able to reveal reproducible differences in the localization abilities of CI users.

The study was supported by MED-EL Germany

RT8-7

Bilateral cochlear implants - Sequential versus simultaneous CI

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Objectives: The purpose of this study was to establish and evaluate a statistical definition for cochlear implant map stability. Once defined, this study aims to compare the length of time taken to achieve a stable map in first and second implants in sequential bilateral cochlear implantation and to identify factors that affect map stability.

Study design: A retrospective cohort study of 30 patients with sensorineural hearing loss who received sequential bilateral cochlear implantation (Cochlear, Melbourne, Australia only) by the senior author. Psychophysical parameters of hearing threshold (T) scores, Comfort (C) scores and the dynamic range (DR) were measured for the apical, medial and basal portions of the cochlear implant electrode array at a range of intervals post implantation. Stability was defined statistically as a less than 10% difference in T, C and DR scores over three consecutive mapping sessions. A senior cochlear implant audiologist, blinded to implant order and the statistical results, separately analyzed the data using the current stability assessment methods involving visually inspecting the map data.

Results: The cohort consisted of 17 females (57%) and 13 males (43%). The median age for the first implant was 47.7 years (1-79 years) and the median age at second implant was 50.5 years (2-81 years). The mean duration between implants was 2.8 years (1-7 years).

For all implants the average time to stability was 69 days using current audiology methods, compared to 68 days using statistical methods, with no difference between the two groups ($p=0.42$). The average time to stability in the first implant was 87 days with current audiology methods and 81 days using statistical definition, with no difference between groups ($p=0.2$). Duration to stability for the second implant was 51 days using current audiology methods and 60 days using statistical definition, and again with no difference between groups ($p=0.13$). There was also a significant correlation between the audiology method and statistical method ($F< 0.005$).

There was a significant reduction in time to achieve stability in second implants for both current audiology methods and the statistical method ($p< 0.001$ and $p=0.02$ respectively).

Conclusions: A statistical definition can be devised to accurately predict cochlear implant map stability. Using this statistical definition and subjective audiology methods second cochlear implants stabilize sooner than the first

RT12 Deep insertion vs. shallow insertion

RT12-1

Rate and place coding: Which is the real pitch?

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In the cochlea of a normal hearing listener, frequency information is coded tonotopically such that lower frequencies are presented to the cochlear apex while higher frequencies are presented towards the base. Each frequency has its own unique location in the cochlea. Additionally, each location in the cochlea is vibrated at the frequency corresponding to that location. Pitch could be coded by the location of the cochlea stimulated (place), the frequency at which the cochlea is vibrated (rate), or a combination of the two. With normal hearing listeners, it is very difficult to independently manipulate rate and place information to determine the relative importance of each variable in coding pitch.

With cochlear implants, rate and place cues are easily independently manipulated. Any electrode can be stimulated at any rate. On a single electrode, increasing the rate of stimulation produces a higher pitch. Similarly, switching from one electrode to a more basal electrode also produces a higher pitch. When an implant user is presented with conflicting changes in rate and place, pitch ranking is made more difficult. Therefore, it is clear that both rate and place contribute to a pitch percept.

Using Multi-Dimensional Scaling, it has previously been shown that a change in rate and a change in place represent two independent perceptual dimensions. Therefore, although both rate and place represent perceptual dimensions labeled as pitch, they do not represent the same pitch quality. Unfortunately, with cochlear implant users, it is very difficult to determine which of these two types of pitches (rate or place) are more like pitch as experienced by normal listeners.

A new patient population with normal hearing in one ear and a long (31 mm) MED-EL cochlear implant array in the contralateral ear provide an excellent opportunity to compare perceptual changes from rate and place with electrical stimulation with the perceptual change from a change in acoustic frequency. Using a multi-dimensional task, we compared the perceptual relationships between a change in rate, place, and acoustic frequency. Acoustic stimuli consisted of pure tones at 75, 150, and 300 Hz. Electric stimuli consist of three adjacent electrodes with amplitude modulations at either 75, 150, or 300 Hz. The experiment was repeated in both the apex and the middle of the array. Results consistently indicate that in the middle of the array, a change in acoustic frequency is perceived as a change in place of stimulation. Results in the apex are less consistent, but suggest that most subjects perceive a change in acoustic frequency as a change in rate. The data suggests that while place and rate pitch are different, the dimension that represents a change in acoustic frequency varies across the array. Furthermore, it suggests that to provide a natural pitch sensation with a cochlear implant, it is important to provide temporal pitch in the apex, but not across the entire cochlea.

RT14 Siebold memorial session – Japanese-German friendship

RT14-1

Siebold Memorial Session - Japanese German Friendship

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I would like to briefly introduce the history of the Siebold Memorial Symposium. I, Dr. Jan Helms and Dr. Joachim Müller, who have known each other for almost 20 years, have exchanged scientific information by inviting each other. Even after I moved to Nagasaki from Kyoto in 2002, this good relationship continued. Since Germany was very advanced in the field of cochlear implantation (CI), I proposed to have periodical meeting between Nagasaki University and Würzburg University to learn about and to exchange the newest information about CI. The 1st symposium was held in 2006, at Nagasaki University Hall. The symposium was named as Siebold Memorial Symposium, because a long time ago, Dr. Philipp Franz von Siebold from Würzburg, Germany, came to Nagasaki in 1823, and tremendously contributed to the distribution and development of western medicine in Japan. Actually many old Japanese pioneer doctors learned from him, and established modern medicine in Japan. The name, Siebold, was therefore, quite a common and familiar name for both of us. During the symposium, we actually learned a lot, and now our Nagasaki University had the greatest number of patients with bilateral CI in Japan. Since then, such symposia or sessions have been held between us with the name of “Siebold Memorial” periodically for 5 times to date, and are now established as a symbol of good mutual friendship between us and our gratitude to Drs. Helms and Müller. The most recent symposium held in June, 2013, was named as “The 5th Siebold Memorial Symposium on Hearing Implants”, and we are aiming at making this symposium as a place discussing about all the hearing implants as well as CI. It is a great honor and pleasure to have Siebold session in this international symposium, and at this opportunity, I would like to express our great gratitude to Drs. Helms and Müller.

S1 Development of rehabilitation concepts

S1-2

Auditory sentence processing in adult cochlear implant users

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With increasing confidence in effectiveness and reliability in recent years, the cochlear implant (CI) has been proven an indication for severe and profound hearing loss and has brought considerable gains to many implant recipients. But hearing with a CI cannot be equated with typical hearing, and those differences affect sustained auditory language comprehension (Hahne et al., 2012). Furthermore, current research supports the claim that auditory sentence comprehension in adult CI recipients is determined by processing semantic before syntactic information (Hahne et al., 2012; Hahne & Friederici, 2001; Friederici, Hahne & Saddy, 2002). The present study therefore examines, whether postlingually deaf or hearing-impaired patients focus more on semantic information when interpreting linguistic utterances by incorporating contextual information, or whether they apply alternative strategies. For this purpose listening training has been developed, which requires both the identification of semantic and syntactic features in the set, and to match sonically fragmentary gap sentences. Furthermore, the empirical study was carried out to contribute to the question of whether to strengthen compensatory strategies or to focus on deficits to overcome hearing limitations. In a cross-over design, n=42 postlingually deafened CI users participated in all three training programs for two weeks each with patients from 14 homogeneous triplets being assigned at random to their first treatment, with a subsequent split into two groups of 7 participants each receiving one sequence of the other two training procedures. The patients were between 20 and 76 years old and had been fitted with cochlear implants unilaterally or bilaterally for at least 2 to a maximum of 9 months before inclusion in the training study. To avoid influences on the results by potential confounding variables, several parameters were considered as covariates with intrinsic and phasic attention as well as vocabulary performance finally serving as control variables. Changes in linguistic performance in audiometric tests were assessed within each group before and after each training regimen and to a control group, which received no specific training in addition to their standard treatment. Results showed that problems with sentence comprehension mainly concerned extracting of morpho-syntactic information. Patients mostly profited from auditory sentence training, which also supports application of top-down driven comprehension and inference processes. In summary, all patients benefited from the sequence of auditory training procedures, but particularly positive changes in performance were found for the semantically oriented training for auditory speech understanding in quiet and in noise.

S1-3

Working with older adults with short term memory loss

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Intro: Sensory deprivation has been identified as a factor contributing to onset of dementia. Hearing loss is independently associated with accelerated cognitive decline. Traditional rehabilitation exercises for cochlear implant recipients, such as analytic and synthetic methods, rely on the recipient having good short term memory skills. For adults who are experiencing a decline in their short term memory function these rehabilitation methods are not effective. A range of dementia therapies have been developed and an example is reminiscence therapy. This therapy uses the individual´s long term memories, which often remain intact, as a means for them to socially interact and have more conversations.

Methods: Reminiscence therapy has been used at YAIS since May 2013 in cases where either the cochlear implant recipient or their main conversation partner showed signs of memory problems. Memory problems were identified through observation or self-report. To date two cochlear implant recipients have been identified as having short term memory problems. Another two adult cochlear implant recipients have been identified as the main carers for a spouse with a diagnosis of dementia.

Results: Reminiscence therapy is easy to use and cochlear implant recipients living with memory problems are able to use the techniques at home with family members and carers.

Discussion: Facilitating reminiscence amongst cochlear implant recipients and their families can increase conversational opportunities. Reminiscence therapy techniques are also helpful for people who have limited conversation with their families despite no apparent cognitive difficulties. When providing rehabilitation activities for people to complete at home with their families it is important to provide activities which are achievable. If a relative has memory problems reminiscence therapy can be a vehicle for them to help the cochlear implant recipient to have increased listening practice.

Conclusion: The number of adults with memory problems seen at YAIS since May 2013 are small. Current criteria and outcome measures for cochlear implantation include speech sentence testing, which require good short term memory. A long term study to determine the effectiveness of reminiscence therapy is recommended. Outcome measures would include information about quality, frequency and duration of conversations post reminiscence therapy.

Learning outcome: Learn about reminiscence therapy as an approach to working with adults living with memory problems.

S1-6

Different options for auditory training - adaptive rehabilitation -

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Incidental or natural learning describes a process that happens unplanned, all day, initiated by and immediately integrated in daily life activities of a child or adult.

In case of hearing loss, natural learning might be in danger. The main aim of medical treatment and technical interventions, like hearing aids and cochlear implants, is to restore natural learning. The primary aim and method of “early intervention” (or post-operative rehab) is to monitor and optimize the process factors that allow and secure incidental learning.

However, depending on a set of factors, being personal and/or environmental, the natural learning process might not be enough. In that case, various intervention strategies might be added to initiate, support, complete or even replace natural learning.

In this presentation, the advantages of incidental learning will be summarized. Also, the process factors that have to be monitored will be discussed.

Auditory training is one of those options: training is based on planned and formal learning strategies, activities and contents.

For parents as well as for professional educators/therapists “training” is related to a different educational style. Training can be strongly targeted and training effects can be administered clearly and immediately.

Adaptive Rehabilitation is a concept that explores the options and needs of a hearing impaired person. It offers a combination of methods and contents, which will enable and optimize the overall processes of “learning to listen” and “learning through listening”.

Adaptive Rehabilitation is “community based” at the social level of family, school, work place and tries to realize the concept of “inclusion”. These community-based elements in Adaptive Rehabilitation include relevant factors like communication style in the family, the acoustic environment at home, in school, at the work place, etc.

S2 Intraoperative/objective measurements

S2-2

Clinical application of postoperative stapedius reflex testing for the fitting of cochlear implants in children

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Intro: Fitting of cochlear implants (CI) based on objective measures is important in children who cannot provide sufficient feedback about loudness sensation when stimulated via cochlear implant. It has been demonstrated by numerous authors that postoperative electrical stapedius reflex thresholds (ESRT) can serve as good estimators for psychoacoustic comfort levels. However, the procedure of ESRT testing is not generally applied as there exist some limitations for routine application in daily clinical practice. Aim of the study was to analyze the clinical applicability of postoperative ESRT testing in an unselected clinical sample of children in whom fitting based on objective criteria was needed.

Methods: In a retrospective evaluation, data from 70 unselected children supplied with MED-EL cochlear implants were examined. It was analyzed, how often the ESRT testing procedure based on acoustic impedance audiometry could be successfully applied and ESRT data could be used for CI fitting in children. Also, the incidence of middle ear problems as possible limit of application was registered in the sample considered. In addition the efficiency of a minimal intervention by an otolaryngologist (i.e. medication of nose drops, ventilation of the Eustachian tube etc.) in case of minor middle ear problems was analyzed.

Results: ESRT testing could be applied successfully 2 months after implantation in 80-90% of patients. In 10-20% of cases a minimal medical intervention was needed. In principal values for ESRT could be determined in about 85% of cases.

Conclusion: The study demonstrated, that ESRT testing can be successfully applied postoperatively in a high number of patients as long as the general requirements for stapedius reflex detection are met. ESRT testing can serve as a useful objective tool for the CI fitting procedure in children when using appropriate instrumentation and clinical infrastructure.

S2-8

Relating objective measures of auditory function to behavioral speech outcomes among high level adult performers with the MED-EL Flex Electrode

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Intro: The aim of this study is to determine whether there are objective measures predictive of above average speech performance in CI users. Our hypothesis is that adult CI recipients deemed to be “above average” performers will differ in their neurophysiologic responses recorded at one or more levels of the auditory pathway (i.e., electrically evoked compound action potentials and cortical auditory evoked potentials.

Methods: 18 adult CI recipients, mean age of 63 years, (8 “above average” and 10 “average”) were included. “Above average” performers were defined as CI recipients who scored greater than 80% on AZBIO sentences at 3 months post activation and improved more than 20% on CNC words over the same period. Participants were evaluated on measures of ECAP at three time points: at CI activation, at 1 month, and at 3 months. CAEPs were measured at 3-months post CI activation. Differences in evoked potential responses and behavioral measures of speech (AZ BIO and CNC words) between the two groups were examined for statistical significance.

Results: “Above average” performers were younger (mean of 59 years vs. 67 years), had better speech performance at CI activation, and had better qualitative ratings of implant performance as measured on SSQ and HISQUI, all $p < 0.05$. Results of CAEP recordings indicate better N1 and P2 latencies for the “above average” performers and lower apical electrode impedances at CI activation ($p < 0.05$). Subsequent analyses will present ECAP findings in relation to speech performance.

Discussion: Numerous studies have looked for physiological measures to predict auditory nerve survival as a means of exploring CI outcome. Recent human studies have shown a relationship between speech performance and the slope of the ECAP growth function. Other research has correlated speech performance to cortical auditory evoked potentials (CAEPs). The current study confirms such findings and will explore emerging trends.

Conclusion: Above average implant performers have differences in objective measures of neural survival and auditory processing compared to average implant performers.

Learning outcome: To explore and determine characteristics of objective measures that can help guide CI outcomes.

S2-9

The relationship between electrical auditory brainstem responses and perceptual thresholds in Digisonic® SP cochlear implant users

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Aim: Determining the electrical stimulation levels is often a difficult and time consuming task because they are normally determined behaviorally - a particular challenge when dealing with pediatric patients. The eSRT and the ECAP have already been shown to provide reasonable estimates of the C and T-levels, although these estimates tend to overestimate the C and T-levels. The aim of this study was to investigate whether the eABR can also be used to reliably estimate a patient's C and T-levels.

Material and methods: Behavioral C and T-levels were taken directly from each patient's existing MAP file for their standard 'everyday usage' program map. eABRS were measured postoperatively on a basal, a medium and an apical electrode.

Results: The correlation between eABR detection thresholds and behaviorally measured perceptual thresholds was statistically significantly ($r = 0.71$; $p < 0.001$). In addition, eABR wave V amplitude increased with increasing stimulation level for the three loudness levels tested.

Conclusions: These result show that the eABR detection threshold can be used to estimate a patient's T-levels. In addition, wave V amplitude could provide a method for estimating C-levels in the future. The eABR objective measure may provide a useful CI fitting method - particularly for pediatric patients.

S2-11

New approaches determining the ECAP threshold

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Background: The electrically evoked compound action potentials (ECAPs) of the hearing nerve are routinely recorded for intra-operative testing of the cochlear implants integrity and its coupling to the auditory system. Post-operatively, the parameters for fitting of the dynamic range are partially derived from the ECAP threshold. Because of the large amount of data and the steadily increasing number of cases it is desirable to use automatic threshold detection algorithms and to improve their accuracy.

Data acquisition: In 12 persons provided with MED-EL Flex28 electrodes, two series of ECAPs were recorded immediately after implantation: 1st a full profile involving all 12 channels in steps of 200 current units and 2nd a high resolution (20 records in the close neighborhood around the threshold) amplitude growth function in one selected channel. It was the aim to study the details of the threshold transition in order to find valid threshold criteria.

Data treatment: The exploration of the ECAP functions is hampered by the stimulus artifact which requires a special treatment, e.g. correction by an exponential function. After this, the ECAP coordinates (minimum N1 and maximum P1) can be determined automatically or manually. Following the conventional procedure, the function describing the intensity dependence of the response amplitude (amplitude growth function) is extrapolated linearly in order to find the threshold. This approach goes along with serious problems since a linear function does not reflect the reality. It appears more appropriate to define the threshold as the stimulus intensity where the response disappears. This threshold can be obtained by choosing fixed places for the extreme values N1 and P1 at all stimulus intensities (this procedure is justified since the latencies do not depend on stimulus intensity); based on these coordinates, the response area, which is a measure of the physiologic activity, and the noise variance can be determined. The response threshold is then derived from the signal to noise ratio which should exceed the limit of 6 dB. An alternative, completely different approach is based on the cross correlation functions obtained from convolution of each curve with an universal or individual template.

Results: The ECAP thresholds obtained from the automatic procedure coincide well with those determined by manual evaluation and visual inspection.

Conclusions: Implementation of the new algorithm will probably lead to reliable results without any user intervention.

S2-12

Recordings of acoustic evoked potentials directly from the different places of cochlea via intracochlear electrodes in cochlear implantees with partial deafness

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The latest developments in cochlear implants, electrodes and surgical techniques allowed for expansion of indication criteria in cochlear implants. Currently, it is possible to implant patients with Partial Deafness (PD, with normal hearing up to 1.5kHz and with high frequency severe to profound sensorineural hearing loss with certain degree of hearing preservation after the cochlear implantation (Skarzynsky et al., 2002, 2006, 2007, 2009; 2012; 2013) Using an appropriate tools it allows us to perform measurements that have never been obtained in human and further to improve our understanding of inner ear and hearing. For instance, to this date it was not possible to record acoustically evoked or acoustically and electrically evoked response directly from the cochlea. Currently, there are available only studies recording the acoustic potentials via far field recordings (i.e. using a clinical ABR technique) or intraoperatively via an electrode placed in the vicinity of the round window (Marco Mantala et al., 2012). However, none of these approaches allows us to get better understanding of pattern of excitation within the cochlea. Specifically, using such measurement set-ups it is not possible to obtain frequency specific information. Our pioneering work showed that recordings of acoustic evoked potentials directly from the different places of cochlea are possible. The paper will present a new method of recordings via intracochlear electrodes and its possible use in cochlear implantees.

S3 Development of surgical techniques

S3-2

Cochlear® Hybrid™ system: Factors involved in outcomes

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Introduction: The Cochlear Hybrid System presents an opportunity for those with precipitous high-frequency (HF) sensorineural hearing loss to improve their speech perception abilities via electrical stimulation of the basal region of the cochlea. Electric stimulation is used in conjunction with low-frequency (LF) acoustic amplification provided by a combined electric-acoustic sound processor. Factors affecting outcomes, as measured via speech perception measures presented in quiet and in noise, will be discussed.

Methods: The 50 subjects were required to have severe HF sensorineural hearing loss (PTA > 70 dB HL 2k - 4k Hz) with LF hearing no poorer than 60 dB HL up to and including 500 Hz. Subjects were assessed preoperatively with appropriately fit hearing aids and postoperatively with the Hybrid device at 1m, 3m, 6m and 12m postactivation of the device. Primary outcomes measures were the CNC monosyllabic word test in quiet and AzBio sentences presented at a +5dB SNR.

Results: Mean scores for 49 subjects, who completed the 6 month evaluation, improved from 28%, preoperatively, to 65% for CNC words after 6 months experience with Hybrid for the treated ear alone. For AzBio sentences in noise, mean performance improved from 16% preoperatively to 49% after 6 months experience. Subjects who retained functional LF acoustic hearing postoperatively experienced the most improvement but most subjects benefitted by electrical stimulation alone. Univariable analyses of preop characteristics indicated that gender, age at implantation, and duration of overall hearing loss were the main factors impacting postoperative speech perception outcomes. When subjected to multivariable analyses, duration of hearing loss and gender were related to CNC word outcomes only. Individuals who presented with the poorest outcomes had a mean duration of overall hearing loss of 45 years, while subjects who showed improved outcomes, regardless of retention of LF hearing ipsilaterally presented with a mean duration of around 22 years.

Discussion: All subjects who meet candidacy for the Hybrid system have the potential to benefit from electric stimulation regardless of postoperative LF hearing status and should be presented with the opportunity to experience Hybrid hearing.

Conclusion: Electric-acoustic stimulation, as delivered by the Nucleus Hybrid L24 cochlear implant system, is a viable option for individuals with residual LF hearing and severe HF hearing loss. Results showed that a cochlear implant electrode array can be inserted within the cochlea while maintaining useful levels of acoustic LF hearing in most individuals. Even in electric alone conditions, the stimulation provided by the Hybrid cochlear implant yielded superior speech perception capabilities for most subjects when compared with the use of hearing aids alone, preoperatively.

S3-3

Apical versus non-apical electric stimulation of the cochlea using the same system

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Intro: Various factors may influence cochlear implant recipients' postoperative speech perception performance, including electrode insertion depth. In theory, a deeper electrode insertion could offer better low-frequency representation although at an increased risk of surgical trauma. Previous studies designed to assess the effect of insertion depth on postoperative performance have yielded conflicting results. These investigations have mostly utilized acute electrode deactivation strategies within subjects implanted with long arrays. This experimental design suffers from limited listening experience with the modified maps and reduced channel numbers because of deactivation. Generalizations across subjects are further complicated by an inability to control for surgically-induced trauma. Similarly, comparisons across manufacturers have the limitations of differences in electrode design, number and spacing of active electrodes, and signal coding strategy. The present study aimed to assess the effect of apical cochlear stimulation while controlling for coding strategy, electrode number and the presence of surgical resistance and basal buckling.

Methods: Subjects were conventional cochlear implant candidates scheduled to undergo surgery. They were randomly assigned to receive either the standard (26.4 mm) or medium (20.9 mm) electrode array from MED-EL Corporation. During the surgical procedure, surgeons indicated the surgical approach, insertion depth, level of resistance experienced during insertion, and evidence of basal buckling. Speech perception was assessed prior to surgery and at 1, 3, 6, 9, and 12 months post-initial stimulation. Test materials included CUNY sentences, HINT sentences (quiet, SNR+10), and CNC words.

Results: Thirteen subjects participated, with 7 receiving the standard array and 6 the medium array. There was no difference in age at implantation or duration of deafness. There was a difference between preoperative unaided CNC word scores, with those implanted with the medium array achieving higher speech perception scores. Postoperatively, all subjects experienced an improvement in aided speech perception abilities in both quiet and noise. Recipients of the standard electrode array initially showed a trend for better performance, but this was non-significant ($p=0.07$).

Discussion: Electrode insertion depth may impact postoperative speech perception performance. Additional investigations are needed to determine the influence of electrode length in combination with other medical/surgical and auditory variables.

Conclusion: Electrode insertion depth may influence speech perception acquisition within the first months of listening experience.

Learning Outcome: The participant will understand the potential impact of electrode insertion depth on cochlear implant outcomes.

S3-4

The development of the small incision for cochlear implantation

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In 1994, I began to use a small incision for cochlear implantation and reports were published in 1995and 1997. At this time various incisions were being used such as a large C incisions C , an inverted U incision, and an extended endaural incision. It was generally assumed that the incision should not pass over the top of the implant and that sufficient exposure should be made to allow the device to be secured to the skull.

Methods: I developed an entirely straight incision immediately behind the pinna. It was possible to fashion a tight periosteal pocket so that it was not necessary to tie the implant to the skull. A retractor was utilised to elevate the scalp so that an indentation in the skull could be drilled to house the body of the implant. In children a very short incision was possible as the scalp could be easily restricted but a longer incision was sometimes needed especially in young adults to gain sufficient exposure.

Results: The results were published in 2004. 844 consecutive implants were studied retrospectively. 212 implants were performed using a C incision and 632 using the small post aural incision. The infection rate for the C incision was 2.3%, and for the small straight incision 1.1%. These results were not statistically significant. No implants migrated from the position using the periosteal pocket without any tie down sutures.

Discussion: The small straight incision was not readily accepted by surgical colleagues until it was popularized by the Nottingham team led by O'Donaghue in 2002. It is now the most commonly utilised incision. Although not statistically proven, it seems to reduce the incidence of post-operative wound infection. Other benefits are that only a minimal shave of hair is needed and a reduction in surgical time.

Conclusion: The small post aural incision has been slightly modified into a lazy S shape but essentially remains the same as described in 1995.

S3-12

The outcome of cochlear implant on 1895 Chinese patients

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Objectives: To analyze the outcome of safety of operation and the postoperative speech rehabilitation of cochlear implantation in Chinese patients.

Methods: There were 1895 cases accepting cochlear implantation between March, 1997 and Jan.2014 in our department, 1052 male and 843 female. Among them, 957 cases accepted Asutralian Nucleus implant, with 601 accepting Austria MED-EL implant, 152 accepting American Advanced Bionics implant and 85 acceping Nurotron implant (China). Among those patients, there were 95 cases with post lingual deafness and 1800 patients with prelingual deafness. The age ranged from 8 months to 79 years, 8.1 on average. The safety of cochlear implantation was studied by statistically analyzing intraoperative conditions, postoperative imaging and complication, and outcomes of cochlear implantation was explored into by statistically analyzing categories of auditory performance (CAP) and speech intelligibility rating(SIR) of 276 cases who had a history of more 2 year since the implantation.

Results: Among the 1895 cases, abnormal events occurred in 87 cases with the general complication rate of 3.3%. All the abnormal events were solved successfully. CAP scores and SIR scores of the 276 cases who had a history of more than 2 years since the implantation were 4.5 (total scores,5) and 7.8 (total, scores,8), respectively.

Conclusions: Cochlear implantation was safe and stable, and outcomes of postoperative speech rehabilitation were satisfactory in Chinese patients. Cochlear implantation was effective for severe deafness, and the long-term outcomes required further study in Chinese patients.

S4 Implant hardware & new implant technology

S4-1

Optogenetic stimulation of the auditory pathway as a strategy for better frequency and intensity resolution in future cochlear implants

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Auditory prostheses can partially restore speech comprehension when hearing fails. Sound coding with current prostheses is based on electrical stimulation of auditory neurons and has limited frequency resolution due to broad current spread within the cochlea. In contrast, optical stimulation can be spatially confined, which may improve frequency resolution. Here, we used animal models to characterize optogenetic stimulation, which is the optical stimulation of neurons genetically engineered to express the light-gated ion channel, channelrhodopsin-2 (ChR2), of the auditory pathway. Optogenic stimulation of spiral ganglion neurons (SGNs) activated the auditory pathway, as demonstrated by recordings of single neuron and neuronal population responses. Furthermore, optogenic stimulation of SGNs restored auditory activity in deaf mice. Approximation of the spatial spread of cochlear excitation by recording local field potentials in the inferior colliculus in response to suprathreshold optical, acoustic and electrical stimuli indicated that that optogenetic stimulation achieves better frequency resolution than monopolar electrical stimulation. Virus-mediated expression of a ChR2-variant with greater light sensitivity in SGNs reduced the amount of light required for responses, and allowed neuronal spiking following stimulation up to 60 Hz. Our study demonstrates a strategy for optogenetic stimulation of the auditory pathway in rodents and lays the groundwork for future applications of cochlear optogenetics in auditory research and prosthetics.

S4-4

A non-linear approach for the reconstruction of EAP-signals from Sigma-Delta sequences

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MED-EL cochlear implants $PULSAR_{CI}^{100}$, $SONATA_{TI}^{100}$ and $CONCERTO_{TI}^{100}$ are equipped with EAP-measurement systems which utilize Sigma-Delta modulation for Analog-to-Digital conversion. For an EAP-measurement, the analog input signal is sampled a rate of 1.2 MHz and converted to a binary Sigma-Delta sequence comprising 2048 Bits. Usually the reconstruction of the analog waveform from the Sigma-Delta data is based on digital low pass filtering. In the present work a non-linear approach, the so-called "thread method" is discussed. A "system of conditions" is generated from the accumulated Sigma-Delta sequence which allows to compute an estimate of the input signal. If the estimate itself was converted to a binary Sigma-Delta sequence, the resulting sequence would be identical to the Sigma-Delta sequence of the original input. In contrast to signal reconstruction based on low pass filtering, all problems such as ringing artifacts, finite settling time, etc. are avoided. In particular, signals reconstructed with the thread method have no time delays relative to the original signals. Thus signal details at the very beginning of the measurement window are perfectly re-established.

Examples for signal reconstruction are presented, including in-vitro signals measured in saline solution and in-vivo EAP-signals assessed in CI-patients.

S5 Electric-acoustic stimulation

S5-1

The influence of different types of acoustic amplification on hearing performance in subjects with electric-acoustic stimulation

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Introduction: Different types of acoustic amplification were made available for CI subjects using electric-acoustic stimulation (EAS). The Freedom Hybrid and the Nucleus 6 processor (CP900) with an external receiver for acoustic amplification were used for this investigation. The effect of acoustic amplification with Freedom Hybrid and CP900 with different types of ear moulds and domes was investigated.

Material/Patients and methods: 24 experienced CI subjects with EAS and an average unaided pure tone average (125-1500 Hz) of 72.5 dB were enrolled. A prospective AABB cross-over design was used to measure speech understanding in noise (S0N90) and in quiet. Questionnaires and aided thresholds were analyzed. An acclimatisation period of 3 weeks was applied between the individual evaluation visits.

Results: The speech understanding in noise with EAS on the CP900 showed a significant (p=0.0019) improvement of 1.7 dB SNR over the Freedom Hybrid, irrespective of the type of ear mould used. That improvement was confirmed by the speech understanding in quiet results (p=0.06) and the questionnaire data. Similar aided thresholds were found with Freedom Hybrid and CP900 with acoustic component.

Conclusion: Upgrading existing EAS user to a different type of acoustic amplification with CP900 and acoustic component can further improve the speech understanding and the subjective performance data.

S5-2

The effects of speech maskers in electric acoustic stimulation

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Background: The primary objective of this study was to investigate whether EAS users experience a release from masking with increasing F0 difference between target talker and masking talker.

Methods: The study comprised 29 patients in total and consisted of three groups of patients: EAS users, CI users, and normal hearing listeners. All CI and EAS users were implanted with a MED-EL cochlear implant and had at least 12 months experience with the MED-EL OPUS2 or DUET2 audio processor.

Speech perception was assessed with the Oldenburger sentence test (OlSa), using one sentence from the test corpus as speech masker. The fundamental frequency in this masking sentence was shifted upwards by 4, 8, or 12 semitones, yielding the masker conditions semi0, semi4, semi8, and semi12. For each of these masker conditions the speech reception threshold (SRT) was assessed by adaptively varying masker level while presenting the target sentences at 65 dB SPL (EAS and CI users) or 55 dB SPL (normal hearing listeners).

Results: In normal hearing subjects as well as in EAS patients, speech perception improved as the shift in fundamental frequency between target sentence and masking sentence increased (normal hearing subjects -1.7 dB, EAS: -2.7 dB, both significantly different from 0).

In CI patients (classic CI or EAS users with electrical stimulation only) speech perception was independent from differences in fundamental frequency between target and masking sentence.

Conclusion: A release from masking with increasing difference in F0 between target and masking speech was only observed in listeners and configurations in which the low frequency region was presented acoustically. Thus, the speech information contained in the low frequencies seems to be crucial for allowing listeners to separate multiple sources. Centrally combining the information presented acoustically and electrically, EAS users even manage as complicated tasks as segregating the audio streams from multiple talkers. Preserving the natural code like fine structure cues in the low frequency region seems to be crucial to allow best benefit to CI users.

S5-4

Apical electrical stimulation after deep electrode insertion in patients with partial deafness

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As the low frequency hearing can be preserved to the large extend after deep electrode insertion the region in the cochlear which is stimulated electrically can overlap subcutaneously with the acoustic stimulated region.

Place overlap between electric and acoustic stimulation may have either negative or beneficial effect on the transfer of auditory information. Negative effect occurs when presence of electric stimulation substantially impairs acoustic information transfer, or vice versa. Positive effect stems from the integration of complementary cues extracted from acoustic and electric stimulation.

The aim of the study was to investigate the impact of an overlap of electrically and acoustically stimulated regions on speech benefit after the round window deep insertion of cochlear electrodes.

Twenty eight PDT subjects participated in the study. Speech discrimination was evaluated in subjects with low frequency hearing prior to surgery, implanted with round window deep insertion of MED-EL standard or FLEXsoft electrode arrays. Twenty-one females and 7 males are reported on here. The mean age of the study subjects during the surgery was 46 years (18-68.4 years). Patients were randomly assigned to 2 groups: overlap and non-overlap. In overlap group all electrodes which elicited hearing sensation were activated during the first fitting of a speech processor. In the non-overlap group 3 most apical electrodes were switched off. In both groups FS4 strategy was used. After 12 months patients from overlap group had 3 most apical electrode switched off and tested immediately and 3 months later in overlap and non-overlap condition. Patients from non-overlap group had 3 most apical electrode switched on and tested immediately and 3 months later in overlap and non-overlap condition. In both groups speech tests were conducted. Subjects were tested in the best aided condition (PDT-EC or PDT-EAS) and contralateral ear unplugged or aided, and in the CI only condition with monosyllabic speech test at the level of 60 dB HL in quiet and in noise (10 dB SNR).

The differences in speech discrimination scores between overlap and no overlap groups were not statistically significant in EAS and EC conditions. In CI only condition the scores were statistically significant higher in overlap group.

There is no negative effect of overlap in place of stimulation between acoustic and electric stimulation.

S5-13

Intracochlear electrocochleography in cochlear implant patients

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Hypotheses: It is feasible to record electrocochleography (ECoG) in response to acoustic stimulation via an intracochlear electrode. Furthermore, these responses demonstrate greater amplitudes than at the round window and they can be used to detect intracochlear damage during cochlear implant (CI) electrode insertions.

Background: Recently, we demonstrated that cochlear responses to sound are present in nearly all cochlear implant recipients when measured at the round window (RW). The goal of this study is to compare RW to intracochlear recording sites, and to determine if cochlear function can be monitored during insertion of the electrode array.

Methods: Auditory stimulation (500 Hz tones at 85-95 dB HL) and ECoG recordings were made intraoperatively in patients receiving a CI from the RW and from just inside scala tympani (n=24). Further recordings were obtained during 20 mm insertions of a custom-designed temporary (n=6). Response magnitudes were measured as the sum of the first and second harmonics.

Results: All patients had measureable responses at the RW. The response magnitude increased by an average of 6.54 dB with intracochlear electrode placement. In 4 of the 6 longitudinal insertions, increasing signal amplitudes were observed with increasing depth of insertion. In these cases, a return to baseline was observed with withdrawal of the electrode. Two tracks showed peak amplitudes during the insertion and decreasing amplitudes with increasing depth of insertion, and the response was below baseline after the electrode was withdrawn indicating decreased cochlear function.

Conclusions: Intracochlear ECoG responses are typically greater than those measured at the RW. Some, presumably non-damaging insertions, demonstrate increasing response magnitudes as the electrode is advanced. Reductions in response magnitudes, on the other hand, might suggest cochlear trauma.

S5-14

Influence of CI electrodes on acoustic waves in the cochlea

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The supply of profoundly hearing impaired patients with cochlear implants has become a standard with large success related to speech understanding without disturbing noise. As is known in noisy environments the additional transmission of the low frequency pitch of speech increases the sentence recognition rate. Therefore the surgeons try to preserve the low frequency abilities of patients by a conservative operation technique and short CI electrodes.

For a better understanding of the wave propagation in the cochlea with implanted electrodes human temporal bones were scanned by a µ-CT and three-dimensional reconstructions of the data set were created (Figure 1, Braun, MD Dissertation, TU Munich, 2014). With that the acoustic fluid-structure coupled system was evaluated by numerical methods.

An important feature of the cochlear partition is the orthotropic mechanical property of the basilar membrane (Iurato S., JASA, 1962), which arises from the stiff transversal fibers containing type II collagen (Dreiling et al., Hearing Research, 2002). The mechanical parameters (Young's Moduli, Poisson ratios, etc.) describing this orthotropy must be known. At first straight-lined box models of the cochlea were examined using different finite element software tools (SIFEM, ANSYS). For a better representation of the in fact curvilinear cochlea a correct assignment of the mechanical parameters is necessary. This is done approximately by using a polar coordinate system reference and assignment of parameters to an ideal geometrically spiral system. However the real cochlea is not a spiral and therefore mapping algorithms must be developed to manage this task.

The results show the displacements of the cp and the basilar membrane under varying conditions in three dimensions. Surprisingly even the increase of the cp displacement with an implanted CI electrode was found. The small effect, which is also found in audiograms of CI patients without electric supply, is attributed to the distribution of acoustic energy to those places which are not fixed by the CI electrode.

The numerical simulations give details to future implantation techniques and the design of better CI electrodes.

S6 Music and CI I

S6-1

Recognition of musical emotions in patients with cochlear implant

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Introduction: Whereas cochlear implantation is rather successful in restoring speech understanding in quiet (Nimmons et al., 2008), other auditory tasks are still very challenging for cochlear implant (CI) users. In particular, very little is known concerning emotional processing of auditory information after rehabilitation by CI.

The aim of this study was to investigate the effect of cochlear implantation in the recognition of emotions expressed by music using musical excerpts (Vieillard et al, 2008). Capacities to identify musical emotions and to judge emotional valence and arousal were compared between normal hearing and cochlear implanted subjects with good verbal recognition performances.

Methods: 13 cochlear implanted patients with a minimal post-CI duration of one year and good verbal performances (dissyllabic words and sentences recognition in quiet ≥ 70%) and 13 healthy participants matched in age, gender and education to the implanted patients were included.

40 musical excerpts were selected from Vieillard et al. study (2008). The task consists of 10 short musical excerpts for each emotional category intended to express fear, happiness, sadness, and peacefulness. Participants were asked to rate (from 0 to 10) to what extent each musical excerpt expressed these four emotions and to judge their valence (unpleasant-pleasant), and arousal (relaxing-stimulating). Musical stimuli were presented in pseudo-randomized order. Mean correctness scores (emotional categories recognition) and mean ratings (valence and arousal) have been analyzed.

Results: Results of non-parametric analyses (Mann-Whitney tests) suggest that CI users are generally impaired in recognizing Happy, Scary, and Sad (but not Peaceful) emotional categories ($p< 0.05$) compared with normal hearing participants although they were largely above chance level. Moreover, the rating of arousal was altered in these participants with an effect of group for Happy ($p< 0.05$), Peaceful ($p< 0.05$, Scary ($p< 0.001$), and Sad ($p< 0.01$) musical excerpts. The rating of valence did not differ from control participants for the different emotional targets. These findings suggest that recognition of musical emotion, and particularly judgments of emotional valence of musical excerpts, can be restored after auditory rehabilitation by cochlear implantation.

Discussion: The main result of this study is that cochlear implanted patients have abilities to recognize musical emotional categories above the chance level. In line with data of previous studies reporting better performances for perception of temporal features (rhythm and metric) than spectral (pitch and timbre), musical emotional categories could have been identified on the basis of temporal information (Cooper et al., 2008).

Conclusion: These findings raise the relevance to create tools and to develop specific training programs for the evaluation and the enhancement of nonverbal emotion processing in CI users.

S6-2

Auditory and gestural influences on song learning in children with cochlear implants

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Music perception of cochlear implants (CI) users is constrained by the absence of salient musical pitch cues, yet musical timing cues are largely preserved by current devices. The task at hand becomes one of optimizing the cues that are available to CI users by exploring ways that musical cues are encoded simultaneously across multiple modalities. We examined how learning tasks that engage active music listening and movement through dance might enhance the song learning skills of deaf children with CIs. Ten CI children (*M* = 7.2 years, *SD* = 2.9; range = 5.5 to 11.7 years) and age-matched hearing controls learned new songs in two contexts: 1) by listening alone, and 2) dancing to music. Their song learning skills were assessed in a subsequent task that tested their ability to identify the original version, as well as melodic and mistuned renditions of songs. Kinematic information of their dances was extracted by motion capture technology and the associations with acoustic features in songs were examined. While our findings indicate that movement in conjunction with music listening have modest gains in enhancing identification of novel song renditions in the short-term, greater long-term potential for learning is indicated by CI children's ability to move in synchrony to the beat at levels comparable to hearing age-matched peers. Methods that encourage CI children to engage auditory and motor modalities in music learning may be particularly effective in consolidating representations of music in memory than those achieved by listening alone.

S6-3

The ´magic´ of music made real in daily routine: a new habilitative tool for infant and toddler with hearing loss

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Age of intervention in children affected by hearing loss is decreasing and increasingly often specialists have the possibility to work with them already by the age of 3 months. Early intervention requires an important change in the traditional concept of “rehabilitation”, namely that of “habilitation” and “guide” to optimize the environment of the young children so that they can naturally recover the normal learning process of communication and language acquisition (incidental learning). In this concern, daily interactions and routines become important opportunities of learning and development. On the other hand, it is well known a sing song voice (IDS) and music are important during the early phases of growth: infants and toddlers like music and songs, that naturally provide the possibility to play with voice, prosody and language. At the moment there are not habilitation sources in Italy, that join these two important sources of learning.

The present work has two aims. The first one is to show the implementation of an habilitation tool “CHE BELLA GIORNATA!”, that takes advantage of the playful aspects of music and songs, to help both professionals and parents to adequately develop listening and communication skills of infants and young toddlers with hearing aids or cochlear implants, during their daily interactions and routines. The second aim is to show the preliminary impact of the new tool on parents and children.

Four Centers (one in London and three in Italy) cooperated to implement “CHE BELLA GIORNATA!”, available both in English and Italian. The tool is directed to children aged 3 to 36 months and structured in three parts:

- a simple illustrated book that narrates the daily time of a child with musical tracks and songs thought for each fundamental routines;
- activities and simple games suggested for each daily moment selected for infant (3-18 months) and toddler (19-36 months) to guide parents and professionals to effectively communicates during all the day with their children;
- a section containing simple and clear descriptions of the normal steps that each child follows during his growth and checklists to monitor the child progress and discuss it with professionals.

A questionnaire was implemented to measure the easiness, the perceived benefit, the acceptance and the pleasure of the tool.

Theoretical basis, the structure and samples of “CHE BELLA GIORNATA!” will be presented, together with the preliminary results on 15 families of children aged 6-18 months and 19-36 months.

“CHE BELLA GIORNATA!” is well accepted. Parents express the usefulness of the tool in considering the natural use of music and songs during the interaction with their children, in improving their mode to communicate with children during the day and, finally, in having a clear idea and certainty of what is doing and which will be the next step along the normal developmental stages, so quieting excessive anxiety and requests to the child.

S6-12

The effect of music therapy and training on speech and music perception in cochlear-implant users

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Background: Music is reported to be the second most important acoustical stimulus by cochlear-implant (CI) users. Normal-hearing musicians have been shown to have better speech perception in noise, pitch perception in speech and music and voice timbre recognition, as well as a better working memory and enhanced neural encoding of speech. Previous literature has shown that enjoyment and perception of music in CI users is worse than in normal-hearing listeners. Based on these ideas, we explored the hypothesis that music therapy and musical training may have a positive effect on speech and music perception in CI users.

Methods: We aim to recruit three groups of 7 CI users with no professional musical background for six weeks of music therapy, musical training and non-musical training for 2 hours per week. Music therapy will involve group activities related to rhythm, musical speech, singing, emotion recognition and improvisation. Musical training will involve individual computerized training with melodic contour identification and instrument recognition. Non-musical training will involve group activities of cooking, working with wood and writing. Outcome measures vary. After each music therapy session, CI users will report if they observed improvement on the tasks. Furthermore, before and after the study, all participants will be tested for speech intelligibility, and speech- and music-related tasks, such as gender categorization, emotion recognition and melodic contour identification. Last, quality of life (QoL) will be measured using questionnaires.

Results: The results showed that music therapy in 7 CI users has a positive effect on emotion recognition, both behaviorally and subjectively measured. No other effects were shown in the music therapy group. The data from the other training groups are incomplete. The preliminary data with the musical training group showed an improvement on melodic contour identification for the organ. The preliminary data with the non-musical training group showed no effect on music perception and QoL.

Conclusions: While the full set of results are still to be determined, preliminary data showed indications for positive effects of training. Music therapy has a positive effect on emotion recognition in CI users, and musical training on melody contour identification with organ. These positive effects might point toward the implementation of some form of music therapy or training in the rehabilitation of CI users.

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S7 Language acquisition and speech production after CI

S7-3

Lexical and semantic development in children with cochlear implants

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Intro: The variation of vocabulary outcome in children with cochlear implants (CI) has not yet been fully explained and there are few longitudinal studies of lexical-semantic development in the same cohort of children with CI and with NH controls. One aim was to examine lexical and semantic abilities over time in a group of children with CI. A second aim was to investigate their linguistic abilities at the age of 8-9 years in comparison with age-matched children with CI who had higher group mean age at 1st implantation and with a group of age-matched NH peers.

Methods: 18 children with CI were examined twice, another 16 children with CI and 19 NH controls were examined at one occasion. The majority of children with CI had bilateral implants (82 %) and all were mainstreamed, except for 7 children who attended classes for hearing-impaired children. All children communicated with spoken Swedish and had normal non-verbal cognitive ability. Receptive- and expressive vocabulary and word fluency ability were examined. Early spoken language data from clinical follow-up visits were collected from medical records and included in some of the statistical analyses.

Results: Children with younger group mean age at 1st implantation (CI-Y) did not reach age-equivalent results on receptive vocabulary until the age of 8-9 years, while children with higher mean age at 1st implantation (CI-O) still had significantly worse results than NH controls. The latter CI group also showed a more atypical pattern regarding lexical and semantic development compared to children with younger mean age at 1st implantation. They had better expressive- than receptive vocabulary and significantly worse phonemically based word fluency ability compared to the other two groups (CI-Y and NH controls). Children in the CI-Y group showed a more typical lexical and semantic developmental pattern. Age at 1st implantation were significant correlated to early language skills, but not to lexical and semantic abilities at later ages in neither of the two groups of children with CI.

Discussion: Early spoken language development was significantly influenced by and related to ages at implantation. However, over time, when the children reached school age, the impact of age at implantation leveled off and other factors like lexical and semantic abilities influenced more on the continued development of receptive and expressive vocabulary.

Conclusion: Future studies of lexical and semantic abilities should have a longitudinal approach because of potential atypical developmental patterns in groups of children with CI.

Learning outcome: participants will learn more about lexical and semantic development in small, heterogeneous groups like children with CI.

S7-4

Cochlear-implanted adult performance in figurative language comprehension

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Intro: Considering that figurative language is an ordinary phenomenon in everyday language and that the non-comprehension and non-production of figurative expressions may be an obstacle to oral communication, this research intends to fill the gap in studies on oral language acquisition by hearing impaired people, as well as in figurative language studies. To the best of our knowledge this is the first study to investigate primary metaphor and idiom comprehension in deaf subjects who use cochlear implants and to compare their performance with a group of hearing subjects.

Method: Participants were 40 Brazilian Portuguese monolingual adults. The experimental group was 10 deaf adults (users of MED-EL OPUS 2) and the control group was 30 adults with normal hearing, matched by age and selected by convenience. To access metaphor comprehension we have used the Primary Metaphor Comprehension Instrument (Siqueira, 2004), composed by a verbal and a non-verbal task. To access idiom comprehension we developed a verbal comprehension instrument with six idioms, all highly frequent in Brazilian Portuguese. We hypothesize that the comprehension of expressions derived from primary metaphors (e.g. *The situation is dark*) depends less on auditory input and contextual information, and are more determined by embodied experiences, compared to that of idioms. The mapping between the conceptual domains BAD and DARK for instance originates from situations such as going down the stairs while in the dark. That provokes a feeling of fright because of the danger such a situation may represent. Those therefore are two experiential domains that co-occur frequently and illustrate the conceptual mapping between a target (BAD) and a source domain (DARK). Furthermore, we hypothesize that patients will perform better in the nonverbal task when compared to the verbal task since the former has the picture stimulus and depends less on the oral language comprehension. Finally, we expect that the control group will perform better than the experimental group on both verbal tasks (metaphors and idioms), since they are heavily dependent on auditory input.

Results/Conclusions: Results have shown good performance for both groups in the nonverbal task and poorer performance in the verbal tasks for participants in the deaf group. Those results indicate that despite their capacity to form metaphorical mappings, people with profound hearing impairment have difficulty understanding figurative linguistic expressions. As for the idiom comprehension, it is an expected result considering that this is an ability based solely on auditory stimuli. As for the metaphors, those results may derive from the fact that even though the comprehension of primary metaphors happens primarily through embodiment, its comprehension is made stronger by hearing input.

S7-5

Auditory strategies and techniques to develop listening and spoken language skills

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Families of children with hearing loss who are using a listening and spoken language approach to develop receptive and expressive communication need to facilitate auditory learning to support their child's language development. Speech-language pathologists who choose to serve this population will need specific skills to ensure listening becomes part of the family's personality. This session will address the unique therapy techniques needed to develop listening and spoken language skills with children using amplification or cochlear implants and how to transfer these skills to caregivers. Specific techniques will be demonstrated and practical clinical applications included.

Measurable Outcomes:

1. Participants will describe a listening and spoken language approach to therapy.

2. Participants will be familiar with at least five listening and spoken language therapy strategies.

3. Participants will be able to develop a listening and spoken language goal.

S7-8

Speech production quality and duration of deafness before cochlea implantation

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Background: Speech of cochlear implant (CI) users might be altered due to restricted auditory feedback on speech production.

Patients and methods: In a prospective study, speech of 58 adult CI users (38 women and 22 men) aged 51.9 ± 18.3 years with uni- or bilateral cochlear implant(s) was evaluated during regular out-clinic examination. They received different cochlear implant generations from three manufacturers. Implantation was performed at least 6 months prior to the investigation. They were recorded while reading 97 words containing all German phonemes in different positions in a word. For the evaluation of speech of CI-Users, an automatic speech recognition (ASR) system was adapted to test for speech quality using word recognition rate. Results refer to speech production intelligibility and are called “speech intelligibility degree”.

Results: Speech intelligibility degree and duration of deafness show a significant correlation (p= 0,045). Age or gender had no influence on the speech production results. CI-users who developed a hearing loss after speech acquisition and received a CI quickly after hearing loss show significantly higher word recognition rates than patients that are provided with a CI more than two years after hearing loss or that had a hearing loss already during speech acquisition as children.

Conclusion: Auditory feedback after implantation s is not always sufficient to enable normal speech quality.

The use of ASR can reveal the need for rehabilitation of speech production next to hearing rehabilitation for CI-users. When common hearing aids are not sufficient anymore, cochlear implantation should be proposed quickly to prevent from persistent speech alterations.

S7-9

Training of the singing voice of children with cochlear implants

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Intro: Musical training has been shown to be useful in both supporting normal language development and restoring disturbed language processing, because musical activity addresses neuronal resources shared by music and language processing systems. Also for hearing impaired patients using CIs positive effects of musical training has been demonstrated, but most studies used musical instruments. Only a few studies have assessed the effects of vocal singing on both language and musical abilities but have not been performed with children below age of 4 years, i.e. in a period when basic language development takes place. This study aims on proofing the hypothesis that the brain plasticity of the developing auditory and language systems enables young children wearing CIs by receiving an intensive training of their singing voice to (a) better resolve pitches, (b) enjoy music more than children without such a training, and (c) have a quicker language development and better language outcome, in particular in understanding speech in noise than a control group without such a training. Furthermore, it shall be proven whether a musical training of CI-implanted children can be done by telemedical tools.

Methods: The study involves two groups of children (*N*=15 per group) fitted with CIs and aged between 1 year and 4 years. One group receives musical training, the other one does not. Training is performed two to three times per week for 30 to 45 minutes by both face-to face and teletraining sessions. Assessment of the training effects and its neuronal correlates is done musical and language tests and by electrophysiological ERP recordings.

Results: Because the study is still in progress, only preliminary data can be shown which support the expectation of the following outcomes of the singing training: (1) an improved pitch resolution, pitch perception, and awareness of pitch, (2) an increased enjoyment and appreciation of music, (3) a transfer to language functions; improved language development and rehabilitation, in particular with respect to understand speech in noise, and (4) the feasibility of telerehabilitative tools for singing training in children fitted with CI.

Discussion: If the hypotheses will be confirmed, this would open new opportunities in rehabilitation of hearing, language, and musical abilities of those children. To find out to which extent children wearing CIs are able to train their singing voice and how this transfers to neuronal mechanisms enhancing prosody, musical, and language development is of scientific and clinical interest.

Conclusion: The preliminary study outcome suggests that neural changes accompanying vocal singing may facilitate both language and musical development of children with CIs.

Learning outcome: The audience will be able to evaluate the effects of training of the singing voice on language and musical development of children in general and in particular of children fitted with CI.

S8 New trends in electrode development & new technologies

S8-1

Investigation of inner ear trauma using three dimensional force measurement system

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Histology and computerized tomography (CT) are the main techniques for analyzing intracochlear trauma after cochlear implant electrode insertion. To understand the mechanics, and the dynamic interaction of the electrode array with the human cochlea, these typical image analysis method are not appropriate. Therefore a combination of a highly sensitive 3-dimensional force measurement with synchronized microscopic video recordings was used to measure the insertion forces applied by a cochlear implant electrode array on the inner ear structure.

The inner ear of the human temporal bones were scanned using a Skyscan 1173 machine (40-130 kV source, 5 Mp, 12 bit CCD sensor), resulting in images with pixel size varying from 8 to 16 µm. Then, the bony capsule of the scala vestibuli was removed, resulting in a clear view of the osseous spiral lamina and the basilar membrane. The cochlea was then mounted on the 3D force measurement system (Agilent Technologies, Nano UTM, Santa Clara, USA), and a lateral wall electrode array was inserted through the round window using a fixed speed of 0.5 mm/s by an automated arm. The force measurement system recorded forces in three dimensions with a sensitivity of 0.2 µN. The corresponding angular planes are as follows: z-forces are recorded in the direction of insertion (horizontal plane), y-forces are recorded in the cochlear vertical plane (parallel to central nerve axis) and x-forces are recorded in the direction orthogonal to “Z” and “Y”. The obtained 3D force profiles were correlated with microscopic recordings, and the anatomy of the cochlea.

Preliminary data show that the z-force is the dominating force present during insertion. Depending on the insertion angle through the round window, trauma to the modiolar wall occurred and was seen as a peak in the z-force profile of approximately 15 mN. Buckling of the proximal part of the electrode array was identified as a rapid rise in forces, mainly in the x-plane. The main force (z-force) started to increase approx. 8 mm from the round window. The amplitude of the z-force is an indication of friction between the electrode carrier and the lateral wall. Penetration of the electrode array through the basilar membrane was identified as an increase of the y-force of approx. 10 mN. Repeated trials in the same temporal bone showed almost identical force profiles. The effect of the cochlear anatomy is currently under investigation.

3D insertion forces convey detailed information about the electrode mechanics inside the cochlea. We were able to identify the main dynamic effects of a lateral wall electrode array and correlate to possible trauma to the inner ear during the insertion process by using this highly sensitive 3D force measurement system.

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S8-4

Hydrogel-based self-bending mechanism for cochlear implants

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Intro: Reducing the distance between electrode contacts and nerve cells of the cochlea is one major goal in auditory research [1]. Hence, a self-bending electrode shaft is desired fitting to the individual anatomy of the patient. Since insertion trauma must also be reduced, clinging to the modiolus should start after implantation. Therefore, a novel electrode shaft is presented (fig. 1), consisting of a flexible carbon nanotube based electrode array (black) and an eccentrically positioned hydrogel-based swelling element (green), all immersed in silicone rubber (grey). Since hydrogel-based actuation has received much interest, several triggering mechanisms like temperature, specific ions and solvent composition were investigated [2]. For this application a swelling polymer was provided, responding to the specific ion concentration of the perilymph. After implantation, the shaft should bend itself due to water uptake of the swelling polymer.

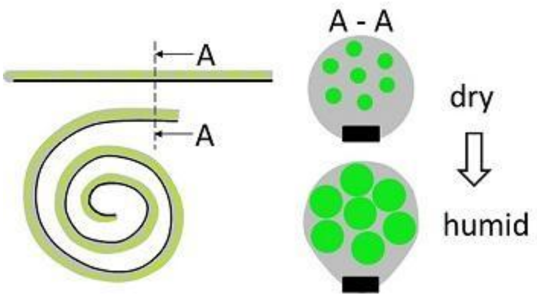
Methods: The shafts were produced using a novel coextrusion and overmolding device. Mechanical actuations of the shafts were tested in vitro, by storing latter in pure water and changes were quantified by using light microscopy.

Results: Curving of the shafts was observed and up to 2.5 rotations were measured (30mm long and 0.75mm wide shaft).

Discussion: Results show, that hydrogel swelling in electrode shafts can achieve high degrees of curvature.

Conclusion: An anatomical number of rotation was reached, leading to a potentially modiolar clinging.

Learning outcome: Hydrogel-based microactuation is a promising candidate for actuated active implants.



[Figure 1: Schematic self-bending mechanism]

[Figure 2: Hydrogel-based self-bending of the shaft]

Acknowledgements: This project is supported by the Deutsche Forschungsgemeinschaft and Lower Austria Life Science grants LS 010-017.

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S8-7

Carbon nanotube-based interfacing of neural structures

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Intro: Up to 22 electrode contacts in cochlear implants (CI) stimulate an area with about 3,400 auditory channels [1]. One goal in auditory research is to obtain a larger number of electrode contacts without stiffening the electrode by using more platinum wires. For a more flexible electrode, carbon nanotubes (CNT) are immersed in liquid silicone rubber (LSR) to make use of the CNTs very good electrical conductivity [2] and good interaction with neurons [3].

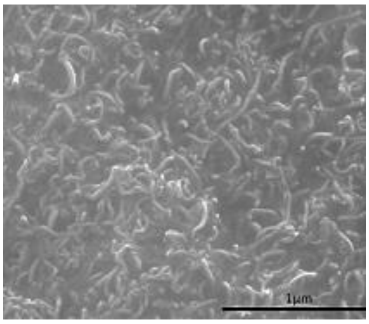
Methods: Etching methods are implemented to remove a surface coverage of the CNTs with LSR at a nanometer scale level at the electrode-cell interfaces. The surface structure was investigated by scanning electron microscopy (SEM). Effects of the samples on GFP-labelled fibroblasts were evaluated and visualized with fluorescent microscopy (FM). Interfaces between fibroblasts and CNTs were observed with environmental scanning electron microscopy (ESEM).

Results: Insulating LSR was removed from CNTs. Cell growth and morphology showed the biocompatibility of the samples. The surface in Figure 1 was etched with a silicone remover for 1h. Figure 2 shows fibroblasts on an equally treated surface after 72h cultivation.

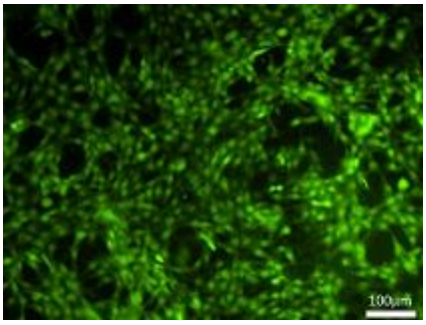
Discussion: Etching leads to a reduced contact resistivity, but keeps the CNTs anchored in the polymer matrix to prevent dissolution in body fluids. Cells grow on altered surfaces.

Conclusion: The materials conductivity could be increased and it showed good biocompatibility.

Learning outcome: CNT-LSR is becoming a promising material for neural interfacing.



[Figure 1: SEM image of CNT-LSR surface]



[Figure 2: FM image of cells on CNT-LSR surface]

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S8-8

NANOCI - first steps towards a gapless auditory nerve - cochlear implant interface

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Current cochlear implant systems are efficient and powerful devices which enable to restore hearing in the majority of deaf recipients, adults and children alike. Despite the success, some limitations remain.

The bottleneck for optimal stimulation is caused by the anatomical gap between the electrode array and the auditory neurons in the inner ear. As a consequence, current devices are limited through (i) low frequency resolution, hence poor sound quality and (ii), strong signal amplification, hence high energy consumption responsible for significant battery costs and for impeding the development of fully implantable systems. Recent findings indicate that auditory nerve fibers can grow under neurotrophin stimulation towards the

electrodes, which opens the door to address all issues simultaneously.

Based on these findings, our laboratory recently started to work on an interdisciplinary EU-FP7-project „NANOCI“ (www.nanoci.org), where auditory nerve fibers will be guided towards a nanotechnologically modified electrode array with the aim to form a gapless man: machine interface. If successful, such a system could enable a higher resolution, more independent (non-overlapping) stimulation channels and ultimately, an improved sound quality.

The NANOCI project therefore is one example, how regenerative medicine could enter into the field of otology: by contributing to an existing hearing loss therapy. Concepts, preliminary results and remaining challenges will be discussed with a special emphasis on the application of regenerative principles in the NANOCI project.

S8-12

Predicting speech understanding and psychophysical tuning curves from focused thresholds and medial-lateral electrode distance

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Introduction: Speech understanding varies significantly across users of cochlear implants. In this work, we examine how speech understanding and psychophysical tuning curve width varies with focused threshold levels and medial-lateral electrode distance.

Methods: Electrode positions were determined from analysis of high-resolution CT scans of the cochleae of CI users with percutaneous Contour Advance implants. The focused thresholds were obtained with biphasic, pulse-train stimuli at a 250-pps rate with 100-µs phase duration, 0-µs interphase-gap, and 200-ms train duration. Psychophysical tuning curves were measured with a forward masking paradigm using focused multipolar stimuli. The probe was held fixed at a soft level while the masker level was adaptively varied to find masking threshold in a 3I-3AFC task. The masker position was changed to find the effect of masking at different spatial offsets from the probe. Speech understanding was examined by obtaining Consonant-Nucleus-Consonant (CNC) word scores using a monopolar ACE strategy with two lists per test presented at 70 dB SPL.

Results: The sharpness of the tuning curves was 5 dB/mm on average across subjects and electrodes. Sharpness increased with decreasing probe electrode threshold level. Electrodes at greater than average distances had shallower slopes indicating broader spread-of-excitation: with each millimeter increase in medial-lateral distance the tuning curve slope was reduced by 3.2 dB/mm ($p = 0.001$; $n = 6$) excluding one subject with Ménière´s disease who showed a very different pattern. CNC Word scores were well described by an inverse logit function of 1.18 -0.02*variance(focused thresholds) ($r=-0.91$; $p=0.0003$; $n=10$) indicating that greater variance of focused thresholds was associated with reduced speech understanding.

Discussion: One hypothesis for why larger distances between the electrodes and the modiolus (i.e., higher "wrapping factors") correlate with poorer speech scores is that more distant electrodes may elicit broader neural excitation patterns that interact more with those from neighboring electrodes, thus negatively impacting the neural representation of speech. This is consistent with our findings. A hypothesis for why the variance of the focused thresholds correlate with speech understanding is that this variance indicates reduced, variable neural survival. This is consistent with our findings in that neither distance, nor bone or fibrous tissue growth could explain the relationship found.

Conclusion and Learning Outcome: Channels with lower focused thresholds have sharper tuning. Electrodes at a greater distance are masked more by their neighbors: tuning curve sharpness is significantly correlated with distance (when excluding an outlier with Ménière´s disease). Speech understanding is well predicted from information about focused thresholds.

CJL, ZMS, and WSP are employed by Cochlear Ltd. TAH acknowledges the support of NIH NIDCD R01 DC00581 & R01 DC009010.

S9 Intraoperative/objective measurements II

S9-1

Acoustic neural response telemetry: the clinical indications

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Introduction: Clinicians are familiar with electrically-evoked neural response telemetry (eNRT) which measures the response of the first order cochlear neurons to electrical stimulation. NRT® was developed by Cochlear Ltd but similar recordings are possible using the other leading manufacturer's devices. It is also possible to record the acoustically-evoked NRT (aNRT) using the same equipment with the addition of a sound transducer placed in the ear canal. The sound stimulus provided by the transducer is synchronized with the NRT recording equipment.

Methods: The surgeon can place a few electrodes inside the cochlea, either through the round window or through a cochleostomy. The aNRT provides the same data as the electrocochleogram. It provides a robust measurement of the threshold of any residual cochlear function. The aNRT can be repeated after insertion of the electrode array to determine if cochlear function has been preserved, and can be repeated at any time, months or years, after the surgery to reveal any alterations in the remaining cochlear function.

Results: Clear potentials indicating the residual cochlear function can be obtained. Examples will be shown.

Discussion: The clinical indications are:

1. To determine accurately the residual cochlear function especially in very young children. The surgeon can then decide on whether to use a shorter array to preserve residual hearing or to make a deep insertion.
2. To determine if hearing has been preserved after the array has been inserted.
3. Post-operatively, at 'switch on' to determine, especially in young children, whether sufficient hearing remains to utilize a 'hybrid' processor.
4. To reveal any changes in thresholds over the months after surgery.

Conclusions: An adaptation of the NRT equipment enable an accurate assessment of residual hearing to acquire before, during and after insertion of a cochlear implant.

S9-10

Cortical refractoriness measurement in cochlear implant listeners by means of auditory evoked potentials

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Introduction: Auditory evoked potentials (AEP) provide useful information on central auditory performance and allow objectifying cortical activities. Former studies demonstrated a significant influence of stimulus parameters as intensity, duration and interstimulus interval (ISI). In particular, by varying the ISI cortical refractoriness in both children and adults can be determined [1, 2]. In cochlear implant (CI) listeners, AEP registration has to be modified in order to reduce electrical artifacts emerging from the CI. The main goal of this study was to develop a procedure to measure the influence of the interstimulus interval for cochlear implant users on cortical AEP.

Methods: Auditory evoked potentials were measured with the NEUROSCAN Synamp II at vertex in experienced CI-users provided with a nucleus freedom or CI512. Stimuli were built of pulse trains with duration of 300 ms for three different electrodes (apical, medial and basal). The C-level was customized to a comfortable loudness level ('comfortable loud') for each electrode. Interstimulus intervals were set to 300 ms, 900 ms, 1400 ms, and 5000 ms. These CI-stimuli were presented using a research speech processor (L34 Cochlear Ltd.). AEPs were analyzed with regard to the N1-P2 complex.

Results: Cortical AEP were measured reliably in all CI-listeners without disturbing artifacts. First results (n=5) show an increase of the (N1-P1) interpeak magnitude with increasing ISI from about 2 µV for 300 ms to 8 µV at 5000 ms. Additionally, amplitudes increase from basal to apical - particularly for the larger ISI.

Conclusion: Auditory evoked potentials can be reliably measured in CI-users with sufficient amplitude and latency information. Increasing the stimulus rate results in lower potential amplitudes, which is evidently due to refractory cortical neurons. Current studies investigate the impact of the refractoriness on psychophysical performance and speech perception in CI-listeners.

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S10 CI in the elderly

S10-1

Speech perception under adverse conditions and auditory localization in seniors

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Introduction: In the elderly population, degraded speech perception in noisy environments as well as the deterioration of directional hearing is frequently observed. The present study assesses speech perception measures and the accuracy of localization in reference to a control group of elderly subjects in order to compare the benefit obtained with hearing aids or cochlear implants in senior patients.

Materials and methods: Eighty subjects between age 60 and 90 years divided in three groups of (1) normal range of hearing corresponding to ISO 7029, (2) patients using hearing aids, or (3) cochlear implants (CI) were included. A test battery comprising pure-tone audiometry, Freiburger numbers and monosyllables tests was administered. Unaided speech scores were measured with different sound levels. Speech reception threshold (SRT) in background noise was assessed in two different loudspeaker configurations (S0N0 and Multi-Source Noise Field) and two different noise characteristics (continuous 'Olnoise' and amplitude modulated 'Fastl noise'). Individual auditory localization ability was measured by means of a pointing method in the horizontal plane. In addition, screening for potential dementia (DemTect test) and determination of short-term memory span was carried out.

Results and discussion: Control group subjects, who regarded their hearing in daily life otherwise as normal, showed considerable hearing disability. In the poorer performing ear only 50% of all control group subjects gained a score of at least 80%. At 65 dB speech level, this number decreased down to 17% of all subjects. The results of the sentence test in noise showed a negative correlation between age and speech reception threshold (SRT, S0N0 OLNoise condition) in the control group data. A mild, but significant correlation between DemTect score and OLSA SRT was testified ($r = -0.40$, $p < 0.05$, the lower the DemTect score, the poorer the SRT). For the S0N0 condition, an improved SRT in modulated noise was found in the control group, probably generated by gap listening. In contrast, the CI group showed deteriorated SRT in this condition.

Conclusion: A large number of control group subjects suffered without their own notice from an asymmetric hearing loss. Nearly 20% of this group should be provided with a hearing aid at least in one ear. The impact of slight cognitive impairment on speech performance in noise was present in all groups. Accuracy of localization was poor in all groups compared to reference data.

S10-2

Speech perception in elderly CI listeners above the age of 75 years in quiet, in noise and in speech-modulated noise

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As a consequence of the demographic change in industrial nations Cochlear implant candidacy is faced more and more with elderly people. One common objection is that older people have problems with the 'electrical hearing'. As general knowledge it is supposed that older people perform less in particular in difficult listening situations. The aim of the study was to compare speech perception of CI listeners for younger and older CI users in different noise conditions.

In total, 50 experienced CI listeners provided with a nucleus CI24RE implant and more than one year CI experience took part in the study. Twenty-five were below 75 years old (mean=50 yrs.), and 25 above 75 years (mean=79 yrs.). Speech perception in quiet, in stationary noise, and in speech-modulated noise was measured for monosyllabics and sentences. Additionally, hearing related quality of life was evaluated.

Results show that older subjects may benefit substantially from cochlear implantation. No significant differences for speech understanding neither in quiet nor in stationary noise were found. However, the older subjects improve less by introducing gaps in the noise signal. No significant differences were found for hearing related life quality. In summary, the benefit of cochlear implantation for older and younger subjects is quite similar.

S10-14

Does hearing intervention improve domains of cognitive function? A systematic review

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Objective: To systematically review the level and quality of the evidence supporting cognitive outcomes following hearing intervention. The review aimed to summarize the evidence and comment on the rigour of the research methodologies of included studies and discuss avenues for future research.

Methods: Level 1 and 2 studies were included, based on the Oxford-Centre for Evidence-Based Medicine Levels of Evidence. The review followed guidelines proposed by the Cochrane Handbook for Systematic Reviews of Interventions and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. To identify studies published as of 2013, a structured search strategy, which combined relevant controlled vocabulary terms (such as MEDLINE's Medical Subject Headings) with additional non-index terms, was developed. Terms included “cognitive risk”, “hearing loss”, “hearing”, “dementia”, “cognitive”. The search strategy was applied to the following major biomedical bibliographic databases from inception September 2013: PubMed, CINAHL, EMBASE (Ovid), PsycINFO, Scopus, Academic Search Premier, The Cochrane Library, The Centre for Reviews and Dissemination.

Results: The electronic search revealed 35 relevant articles and is being supplemented by manual searches of the references from articles.

Conclusions: Analysis of included articles is still in progress and is expected to be completed by December 2013. A copy of the protocol for this study is lodged with the Centre for Reviews and Dissemination (University of York, UK).

S12 Drug delivery

S12-1

Studies on the efficacy of dexamethasone-eluting electrodes and evaluation of potential risks

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Protection of the cochlea during implantation is likely to have benefits for most CI candidates, either through hearing preservation or through increased protection of the auditory nerve. Steroids are known to have a therapeutic effect against the inflammatory response of the cochlea to implantation. The invasive nature of CI electrode insertion itself provides both an opportunity for accurate local drug delivery and a platform for the development of a delivery device. However, aside from its beneficial effects dexamethasone is also known for his side effects such as a delay in wound healing. In this presentation an overview on several animal studies implanted with dexamethasone-eluting electrode rods is given. We focus on the efficacy, wound healing and potential infection risk.

We investigated the efficacy of dexamethasone (DEXA) elution in reducing hearing loss after cochleostomy and insertion of rods of implant grade silicone into guinea pig cochleas. The degree of hearing loss after implantation of eluting and control silicone rods was evaluated (n=18/group). Auditory thresholds were established using tone-burst BERA and DPOAEs. At 6 months post-intervention there was a significantly lower threshold shift, at mid to high frequencies, after implantation with DEXA-eluting rods than in animals implanted with control rods.

To investigate whether dexamethasone eluted from implants influences cochleostomy healing and tissue growth silicone rods with 10% dexamethasone or without dexamethasone were implanted in guinea pigs (n=9/group). The implants were allowed to heal for various time spans to identify a point of time when the healing of the cochleostomy results in a full closure. Animals were sacrificed and bullae were filled with a suspension of ink particles. The assessment of the full closure was performed by histological staining and identification of intracochlear ink particles. Un-implanted control cochleae did not contain ink particles. Results demonstrated that ink particles may still be found within the cochlea 12 days and in some cases even at the end of the experiment after 35 days of healing. There was no statistical difference between the two groups.

To investigate potential risks of a DEXA-eluting electrode we first established an animal meningitis model in guinea pigs. After this we implanted guinea pigs with and without DEXA-eluting rods (n=15/group). Five weeks after implantation we induced an intratympanal infection with the previously evaluated germ concentration. Four animals implanted with a DEXA-eluting rod developed meningitis. We found no considerable difference between DEXA loaded rods compared to unloaded rods and therefore no explicit increased risk of meningitis of DEXA loaded rods.

In conclusion CI electrodes could be loaded with dexamethasone. Sustained cortisone delivery to the inner ear for months could protect the residual hearing of the patient without disadvantages or a higher risk for severe infection.

S12-2

Mechanisms involved in loss of residual hearing post implantation and therapeutic implications

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Intro: Electrode insertion trauma during implantation causes Cochlear implant not only direct tissue trauma and cell losses, but also generates molecular events that may initiate programmed cell death (PCD) via various mechanisms such as oxidative stresses, release of pro-inflammatory cytokines; activation of the caspase pathway; generation of pro-apoptotic signal cascades within the damaged tissues of the cochlea which can lead to a loss of residual hearing. Understanding molecular mechanisms involved in loss of hair cells will have significant therapeutic implications.

Methods: Guinea pigs were categorized in different groups: CI insertion; pre-treated with inhibitor of JNK pathway at round window ½ hr before CI, and unoperated contralateral ears as controls. Immunostaining for phospho-c-Jun, activated Caspase-3, CellROX and HNE were performed at 6hrs, 12hrs and 24hrs post-EIT.

Results: 6 hrs Post-EIT immunostaining of both HCs and SCs demonstrated that phosphorylation of c-Jun and activation of caspase-3 starts in SCs. Caspase-3 activation was not observed in HCs of any turn at 12 and 24hrs, but p-c-Jun labeling was observed at 12 hrs in both HCs and SCs of middle and basal turn and in HCs of all turns at 24hrs. Lipid peroxidation starts 12hrs post EIT in both HCs and SCs of basal turn, and reaches up to apex turn at 24hrs post CI. Group treated by inhibitor of JNK pathway showed no phosphorylation of HCs and SCs at 6hr, 12hr and 24hrs post-EIT.

Conclusion: Molecular mechanisms involved in PCD of hair cells are different than the one involved in PCD of support cells. These finding, there is a window of opportunity to treat the cochlea before onset of cell death in HCs using specific otoprotective drugs (e.g JNK inhibitors) to prevent PCD.

Learning outcome: Loss of residual hearing post implantation can be prevented by development of drugs that can interfere with PCD of SCs and HCs.

Funding: Grants by MED-EL Corporation, Innsbruck, Austria to Pr Adrien Eshraghi

S13 Development of implanted children incl. cognitive and social development & educational aspects

S13-1

Progressive hearing loss in children - diagnosis, referral & outcomes of cochlear implantation

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Objectives: Guidelines for referral for consideration of CI are standardized across our region (unaided responses of ≥90 dB HL average at 2kHz & 4kHz in the better hearing ear). Despite this we regularly see children with progressive loss referred with thresholds much worse than this.

It is known that for adults, duration of deafness is an independent predictor of outcome of cochlear implantation. This would suggest that implantation earlier in a child's disease process could achieve better outcomes.

The aim of this study is to correlate pre-operative hearing levels with outcome of implantation to determine whether delaying a CI in children with progressive hearing loss is associated with poorer subjective outcome measures.

Methods: From our database of 365 children who have undergone a CI at our center, we identified those with progressive hearing loss based on medical history taken from the assessing clinician and review of serial audiograms.

Hearing level at assessment was categorized into < 100dB (group 1), 100- < 115dB (group 2) and ≥115dB ([A&J1] group 3) for best result averaged at 2kHz and 4kHz. Outcome measures used were CAP, MUSS, MAIS and SIR. Post-implant data was correlated with pre-operative hearing levels. Repeated measures regression model was used to analyze the data.

Results: Audiology data was available for 50 patients of which 18 were assigned to group 1, 22 to group 2 and 10 to group 3 with comparable ages. *CAP* - trends of improvement between the groups over time were not significantly different. However as group 3 started at a lower baseline score a statistically significant difference was found in overall outcomes between group 3 and the other 2 groups (p=0.047). No statistically significant difference was seen between group 1 and 2. *MAIS* - no difference was shown between the trends of improvements for each group or overall outcomes between groups. *MUSS* - again no difference was found between the trends of improvements for each group. However due to the lower baseline score of group 3, despite improvements the overall scores were once again statistically lower than groups 1 and 2 (p=0.010 for parent's score and p=0.003 for the teacher's score). *SIR* - this outcome showed the greatest difference between groups. Group 3 was not found to advance over time, with trends of improvement being significantly poorer than groups 1 and 2 respectively (p=0.05, p=0.03). By 5 years, group 3 on average had speech that was largely unintelligible in contrast to groups 1 and 2.

Discussion: Patients with pre-operative hearing levels ≥ 115dB had poorer outcomes with CIs particularly with regards to speech intelligibility and the daily use of language. As these children have progressive loss, we hypothesise that referral for CI could have been made earlier potentially leading to better outcomes.

Emphasizing the need for regular audiological monitoring of children with progressive loss may help reduce delay in implantation.

S13-5

Progress of auditory and speech rehabilitation of CI children as compared to normally hearing group

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Introduction: In children with hearing loss the aim of the therapeutical activities is to optimally develop auditory and linguistic skills adequately to the intellectual potential and age. Regular hearing and speech rehabilitation may provide the development of the linguistic skills necessary to fully participate in the education and social life.

Objective: The aim of this study is to investigate the development of auditory and linguistic skills of the children with the cochlear implant at age 0-4 years old as compared to normally hearing children in the same age. Secondary objectives are to look for the trends and correlations taking into consideration such factors as time of implantation, unilateral or bilateral implant application as well as intensity of auditory and speech rehabilitation.

Method: It is a multicenter study with prospective recruitment of CI users between 0-4 years old. Simultaneously, control group that consists of normally hearing children was observed. Integrated Scales of Development was used to assess the progress of hearing and speech rehabilitation. It outlines the typical levels of the development in the areas of listening, receptive and expressive language, speech, cognition and social communication. The observation was conducted since the first sound processor fitting till 48th month of life of the child in intervals of 3 months up to 18th month of life and afterwards every 6 months.

Results: This is to present the multicenter observational prospective research protocol as well as preliminary data for 85 CI users from 13 speech therapy centers compared to results obtained for 25 normally hearing children.

Conclusions: The development of auditory and linguistic competence of implanted children with profound hearing loss can be assessed according to Integrated Scales of Development and therefore compared to the children with normal hearing.

Keywords: Auditory and speech rehabilitation, children, cochlear implant, progress, ISD, Integrated Scales of Development

S13-8

Developing the musical brain to boost early pre-verbal, communication and listening skills through a musical early intervention approach and resource, pre and post cochlear implantation, for babies and very young children (3 months - 24 months)

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Developing early communication and listening skills in hearing impaired babies and infants with hearing aids and cochlear implants through home based interventions focused on empowering parents, supports the goals of early intervention best practices. Providing age appropriate support for newly diagnosed babies and infants under the age of 12 months with hearing aids, waiting for their cochlear implant, can be challenging. The age of implantation has decreased so family centered resources need to fully support the pre-verbal stage, the home provides a natural environment to develop these skills. Musical activities can naturally develop the areas of attachment, listening and communication. Research indicates that developing the musical brain can boost early development of communication skills.

The study objective was to determine the effects of a musical, multi-sensory resource and monitoring tool for babies aged 3 months - 24 months that promotes music, listening and early communication. This resource aims to support the natural development of attachment, to build early developmental skills, essential for later language development. It aims to bridge the gap between having a hearing aid and waiting for a cochlear implant. 20 families; 14 aided babies waiting for a cochlear implant and 6 babies with cochlear implants participated in a pilot study; working with the resource at home for 6 months. Parental feedback was positive, ideas from the resource were carried over into the families everyday routines. Monitored evidence showed that parents observed increased vocalization, attention and anticipation of the activities in their babies. Parents also reported their increasing confidence in singing, moving and playing with their baby during this program. The finding that early intervention is essential to maximize outcomes, led to the development of Baby Beats, aiming to support parents to actively engage their baby through the 4 staged program; helping develop early communication, listening and language skills. Furthermore, it aims to support the child's social and emotional development.

The resource has been shown to be appropriate for babies (3months +) ,practical and flexible for use in the home environment. Evidence to illustrate how the resource was used to support the natural development of attachment, early listening and communication skills through music will be shown. Outcomes will be shown to demonstrate the effectiveness of the intervention, particularly in bridging the gap between having a hearing aid and waiting for a cochlear implant.

Understand how Baby Beats supports the evidence stated for early intervention goals for babies who are hearing impaired.

Understand how Baby Beats activities support parents in interacting with their baby who is hearing impaired while awaiting cochlear implantation.

Describe how Baby Beats, working in synthesis with latest hearing technology, supports the development of pre-verbal skills.

S13-16

Developing the competences of written German by children with cochlear implants

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Aim: The study intends to verify whether existing findings, indicating that hearing-impaired children tend to exhibit suboptimal performance in the process of learning to read and write, can be corroborated using a larger sample size of children with cochlear implants (CI), and what the distinctive features of this process are in the children studied.

Material and methods: The study population comprises 34 CI-recipient children who attend either mainstream schools or schools for the hearing impaired. They are being tested, using various standardized procedures, at the end of school years 2, 3 and 4.

Results: The available results from the first and second phase of data collection show that children with CIs achieve considerably better outcomes than expected in terms of single-word and sentence reading, as well as in spelling. In text comprehension, however, considerable weaknesses are evident.

Conclusions: Available data show that the development of the written German competences of children with CI runs widely positive and is absolutely comparable with progresses which can be also found in the normal hearing pupil´s population. It is obvious that the former findings about massive problems, the children with hearing impairment showed with the reading and spelling skills, must be mostly revised for the today´s generation of CI-supplied children.

S14 Sound processing

S14-6

Coding of interaural time differences with fine structure coding strategies

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Purpose: Normal hearing people rely on both Interaural Time Differences (ITD) and Interaural Level Differences (ILD) for sound localisation. With Continuous Interleaved Sampling (CIS) coding strategies, fine structure temporal information of the signal is lost. This means that users need to rely mostly on ILDs to localize the sound. The MED-EL FS4 strategy allows for the presentation of new low frequency cues, which may improve ITD perception for bilateral CI users. This study aims to assess ITD coding effectiveness for FS4 and HDCIS, and to make a comparison between the two. For periodic pulse-trains, sustained ITD sensitivity is sharply reduced as the stimulation-rate is increased. It has been reported that ITD perception for higher rates can be improved by adding bilaterally synchronized binaural jitter to a periodic carrier. Signal processing in FS4 produces variations in inter-pulse intervals in the time domain, largely synchronized bilaterally.

Methods: 10 experienced bilateral MED-EL Cochlear Implant users have been recruited for the study, who have at least 6 months' experience with either the HDCIS or FS4 coding strategies. The minimum perceived ITD is measured in different conditions, using a Matlab based software to generate the signals. Firstly electrical direct input signals are used, testing different pulse-rates, single and double pulses, and different amounts of jitter added to the signal. For the second part, direct acoustic input to the processors is tested for both HCIS and FS4 strategies, using different fitting configurations. The input signal will be pink noise.

Results: For every tested case, the minimum perceivable ITD is measured. For the direct electrical input part, a comparison of the results is carried out, in order to assess the effects of different changes (doubling of the pulses, addition of jitter) in ITD perception. For the second part, there is an assessment of the two tested coding strategies.

S14-12

Effects of pulse polarity on temporal interactions: Detection thresholds and loudness growth functions

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All modern cochlear implants (CIs) present pulses non-simultaneously in order to reduce charge interactions. However, the membrane of auditory nerve (AN) fibers needs time to return to its resting potential, causing the probability of firing in response to a pulse to be affected by previous pulses. This is particularly important for the high pulse rates used in contemporary CIs. Here we provide new evidence on the effect of pulse polarity on these interactions and demonstrate that, in a condition where loudness is assumed to be strongly affected by cathodic current, it can vary non-monotonically with level.

Seven users of the Cochlear Freedom device took part. Detection thresholds and loudness balanced levels were measured for six electrical stimuli presented at 100 pps on a middle channel of the array. Two of the stimuli were anodic-1st (A) and cathodic-1st (C) single-pulse-per-period pulse trains. The remaining four stimuli were two-pulses-per-period pulse trains (TPPP) consisting of a biphasic pulse followed by another pulse of the same or of opposite polarity. All four combinations of pulse polarities were studied (“AA”, “CC”, “AC”, and “CA”).

For TPPP, thresholds were significantly lower when the adjacent phases of the two pulses had the same polarity (AC and CA) than when they had different polarities (AA and CC). About half of the subjects showed the threshold for AC to be lower than that for CA while the other half showed the opposite. This demonstrates for the first time that, at threshold, AN fibers are polarity sensitive and that a cathodic stimulus may sometimes be more effective than an anodic one. Contrary to the threshold data, the stimulus that required the highest current to evoke a comfortably loud sensation was always AC, even for those who showed a lower threshold for AC than for CA. The level of AC had to be 2.9 dB larger than that of CA on average, consistent with previous findings that an anodic pulse is more effective than a cathodic pulse at comfortably loud level.

In an additional experiment, we asked the same subjects and 6 others to compare the loudness of 11 pulse trains of different levels (spanning the top ¾ of their dynamic range) both for AC and for CA. Several subjects showed a non-monotonic growth of loudness as a function of level for AC but not for CA; at some point in the dynamic range, loudness decreased with increases in level. This behavior was observed in 40% of the electrodes tested and could occur for a given subject on some but not all electrodes. This surprising finding may relate to a nerve conduction block produced by hyperpolarization of the central processes of the nerve fibers and may have important implications for the selection of novel stimulation protocols in CIs.

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S14-14

An explanation for lower threshold levels using anodic stimulation of the human auditory nerve from computational modeling

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Experimental studies describing electrical stimulation of the auditory nerve in guinea pigs and cats have demonstrated lower threshold levels for monophasic cathodic pulses than for anodic ones. In contrast, both subjective (psychophysical) and objective (brain stem potential) threshold measurements in human subjects suggest a preference of the auditory nerve for positive electrical currents. A factor that could be determining experimental outcomes in stimulation threshold studies is the different morphology of the auditory neuron in different species. Unlike the myelinated cell body of neurons in species other than man, the somas of the majority of human auditory nerve fibres are surrounded only by very few myelin layers. This causes the human cell body to carry a large capacitance that is likely to influence the behavior of the neuron when stimulated electrically. In this study, a computational model is used to investigate the conditions under which the implanted human cochlea can exhibit lower threshold levels under anodic stimulation.

First, a newly developed double cable model for the human auditory nerve fiber is used to describe a straight neuron in a homogeneous medium. If the stimulating electrode is positioned in the vicinity of or directly above the cell body, for certain radial distances of the electrode to the neuron, lower thresholds are found for anodic pulses than for cathodic ones. In this case, the action potential is generated in the unmyelinated terminal of the neuron (first node of Ranvier) due to the depolarizing excitation area in the peripheral process, flanking the hyperpolarized main stimulation area in the axolemma directly underneath the electrode. In contrast, for the same configuration, the cathodic pulse has to depolarize the current integrating cell body in order to generate an action potential, and is therefore only able to do so at higher current levels. It is demonstrated that the presence of the peripheral process, the size of the unmyelinated terminal and the degree of myelination of the cell body is of influence on this effect.

Secondly, the nerve fiber model is integrated in a 3D volume conduction model of the human cochlea. In this situation, the peripheral processes of nerve fibres follow a curved path. For neurons located in certain areas along the basilar membrane the anodic pulse is still a more efficient stimulus than the cathodic one. If the excitation takes place further from the cell body the effect is not evident.

It is concluded that for electrical stimulation of the human auditory nerve, the specific morphological properties of the neurons define conditions under which positive electrical stimuli require lower current levels to elicit an action potential than negative ones. These model results are in line with the ones found in other studies, for deep brain stimulation in human subjects, and can explain the abovementioned clinical observations in cochlear implant users.

S14-15

The perception of spectral irregularity with fine structure coding strategies

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Most strategies in use in cochlear implants (CI) transmit mainly envelope information. Most CI-listeners using those strategies show good speech perception but struggle with the perception of musical stimuli. Apart from extracting only envelope information, the fine structure (FS) processing strategies FSP and FS4 (MED-EL Corporation) additionally transmit the FS-information of an incoming sound signal. This is achieved by using channel specific sampling sequences (CSSS) on the most apical channels. The stimulation pulses are initiated when the bandpass-filter output passes zero-crossing points corresponding to the FS of the input signal. Whereas the FSP strategy provides FS-information variable on one to three apical electrodes, the FS4 strategy provides FS-information fixed on four electrodes.

The transmission of low-frequency FS-information may provide additional assistance on music perception and appreciation. One essential cue of musical sounds is timbre. Timbre distinguishes two sounds that are otherwise equal in pitch, loudness and duration. Normal-hearing (NH) listeners are able to distinguish musical instruments playing the same note with an equal loudness because of timbre. In CI-users the ability to perceive the timbre of musical instruments is reduced in comparison to NH-listeners. One important timbre cue is the spectral irregularity (spIrr). However, using conventional coding strategies, this cue is only poorly perceived by CI-users. SpIrr refers to amplitude variations between adjacent harmonics and thus addresses fine structure of the signal. This information is not coded with envelope driven strategies. FS-coding strategies seek to compensate for this lack of information.

The aim of this study was to investigate if spIrr might be a more useful cue in CI-listeners when using FS-coding strategies. It is hypothesized that using FS-coding strategies improves the perception of spIrr, as additional information about timing cues of the incoming signal is coded. Here, FS4 might even outbalance FSP as there are generally more electrodes transmitting the temporal information.

Tonal stimuli of the instrument “horn” were artificially changed in spIrr and presented to CI-users in an adaptive 3 interval, 3 alternative forced choice (AFC) paradigm to measure the just-noticeable-differences (JNDs). In addition, the results were compared to studies with CI-listeners using only envelope transmitting strategies.

The results show that CI-users trend to achieve better JNDs with the FSP strategy. By using the FS4 strategy, discrimination thresholds decreased significantly.

Generally, CI-listeners´ ability to perceive differences in spIrr improved when using FS-strategies. Therewith, the spectral irregularity turns to a useful parameter and might improve the perception of timbre. As a result, CI-listeners´ ability to differentiate natural musical instruments might enhance.

S15 Hearing and structure preservation

S15-1

Hearing preservation classification

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Over the past years the criteria for cochlear implantation widened. With the improved surgical skills and implant technology it is now possible to preserve the hearing after the cochlear implantation

Several studies have shown that with appropriately designed and inserted electrodes, acoustic hearing can be preserved in the majority of subjects during cochlear implant (CI) surgery.

Having increasingly higher number of cochlear implant patient with hearing preserved, there is a need for hearing preservation classification. There have been several attempts to classify hearing preservation after cochlear implantation. However, none of these classifications were independent from the initial hearing; classifications were suitable only for a limited group of subjects. What is more, the classifications did not implement the fact that hearing preservation in patients with substantial hearing is more difficult to achieve than hearing preservation in patients with poorer preoperative hearing. The goal of the hearing preservation classification is to have one reliable method of classifying possible postoperative hearing loss in patients within different CI centers.

Currently, the group of HEARRING centers proposed an optimized classification. The proposed classification fulfills the following criteria

- Classification independent from initial hearing;
- Classification for all cochlear implant patients; i.e. covering the whole range of patient with the pure tone average from 0 to 120dB;
- Classification easy to use and easy to understand.

S15-3

Long-term hearing preservation in Electric-Acoustic Stimulation patients, up to 10 years

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Background: Hearing preservation (HP) surgery was initiated more than ten years ago for combined Electric and Acoustic Stimulation (EAS). Preserved residual low-frequency hearing has been demonstrated to improve speech reception in noise as well as music appreciation in EAS users up to 2 years. Multiple study groups aimed to evaluate initial loss of residual hearing (RH) as a consequence of HP surgery. However at one year and 2 year follow-up further decline was reported.

Therefore, the study aims to focus on long-term RH, speech reception and subjective benefit after first fitting up to 10 years in EAS users who underwent HP surgery.

Subjects and Methods: 9 post-lingual partially deaf patients who underwent HP surgery in the Antwerp University Hospital were included in the study (11 implanted ears). HP (0%= Loss of hearing; >0 - 25%= Minimal HP; >25 - 75%= Partial HP; >75%= Complete HP), speech reception and subjective benefit (APHAB) were evaluated on a long-term.

Results: Complete HP was obtained in 3/11 ears, partial HP in 5/11 ears, minimal in 2/11 ears and one subject lost his RH completely over time. Mean HP rate was 48% (ranging from 6 up to 10 years post- first implantation). Speech reception analysis up to 10 years showed a continuous statistically significant improvement. The maximum subjective benefit was found already 3 months after the implantation, the subsequent stable period remain statistically significant for the following 10 years.

Conclusion: Long-term HP in EAS users after soft surgery turned out to be possible, although there is a small continuous decline of HP rate of 3% per year (measured from first fitting up to 6 years post-operative). Nevertheless, a continuous improvement was found in the speech reception results of the EAS users. Moreover, the positive subjective benefit, assessed 3 months post-operative, remained stable up to 10 years.

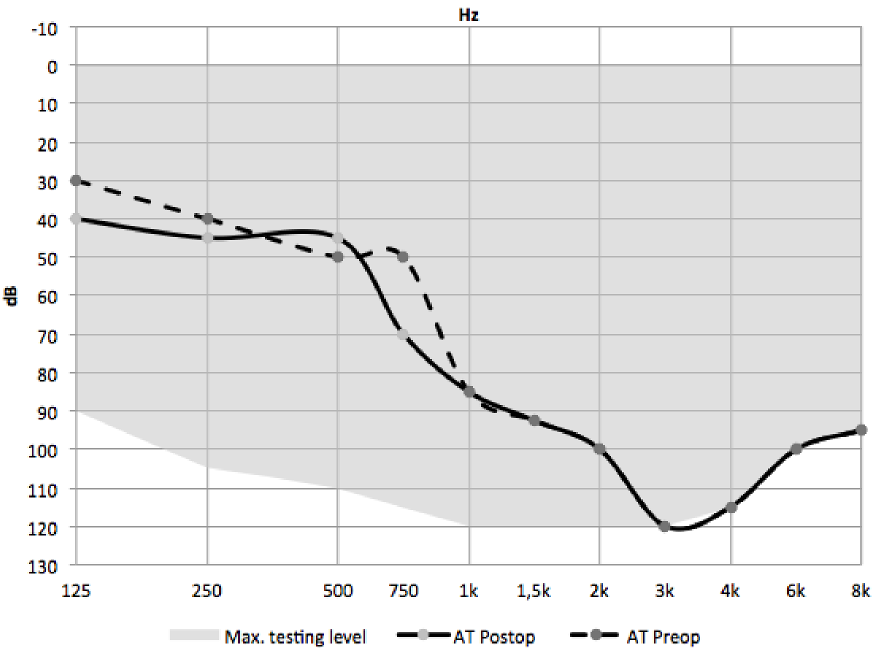
[Hz]	125	250	500	750 (optional)	1k	1,5k (optional)	2k	3k (optional)	4k	6k (optional)	8k
AT Preop	30	40	50	50	85		100	120	115	100	95
AT Postop	40	45	45	70	85		100	120	115	100	95
Max. testing level	90	105	110	115	120	120	120	120	115	100	95

hearing
Comprehensive Hearing Implant Centers

Please fill in testing results into the grey cells!

Patient:	Antw_001
Side of Ear:	R

S =	91,1	[%]
PTApreop =	79,8	[dB]
PTApost =	82,5	[dB]
HL =	2,7	[dB]



[Example Hearing Preservation Calculation]

S16 Hearing implants in the military

S16-3

Middle ear implants helping soldiers return to duty

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In the Military, the ability to hear and communicate is critical to the safety of each warrior and their unit, and is central to effective command and control, and mission accomplishment. In spite of current hearing conservation efforts, hearing loss and auditory injuries in the military continue to rise as the most predominant wounds of war, and the cost of disability for hearing loss is over one billion dollars annually. Blast injury and noise induced hearing loss profiles can be problematic for traditional hearing aids, and hearing aids can be incompatible with professional and protective equipment in the military. Military members have very specific roles and are often involved in complex tasks that require extensive training and cost. When soldiers are no longer able to work in their trained fields, further they have to be retrained or released from service. Middle ear implants offer advantages over traditional hearing rehabilitation and can be viewed as a means to rehabilitate hearing loss and acoustic injuries that allow troops to be retained and reintegrate into their units. A comparison of the indications and outcomes of three middle ear implant systems will be compared with military specific outcomes related to improving hearing loss profiles according to the United States profiling system.

S17 Hearing and structure preservation

S17-21

Hearing preservation cochlear implantation - the influence of electrode length and design

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Introduction: Hearing preservation in cochlear implantation is a prerequisite for electric-acoustic stimulation in patients with partial deafness. Several electrode systems with differences in length, shape and mechanical properties have been developed. We report about the short and midterm results of hearing preservation in a large patient population using different electrode designs.

Material/Patients and methods: The following electrode systems were used: Hybrid-L (N=97), CI422 with SRA electrode (N=100), Flex20 electrode (N=41), Flex24 electrode (N=27), Flex28 (N=22). The median hearing loss postoperatively at time of initial fitting 3, 6, 12 and 24 months was derived from pure tone audiograms. The results were grouped in good preservation (< 15 dB hearing loss), partial preservation (15-30 dB hearing loss) and loss of hearing (> 30 dB hearing loss). Intraoperative findings, precochlear anatomy as derived from imaging and medical history were analyzed to identify potential mechanisms of hearing loss

Results: The lowest median hearing loss and highest percentage of hearing preservation was found with Hybrid-L electrode (91 %), followed by the CI422 (87 %), the Flex20 (75 %), the Flex24 (80 %) and the Flex28 (50 %). Hearing was stable over time with a slight increase after 12 and 24 months.

The most important factor of hearing preservation was the electrode length with significantly better result for the electrode shorter than 20 mm. Good results were achieved with an electrode of a total lengths between 20 and 24 mm while a longer electrode remarkably increases a risk of hearing loss. Patients with sudden hearing loss in their medical history show a higher risk of postoperative hearing.

Conclusion: Hearing preservation cochlear implantation is possible with different types of electrodes. Due to the increasing risk with electrode length the type should be chosen in relation. Hybrid electrode should be selected depending also on the degree of preoperative residual hearing and the medical history.

S17-23

Residual hearing preservation in multichannel cochlear implanted patients

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Introduction: The preservation of residual hearing is a concept that has been gaining clinical relevance in the recent years. Following the successful outcomes in implanted patients with profound hearing loss, patients with better residual hearing have been considered to be candidates for cochlear implant. The possibility of electro-acoustic stimulation and the use of regenerative therapeutic in the future are factors justifying strategies for hearing preservation.

Objective: To investigate audiological aspects and residual hearing preservation in multichannel cochlear implanted patients.

Study Design: Retrospective chart review.

Methods: Medical records of 32 consecutive implanted adult patients with detectable threshold at pre-operative hearing tests were analyzed, comparing the averages of the audiometric thresholds by frequency (AATf), as well as the difference between the averages of audiometric thresholds (AAT), 0.25kHz to 8kHz, per patient in pre and post-operative conditions (6 months after surgery). The preservation of residual hearing was classified as complete when the difference of AAT and AATf in pre and postoperative conditions were ≤ 10dB and partial when > 11dB and no preservation when no response was detected.

Results: Total hearing preservation was observed in 37.5% of implanted ears, partial preservation in 25% and no preservation in 37.5% of the cases. Differences of pure tone thresholds per frequency showed that fully preservation, when detectable, was constant in the frequency of 0.25 kHz and partial in frequencies between 0.5 kHz and 6 kHz. No preservation could be observed at 8 kHz frequency.

Conclusion: hearing preservation was possible in around 62% of our cases. The analysis of pre and post-operative thresholds confirmed that preservation at low and medium frequencies is more feasible compared to high frequencies. Surgical aspects and different electrodes used will also be analyzed during final presentation.

S18 Accompanying modalities: awareness, self-helping rehabilitation, self-helping groups to support performance, support & aftercare in assistive listening devices, growing populations

S18-1

Empowered parents by the *Muenster Parental Programme* - Feedback from parents

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Background: After the diagnosis of hearing loss (HL) of their child within NHS, parents wish for immediate, qualified, and family-centered support. Without this support parents are concerned to lose the advantage of early identification [1]. Studies show that - besides the early diagnosis and the child's supply with a hearing device - it is the early start of intervention combined with a high level of parental participation that are essential factors for a successful speech-language development of the child [2, 3].

The *Muenster Parental Programme (MPP)* [4] is a family-centered responsive parenting intervention immediately after identification by NHS. The 3-months program is for parents of preverbal children with uni- or bilateral HL at the age of 3-18 months, with or without additional special needs. The *MPP* concentrates on empowering parents to communicate successfully with their children as an important foundation for their language development. It also gives parents the opportunity to share their experiences with other affected families. They consider this interaction to be very supportive [5].

The *MPP* follows communication-oriented principles, concentrates on natural oral language development, and links these aspects with core elements of responsive parenting programs [4]. It combines parent group sessions with single sessions including video-feedback. The program also addresses families of pediatric CI candidates. It supports them in bridging the time until the implantation and/or can be used as a module of habilitation after implantation.

Evaluating the program we showed, that parents could enhance their responsiveness to vocal, preverbal, and non-verbal signals of their infant. Moreover, children of trained parents vocalized significantly more after the MPP than children of untrained parents 6]

Method: We asked 23 participating parents (7 children with CI candidacy) for their feedback on the *MPP* by means of a standardized treatment evaluation questionnaire and the self-developed questionnaire specific to the *MPP*.

Results: Parents' satisfaction with content, didactics and setting of the MPP is high in both questionnaires. In their answers to open questions parents especially appreciated the contact and exchange with other affected parents, the individual video-feedback, and the concrete help they received for the communication with their preverbal infant. 89 % of the parents state, that their communication towards their infant has changed as a result of participating the *MPP*, and 96 % of the parents would recommend the MPP to parents in a comparable situation.

Conclusion: The positive feedback from parents concerning execution and individual benefit show that the MPP not only leads to enhanced parental communication skills towards their child, but also satisfies the parents' need for early, qualified and family-centered intervention after identification of HL within the NHS. Parents value the MPP as useful before cochlea implantation.

S18-6

Evaluation of deafened adults with eye tracking technology - preliminary results on 72 subjects

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Objective: The aim of this study is double. Firstly, it is to investigate via the eye tracking technology how the gaze of deafened adults differs from normal hearing people. Which visual clues are used by deafened adults compared with normal hearing people? Is lipreading still relevant when they get a cochlear implant? Secondly, it is to investigate whether the eye tracking technology could be a reliable alternative to classical speech therapy evaluations.

Materials and method: 72 participants: 43 deafened people with Hearing Aid and/or Cochlear Implant (8 bilateral CI), 10 deafened people without hearing aid, 19 normal hearing people. The twofold evaluation consisted in repeating triphonemic words and everyday sentences with a real speech therapist and with the same one filmed, in 3 different conditions:

1. hearing aid(s) + lipreading, comfortable intensity level
2. hearing aid(s) + lipreading, low intensity level
3. lipreading only

Throughout the duration of the two tests, the eye tracker recorded the locations and duration of eye fixation.

Results: The rate of visual recording was about 70%, which shows a good reliability. All subjects prefer to look at the right part of the face, rather than at the left one. The 4 left-handed participants of our sample also show a preference for the right side of the speech therapist face. In each group, participants significantly look more at the mouth than at the nose or the eyes. Even normal hearing people gaze the mouth. Rehabilitation with 2 cochlear implants leads to a similar visual behavior as the one observed with normal hearing people. All participants, including those with good hearing, are able to perform in lipreading. Normal hearing people obtain lower scores than the 2 groups of deafened people. The intelligibility is better in the face to face condition (3D) rather than in the video condition (2D) for the phonemes ($F=15{,}125$, $p< .001$), the words ($F=15{,}675$, $p< .001$) and the sentences ($F=6{,}829$, $p< .001$). But the patterns of confusion don't differ (Marascuilo Procedure).

Discussion: Speech assessments may only be partially automated with eye tracking. The pattern of results is similar but lower in the video condition. Subjectively people prefer the test with the real person. But even in this condition, the eye tracker provides relevant information. Deafened people with 1 or 2 cochlear implants still use lip reading. Those with normal hearing also do. Theories of salience may explain this phenomenon: the lower part of the face is the most mobile, therefore attention is drawn towards it. Patients with 2 cochlear implants tend to look more at the eyes area than those with 1 cochlear implant or 1 cochlear implant and 1 hearing aid, suggesting that their rehabilitation makes them close to the normal hearing people.

Keywords: Lip reading, Eye tracking, Cochlear implant

S18-8

Musical rehabilitation in adult cochlear implant recipients with a self-administered software: *MusicEAR*

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Introduction: Despite significant advances in speech performance for cochlear implant users, music perception and enjoyment remain challenging for most, as implants lack the spectral resolution necessary to fully capture a musical piece. Little progress has been made to address the rehabilitative aspect of music perception. In this study, a self-administered music rehabilitative software - MusicEAR - was designed to help improve the perception of musical patterns of increasing complexity, as well as pitch and timbre perception, premised on focused and divided attention.

Methods: 17 adult CI users (10 Female, 7 Male) were recruited, ranging in age from 32 to 82 years. Time since hook-up varied from 2 months to 143 months (Median = 14 months). Participants were tested with a validated “diagnostic” version of the MusicEAR program before and after 4 weeks of training; it includes tests of pitch perception, timbre perception, and pattern identification with increasing levels of difficulty and complexity. Participants completed a number of subjective tests including one of music appreciation, an assessment of past musical experience, and a (post-training) questionnaire pertaining to the training process and software program. Speech data in quiet and noise was also collected both pre- and post-training. Participants trained with the “rehabilitative” version of MusicEAR on their home computer for a minimum of 3.5 hours a week, for 4 weeks. Training was monitored while results were captured and transferred into an online database, including information such as time spent on task, reaction times, percentage scores, etc.

Results: Post-training diagnostic MusicEAR test scores, as compared to pre-training scores, indicated significant improvements in musical pattern perception. Tests of speech perception in noise were notably improved in a subset of this cohort. All of the training participants felt that the training helped to improve their recognition skills, and found the program to be beneficial.

Discussion: Results of this study suggest that even with the limitations of current CI speech processors, auditory training can improve music perception abilities, lending further support to rehabilitation being an integral part of the post-implantation paradigm. The intensity required for focused and divided attention may have resulted in significant benefits in speech perception for some patients. A high degree of patient compliance and motivation is necessary to achieve the desired outcomes.

Conclusion: A self-administered music rehabilitative computer program can improve music listening skills through intense training.

Learning outcome: Discuss results of a new at-home music rehabilitation program.

S18-9

Skype™ offers a better speech perception for cochlear implant users compared to conventional telephony

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Objective: Internet telephony (VoIP) offers significantly improved speech perception compared to conventional telephony (PSTN) under ideal laboratory conditions due to doubling the frequency range (0.1 - 8 kHz vs. 0.3 - 3.4 kHz) and conserving audio quality through digital signal processing. The goal of this study was to explore speech perception by cochlear implant users by using Skype™ and accessories under real network conditions.

Methods: 19 adult users of cochlear implants, were tested monaurally in the free sound field using the German HSM sentence test in background noise. Speech perception was assessed using the conventional telephone line and Skype™ (PC based) under real network conditions with increasing loss of digital data packets (from 0 to 20%). Headphones, CI audio cable (3.5mm jack), audio induction loop, loudspeakers and a Skype™ DECT telephone were tested.

Results: Speech perception scores using Skype™ under ideal network conditions were significantly better (median 91.6% (range 48-99.1) compared to PSTN (median 48.1%, range 11.3 - 85.8, $p < 0.001$). Speech perception scores remained superior even with low quality internet connections and data packet loss up to 10% ($p < 0.001$). Best performance was seen with PC loudspeakers although there was no significant speech perception difference among the telephone accessories used.

Conclusion: This experimental study confirms that Skype™ offers improved speech perception compared to conventional telephone quality even under adverse network conditions with mild to moderate packet loss. Telephone accessories might be helpful for coupling to the CI, however, there was no significant difference in speech perception performance.

S18-12

The near future of induction loop systems in public rooms

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A designer of inductive hearing systems is frequently asked whether such a system is an acceptable investment for the future. Is the induction loop after more than 60 years of usage still up-to-date, compared to Bluetooth, WLAN and ZigBee? Is the induction coil inside of hearing systems a necessary device?

The advantages and weaknesses of the inductive technology are well known:

- high speech intelligibility,
- individually fitted receiver,
- low investment and operating costs,
- standardized characteristics,
- only one-channel transfer,
- possible interferences by tree-phase net,
- overspill of the magnetic field

Induction systems are not usable without individually fitted receivers (hearing aids, cochlear implants, implantable hearing aids). A market analysis about available hearing systems, carried out by the author, showed that about 60 % of all devices contain an induction coil (T-coil). Mostly the CIC-devices and the well-designed BTE-mini-series don´t have any receiver coil due to a lack of space. For all other devices the audiologist determines, whether the inductive coil is activated and a specialized program is available.
An overview of communication systems of hearing aid manufacturers reveals that these systems aren´t compatible. A manufacturer independent, uniform radio standard is still far away. Therefore inductive systems keep their importance also in the medium term.
This development is supported by international efforts to integrate handicapped people. The new German standard DIN 18040 has been valid for two years now. Among other things it specifies the support of hearing impaired people by:

1. Installation of inductive hearing systems into counters with glazing and intercom systems,
2. Installation of assistive listening devices (preferably inductive) in all communication rooms having a PA system.

These specifications apply to new buildings, but they are also used in the case of complex reconstructions. Furthermore, the associations of hearing impaired people support the specifications of the standard and regard them as minimum requirements. It may be recognized that inductive hearing loops will play an important role in the near future. Nevertheless, there are some tasks that need to be completed:

- uniform implementation of the standard IEC 60118-4 as a quality benchmark,
- clear, uniform identification of all assistive listening devices,
- motivation of the audiologists for giving advice about activating the inductive receiver in hearing systems.

S21 Speech coding

S21-11

Mismatch between electrical stimulation map and cochlear place frequency map delays and decreases speech perception with cochlear implant

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Objectives: To evaluate the effect of mismatch between frequency of stimulation and auditory neuron frequency on the speech perception outcomes (maximum value and time elapsed to reach a 70-80% of maximum value) after unilateral cochlear implantation.

Design: Retrospective study in a tertiary referral center. Subjects implanted with MED-EL Concerto devices with various lengths of electrode arrays (24, 28 and 31.5mm) were included in this study. Individual place mapping of auditory neuron frequency was performed for each electrode thanks to cone beam CT scan. The frequencies of stimulation on each electrode with the cochlear implant were compared to the frequency of auditory neuron to determine their involvement in speech perception outcomes (maximum monosyllabic PBK score and time to reach 70-80% of this score). Additional factors like the age, the duration of profound hearing loss, the number of stimulated electrodes, and the depth of insertion of the most apical electrode were also used to perform multivariate analyses.

Results: Data from 23 subjects (24 mm, n= 6, 28 mm, n= 5 and 31.5 mm, n=12) were analyzed. Insertion depth was 361.67±38.89°, 478.00±28.80°, and 566.67±93.89° with each type of electrode array respectively. The mean of maximum speech perception score was 75.54% and the time to reach 70-80% of maximal score was 7.22±2.88 months. The mismatch calculated as the frequency shift was higher for 31.5mm arrays between the 2nd to the 7th electrodes (ANOVA< 0.05). Multivariate analyses showed that the PBK score was significantly associated with all factors excepting the number of active electrodes. A younger age, a shorter duration of auditory deprivation, a lower frequency shift and a shorter time to reach 70-80% of PBK max were associated with higher PBK scores. Conversely, a deeper electrode insertion was associated with lower PBK scores. Additionally, factors associated with the time to reach 70-80% of PBK max were the frequency shift, the PBK max and the age. Therefore, a lower frequency shift, a high PBK max and a younger age were associated with a shorter time to reach 70-80% of PBK max.

Conclusion: Frequency mismatch impairs speech perception outcomes (maximum value and time elapsed to reach a 70-80% of maximum value) after unilateral cochlear implantation. A careful selection of the length of the electrode array according to individual cochlear size variations may reduce this mismatch.

S21-12

Understanding noise in speech: A new hypothesis to explain the lack of masking release in CI users

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Introduction: Understanding speech in noise remains a critical challenge for cochlear implants (CIs). Recent work using vocoder simulations of CI processing has indicated that inherent fluctuations of so-called "steady" noise may play an important role in masking speech. In this study, speech perception was tested in CI users, in noise and in tones, designed to produce the same overall excitation as the noise, but without any inherent temporal fluctuations. Based on the results from normal-hearing (NH) listeners in simulations, the prediction was that the tones should be much less effective maskers than the noise, because of the lack of inherent temporal fluctuations.

Methods: Sentence recognition was tested in 12 postlingually deafened adult CI users, and 4 NH listeners. Maskers included: 1) Gaussian noise, spectrally shaped to match the long-term spectrum of the speech; 2) 16 tones, with frequencies corresponding to the center frequencies of the CI channels for each CI user; and 3) 16 tones, amplitude-modulated with the envelope of a noise filtered by the corresponding CI frequency channel, giving the masker a spectrum similar to (1), but temporal envelopes similar to (2). Stimuli were presented unprocessed or via a 16-channel tone-excited envelope vocoder with and without a simulation of current spread to reduce spectral resolution.

Results: In NH listeners, consistent with previous results, the inherent fluctuations in noise led to poorer speech recognition thresholds. However, in CI users no difference was observed between the tone and noise maskers. This surprising result was illuminated by a very similar finding in the NH listeners, with the vocoder simulating a loss of spectral resolution.

Discussion: The results suggest that, in contrast to NH listeners, CI listeners are often unaffected by the inherent fluctuations in steady-state noise. This unexpected finding can be explained by the summation of temporal envelopes from adjacent CI channels, which in turn leads to reduced fluctuations. This outcome suggests a potentially important interaction between spectral resolution and temporal processing, and provides one explanation for why CI users show little or no masking release when comparing speech reception in modulated versus unmodulated maskers.

Conclusion: In contrast to NH listeners, CI users do not show sensitivity to inherent fluctuations in noise when listening to speech. This outcome can be explained by poorer spectral resolution, leading to a summation, and hence smoothing, of the noise temporal envelopes. The results provide a new framework for explaining the lack of masking release observed in CI users.

Learning outcome: Improved understanding of how changes in spectral resolution can lead to unexpected changes in effective temporal processing.

S21-15

Quantitative evaluation of fine structure coding in cochlear implants

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The auditory nerve codes sound signals not only with a rate-place-code but also by precise temporal coding. Although the relative contribution of these two codes for speech coding it is not quite, accumulating evidence arises that the temporal code might be more robust than the rate-place code, particularly in noisy conditions. It is therefore not surprising that modern cochlear implant (CI) coding strategies try to code more and more information in the time-domain, e.g. by increasing stimulation frequencies or by specific “fine-structure” coding strategies.

This investigation introduces a method that provides a quantitative evaluation of fine-grained temporal information in pulse trains and neuronal spike trains. Our method calculates the magnitude spectrum of spike-trains (window length: 25 ms) in every frequency channel and discards all frequencies above the cut-off frequency of the individual auditory filter. In the next step, the spectra are summed up for all frequency channels and the frequency axis is transformed to the MEL-scale. This procedure discards all place information. These features are then fed into an automatic speech recognition system, which then evaluates only information coded in the time domain.

Evaluations were performed with a speech database with and without noise (noisy ISOLET). When conventional rate place features were tested, the automatic speech recognition system reached similar recognition rates for all tested CI coding strategies (MED-EL HD-CIS, CIS, FSP and FS4): for speech signals without noise recognition scores were 88%, when the signal to noise ratio was 10 dB, recognition dropped to 70%. The evaluation of temporal features revealed that fine structure coding strategies are able to code much more information in the time domain relevant or speech understanding than HD-CIS: speech recognition rates (clean speech) were 82% or HD-CIS, 85% for FSP and as high as 90% for FS4.

These results show that a remarkable amount of speech relevant information can be coded in the time domain, even when place information is completely discarded. This explains for example why already single-channel implants, which coded speech information only in the time domain, were more successful than predicted at the time they were introduced. The question to which limit and with which mechanisms the neuronal system analyses temporal information still requires further investigation.

In summary, our method provides a quantitative tool for quantitative comparisons of rate-place coding with temporal information coded in spike trains. It provides a valuable tool to optimize novel coding strategies before they are tested in large groups of CI recipients.

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S21-16

A new stimulation mode: the virtual tripole

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Spectral resolution is a limiting factor in performance with cochlear implants. Current shaping techniques have been used in attempts to improve spectral resolution. Current steering (e.g. virtual channels) has been used to increase the number of channels beyond the number of electrodes. Current focusing (e.g. partial tripolar stimulation) has been used to reduce the interaction across two channels in order to increase the independence of each channel and therefore improve spectral resolution.

We propose a new stimulation mode called a virtual tripole (VTP), which is a modification of a traditional tripole. The VTP is designed to reduce spread of excitation as well as allow for current steering. Tripolar stimulation consists of stimulation on one electrode combined with simultaneous out-of-phase stimulation on adjacent electrodes to reduce the spread of current. With a VTP, each of the three electrodes in a tripole is replaced with a virtual channel, theoretically allowing for both current focusing and current steering.

Six users of the CII or HiRes90K Advanced Bionics device have participated in this study. Spread of excitation was measured for monopolar, partial tripolar (σ = 0.75) and VTP (σ = 0.75 and 1) maskers located at electrode 9 using a forward masking technique. The probes were partial tripolar (σ = 0.75) pulse trains located at electrodes 6 through 12. Spread of excitation was also measured for monopolar virtual and VTP (σ = 0.75 and 1, when possible) maskers located at electrode 8.5. The probes were VTP (σ = 0.75), located at electrodes 6.5 through 10.5. Results suggest that VTP stimulation provides a reduction in spread of excitation compared to the spread from monopolar stimulation. VTP (σ = 1) stimulation provides a narrower spread of excitation than partial VTP (σ = 0.75) stimulation. However, partial tripolar (σ = 0.75) stimulation using physical electrodes seems to produce a narrower spread of excitation than even a full VTP (σ = 1) stimulus. Effect on spectral resolution was measured using a modified spectral ripple task, the SMRT task (Aronoff and Landsberger, 2013). Subjects tested showed better spectral resolution with a VTP compared to MP stimulation.

S21-18

Stimulation of the apical cochlear region: influence on speech understanding and subjective preference

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Background: In earlier speech understanding, pitch perception, EAS, and compound action potential studies, benefits of stimulating the apical region of the cochlea have been demonstrated. Critical discussions suggested that patients may have been "imprinted" regarding their cochlear coverage, beginning at the time of first activation. To challenge the imprinting hypothesis, we are conducting a study where patients are initially activated with different cochlear activation conditions.

Methods: Patients who received a standard 31mm MED-EL electrode array with full surgical insertion are activated with both eight basal and eight "spread out" electrode activation maps. Subjects´ subjective preference and performance during the first seven and a half months is assessed various speech perception tests. At later test and fitting visits, patients select the subjectively preferred map based on their experience. Depending on that choice, a map with a different electrode activation is created and programmed together with an optimized version of the preferred map into the processor.

Results: Twenty subjects have completed the study so far. A significant majority of the subjects prefers the spread out conditions and perform better or equal in these. Some patients however prefer (and perform better in) conditions not spreading over the whole cochlea.

Conclusion: Full use of the cochlea and its apex performs equal or better in the majority of subjects. Subjective preference correlates well with performance, and most subjects prefer a wider spread of electrodes over basal or mid coverage. Subjects who were initially activated with full spread, also exhibit the same preference. From the current cohort of subjects, we do not find any evidence of imprinting.

S21-22

Perceptual consequences of listening experience with novel auditory stimulation

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Over time, new recipients of cochlear implants learn to make better use of the auditory cues provided by their devices. While such learning is responsible for successful hearing outcomes, the role of listening experience may bias subjects to their everyday coding strategy and settings when evaluating novel auditory stimulation in a research setting. This study examines the effects of short- and long-term exposures to various changes to cochlear implant subjects' sound coding strategies to see if such biases exist and can be overcome. In a first set of experiments, we altered the cochlear place of stimulation by switching from a monopolar to a focused-multipolar stimulation mode. This significantly decreased initial sound quality. However, audiobook listening of about an hour was found to overcome this drop. In a second set of experiments, subjects were switched from the commercial ACE strategy to a temporally sparse research coding strategy. This more radical change to the patterns of stimulation took several weeks of acclimation for perceived sound quality and speech understanding to recover. These results suggest that 1) long-term listening experience with a particular coding strategy generally biases listeners to prefer and perform better with that strategy in comparison to less familiar forms of stimulation and 2) new stimulation paradigms may require anywhere from hours to weeks of acclimation before overcoming these effects.

S22 Difficult and atypical patients, challenging situations, borderline cases, CI for children in deaf families

S22-1

CI provision for children of deaf parents - a research program

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When, at the end of the 1980s, the first cochlear implantations were performed on children in Hannover, it was highly improbable that deaf parents or severely hearing- impaired parents would consider the CI option for their children. On the contrary, deaf adults were vehemently opposed to the procedure. Notwithstanding, the mid-nineties witnessed the advent of CI provision for deaf children of deaf parents (Begall 1995).

The research program entitled „CI provision for children of deaf parents“, established in 2000, meanwhile comprises 7 sub-studies. The pilot study (2001-2004) was followed by the compilation of informative handouts for deaf parents (2006-2009), based on comprehensive evaluation and scientific back-up and meanwhile translated into Turkish, Russian, Polish, Greek and English for non-native parents.

Further sub-studies embrace:

- semantic development in both acoustic and sign language skills in these children (sign language being the language for family communication and acoustic language perceived as “the bridge” to the world of the Hearing).
- the family situation (severely hearing- impaired parents and CI children) and
- interviews with young CI adults, who (as a result of childhood cochlear implantation) grew up with both acoustic and the family sign languages, focusing on their current attitude towards CI provision.

A further study highlights pre-school and school integration of these children. It shows that not only children of hearing parents but also early -implanted children of deaf parents can be likewise integrated into mainstream education. Emphasis is placed on the correlation between integrative success and commitment and flexibility of the hearing-impaired parents.
A comparison of cochlear implanted children of hearing and deaf parents shows a great number of similarities as well as distinctive features.
The number of deaf parents opting for CI provision for their children is steadily increasing. Whereas the first CI provisions often ensued according to the wishes of the children themselves (older kindergarten children and primary school children) or in some isolated cases, the grandparents, nowadays parents take the decision into their own hands at an early stage of childhood.

S23 Bone conducting hearing devices

S23-1

Global clinical outcomes of a magnetic retention bone conduction hearing system

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Introduction: Recently, a novel bone conduction hearing system that uses a magnetic rather than a percutaneous attachment between the sound processor an internal osseointegrated implant has become clinically available. With any new system, it is important to evaluate the performance of such a system in a clinical population, and compare with the percutaneous option.

Methodology: In total, 224 adult and paediatric (>8 years) patients participated globally in the investigation across 73 centers in Europe, North America and Australia. The cohort was followed for between three to nine months following surgery. Two questionnaires were used to assess outcome. The first, at time of surgery and the second, at the time of sound processor fitting. In addition, an event form was used to capture any events that could affect clinical outcomes such as soft tissue healing, sound processor magnet change or acoustic feedback.

Results: Questionnaires were returned from 89% of surgeries and 90% of fitting visits. An additional 16 event forms were received relating to soft tissue, sound processor magnet change or acoustic feedback. In each occurrence, the reported event was later satisfactorily resolved. The system was used across all the Baha indications with 52% conductive, 16% mixed hearing loss and 32% of single-sided sensorineural deafness patients receiving the system. In terms of sound processor selection, 54% chose a power sound processor and 44% the less powerful variant. This proportional increase in use of a power sound processor is to be expected given the additional sound attenuation when transmitting through the skin rather than through a percutaneous abutment. The presentation will also discuss outcomes in terms of perceived loudness, sound quality and hearing performance. Additionally, the effects of magnet selection will be discussed in reference to hearing performance and soft tissue outcomes.

Conclusion: The follow-up of the first 224 patients to receive a magnetic based bone conduction hearing solution is positive, with reportedly good hearing outcomes combined with low rates of clinical events. Interestingly, 38% of patients had previously decided against the percutaneous system due to adverse feelings about a skin penetrating abutment. Given this, it could be that such a cosmetically appealing magnetic retention system may offer an additional clinical option. We will further compare relative benefits of either system.

S23-5

Clinical outcomes from an international multi-center clinical investigation of a new magnetic bone conduction implant system

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Introduction: A new magnetic bone conduction implant that relies on transcutaneous transmission of sound has been developed. The implant relies on the proven principles of osseointegration to obtain a stable foundation for the implanted magnet. The external magnet uses new technology to evenly distribute the pressure on the skin in order to minimize pressure-related complications. A multi-center clinical investigation was undertaken to evaluate the safety and efficacy of the device.

Methods: Four sites in Australia, Hong Kong, Israel and Chile were included in the prospective clinical investigation. Twenty-seven adult patients with a conductive hearing loss or single-sided sensorineural deafness were included in the investigation and received the Cochlear Baha Attract System. Outcome measures included audiological tests in free-field, evaluation of surgical parameters, wearing comfort, magnetic retention, wound healing, soft tissue status and daily usage. Audiological performance with the test device was compared with the patients' unaided hearing and the performance with the sound processor on a Softband.

Results: Surgery and healing was uneventful. After 3 months of follow-up, statistically significant improvements in speech understanding in noise were recorded for the test device compared to unaided hearing ($p < 0.0001$) and compared to results with the sound processor on a Softband ($p=0.01$). Speech tests in quiet showed statistically significant improvements with the test device compared to unaided hearing ($p < 0.0001$), and similar results as with the sound processor on a Softband. The reported average daily usage time was 7 hours/day. Good soft tissue outcomes were reported, without major pressure-related complications; only two cases of mild redness were recorded which resolved without medical treatment. At 3 months, all patients continued to use and benefit from the device. Results after 9 months of follow-up will also be presented.

Discussion: Significant improvements in hearing performance were obtained and a very low complication rate was reported, suggesting that the test device is efficacious and safe for the tested indication. Transcutaneous systems have the advantage of providing improved cosmetics and eliminating the need for the daily cleaning of the surgical site that a skin-penetrating system requires.

Conclusion: The Baha Attract System provides good hearing performance in subjects with a conductive hearing loss or single-sided sensorineural deafness, with good wearing comfort and minimal soft tissue complications.

Learning outcome: Evaluate the clinical performance of a new magnetic bone conduction implant system.

S23-7

Experimental and numerical modeling of bone acoustic transmission around the skull

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Background and Objectives: So far, our knowledge in the sound transmission processes driven in the cranio-facial area is incomplete. Research and development programs necessitate to better knowing how the sound is amplified and dampened when driven through the bone of the skull.

The objectives of this work were first to evaluate the modalities of sound propagation across the skull and to determine dampening parameters, relative time of propagation, the frequency of stimulation and trajectories. Second, we aimed to build, from these data, a numeric finite element model of the cephalic skull in order to promote virtual analysis.

Methods: Sound propagation into the skull was recorded using piezoelectric accelerometers located on 18 different sites around the skull. Vibrations transmitted to the cochlea were recorded using a Laser Doppler Vibrometer (LDV, Polytec, USA) focused onto the round window membrane. Vibration were induced using at three different locations around the external auditory meatus, using a vibrator, at 0°, 45° and 90° relative to the orbito-meatal plane. Three different types of excitation were applied: a short pulse, low-frequency and high-frequency range chirps). Therefore, 5 trials were carried out successively on 5 different cadaveric heads.

From a numerical point of view, each head was scanned using a CT-scan (Siemens) to build a 3D volumetric model and then meshed. The experimental procedure was simulated (Abaqus) to get the temporal response (propagation) and the frequency response (modal analysis) from each head.

Results: Energy recorded by the accelerometers and velocities from the LDV were compared at each location and for the three different excitations. Dampings vary according to the frequency bandwidth. There was no significant difference in the magnitude of the accelero responses. However, it was found that the frequency range from 1000-2000 Hz was the least damped.

Using the numeric model, we found that 2 different modes of vibrations could be elicited: a translational mode for the low-frequency range and a 3D vibrating mode for the high-frequency range.

Conclusion: This work helps to better understand the modalities of sound propagation around the skull and especially the dampening properties that may be of significance with regards to bone anchored acoustic devices. The numerical model suggests that the vibrating feature of the skull changes across the frequency range. From a patient perspective, automatization of numeric validation of a specific skull may help to tailor the choice of bone conduction implants as well as the optimal location of the implantation, according to the auditory assessment.

S23-12

Bonebridge implantation: Outcome measures in performance and quality of life

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Introduction: The MED-EL Bonebridge is an active, semi-implantable bone-conduction auditory prosthesis, indicated for patients with conductive or mixed hearing loss, as well as single-sided deafness. Its transcutaneous activation significantly reduces the skin related issues of percutaneous devices. The aim of this study is to present our early results with this device.

Methods: 13 patients were implanted with the Bonebridge device: ages ranged from 41 to 77 years, 11 female and 2 male. 7 patients had conductive or mixed hearing loss and 6 had single-sided deafness. All patients underwent preoperative testing including air and bone conduction audiometry in pure tone and speech, high resolution CT scanning and health related quality of life questionnaire assessment. Inter-aural attenuation measurements and adaptive Hearing In Noise Testing (HINT) were also conducted at 0, 90 and 270 degrees with noise at 0 degrees. Data from the Hearing Utility Index Mark 3 (HUI-3), the Speech, Spatial and Quality of Hearing Scale (SSQ), the Tinnitus Handicap Inventory (THI) and the Bern Benefit in Single Sided Deafness questionnaire (BBSS) were collected. Follow up was performed at 1 month and 6 months post activation.

Results:

Tinnitus Outcomes: All 7 patients reporting tinnitus preoperatively experienced significant improvements in their tinnitus perception as measured on the THI one month post-activation ($p < .05$). Overall, patients improved by 41% on the THI. Within the functional and emotional subcategories, patients improved by 31% and 52%, respectively, with a trend towards significant improvements in the catastrophic subcategory ($p = .096$). Notably, six patients did not have tinnitus prior to implantation and none reported it post-op.

Adaptive HINT Outcomes: At 1-month post implantation, there was a mean improvement in signal-to-noise ratio as measured by the adaptive HINT of 4.56 dB HL (range 3.21 to 5.91) when the device was on compared to off.

Other Qualitative Outcomes: The mean utility as measured by the HUI-3 increased from 0.62 to 0.88. Furthermore, marked improvements in all subsets of the SSQ questionnaire emerged. High frequency gains were significantly improved at 4 and 6 kHz.

Discussion: Preliminary results suggest that the Bonebridge is not only a preferred choice over percutaneous devices, but also provides significant benefit by reducing tinnitus, improving signal-to-noise ratios, and overall improvements in quality of life measures. All of the participants in this study are reporting positive gains from this experience. Further outcomes at the 6 month follow up period will be presented.

Conclusion: Bonebridge implantation appears to be a viable and promising option for those with the appropriate indications.

Learning outcomes: Discuss results of study examining new transcutaneous bone conduction device.

S23-17

Long term observation in patients with Bone Anchored Hearing Aids (Baha)

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Treatment of patients with conductive and mixed hearing loss in bilateral microtia with auditory canal atresia or after chronic otitis media can be conducted with Bone Anchored Hearing Aids (BAHA).

Our aim was to assess the effects of using different surgical techniques in implantation of titanium fixtures (U-graft, Dermatome and Linear incision) affecting postoperative healing and occurrence of early and late skin reactions needing surgical intervention.

Our method of choice in treatment of hearing loss in presented various ear defects is attachment of titanium implant to the temporal bone and removal of subcutaneous tissue. Three skin incision techniques were used: U - graft, Dermatome, Linear incision. Tissue around attachment was thinned without collecting skin graft. Our material consists of 124 patients from 3 y.o. to 67 y.o. Device fitting was performed after wound healing and osseointegration of the fixtures (6 weeks - 6 months - depending on bone thickness, length of the fixtures, one- or two-stage surgical technique and condition of the wound). Universally adopted Holgers classification of skin reactions was used to determine soft tissue reactions around the transcutaneous implants. In case of severe infection of the soft tissue in the implant site (Grade 4, according to Holgers scale) tissue reoperation was performed.

Assessing the results of treatment, 17 reoperations were performed due to inflammatory tissue reaction in the implantation site (Grade 4), including 15 in patients after U-graft technique, one reoperation in a patient after Dermatome and one after Linear incision. It was observed that the skin incision technique affects significantly occurrence of reoperations ($p = 0,00167$). In the groups where Linear incision or U-graft techniques were used nearly 20% of patients required reoperation, and in the group operated using Dermatome technique reoperation was necessary in little above 2% of cases. Comparison of hearing thresholds for BAHA type device applied on titanium fixture (direct stimulation of bone) with results from the same hearing device applied on BAHA test band (percutaneous stimulation of bone that muffles sound via skin and subcutaneous tissue) indicated that lower thresholds levels were obtained for the BAHA device. Differences for the single frequencies were approximately: 500 Hz - 8 dB, 1000 Hz - 6 dB, 2000 Hz - 6 dB, 4000 Hz - 8 dB.

Assessment of the effects of different surgical techniques in titanium fixtures implantation (U-graft technique, Dermatome technique and Linear incision technique) on postoperative wound healing and early and late skin reactions shows that the best results can be obtained using the Dermatome technique. Gain assessment of the hearing aid on a titanium fixture comparing to universally used Baha test band using bone percutaneous stimulation reveals that use of Baha directly stimulating bone provides lower hearing thresholds.

S23-19

The effect of transcranial attenuation on speech perception in noise with a bone conduction hearing implant in single-sided deaf patients

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Intro: The benefit of fitting an bone conduction hearing implant (BCI) in a single-sided deaf (SSD) patient is for the most part based on partially lifting the head shadow effect (HSE). The HSE is mainly present in the high frequencies. Attenuation in this frequency range might adversely affect the benefit offered by a BCI. The aim of the current study is to find out if transcranial attenuation (TA) is related to post-operative improvement of speech perception in noise with a BCI in SSD patients.

Methods: 29 SSD BCI users were included in the study. TA was measured in all patients for the frequencies 0.25, 0.5, 1, 2 and 4 kHz subtracting the unmasked contralateral bone conduction thresholds (normal hearing side) from the unmasked ipsilateral bone conduction thresholds (deaf side). Also, speech perception in noise testing was performed in different noise configurations: S_0N_0, S_0N_{bci}, S_0N_{contra}, $S_{bci}N_0$ and $S_{contra}N_0$.

Results: A statistically significant correlation was found between SRT benefit and TA at 4 kHz in the $S_{bci}N_0$ condition with speech presented at the BCI side (r = -0.726, *corrected p = 0.0015,* Spearman correlation). The higher the TA, the less the benefit. SRT benefit in the same $S_{bci}N_0$ condition was statistically significantly worse (no improvement) in patients with extremely high TA values at 4 kHz (*corrected p = 0.0345,* Independent Samples Mann-Whitney U test).

Conclusion: A statistically significant correlation has been seen concerning the relation between high-frequency TA and speech perception in noise with the BCI on the abutment. Better results can be expected in patients with lower TA values at 4 kHz.

Learning outcome: Pre-operative TA measurements may give an indication of speech-in noise results in the most beneficial noise condition in SSD BCI candidates, especially concerning extreme TA values.

S24 Speech testing (in adverse listening conditions, testing across languages)

S24-1

Psychometric functions of cochlear implant users in fluctuating and steady-state noise

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Most clinical tests quantify speech understanding of cochlear implant (CI) users in noise with steady-state maskers. In such tests, many CI users perform impressively well. Nevertheless, almost every CI user reports massive problems in everyday listening scenarios like competing talkers. This discrepancy leads to the hypothesis that testing speech understanding in steady-state noise is not representative for everyday listening performance.

We tested this hypothesis with speech material of the German Oldenburger sentence test and compared speech recognition scores in fluctuating versus steady-state noise. The target sentence (male talker) was embedded in amplitude modulated (Fastl)- or steady-state (OL)noise (reference). 9 normal hearing (NH) listeners and 7 excellent CI users (average understanding of monosyllables in quiet: 93 %, all provided with MED-EL CI systems) participated in the experiment.

For every test subject individual unilateral speech reception thresholds (SRT in % correct) were determined as a function of the signal to noise ratio (SNR) to measure individual psychometric functions. In steady-state noise CI users achieved significantly lower but still relatively good scores compared to NH listeners (50% SRT: -2.3 dB versus -6.7 dB, $p< 0.01$).

In fluctuating noise our results revealed opposite effects of speech recognition scores at the individual SRTs: while NH listeners showed a release of masking in terms of an **increase** of speech recognition scores from 50% to 95% at -6.7 dB SNR, average performance of CI users **degraded** to 35% at -2.3 dB SNR. Furthermore, the steepness of the psychometric function, which is a degree for test quality, was reduced in CI users (11 %/dB in steady-state versus 7 %/dB in fluctuating noise).

The present study indicates that the relatively good performance of CI users in steady state noise offers a deceptive impression of their speech perception in real life conditions. In everyday listening scenarios with fluctuating background noise performance may be considerably lower than the values suggested by clinically established tests.

S24-6

Effect of background noise and reverberation time on speech intelligibility of cochlear implant users

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The aim of this study is to evaluate the individual and combined effect of reverberation and noise on speech intelligibility by cochlear implant (CI) users. The speech intelligibility of a list of sentences is investigated under the conditions with different reverberation time and the background noise level (or signal to noise ratio).The evaluation will be carried on in CI users with and without temporal information in their electrical stimulation on the auditory nerve.

Design: Reverberation, Noise and a combination of Reverberation with Noise are used to decrease speech intelligibility of a list of sentences. These ones are implemented for speech intelligibility by unilateral CI users with envelope and with envelope + temporal information on their coding strategies.

Study sample: 17 CI users participated (MED-EL and Nucleus) and 20 normal hearing people were examined with the test to have a comparison. The cochlear implant users were inside the 6th category of Geers & Moog. Is possible to segment the patients in three groups: patients with complete cochlear coverage and a coding strategy with envelope + temporal information; patients with complete cochlear coverage and a coding strategy with only envelope; and patients with a partial cochlear coverage and a coding strategy only with envelope.

Methodology: A list of sentences from a Latin American Protocol was used. The test was distributed in 9 series with 10 sentences each one. And the combinations for the series were with: three reverberation times (T60=0.00s, T60=0.42s and T60=0.88s) and three signal to noise ratio (SNR=+inf, SNR=10dB and SNR=5dB).

Results: The results showed, at first place, that there is a strong difference between cochlear implant users and normal hearing persons in an acoustic difficult situation. In the worst case (maximum reverberation and minimum signal to noise ratio) normal hearing listeners scored 94% while the best group of CI scored 37%. In terms of cochlear implant users it was found that the CI users with complete cochlear coverage + temporal coding information reach the best results (37% in the worst condition), next were the CI users with partial cochlear coverage + envelope information (24% in the worst condition) and finally the patients with complete cochlear coverage + envelope information (12% in the worst condition).

Discussion: It can be observed that the decrease given by the effect of reverberation is greater than caused by noise. That is because the reverberation strongly modifies the envelope of the signal, which is one fundamental parameter of the CI coding strategies. Is clear that is necessary a progress in the CI digital signal processing to improve the results in difficult acoustics situations. Finally, the reverberation is a parameter that has to be taken into account because it makes important changes from a psychoacoustical point of view.

S24-14

Cochlear implant listeners at a cocktail party: evaluating CI performance in muti-talker listening situations with the CRM (Coordinate Response Measure)

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Introduction: Cochlear implants (CI) provide excellent speech discrimination in quiet, with large variance in individual results. However, standard tests of speech recognition do not replicate real-life listening conditions where multiple, spatially separated maskers (background noise or competing talkers) create difficulties for CI listeners. Binaural cues are important for normal hearing (NH) listeners in solving the 'cocktail party' problem, along with others such as differences in voice pitch that may also be unavailable to CI listeners.

The CRM (Coordinate Response Measure) test measures the ability of listeners to selectively attend and respond to a target sentence in the presence of distracter talkers either co-located or at random spatially separated locations. We found that NH listeners (n=12) achieved an SRT (50% correct) on this task at negative target-to-masker signal to noise ratios (SNR); median SNRs were: condition (A): -19.5 dB (two talkers, one female/one male, from single speaker at front); condition (B): -10.8 dB (7 talkers, locations of target and maskers randomised across an array of 9 loudspeakers, with an 800 ms onset delay between target and masker sentences); condition (C): -1.7 dB (7 talkers, locations of target and maskers randomised across an array of 9 loudspeakers, target and masker sentences presented in pairs with no onset delay). The ability of adult CI listeners to perform this task is predicted to be poorer than for NH listeners and is reported here.

Methods: Performance of a sample of CI listeners with good implant-only speech recognition scores (>80%) was assessed on the CRM sentence test in the three conditions described above. Stimuli were presented from an array of 9 head-height loudspeakers (the 'Crescent of Sound) in the sound field. Both monaural and bilateral CI listeners were tested. The target sentence contained a pre-determined 'call sign' that listeners listened for. All sentences had the form 'Ready (call sign) goes to (color)(number) now. Listeners reported the target color and number (closed set choice of 16 responses (four colors/four numbers)). An adaptive procedure varied the relative level of target and masker sentences to find the SNR.

Results: CI listeners showed great variance in performance on the CRM task, frequently reliant on positive target/masker SNRs to achieve SRT. Variable evidence of the benefit of binaural listening on this task was found.

Discussion: Results on the CRM test with CI listeners are consistent both with patients' reports of real-life difficulties in multi-talker listening situations and with expectations based on their reduced access to important cues for cocktail-party listening.

Conclusion: Results with the CRM test are consistent with predictions of poor CI performance in challenging listening environments.

Learning outcome: Measures of CI performance should include tests of speech recognition in multi-talker environments to provide greater face validity.

S24-18

Speech and language development in bilingually raised children with cochlear implants and /or hearing aids

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Intro: Bilingually raised children with a hearing disorder seem to have a higher risk to develop a speech and language impairment. Studies with this specific target group are difficult to plan. The speech and language abilities of bilingually raised children vary considerably due to the starting point of their learning process with regard to the age and the amount of information they receive in both languages. In addition some children are confronted with more than one other language. The diagnostic procedure for this patient group is difficult to plan because there is only limited diagnostic material available.

Method: In a prospective cross-sectional study we included bilingually raised patients with hearing impairment (n=42) and monolingually raised children with hearing impairment (n=54) with an age range of 3;0-10;11 years in order to assess speech and language abilities. For comparison between patient and controls we also included bilingually raised children with normal hearing (n=23). We conducted a standardized anamnesis and used standardized as well as non- standardized German language tests available and suitable for the age of each individual participant.

Results: 44 children had been fitted with hearing aids, 34 with bilateral cochlear implants and 18 children were bimodally fitted. In each group some of the children demonstrated an age appropriate speech and language development in the German language. The comparison of monolingual and bilingual children with hearing loss yielded significantly lower speech and language abilities in bilingual children.

Discussion: Examination of not selected but nearly complete cohorts often demonstrates less favorable outcomes. Due to language barriers bilingually raised children and their parents often do not participate in studies.

Conclusion: Our study confirmed our assumption that bilingually raised children with hearing loss should have speech and language examinations on a regular basis.

Learning outcome: Methodical problems of the examination of speech and language in children with more than one language will be discussed.

S25 Radiology

S25-18

Functional near infrared spectroscopy (fNIRS) imaging of brain function in patients with cochlear implants

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fNIRS detects changes in hemodyamic response using near-infrared lightand provides information about metabolic function of brain regions of interest It is comparable to BOLD response in fMRI. Using two different wavelengths, changes in the concentration of oxy and deoxyhemoglobin can be determined. Other optically-based measurements of oxygen concentration in medicine are pulse oxymetry and cerebral oxymetry used intraoperatively. A single NIRS measurement is sensitive to a volume of tissue that falls between the source of light entering the tissue and the detector receiving the light that diffuses out of the tissue. NIRS is limited by depth sensitivity which in adult humans typically reaches 5 to 10 millimeters beneath the inner surface of the skull for brain activation. This can be improved with time-domain methods where depth sensitivity increases with delay detection of the propagating pulse of light. Like evoked potentials or ERPs fNIRS activity needs to be averaged over the duration of the task. it is helpful to think of fNIRS as a measure reflecting percent change in hemodynamic response over time, as opposed to voltage over time for an evoked potentials measure. The optical sources and detectors are arrayed based on the 10-20 system. In our cochlear implant subjects, we concentrate on recording activity form the prefrontal, and temporal cortex: inferior frontal gyrus, and superior temporal gyrus, right and left. The tasks for these measurements are a rhyming task, a tone identification task and listening to a passage. Our subjects are 10 adults with cochlear implants, with various lengths of experience with the implant, and 10 normal-hearing controls. We have both unilateral and bilateral implantees, as well as patients with a cochlear implant and a hearing aid. Our preliminary data analysis indicates similarities between controls and CI subjects in terms of metabolic changes at our two detections sites, with magnitude differences: a lower concentration change has been noted in the CI subjects for identical tasks when compared to the normal hearing controls. Additionally, in some CI subjects the tone identification task resulted in more frontal lobe activation than temporal cortex activation. It is our belief that fNIRS can become a useful investigational modality in the field of cochlear implants. It has several advantages over ERP measure: no electrical interference from CI; lower cost than fMRIor PET; absence of noise interference as in MRI; it is portable; tolerates movement as long as the optical devices are stable; good spatial cortical resolution. The disadvantages are the currently poorer temporal resolution compared to ERP, and it cannot be carried out under any type of general anesthesia.

S26 Active middle ear implants II

S26-4

Experimental investigations and simulation models on the influence of coupling conditions and direction of active middle ear implants

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Intro: Coupling site and direction of active middle ear implants (AMEI) at the ossicular chain influences the transducer performance due to differences in load impedance. Simulation models and experimental investigations and comparison of their results are helpful to identify ideal coupling points and conditions.

Methods: Finite element model (FEM) simulations and measurements on human temporal bone specimen using the floating mass transducer (FMT) of the vibrant soundbridge were used. Ideal actuator excitation and coupling conditions were assumed for the FEM. Experimentally the middle ear transfer function was measured using laser Doppler vibrometry on the stapes footplate or a round window microphone. All measurements were calibrated within each specimen for the intact ossicular chain and shown as the changes from these baseline measurements.

Results: The stapes head and its footplate are the most favorable attachment points, since these positions seem to be nearly insensitive to the direction of excitation. Angle deviations off the longitudinal stapes axis up to 60° reduce the achieved equivalent SPL by only about 5 dB. Additionally, a reduction of the load impedance by excision of the malleus and incus shows beneficial effects in the resulting METF. Force-driven actuators can benefit from the impedance matching of the middle ear when they are coupled to the umbo. The incus body may be an unfavorable coupling site, as physiologic middle ear motion patterns possess nodal lines at the incus body. Therefore, incus coupling bears the risk of exciting ineffective motion patterns of the ossicular chain. In all cases, simulation and experimental data show that tension of the annular ligament reduces the METF up to 25 dB.

Discussion: The experimental and simulation data demonstrate the dependence of the actuator type, its coupling site and direction to the intact ossicular chain or their remnants. These results are helpful to optimize the transducers' performance.

S26-5

Vibrant soundbridge long-term follow up in sensor neural hearing loss

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Objective: The middle ear implant Vibrant Soundbridge (VSB, MED-EL) is successfully used to treat sensor neural hearing loss (SNHL) for over one decade. The aim of the here presented mono-centric study was to assess its safety and effectiveness in patients with moderate-to-severe SNHL > 10 years after the intervention.

Subjects and Methods: Of 241 VSB surgeries at the ENT Dept., Medical University Hannover, Germany from February 1997 to March 2012, 131 VSB implantations were performed in 113 patients with sensor neural hearing loss and medical conditions such as: otitis externa, stenosis, psoriasis and/or skin allergies which prevented the use of conventional hearing aids. In a retrospective single-subject repeated mono-centric study audiological results of these SNHL patients with the VSB coupled to the incus were analyzed. After exclusion of children and mixed hearing loss cases (ABG > 20 dB), 105 German speaking adults (50 females and 55 males; age Ø 54.5 years, min. 19.0 years and max. 80.4 years at the time of implantation) contributed data to this study. 17 patients were implanted bilaterally resulting in a total number of implantations of N = 122. For analysis patients were divided into 4 groups according to the time after surgery.

Results: Pre- and post operative thresholds shortly after surgery (group 1 < 1 year; avg. 0.5 yr (0.1 - 0.8 years; N = 34) revealed a small (< 3.2 dB), but significant drop in bone conductions (BC) thresholds at high frequencies (> 3 kHz) that disappeared in group 2 (1 < 4 years; avg. 2.4 years; min: 1.2 - max: 3.8 years; N = 51). A decrease in BC thresholds at longer periods after implantation (4 years < group 3 < 8 years and group 4 > 8 years) was found comparable in size to the natural hearing loss. Statistical analysis indicated no accelerated progression compared to the contra-lateral, non-implanted side in monaurally implanted subjects. Also the functional gain and monosyllable intelligibility was still satisfactory in the long-term group (group 4 > 8 years; avg. 11.1 years; min: 8.2 - max: 13.9 years; N = 16).

Conclusion: No acceleration in SNHL progression due to the implantation of the VSB was found in our analysis. Comparison of pre- and post-operative BC thresholds detected neither impact on inner ear integrity nor hearing loss acceleration by the implantation. Functional gain and monosyllable intelligibility was still satisfactory demonstrating that the VSB is still beneficial in long-term (> 10 years) follow-up.

S26-8

Reinforced implant fixation in Incus Vibroplasty

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Introduction: The active middle ear implant Vibrant Soundbridge® (VSB) was originally designed to treat mild-to-severe sensorineural hearing losses. The Floating Mass Transducer (FMT) is crimped on the long incus process in these cases with proper middle-ear anatomy. The application is termed Incus Vibroplasty to distinguish it from the applications in conductive and mixed hearing losses. Difficult incus anatomy, necrosis of the long incus process, secondary detachment as well as loosening of the FMT with lack of amplification are rare but possible complications. The aim of this study was to evaluate the FMT fixation at the long incus process with an additional reinforcement using the head of a Soft CliP® stapes prosthesis in temporal bones and in clinical practice.

Materials and methods: A subtotal mastoidectomy and a posterior tympanotomy were performed in ten fresh human temporal bones. As a control for normal middle-ear function, the tympanic membrane was stimulated acoustically and the vibration of the stapes footplate and the round-window (RW) membrane, respectively, were measured by laser Doppler vibrometry (LDV). Fixation of a FMT to the long incus process (standard coupling) was compared with an additional reinforcement of the FMT attachment using the head of a Soft CliP® stapes prosthesis. Additionally, the outcome in two groups of patients with Incus Vibroplasty using standard and reinforced FMT fixation were compared. Eleven patients were treated by standard coupling; 9 patients obtained the additional reinforcement with the head of Soft CliP® stapes prosthesis. Three to six months postoperatively auditory thresholds for frequency-modulated (warble) tones and Vibroplasty thresholds were measured.

Results: In temporal bone, LDV measurements show significantly enhanced displacement amplitudes of the stapes footplate and the RW membrane for FMT attachment on the long incus process with additional reinforcement with the head of a Soft CliP® stapes prosthesis in comparison to the standard fixation (5-10 dB at frequencies below 1 kHz and above 4 kHz). The clinical data showed lower thresholds in free field pure tone audiometry as well as Vibroplasty thresholds of 5 dB in low and up to 15 dB at high frequencies in the group with additional reinforcement by the head of a Soft CliP® stapes prosthesis.

Conclusion: Supplemental reinforcement of the FMT fixation with a Soft CliP® stapes prosthesis leads to an enhanced mechanical and functional coupling of the FMT on the long incus process.

S26-16

Long-term compliance and satisfaction with bone conduction hearing devices in patients with congenital unilateral conductive hearing loss

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Congenital unilateral conductive hearing loss (UCHL) can be treated conservatively, surgically, or by means of a bone-anchored hearing implant (BAHI). The current study evaluates the long-term compliance and satisfaction in a group of 53 consecutive patients with congenital UCHL implanted with a BAHI. These patients were telephonically interviewed about the current status of device usage and were asked to fill out the Speech Spatial and Qualities of hearing questionnaire (SSQ). Compliance with the device was 56.6% and the age of the users was significantly higher than the age of the non-users. The mean time of device usage before quitting was five years. The most important reasons for quitting device use were too much amplification of disturbing noises and no subjectively experienced benefit. The SSQ revealed significant improvement in the aided situation compared to the non-aided situation, in contrast to the non-users. These low compliance figures might advocate a careful approach in applying bone anchored hearing devices in this specific population, especially in children.

S27 Fitting

S27-3

Selective suppression of facial nerve activation in CI patients with triphasic stimulation

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Background: With incidence rates from 1% to 15%, facial nerve stimulation (FNS) is one of the most frequent side effects of electrical stimulation in cochlear implants (CIs). Strategies for managing FNS include changes in mapping such as bipolar stimulation or switching off electrodes. Here, we report on a successful new map-based approach to managing FNS in straight-electrode patients using triphasic pulse shapes.

Methods: 16 MED-EL CI recipients (18 ears) have been suffering from strong to severe FNS or other side effects with their clinical devices. 15 of them were implanted with different versions of the MED-EL atraumatic straight electrode array, one had been re-implanted with a custom-made Medium electrode array with a round-window placement of the remote ground electrode.

Patients were switched from their clinical biphasic monopolar maps to triphasic monopolar stimulation. Both bi- and triphasic stimuli had leading negative phases. Triphasic pulses had three phases of equal amplitude and a central phase of double the duration of the two flanking phases in order to guarantee charge balance. For each intracochlear electrode, charge values of unmodulated trains of triphasic pulses were gradually increased until most comfortable loudness (MCL) levels or FNS thresholds were reached.

Results: Across subjects, standard biphasic stimulation triggered FNS on multiple electrodes at soft to moderately loud levels. In acute testing, in 15 of the 16 patients substantially louder stimulation or even MCLs could be obtained on most electrodes without eliciting FNS or other side effects. In one subject with a common cavity there was no effect of stimulus pulse shape on FN activation. 13 patients so far received a permanent triphasic map, including three patients who had become non-users of their standard biphasic maps. 12 of the 13 patients show a stable benefit over time. One of three non-users with most severe FNS across all electrodes suffered recurring side effects after several months of triphasic stimulation, resulting in a sporadic implant use. Average charge increments across subjects and electrodes with triphasic compared to biphasic stimulation were 117% (78% - 174%). This provided an immediate subjective benefit and sufficient processor loudness to attend to conversational speech.

Conclusion: Triphasic pulse shapes may be more effective than biphasic stimuli for a selective stimulation of the auditory nerve in cases of post-implantation FNS. Hence, they may be a simple remedy against FNS or other non-auditory side effects with monopolar stimulation of long atraumatic lateral-wall electrodes. The observed triphasic effect may be due to the long central anodic phase, flanked by two short cathodic phases, producing charging/discharging patterns that preferentially activate auditory nerve fibers, as recent studies have shown that the anodic phase is more effective than the cathodic phase in stimulating the auditory nerve in humans.

S27-6

Influence of pulse rate and interpulse interval on temporal loudness integration in cochlear implants

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Actual cochlea implant stimulation strategies use biphasic pulse trains which are sequentially interleaved on 12-22 electrodes. Loudness integration for complex interleaved stimulation sequences is still not understood. We address the question how each pulse event contributes to perceived loudness.

In this study, we evaluated the influence of temporal distribution of stimulation pulses on perceived loudness. We compared single-electrode stimulation for two different pulse trains: (a) pulse trains with evenly spaced biphasic pulses, (b) pulse trains with double pulses and half rate. In trains of double pulses single biphasic pulses were replaced by two biphasic pulses with an interpulse interval of 20µs. We used the stimulation rates 500, 1000 and 2000 Hz. 15 subjects participated. 19 ears implanted with MED-EL $\text{Pulsar}_{\text{CI}}^{100}$ or Sonata were tested at electrodes 6 and/or 1 (most apical) with the direct stimulation research device RIBII. We measured T-levels and M-levels. Ten subjects also balanced loudness at a level of 20-30% dynamic range; reference was a standard pulse train of rate 500 Hz. We used trains of length 300 or 500 ms with cathodic-leading biphasic pulses with 40µs phase width.

We found a significant reduction of T-levels of more than 20% for each rate doubling and we found little change at M-levels. This results in an enlarged dynamic range for higher rates, which is consistent with literature. For the loudness-balanced data, rate doubling induced a decrease in amplitude of about 7-10%. This change was between the effects on T-level and M-level. The double pulse trains show the same rate effect. Amplitudes for T-levels of double pulse trains with 500 Hz (or 1000 Hz) were similar as the amplitudes measured for normal trains with 1000 Hz (or 2000 Hz, respectively). This indicates that only the number of spikes (or the absolute energy) determined T-levels and not the temporal distribution of the pulses. At 20-30% dynamic range, double pulse trains needed less amplitude to reach the same loudness as normal spike trains with double pulse rate.

These results show that the temporal loudness integration is affected by the amount of stimulation pulses as well as the local temporal pulse shifts. If the stimulation rate and amplitude are lower the effect of rate doubling and temporal pulse shift is larger. At T-levels the stimulation energy is the main influencing factor of loudness. At higher levels the temporal shift gains contribution. If this situation is transferred to a typical situation of interleaved cochlear implant stimulation, the double pulse train simulates a two channel interaction of interleaved pulse trains. This indicates that channel interaction will influence loudness due to temporal integration. However, the exact amount of loudness integration cannot be predicted easily because the contribution of rate and interpulse intervals on loudness depends on the stimulation amplitudes.

S27-7

Improving channel independence before selecting electrodes for deactivation

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Recently, there has been a renewed interest in deactivating electrodes in cochlear implants (CIs) with the primary goal of improving speech understanding. Psychophysical measures, electrophysiological measures, and imaging techniques have been used to select the electrodes to be deactivated. We hypothesize that improving discriminability among electrodes prior to selecting the ones for deactivation may preserve useful channels of information that would be lost otherwise. We call this approach an “optimize and then prune” strategy, as opposed to a “prune only” strategy.

Discriminability among electrodes can be improved by manipulating stimulation parameters such as pulse rate and phase duration. Additionally, discriminability might be improved by shifting the locus of excitation between electrodes through the use of parallel stimulation (“current steering”). Maximizing the number of discriminable sites could potentially provide CI users with additional channels of information.

Using psychophysical data, we will demonstrate that manipulations in phase duration have the ability to increase the number of discriminable sites for some CI users. For such users, we are comparing in speech reception studies the prune-only strategy with the optimize-and-then-prune strategy. Results from the comparison will be presented at the conference.

S27-10

CI-fitting: an inventory on how 47.000 CI users have been fitted

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Intro: The programming of cochlear implants (CI) is essential for good performance. However, to date still no commonly accepted Good Clinical Practice guidelines exist. This paper reports on the results of an exhaustive inventory of the current practice worldwide.

Methods: A questionnaire on current practices was distributed to CI centers worldwide. The results were discussed during an International Debate and checked and verified by means of individual interviews during the months after the Debate. In addition all centers were invited to participate in a cross-sectional study logging the details of 5 consecutive CI fitting sessions in 5 different CI recipients. Descriptive statistics are used to present the results in terms of 5 parameters (median, quartiles, and extremes), histograms and box and whisker plots.

Results: Forty seven CI centers filled out the questionnaire. All together they follow 47000 CI recipients in 17 countries and 5 continents. Sixty-two percent of the results were double-checked by individual interviews and 72% of the centers returned the cross-sectional data for verification. Data indicate that general practice starts with a single switch-on session, followed by three monthly sessions, three quarterly sessions and then annual sessions, all containing one hour of programming and testing. The main focus lies on setting maximum and to a lesser extent minimum current levels per electrode. These levels are often determined on a few electrodes and extrapolated for the others. They are mainly based on subjective loudness perception by the CI user and to a lesser extent on free field audiometry and speech audiometry. Objective measures play a small role as indication of the global MAP profile. Other MAP parameters are rarely modified. Measurable targets are only defined for free field audiometry. Huge variation exists between centers on all aspects of the fitting practice.

Conclusions: The current practice of CI-fitting, although highly variable across centers, is basically the setting of C-levels and to a lesser extend of T-levels, based on merely subjective audibility. Other MAP parameters are rarely modified. Objective or psycho-acoustic tests are only used in a minority of cases. There is no common methodology and well-defined targets appear not to exist.

S28 Various aspects of binaural hearing

S28-10

Across-lectrode integration of interaural time difference in bilateral cochlear-implant listeners

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Binaural hearing provides substantial cues that facilitate our ability to localize and segregate sound sources. Bilateral implantation has been shown to help cochlear-implant (CI) listeners to retain basic left/right localization ability. However, CI listeners´ performance in sound localization and speech understanding in noise is still limited when compared to normal-hearing listeners. It is assumed that those limitations are at least partly due to the CI listeners´ low sensitivity to interaural time differences (ITDs) which to some extent results from the suboptimal encoding of ITD cues with current bilateral CI systems. Most existing studies investigating ITD sensitivity of CI listeners used stimulation at a single interaural electrode pair. In this study, the sensitivity of seven bilateral CI listeners to ITD encoded via multiple interaural electrode pairs was systematically studied in order to clarify conditions improving performance improves relative to stimulation at a single-electrode pair.

Based on pretests, up to three interaurally pitch-matched electrode pairs were selected. In a constant-stimuli paradigm, ITD just-noticeable differences (JNDs) for unmodulated 100-pulses-per-second pulse trains were measured. The pulse trains were presented via interaurally synchronized direct stimulation. Measurements were performed stimulating either one or two electrode pairs. In case of double-pairs, both pairs had the same ITD and the temporal offset across electrodes corresponded to half the interpulse interval. Current levels were varied, allowing comparisons at either constant level or constant loudness. Different tonotopic separations between the pairs were tested. Double-pair JNDs were compared to single-pair JNDs.

For larger tonotopic separations and constant current levels the results showed a small decrease in JNDs for double-pair stimulation relative to single-pair stimulation. For small tonotopic separations, no decrease in JNDs was found. For constant loudness, double-pair JNDs tended to be similar or even larger compared to single-pair JNDs. For most listeners, JNDs increased with decreasing current level irrespective of electrode-pair configuration, demonstrating a substantial effect of stimulus level on ITD sensitivity. JNDs for small tonotopic separations were larger than those for larger tonotopic separations, showing an effect of tonotopic distance.

Our results reveal a benefit of double-pair compared to single-pair stimulation for ITD sensitivity only for large tonotopic separations. The improvements appear to be small compared to across-frequency integration effects found in acoustic hearing. The results show a complex interaction of the factors stimulation current level, tonotopic distance, and effective pulse rate received by the auditory nerve. Implications for the access to ITD cues with current stimulation strategies and for potential improvement with future CI systems are discussed.

S28-11

Improving cochlear implant patients' performance by interleaving the signal across ears

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When multiple electrodes are stimulated in near-succession, as occurs with clinical processors, the stimulation from one electrode interacts with the stimulation from adjacent electrodes, an effect referred to as channel interaction. Channel interaction is one of the main factors that limit cochlear implant patients' performance in difficult listening environments. One way of reducing channel interaction is to increase the distance between electrodes. However, because this results in fewer stimulation sites, the decreased channel interaction is likely counteracted by the decrease in the number of available spectral channels. An alternative approach is to interleave adjacent spectral channels across ears. This reduces the number of stimulation sites per ear, and increases the distance between stimulation sites, while maintaining all the spectral information when the signal from each ear is combined within the central auditory system.

Experimental interleaved and non-interleaved processors were created to determine if interleaving the signal across ears would improve performance. Spectral resolution is a key factor underlying perception in complex listening environments. Patients' spectral resolution was tested with a modified version of the spectral ripple test, called the Spectral-temporally Modulated Ripple Test (SMRT). The results indicated that, for most patients, the interleaved processors resulted in increased spectral resolution, and thus will likely result in improved performance in complex listening environments.

However, interleaved processors potentially distort binaural cues. To determine how detrimental interleaving would be for tasks relying on binaural cues, patients' localization performance was also tested with the interleaved and non-interleaved processors. The results indicated that the effect of interleaved processors on localization abilities was minor.

In conclusion, the results from this study suggest that using interleaved processors is a potentially promising method for improving cochlear implant patients' performance, particularly in complex listening environments that require better spectral resolution.

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S29 Outcomes

S29-3

Relation of cochlear implant performance and genetic evaluation

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Introduction: About 5% of patients do not benefit satisfactorily from cochlear implantation despite showing the same pre-surgical phenotypic traits as excellent performers. Current evaluations including audiometric patterns of severe-profound hearing loss and adequate temporal bone imaging findings appear insufficient to predict post-surgical outcome. Genetic evaluation based on comprehensive genetic platforms of all hearing loss genes may be instrumental in the prediction of post-surgical outcomes. Since a cochlear implant (CI) directly stimulates spiral ganglion neurons and does not rely on other structures of the cochlea (i.e. stria vascularis, hair cells) CI performance might be affected if a genetic mutation caused a pathology in the spiral ganglion rather than other parts of the cochlea.

Methods: In a retrospective analysis performance of CI recipients with a confirmed genetic cause of severe-to-profound hearing loss was assessed. Diagnosis of a genetic cause was established based on next generation sequencing (NGS) technology using a comprehensive platform of genes for genetic deafness. The cohort was analyzed according to CI performance. The audiologic data were correlated to the genetic causes of deafness to determine whether there was a gene-specific relation with CI performance.

Results: A genetic cause of deafness was determined in over 50% of clinically suspected cases of genetic deafness. In accordance with a previous report (Eppsteiner et al., 2012, Hear Res 292) poor CI-performers segregated mutations in TMPRSS3, which is also expressed in the spiral ganglion, while good performers segregated mutations in genes expressed exclusively in other structures of the cochlea such as Myo15a or Myo6.

Conclusions: This investigations confirms variable performance of CI-recipients and supports the hypothesis that the underlying genetic cause of deafness in specific genes may impact the outcome of CI performance. Genes expressed in the organ of Corti and lateral wall appear to be correlated with good CI performance while genes preferentially expressed in the spiral ganglion are found with poor CI performance. These data suggest that genetic testing may be a valuable part of CI evaluation and that associations between genotype and CI-performance should be assessed prospectively.

S29-17

Cochlear nerve preservation during acoustic neuroma removal - our experience and discussion of relevance to a cochlear implantation program

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Introduction: Increased numbers of acoustic neuromas (vestibular schwannoma,VS) are being discovered.

Some patients with VS desire a hearing solution with cochlear implantation.

Some patients with VS would like their tumor removed rather than monitored.

Insertion of a cochlear implant precludes MRI monitoring of an ipsilateral VS.

Provided the cochlear nerve is preserved cochlear implantation can be performed in the same surgery as removal of the tumor.

Methods: 5 patients with VS requesting surgery were selected for attempted cochlear nerve preservation during VS removal. Intraoperative monitoring of the cochlear nerve was performed by either round window electrically evoked auditory brainstem response(EABR), direct stimulation EABR (from cochlear nerve in lateral internal auditory canal) or cochlear implant EABR or a combination thereof. Postoperative audiological assessment of all patients was performed using pure tone audiometry, implant evoked audiometry and speech discrimination measures. A thorough elaboration of our techniques, results and potential pitfalls will be provided.

Conclusion: Cochlear nerve preservation is achievable in selected patients undergoing surgery for VS. Intraoperative monitoring has been of assistance in confirming anatomical preservation of the nerve allowing cochlear implantation.

S30 Single sided deafness (SSD)

S30-1

Cochlear implantation as treatment of single-sided deafness and asymmetric hearing loss - 24 months results

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Introduction: In the meantime cochlear implantation (CI) is an accepted method of rehabilitation in patients suffering from single-sided deafness (SSD), i.e. deafness on one ear with normal hearing on the other ear. SSD is the most extreme situation of asymmetric hearing loss (AHL). In Germany, costs are covered by health insurances in most cases.

Methods: In a monocenter study cochlear implantation was performed in 60 patients with AHL, 32 of them with SSD. Speech recognition in noise thresholds were examined in 3 different presentation conditions, S0N0, S45N45 and S45N45. Localization ability was assessed using an array of 7 speakers at head level separated by 30° azimuth in a frontal semicircle. The audiological tests were performed 12 months after first fitting in all patients as well as after 24 months in 20 patients. Subjective assessment of hearing with and without CI was evaluated using the SSQ questionnaire.

Results: 12 months after cochlear implantation, both patients with single-sided deafness as well as patients with asymmetric hearing loss showed significant improvement of speech reception thresholds in two presentation configurations. There were no significant differences between the two groups (SSD and AHL). Localization error was reduced significantly in both CI groups compared to the unaided situation. The results were consistent even after 24 months.

Conclusion: Our results show that not only single-sided deaf patients, but also patients with asymmetric hearing loss profit from cochlear implantation with consistent results over time.

Learning outcome: Subjectively and objectively, cochlear implantation is the most successful method of hearing rehabilitation in patients with asymmetric hearing loss and single sided deafness.

S30-2

Loudness perception in single-side deaf cochlear implant users

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Introduction: Loudness perception in bimodal and unilateral CI users might be different between ears. A balanced loudness between ears might increase the binaural benefit with CI and the other ear. Currently loudness balancing procedures between CIs and HAs is not a widely used procedure in the clinical routine. Even though bimodal fitting got more and more popular during the last years, the common concept still foresees a fitting of both devices by different professionals, often even at different locations. In addition the loudness balancing is a relatively time-consuming approach. For the development of loudness models simplifying the loudness balancing between CI and HA detailed evaluations of different loudness balancing approaches and their comparisons are necessary.

Method: In two independent studies single-sided deaf CI users (implanted on one side and normal hearing (NH) or mild hearing loss contralateral), were evaluated regarding their loudness perception. Different procedures were used: i) separate, adaptive, categorical loudness scaling of both sides with acoustic signals as well as direct electric stimulation on individual electrodes, ii) adaptive, categorical loudness scaling of CI side with AGC switched-off, iii) loudness balancing with stimulation of both sides alternatingly.

Loudness growth functions of NH side and CI side were compared as well as the loudness on the CI side gathered with acoustic and electric stimulation. A study program was fitted based on loudness perception on the CI side similar to the NH side and tested by the subject in a take-home trial.

Results: Currently six SSD CI users were fitted with a program based on the loudness balancing between both ears. Results show a preference for the study program for some of the users in everyday life. The so far electrically measured loudness growth functions of two of these subjects correspond to the ones measured in both-sided deafened subjects. AGC compression caused a limitation of loudness growth only to “medium” loudness with increasing acoustic level on the CI ear.

Conclusion: Based on the loudness growth functions measured with direct electrical stimulation as well as acoustic stimulation on the CI side a loudness balanced signal processing model should be designed.

S31 Young children

S31-8

Report on complex language skills in prelingually deaf children six years after simultaneously bilateral implantation from 5 to 18 months of age

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Intro: The objective of this study was to examine longitudinal hearing and language development in children who received simultaneous bilateral cochlear implants from 5 to 18 months of age and to compare the results with language development in children with normal hearing.

Methods: The study is a prospective causal-comparative longitudinal study. The sample included 38 children, 19 CI-users and 19 with normal hearing, matched on age and gender mother education. The children with CI were simultaneously bilaterally implanted between 5 and 18 months and had no additional disabilities. Data was collected in a clinical setting at postoperative check-ups at 3, 6, 9, 12, 18, 24, 36, 48, 60 and 72 months of CI-use. Communication assessments included the broad specter of language tests targeting expressive, receptive and morphological language skills.

Result: Longitudinal data shows no significant difference between cochlear implant users and normal hearing children on measures of receptive vocabulary after 24, 36 and 48 moths of implants use. However, after 60 and 72 months normal hearing children scored significantly better than the CI-users which on average scored about one standard deviation from the normative mean. Expressive vocabulary showed no significant differences between the groups on any of the controls. On measures of receptive grammar there was a significant difference between the two groups after 48 months use, but no difference between the groups was found at the remaining controls. On measures of expressive grammar there was a significant difference between the groups at all controls post implantation. The results show that the child's morphological knowledge could be explained 46% of the variation vocabulary knowledge.

Discussion: Early simultaneous bilateral implantation in prelingually deaf children has generally been associated with a development of complex language structures similar to that of children with normal hearing. Although the results are especially promising for children receiving bilateral implantation as young as 5 months, the data indicates that the children remain a group at risk for language and reading impairment. Vocabulary has a key role in language development and limited vocabulary has both immediate and long-reaching negative effects.

Conclusions: Children with bilateral early implantation can perform close to an age appropriate level on many language skills throughout their language development post implantation. Vocabulary and morphology still seems to be a challenge for these children.

Learning outcome: The accusation of age equivalent complex language skills is possible after bilateral early implantation. However increased focus is needed in targeting the enhancement of vocabulary and morphological skills.

S32 Surgical and non-surgical complications

S32-1

Revisison cochlear implant surgery and reimplantation in children

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Revision Surgery and Reimplantation may have some differences from adult cases. Between 1998-2013 1602 cases had primary cochlear implantation at Izmir Bozyaka Teaching and Research Hospital CI Center. Majority of the cases (1013 patient)were children below 18 years. In this presentation retrospective evaluation of these cases would be presented stressing important points and rules in prevention of problems and complications and an analysis of the cochlear implant revision surgery and reimplantation achieved on 97 children would also be given.

S32-2

Cochlear re-implantation - Routine or concern?

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As the number of CI recipients increases there is a growing number of re-implantations due to different causes such as technical hard or soft failures, medical complications, trauma or others. Decision for re-implantation might be challenging, as well as the surgical procedure to replace the intracochlear electrode. Although reports on performance are encouraging, there are some concerns regarding the long-term effects of re-implantation.

We analyzed the medical-technical and audiological data sets available in a university implant center regarding patients implanted between 2000 and 2013.

Out of more than 2000 CI-surgeries, revision surgery rate due to device failure is approx. 3 %. The distribution according to manufacturer, type of failure and surgical procedure will be reported. Audiological data demonstrate an overall seemingly unchanged performance, but there is a certain number of patients performing significantly poorer following re-implantation.

Although re-implantation is mostly a safe procedure, it remains a challenging surgical procedure, especially if the type of electrode is changed, and has the potential to result in poorer outcomes. This consequently leads to ask manufacturers to further improve device reliability.

S32-5

Indications and outcome of cochlear reimplantation - 22 year review from the YorkshireAuditory Implant Centre

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Objectives: Review of prospectively collected data of patients who had required revision surgery resulting in reimplantation. To analyze demographics, causation and overall outcomes of safety and audiological performance.

Methods: Evaluation of 67 re-implantations (23 adults/44 children) performed within 831 patients treated between 1990-2012 at the Yorkshire Auditory Implant Service. Indications for initial surgery, surgical time intervals for initial and reimplantation together with manufacturer failure analysis reports were reviewed. The later information was used to classify the reason for failure. Results of audiological testing were recorded pre and post re-implantation; Open-set sentence test scores BKB &CUNY were documented for adult patients, and CAP & MAIS scores for children.

Results: Overall re-implantation rate was 8% (adult 6.5%/8% paed). Paediatric patients had a shorter time interval between implantation and device failure (median time 1.98 v 3.76 years, P=0.019) and were more likely to have a history of trauma (23.9% paed v 4.25% adults). Children with a history of trauma were younger at device implantation (Median 2.36 v 3.16 years, P=0.019) and at the time of failure (Median age 3.94 v 5.61 years, P=0.007). All adults were classified C - device out of specification; Paediatric 76% C. 20% B2 & 4% D. Open-set sentence tests improved in 16, CAP scores remained stable, or improved at 6/12. No complications were encountered.

Conclusion: Results confirm that cochlear re-implantation is a safe procedure, and allows for continuing auditory development in adults and children. Providers need to plan and budget for anticipated re-implantation rate of up to 1% of their service provision per year.

Learning: Once a CI failure is recognized timely intervention is required especially with unilaterally implanted patients.

There are no significant issues with re-implantation.

S32-10

Complications and survival rates of cochlear implant surgery: The gruppo otologico experience

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Introduction: Cochlear implants are a safe procedure for hearing restoration. Despite the fact that considerable number of publications deal with surgical and medical complications, little attention has been paid to the survival rates of the implants and the stability of the hearing results over time.

Material and methods: The medical records of patients undergoing cochlear implant surgery were retrospectively reviewed. Data including sex, age at implantation, cause of hearing loss, length of follow-up, implant brand and complications was collected. Cochlear implantation is performed in our center by the standard technique through the facial recess (Sanna, 2012). In some cases, obliteration of the middle ear with abdominal fat after subtotal petrosectomy (SP) was required. Complications were classified as major and minor as proposed in the review by Hansen et al. (Hansen 2010). Stability of audiological results with time—The audiological results of the implanted patients were revised to identify those who experienced an unexplained decrease of the audiological results with the time, and the time from the implantation to this decrease. Kaplan-Meyer survival rated were calculated.

Results: The file of 236 subjects (270 implantations) were analyzed. There were 127 females (47%) and 143 males (53%). A total of 17 patients were implanted bilaterally, one of them simultaneously. 210 (77.7%) implants were placed through standard approach by the facial recess and 60 (22.3%) cases required combination with SP. The average duration of the follow up was 30.1 months. The total number of patients who experienced one more complications was 17 (6.27%). Major complications occurred in 7 patients (2.59%) and minor in 10 patients (3.7% of all implantations). A decrease in audiological results was observed in 20 (7.41%) cases. The mean time to decrease in audiological performance was 43.25 months. *Decrease of audiological results* - Kaplan-Meyer 5 year survival rates free of decrease of audiological results were 77.4 %.

Fig.1

Explantation- Kaplan-Meyer 5 year survival rate of the devices, considering all causes of explantation, was 95.8%

Fig. 2

Conclusions: Cochlear implantation is well established procedure for hearing rehabilitation, however, this is not a risk free technique. Complication rates for standard cochlear implantation range from 5.7% to 26.7%. In our series, the overall rate of complication was 6.66%, during a maximum follow up period of 9 years. Long term follow up of 9 years show that 75.5% patients maintained audiological stability. In addition, 95.8% of cochlear implants were in situ at the end of 9 years. Our study shows that on a long term, cochlear implants maintain excellent stability of hearing results with minimal rates of explantation.

S32-11

Management of delayed infection in the pediatric cochlear implant patient

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Intro: This study will discuss the presentation and management of delayed infection occurring in pediatric cochlear implant recipients over an 18 year period in a tertiary care pediatric hospital.

Methods: The medical records of 504 patients representing 724 implants were reviewed for etiology of infection, temporal relationship to initial surgery and for severity. Delayed infection in this review was defined as occurring 30 days after initial surgery. Severity of infection was defined as minor or major. Minor complications were events that were treated conservatively on an outpatient basis without device compromise. Major complications were defined as events that required re-admission to the hospital or compromised the integrity or function of the device.

Results: Our study found 37 patients who experienced delayed infection with an overall delayed infection rate of 7.4%. Minor events occurred in 25 patients, and usually consisted of otitis media, cellulitis or skin breakdown over the magnet. Major events occurred in 12 patients, often years after initial uncomplicated surgical intervention. Nine patients presented with abscess or seroma formation; of these, 5 patients required explantation due to infection. Three patients developed cholesteatoma which presented as otorrhea and were successfully treated for their disease and reimplanted without further issue.

Discussion: A survey of the literature shows the global infection rate to be between 1.67 to 16.6 %. Cunningham *et al*. reported early and late infection rates in a series of 271 pediatric patients and they found an overall infection rate in pediatric patients of 5.9% which was higher than their adult population. The majority of infections occurred in the delayed phase while only 8 occurred in the early post-operative period. Loundon *et al* reported a 9.9% overall complication rate in 434 pediatric CI patients; trauma and inner ear malformations were considered factors in major delayed complications.

Conclusion: Delayed infection can be a significant issue in the implanted patient, potentially requiring aggressive management including intravenous antibiotics and device explantation.

Learning outcome: Surgical and medical management, potential etiology of infection and indications for explantation will be discussed.

S34 Snapshot presentations on health economics and panel discussion

S34-10

Evaluation of cost-utility in middle ear implantation in the"Nordic School" a multicenter study in Sweden and Norway

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Intro: Middle-ear implants are more expensive than BAHD.

It is important to evaluate and compare the cost-utility when a new treatment mode is introduced.

Methods: Prospective, multicenter, single-subject repeated study in six tertiary referral centers.

Twenty-four patients with sensorineural, conductive and mixed hearing losses were implanted with the AMEI Vibrant Soundbridge®(VSB)due to medical reasons. All patients were previously rehabilitated with conventional hearing aids. Multiple validated quality of life patient questionnaires, Health Utilities Index(HUI 2 and 3) and Glasgow Hearing Adjusted Benefit Profile (GHABP), were used to determine the utility gain and quality adjusted life years (QALY). Directly related treatment costs for the implantation were calculated and related to utility gain and QALY.

Results: The cost/QALY for patients with sensorineural hearing loss (SNHL) was estimated at 7260 €/QALY, and for patients with mixed/conductive hearing losses (C/MHL) at 12503 €/QALY.

Conclusion: Hearing restoration using an active middle ear implant (AMEI) is a highly cost-effective treatment for a selected group of patients with no other possibilities for auditory rehabilitation.

S35 Vestibular function and CI

S35-1

Vestibular function changes and cochlear implantation

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Introduction: Cochlear implants are generally regarded as low risk to vestibular function as the vestibule and semicircular canal endorgans are not directly traumatized with electrode insertion. Severe vertigo, occasionally seen in our practices, is rarely discussed in this group of patients. Several articles over the last two decades have documented changes in vestibular function in association with cochlear implantation. This presentation will present the authors' experience with routine pre-and postoperative vestibular function testing in patients undergoing cochlear implantation and its effects on outcomes.

Objective: Determine risk and potential cause of changes in vestibular function following cochlear implantation and possible relationships with speech outcomes perception measures (in quiet and in noise).

Study Design: Retrospective cohort study.

Setting: University tertiary referral center

Patients: Eighty-eight pediatric and adult patients underwent cochlear implantation from January 2011 to December 2013; 32 right, 46 left and 10 bilaterally. Pre- and postoperative vestibular testing were performed, including caloric and/or vestibular evoked myogenic potentials (VEMP), and speech perception measurements.

Results: Of the 88 patients implanted, preoperative caloric weaknesses were found in twelve patients, ten unilateral and two bilateral. VEMP abnormalities, determined by absent responses, were seen unilaterally in 13 patients and bilaterally in 14. Of the 12 patients demonstrating caloric weaknesses preoperatively, two had absent VEMPs bilaterally, two unilaterally and present in eight. Postoperatively, 22 patients demonstrated caloric abnormalities, with 27 having unilaterally absent VEMPs and four bilaterally absent. The analysis was conducted using Repeated Measures Analysis of Variance and the relationship between changes in vestibular function and speech perception (in quiet and in noise) will be reported using a bivariate correlation. Analysis of covariance will explore the impact of electrode array used, method of insertion, and age at implantation as possible interactions leading to changes postoperatively.

Conclusion: A significant number of patients demonstrate change in vestibular function from pre- to postoperative. The incidence of loss, implications for speech perception outcomes and possible factors associated with change will be reported.

S35-2

Changes in balance control after cochlear implant surgery

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Background: Recently, the elderly hearing-impaired have received more focus as cochlear implant (CI) candidates. Patients over the age of 60 years are very likely to have balance problems and suffer falls. Thus in elderly CI patients, there is a potential risk for long-term balance problems to be acquired following the CI surgery, especially if a peripheral vestibular deficit was present pre-operatively. We investigated whether CI patients' balance problems worsened 2 months after CI surgery.

Methods: To date, we have investigated balance control of 9 CI patients of mean age 60 years, 4 months pre-operatively and 2 months post-operatively (some 2 weeks after first speech processor stimulation). 7 patients received a Nucleus and 2 a MED-EL CI. Trunk sway was measured during a battery of 14 stance and gait tasks with a SwayStar™ system mounted at lumbar 1-3, recording trunk roll and pitch velocities. The task battery comprised 4 two-legged stance tasks (eyes open and eyes closed, on a normal floor and on a foam support surface) and 3 one-legged stance tasks (eyes open and eyes closed on normal surface, eyes open on foam) lasting 20s or until balance control was lost. Also two semi-stance tasks (walking eight tandem steps on a normal and foam support surface), three simple gait tasks (walking a distance of 3 meters, either with closed eyes or rotating or pitching the head while walking) and two complex gait tasks (walking up and down a set of stairs with two upward and two downward steps and walking over a series of four low (24 cm high) barriers) were used. Task measures were compared pre- and post-operatively and with respect to age-matched healthy controls. Pathological balance control was defined as sway greater than the 95% limit of controls.

Results: A combination of test results used to identify peripheral vestibular deficits (Allum JHJ &Adkin AL. *Audiol Neurootol* 2003, 8:286-302) indicated that 44% of the patients had pathological balance control pre-operatively and all except one had poorer balance control post-operatively with 66% pathological (pre-op score 471, post-op 572) . Those that remained normal had normal vestibular function pre-operatively. Both stance and gait tests were worse preoperatively. Standing eyes closed on foam revealed an average 100% increase in pitch and roll sway velocity. Walking with eyes closed showed a 12% increase in these measures with an 18% slowing in gait velocity. All changes were greater than expected based on the 6 month interval between tests.

Conclusions: This pilot study is the first to indicate that post-operatively elderly CI patients are likely to suffer increased balance problems due to vestibule-spinal deficits, especially if deficits were present pre-operatively. Appropriate patient counselling and post-operative therapy is therefore recommended. Future studies should investigate the effect of speech processor switch-on on the balance deficits.

S36Robotic surgery: Structured Session and Panel Discussion

S36-1

Minimally invasive robotic cochlear implantation surgery

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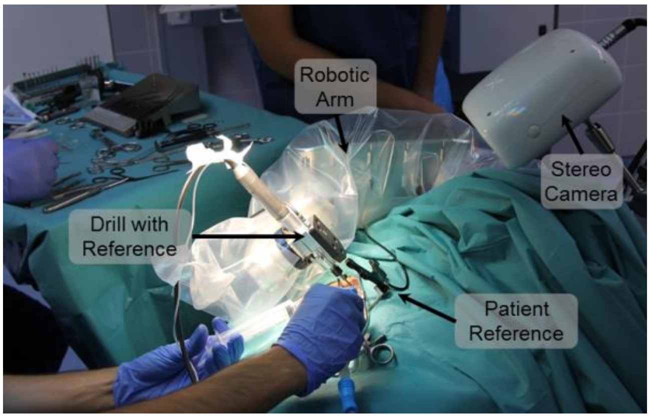
Introduction: Alternative blind approaches to reach the cochlea (varia, suprameatal) could put the facial nerve unduly at risk. The purpose of this abstract is to report on the latest achievements at the University of Bern towards a robotic image guided approach to minimally invasive cochlear implantation.

The Robot Assisted Approach begins with the insertion of four small titanium screws in the bone posterior to the external auditory canal for use as registration markers. Low-dose cone beam CT (CB-CT) data is analyzed using self-developed planning software enables the surgeon to efficiently plan a safe and effective trajectory to the target at the round window. Intra-operatively, the robot arm is mounted directly on the OR table, and the head is fixed non-invasively. A tracking reference is fixed rigidly to the skull, and the position of the head is registered relative to the robot using the implanted screws. The robot automatically moves to the correct drilling axis. The reference fixed to the drill tool is tracked relative to the patient by the navigation camera. This allows the position of the drill to be controlled relative to the head.



[Robot drilling minimally invasive access]

The technical accuracy of the system was shown to be on average 0.15 ± 0.08 mm a laboratory setting using 8 whole head cadaver head specimens. This high accuracy is only one of the aspects of the system which contribute to the safety and reliability of the approach. Process-based pose estimation is a method which can determine the position of a tool within the mastoid by using the drill force history and material density information to estimate the position of the tool to an accuracy of 0.38 ± 0.16 mm at the level of the facial nerve. This estimate is independent of tracking and registration errors, and thus provides redundancy and increased safety. Intraoperative CB-CT scanning is also integrated into the clinical workflow, and system software. The robot system stops automatically 1-2 mm before the level of the facial nerve. An intraoperative scan enables a direct confirmation that the trajectory will safely pass through the facial recess.

Conclusion: The high accuracy of the robot assisted approach together with redundant position estimation and real-time facial nerve stimulation will enhance the safety of the procedure and ensure that the facial nerve remains undamaged during the procedure.

S36-2

The accuracy of a mini-stereotactic frame for minimally invasive cochlear implant surgery

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The concept of Microtable, a patient-specific mini-sterotactic frame for minimally invasive Cochlear Implant surgery has been developed at Vanderbilt University, Nashville, TN. A complete new manufacturing system for rapid prototyping of the microtable has been developed to be able to conduct multicenter clinical studies. The first step was to verify the accuracy of the system. We measured the target error at the facial recess in an extra „post-OP“ CBCT (Cone Beam Computed Tomography) scan.

Material and methods: The Microtable is fabricated to guide a drill on a specified linear trajectory from the surface of the skull down to the cochlea. It is produced based on intraoperatively obtained CBCT-scans after placing three anchor screws around the mastoid. On the CBCT scans the anatomical structures of the temporal bone are segmented automatically. The design of the Microtable is calculated, giving the best trajectory from the surface of the mastoid to the cochlea. This data is transferred to a CNC-milling-machine and the platform of the Microtable is produced within few minutes. Three support legs with defined lengths are inserted to the holes of the platform. After sterilization, it can be affixed to the anchors. This rigidly fixed mini-stereotactic frame allows only one direction for guiding the drill down to the cochlea. For defining the accuracy of the system we performed a conventional mastoidectomy and posterior tympanotomy on five temporal bones. An individual Microtable was produced for each of the specimens, and it was placed on the anchor screws. A sham drill was inserted through the Microtable down through the mastoid and passing the facial recess to the round window region to verify whether vital structures would have been violated by the drill in case it had been used.

Results: Endoscopic views confirmed that the sham drill bit successfully reached a clinically adequate target location and critical anatomical structures would remained undamaged for all five evaluated temporal bone specimens. Postop CBCT-scans were obtained and registered to the plan in preop scans. By this method the mean distance between planned and actual trajectory at the facial recess was calculated to be 0.46mm ± 0.18mm (SD). For one of the specimens we identified the source of an unsatisfyingly large deviation of 0.75 mm to be a result of a worn-out milling head which has been used to create at least four other Microtables previously.

Discussion: During this study the accuracy of an alternative production setup of the Microtable was also evaluated. Because of abrasion of the drill bit, subsequently drilled holes had slightly smaller diameter and the “legs” did not fit into these holes perfectly resulting in an inaccurate product.

Conclusion: We achieved an accuracy of 0.39±0.12 mm in the first four specimens. For the clinical study the drill bit needs to be changed after production of four or fewer Microtable platforms.

S36-3

Image-guided and robot-assisted cochleostomy for cochlear implantation: a feasibility study

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Background: The development of robot-assisted surgery for cochlear implantation raises a growing interest to develop outpatient surgery. This minimal invasive surgery requires a high accuracy to avoid any risk of facial nerve, chorda tympani, auditory ossicles or ear canal lesion. It has been recently demonstrated that a robotic arm guided by a high-accuracy optical camera (OtoBot) was capable of drilling a direct cochlear access (DCA) from the mastoid to the facial recess in order to perform a manual round window insertion of cochlear arrays. Here we investigated the possibility of drilling a cochleostomy through the DCA and inserting electrodes arrays without the need of surgical access to the tympanic cavity.

Methods: Ten temporal bones were used for this study. After placement of 4 cortical screws, the temporal bones were imaged using Newton 5G cone beam CT (125µ*125µ*125µ voxel size). The surgical planning was perform thanks to the OtoPlan software in order to optimize the distance between the facial nerve and the DCA, and to align the trajectory with an ideal trajectory passing through the scala tympani of the basal turn of the cochlea. Each trajectory was defined by the distance to the facial nerve(FN), the chorda tympani (CT), the ear canal (EC) ant the angles between the ideal and the chosen trajectory in the antero-posterior plane (d angle) and the plane passing through the tangeant of the electrode array in the center of the cochleostomy (e angle). After registration of cortical screws on temporal bone, a 1.8 mm DCA tunnel was drilling using a slow speed burr until reaching the facial recess. Then a 1 mm diamonded burr was using to drill the cochleostomy according to the surgical plane. The electrodes arrays (MedEl Flex 28) were inserted through the DCA thanks to a custom made insertion tool. The position of the cochleostomy and the insertion was controlled by postoperative cone beam CT.

Results: Cochleostomy could be performed successfully in all cases. The trajectories chosen had an average d angle of 11.1±2.37° and an average angle of 0.89±2.05°. No damage was done to the FN (mean distance 0.99±0.56 mm), and the bony part of the EC was partially drilled without skin damage (mean distance 1.79±0.78 mm). A round window approach was performed in 2 cases, and enlarged round window approach in 5 cases and a cochleostomy and 3 cases. All cases but 1 (cochleostomy) ended in the scala tympani of the basal turn of the cochlea. After insertion, no scalar displacement was observed. The mean angle of insertion was 305.59±55.18° consisting in the partial insertion in all cases (1 to 4 electrodes out the cochlea).

Discussion: Accuracy of OtoBot allows to realize a cochleostomy for direct percutaneous cochlear implantation without any damage to the facial nerve. However, insertion tool has to be improved to allow a deeper insertion of electrode arrays.

S36-4

Comparison of cochlear array insertion forces with three insertion techniques in temporal bone models

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Introduction: In order to achieve minimal trauma to inner ear structures during array insertion, modifications of array design and approaches have proposed. It would be suitable to predict and lower the peak force at the end of the insertion. The aim of this work to compare insertion forces of an array insertion with 3 different techniques: manual insertion with forceps, insertion with a commercial tool, and insertion with a motorized tool into anatomic specimens.

Materials and methods: Twelve human temporal bone specimens have been prepared in order to expose the basilar membrane to follow the array progression during insertion and visualize scala translocation. Temporal bones have been mounted on a 6-axes forces sensor to collect insertion forces. Each temporal bone has been inserted 3 times in random order with each of the techniques with a 1-J array (Advanced Bionics; Valencia). Peak insertion force values during and at the end of the insertion were studied.

Results: Manual and insertion with the commercial tool generated multiples peaks above 0.1 N during whole insertion length insertion related to fit and start. On the contrary, insertion force with a motorized tool only rose at the end of the insertion. Final peak insertion force was 0.279 ± 0.078 N, 0.331 ± 0.062 N, and 0.227 ± 0.08 N for manual insertion with forceps, insertion with a commercial tool, and insertion with a motorized tool technique respectively.

Conclusion: No difference between the three techniques considering final peak value was observed. However, a more predictable force profile could be observed with the motorized tool. Such a tool coupled to a force feedback could stop insertion to avoid harmful peak force at the end of the insertion.

S36-10

Intraoperative neuromonitoring of the facial nerve during minimally invasive cochlear implantation: A custom stimulating probe

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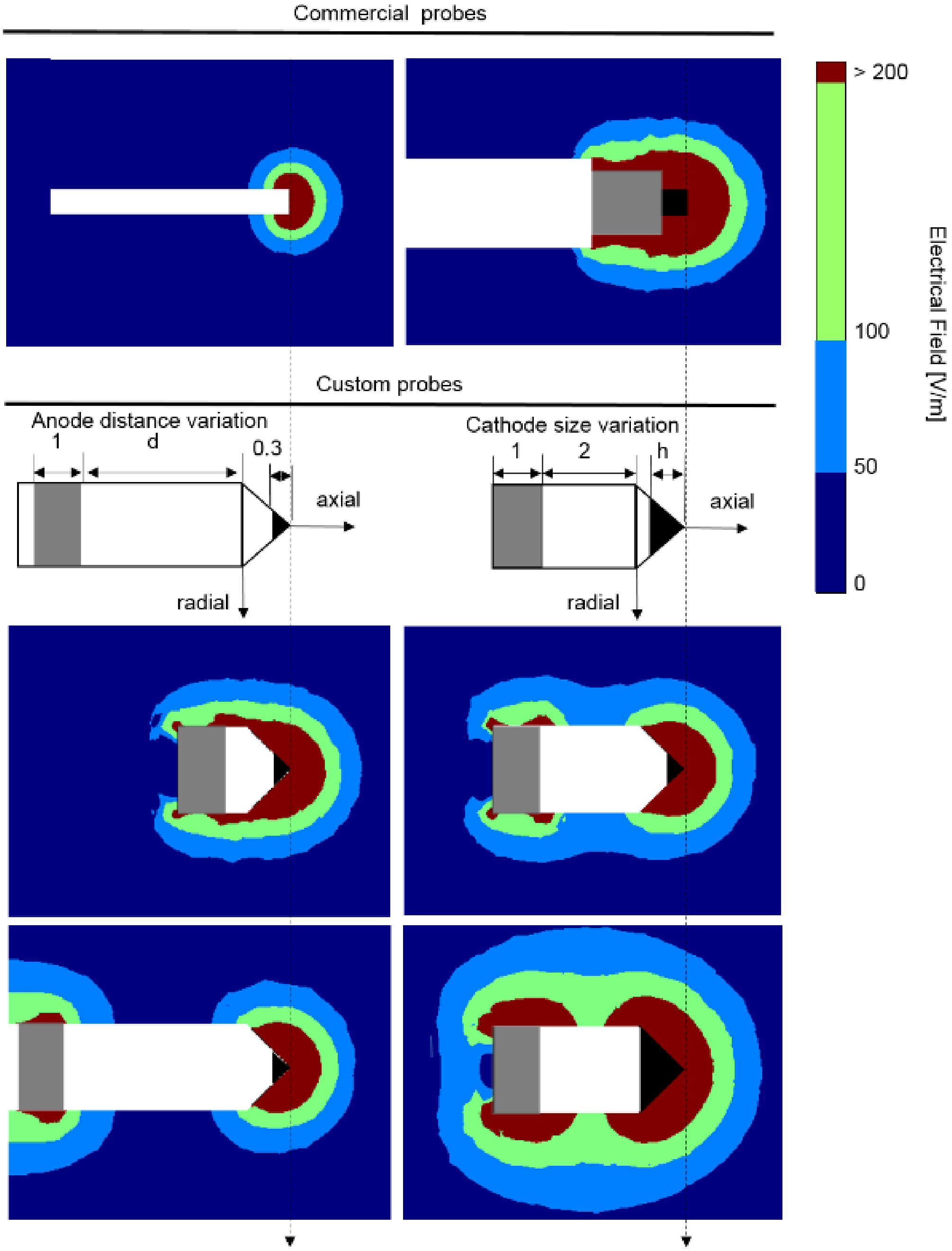
Introduction: Minimally invasive cochlear implantation surgery or direct cochlear access (DCA) aims to replace conventional mastoidectomy by drilling a tunnel the size of the implant electrode array from the surface of the mastoid to the cochlea. To date none of the alternative approaches provides a functional method to preserve the FN during drilling. Previous testing of a standard stimulating drill resulted in insufficient specificity and sensitivity. We propose an application-specific design of a stimulating probe with a focused electrical field for use with robotic DCA. In this preliminary study, the size and location of the stimulating electrodes are evaluated in terms of their effects on electrical field intensity and distribution.

Methods: The geometry of the tool is as follows: the cathode resides at the tip and an array of anodes is arranged along the shaft proximal to the cathode. The cathode is a cone with a variable height h. Each anode is a ring with fixed height (1 mm) and the diameter of the drill (Ø 1.8 mm). The anode to cathode distance is represented as d (see Figure). A parametric study of the probe design was performed using a finite element modeling software (Comsol Multiphyscs). The properties of idealized bone (conductivity 0.2 S/m, at 10 kHz) were used to construct a cylindrical model of the space immediately around the stimulating probe. A voltage of -1 volts was applied to the cathode, and the anode was clamped to ground potential. The magnitude of the electrical field was simulated in the 3D model using standard Maxwell equations. 10 increments for each of the two parameters, h and d, were simulated and the field magnitude was plotted in 2D.

Results: The electrical model indicates that increasing the cathode height (h) will increase the current density in the radial direction. Furthermore, decreasing the distance (d) between anode and cathode to a value of 2 mm, maintains the current density focused in front of the tool tip and avoids radial dissipation of the charge.



[Color plots of electrical field for simulations]

Conclusions: The simulations suggest that increasing sensitivity and specificity of intraoperative facial nerve monitoring during minimally invasive cochlear implantation might be possible through an application-specific tool design. Currently, we are constructing a custom probe to test the performance a living model.

S37 Rehabilitation

S37-1

LENA technology: A window into spoken language access for children with cochlear implants

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This presentation will present information about LENA, a technology that includes: 1) a digital language processor (DLP) recorder of 10-16 hours of the spoken language environment of the child, 2) software that analyzes the frequency of adult words, conversational turns, child vocalizations, the characteristics of the language environment (percent of noise, TV, silence, distant language and meaningful language), and in spoken English an automatic vocalization analysis. Information on children who are deaf or hard of hearing in both English-speaking and Spanish-speaking homes will be presented, corresponding to their typically developing peers with normal hearing. Data describing the language environment of a spoken language preschool as compared to the home environment will also be provided. Additionally, results from a study with the Lena Language and Autism Screen with children who are deaf or hard of hearing will be presented. This technology revolutionizes our ability to provide families with information about optimizing the spoken language learning environment for children with all degrees of hearing loss, including children with cochlear implants.

S38 Quality of life

S38-8

Sound quality perception and quality of life in adults with profound bilateral deafness and unilateral cochlear implantation

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This postoperative data collection study evaluated postlingually deafened cochlear implant (CI) users' self-reported sound quality and quality of life (QoL) and determined their level of music perception and their ease of phone, TV, and radio use.

78 adults with postlingual bilateral deafness and unilateral cochlear implantation, with a minimum of 6 months CI experience participated in the study. Sound quality was self-evaluated using the Hearing Implant Sound Quality Index (HISQUI). HISQUI scores were further examined in 3 subsets: music perception, phone use, and TV and radio use. QoL was evaluated using the Glasgow Benefit Inventory (GBI). GBI scores were further examined in 3 subsets: general, social, and physical benefit. Audiometric tests comprised of pure tone averages (500-4000 Hz), monosyllables in silence, disyllables and sentences in silence and in noise. Subject gender and age at implantation were also recorded. Possible correlations between the scores on any of the test points, audiometric data, and demographic data were examined.

Mean total HISQUI score indicated that subjects derived a “moderate” sound quality perception from their CI, although 46.1% reported “good” or “very good” while 27.2% reported “bad” or “very bad”. Almost half the subjects reported they could accomplish the music perception tasks at least half of the time. TV and radio were much easier to “effortlessly” understand in quiet than in background noise. Background noise also made phone use difficult. Most subjects could differentiate male from female voices on the telephone. Familiar speakers were easier to “effortlessly” understand than unfamiliar. On the GBI, 89% of subjects reported that they derived benefit from having a CI. HISQUI score significantly correlated to all subcategories of the GBI. Age at implantation inversely correlated with the total HISQUI score, and more specifically, with TV and radio understanding. Regarding audiometric results, the most remarkable of the significant correlations was between the % of sentences in noise correctly repeated and all sound perception scores. Women had a better score in music perception and in the phone use than did men.

Cochlear implantation had a significant beneficial impact on subjects' QoL, although their mean sound quality perception was only “moderate”. Understanding TV and radio and using the phone was easier in quiet than in noise. Music perception remains a challenge. HISQUI and GBI are useful and important instruments in that they can provide information about the everyday effects of treatment modalities, rehabilitation strategies, and technical developments.

Participants will learn how adults may improve their QoL and sound quality perception after CI use. They will learn that music perception, TV and radio understanding, and the use of phone are some tasks that can be performed with some limitations. The importance of these results is that they could be useful tools for future research in CI field.

S39 Music and CI II

S39-2

Patterns of participation of pediatric CI recipients in formal music instruction: Factors influencing persistence and success

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Intro: Cochlear Implants (CI), while remarkably successful in conveying speech in quiet, are less effective in transmitting spectrally-complex features of music (e.g., pitch, timbre) (Looi et al., 2010). Interestingly, despite degraded representation of several salient features of music, research indicates that many pediatric CI users do enjoy listening to music, and some are enrolled in music classes in their school or community (Gfeller et al., 2012). Prior studies, however, have not documented specific forms of instruction, patterns of persistence, or the impact of hearing history or perceptual accuracy.

Methods: A survey was administered to 158 CI participants (or parents of younger CI users) enrolled in our pediatric CI program between 1999 and 2012. Questionnaire items quantified participation in the following formal music instruction common in US schools or communities: general music, instrumental lessons, and vocal or instrumental ensembles during elementary, middle, and high school. Responses included the instrument(s) played, and length of time for each instrument and/or instruction type. Total length of participation and length in subcategories (e.g., lessons, band) were correlated with age, months of CI use, and pitch perception accuracy.

Results: Most CI users (93.7%) had enrolled in at least 1 year of general music (Max=8 yrs., Min=< 1, M=4.4 yrs.). 49% took lessons, (Max= 10 yrs., Min< 1 yr.; M=2.6 yrs.). 41% played in instrumental ensembles for at least 1 year, (Max=8 yrs. Min< 1 yr.; M=2.2 yrs.). 28% participated in at least 1 year of choir, (Max=7yrs.,Min< 1 yr.; M=2.1 yrs.). A variety of brass, woodwind, string, and percussion instruments were played; the instruments most commonly played were piano (n=30), drums (n=22), guitar (n=12) and trumpet (n=12). There were no significant correlations between overall or specific forms of participation and age, months of use, or pitch perception.

Discussion: The prevalence of piano and drum compared to other instruments is not surprising, given that CIs are more effective at conveying temporal information; piano and percussion use constant tuning, and provide kinesthetic and visual cues readily accessible to CI users. Given the difficulty of perceiving and matching an external pitch, it is also not surprising that fewer CI users enrolled or persisted in vocal ensembles; few who attempted vocal ensembles persisted for a full year. Unique auditory capabilities of CI users can be more readily accommodated in 1:1 lessons than in ensembles, especially those requiring on-going adjustment on pitch.

Conclusion: It is encouraging to note that pediatric CI users can succeed in formal music instruction; however, judicious choice of instrument or instructional approach is important to success and persistence.

Learning outcome: Those in attendance will be able to describe patterns of music involvement by pediatric CI users, as well as those types of instruction that support success and persistence.

S40 The single sided deaf child (SSD)

S40-1

The unilaterally hearing-impaired child

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For many years unilaterally hearing-impaired children received little in the way of educational attention. This was due to the fact that- in the light of superficial observation-many of these children manifested normal speech development. Additionally, the frequently limited educational resources and institutions for the severely hearing-impaired children took priority. Furthermore, children growing up in quiet surroundings meant that parents were not likely to detect the usual early warning signals of hearing disorders. The implementation of the universal neonatal (bilateral) hearing screening now enables severe congenital unilateral hearing impairment to be detected and provided for. Meanwhile, more thorough observations reveal that children with a mild to moderate infantile unilateral hearing impairment manifest normal development whereas children with severe unilateral hearing impairment suffer disturbed and retarded speech development, affecting both learning and emotional well-being at preschool and primary school. Such hearing defects often result in emotional insecurity, lack of concentration, learning disability, social problems, academic failure as well as physical problems.

Facilitating learning and ensuring participation of unilaterally hearing-impaired children requires a joint effort on the part of medical staff, teachers and hearing aid technicians, whereby not only acoustic aid for the child but also optimal acoustic classroom arrangement is adhered to, facilitating effective communication for those concerned. Since these children normally attend regular rather than special educational institutions for the Hearing Impaired, a thorough briefing of the mainstream educators is especially important. These children and adolescents may seem completely normal at first glance, whereby the effects of unilateral hearing impairment are underestimated or misinterpreted. Enlightenment focuses on the need to understand that- for the unilaterally hearing-impaired child- considerable hearing strain can quickly produce hearing fatigue and loss of attention. This in turn results in loss of concentration, distraction, irritability and fatigue.

S40-6

Rehabilitation of children with single side deafness after cochlea implantation

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In the context of expansion of CI-indication criteria cochlea implantation of children with single side deafness (SSD) is increasingly getting into focus. The promotion of these children represents a new rehabilitative challenge. In following study we present case reports to illustrate the rehabilitational promotions and support this new patient group. We will clarify therapeutical possibilities and new training approaches which meet the special requirements of these young patients. Three children with pre- and postlingual deafness are introduced. Trainings approaches which serve the promotion of the hearing development are presented by video examples. Furthermore we will present possibilities but also problems of the audiological follow-up. We will close with an evaluation how far our single sided CI-children benefit from the cochlea implantation. Therefore we analyze speech audiometric comparison data as well as questionnaires. In summary we do see a benefit in CI-supply for single side deaf children analogue to adults SSD patients. The presented study show first results which can serve as a basis for further examinations.

S41 Maturation and plasticity

S41-2

Long-term electrophysiological survey of auditory maturation in cochlear implantees

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Cochlear Implantation is considered as beeing a good model to understand plasticity of the auditory pathways.

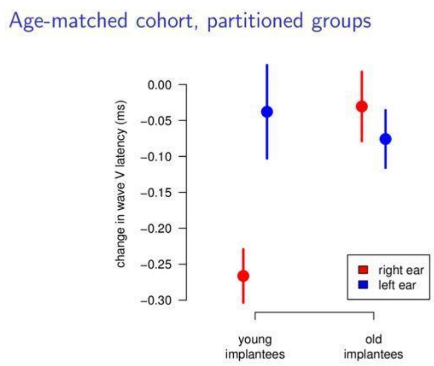
Objective: To determine correlations between profile of electrically elicited Auditory Brainstem Responses (eABRs) and clinical parameters over time in cohlear implant (CI) recipients.

Material: We present the analysis of a large data set collected on cochlear implanted patients enrolled at the University Hospital Edouard Herriot in Lyon, France. The analysis on a reduced fraction of this data set has already been published elsewhere (Thai-Van et al., 2007). This retrospective analysis includes 232 patients (112 females and 120 males) all implanted all implanted with a Nucleus (Cochlear, Melbourne, Australia) device. Electrically evoked compound action potentials measures were collected from one month after the surgery until 14 years and a total of over 13,000 independent measures have been analyzed. Waves III and V latencies were analyzed.

Statistics: Applying a back-fitting procedure to a mixed-effects linear model, we determined characteristics of eABRS , and searched for relationship with age at implantation, duration of CI use, gender and ear side implanted.

Results: We could find evidence for the following effects:

1) a difference in the response of electrodes #5 and #20, related to the anatomical position in the cochlear modiolus.
2) a latency difference between males and females, that correlates with anthropometric data.
3) a fast maturational rate followed by a standing plateau and a later increase of the latencies along the duration of cochlear implant use;
4) a lack of later increase in the latency time with cochlear implant duration use when the interval III-V is considered.
5) a difference in the behavior of right versus left implanted ears that interacts with the age at implantation. This later effect, confirmed in a subset of the data, where patients were selected to form matched groups in age and ear side, gives strong evidence for laterality effects on the maturational aspects.



[maturation_pEA_IC]

S41-6

Effects of single sided deafness (SSD) on binaural processing in the primary auditory cortex of cats

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Implantation of patients with SSD (a no-go about 20 years ago) has been demonstrated to be a successful treatment of tinnitus (Van de Heyning et al., 2008, Arts et al., 2012). More recently it has also become a means that enables patients with SSD to improve spatial localization and speech understanding especially in noise (Firszt et al., 2012, Kamal et al., 2012). Little is known about the impact of cortical plasticity in congenital subjects with a long duration SSD on symmetrical hearing after implantation of the formerly deaf ear. This also applies to binaural deafness in cases where the delay between the 1st and the 2nd implant is very large. The following study is focused on the effect of asymmetric hearing on the cortical development and the ability for binaural processing in cats with congenital SSD and congenital binaural deaf cats which were chronically stimulated in one ear (CDC_{stim}) (Kral et al., 2012). Acutely deafened normal hearing animals (HCs) and bilaterally congenitally deaf animals (CDCs) served as control. When comparing cortical responses of the two groups with asymmetric input (SSD, CDC_{stim}) and the control groups (HC, CDC) it was apparent that the strong contralateral preference which is typically found in the hearing control group and even in CDCs albeit to a much lesser extent was partly absent in the other two experimental groups. In the chronically implanted group asymmetric activation within an early developmental period led to reorganization of aural preference clearly favoring the activated ear. In case of binaural stimulation this ear becomes the dominant ear. Intracortical single and multiunit recordings at the side of the activated ear indicate a significant increase of ipsilateral excitatory responses and concurrently clear decrease of contralateral responses. Ipsilateral inhibitory responses as typically found in normal hearing animals were rare (Tillein et al., 2013). Analysis of various ITD parameters in SSDs revealed that ITD sensitivity was hemisphere-specific. Significantly decreased modulation depths were observed in the cortex ipsilateral to the hearing ear in comparison to CDC and HC. Apart from these differences cortical responses in SSDs were within the range of normal hearing controls while CDCs revealed a clear decrease in cortical responsiveness.

The effect of aural dominance strongly depends on the on-set time of asymmetric activation. If it starts late after the critical period when the main synaptic development has been finalized the effect diminishes or totally disappears (Kral et al 2013). The dominance of the early activated ear might explain the frequent finding of an initially bad performance of the2nd ear in binaurally implanted patients.

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S41-7

Brain responses to language-relevant musical features in adolescent cochlear implant users before and after an intensive music training program

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Music and prosody share many of the same relevant acoustic features: pitch, rhythm, and timbre. For cochlear implant (CI) users, perception of all of these is challenging. Few studies have investigated perception of music, prosody, and speech in the growing population of adolescent CI users with a congenital hearing loss. However, recent studies indicate that to keep pace with their normal-hearing (NH) peers, supplementary measures of rehabilitation are important throughout adolescence.

This study aimed to 1) investigate auditory brain processing of musical sounds relevant to prosody processing in adolescent CI users, and 2) investigate the potential impact of intensive musical training on adolescent CI-users' discrimination of music, speech and emotional prosody.

Eleven adolescent CI users (6 girls, Mage = 17.0 years) participated in a short intensive music training program, consisting of active music making supplemented with daily computer based listening exercises. The program was formed by three elements: rhythm-training, singing and ear training. Ten NH peers (2 girls, Mage = 16.2 years) formed a reference group, who followed standard school schedule and received no music training.

Before and after the intervention period, both groups underwent EEG recordings and behavioral tests for perception of music, speech and emotional prosody. EEG was recorded with an adapted version of the musical multifeature paradigm presenting a musical standard randomly violated by musical deviants (pitch, timbre, rhythm and intensity). Difference waves for the rhythm deviant were analyzed in the time window between 300 and 320 ms. Separate mixed-model ANOVAs were performed for left and right fronto-central electrodes. Paired t-tests were used to analyze the behavioral data. Here we present preliminary analyses of ERP responses to the rhythm deviant stimuli and results from a behavioral rhythm discrimination test.

For both left and right electrode sites we found a main effect of group, driven by higher mean amplitude in the NH group. There was no main effect of training. Left hemisphere sites showed a significant group by session interaction, driven by a larger difference wave (rhythm deviant - standard) in the CI group following training. Right hemisphere sites showed no significant effect. The behavioral rhythm discrimination test showed a significant gain in the CI group after training. The NH group produced significantly higher average scores than the CI group at both sessions. Our results suggest that adolescent CI users, who have only experienced sound through the implant, show brain responses to musical stimuli resembling those of NH peers, and that this response can be altered by intensive musical training. The finding points toward the possibility of improving appreciation of music in general for adolescent CI users, and using music as a motivating element in speech therapy programs.

S41-9

A frequency-place map for electrical stimulation in cochlear implants: change over time

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Introduction: Studies by Vermeire et al. (2008), Dorman et al. (2007) and Boëx et al. (2006) have determined frequency-place maps for the electrically stimulated cochlea from unilateral CI subjects with contralateral hearing. Reiss et al. (2007, 2013) showed electrical place pitch shifts in Nucleus Hybrid users with short electrode arrays, sometimes by as much as three octaves, over the first year or two of implant use. The goal of this study was to look at the effect of experience on electric pitch sensations in patients with longer electrode arrays.

Methods: Five subjects with near-to-normal hearing in the contralateral ear were provided with a MED-EL cochlear implant in the deaf ear in order to reduce intractable tinnitus. After loudness balancing, electric pitch percepts from unmodulated trains of biphasic pulses (1500 pulses per second, 50 µs/phase) were pitch-matched to contralateral acoustic pure tones. To look at the influence of experience, pitch matches were collected before first fitting and after 1, 3, 6, and 12 months of CI experience. Matched acoustic frequencies were evaluated as a function of electrode insertion angles. Electrode placement and insertion angles were determined from high-resolution CT scans of the subjects' temporal bones (Xu et al., 2000).

Results: The mean frequency-place function is about half an octave below Greenwood's map in the basal turn, deviating by a lesser amount and coming close to Greenwood's function for more deeply inserted electrodes. No systematic changes were observed over time. The smallest pitch shifts generally occurred for electrode positions in the second turn.

Conclusion: The results of this study do not show an influence of experience on electric pitch sensation. This is not in agreement with the results found by Reiss et al (2007, 2013). This is likely due to the fact that patients included in this study were all implanted with a standard electrode where the most apical electrode has a distance of 30.4 mm from the marker ring, compared to the 10.5 mm for the hybrid electrode implanted in the majority of patients in the studies by Reiss et al. (2007, 2013). Because of this deeper insertion there is less of a mismatch between the predicted pitch sensation (based on Greenwood's map) and the filter bands assigned to the electrodes during programming. Hence, a long-term cortical remapping of place pitch is not necessary in long-electrode patients. It should also be noted that several studies have demonstrated a long-term preservation of residual hearing in the majority of patients implanted with a long and flexible electrode array.

S42 Outcomes in children incl. multi handicapped children

S42-9

Electrical complementation end electric acoustic stimulation in younger children after partial deafness treatment

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Introduction: Partial deafness treatment (PDT) using cochlear implants brings new possibilities of hearing improvement for much wider group of patients. PDT encompasses different means of supporting the existing residual hearing in low frequencies. The greatest opportunity of the effective therapy is aiding the normal in low frequencies hearing with electric stimulation in high frequencies with the cochlear implant, which should be treated as the complementary electrical stimulation - electrical complementation (EC) or empowered less sufficient low frequency hearing with hearing aids - electric acoustic stimulation (EAS). Encouraged by outstanding results achieved by application of electric and acoustic stimulation in adults the decision was made to perform partial deafness cochlear implantation in children. The aim of the study was to determine efficacy of EC and EAS in group of younger children.

Material and method: The group of 21 children after PDT was randomly selected. Age at testing time in study group ranged between 5 and 14 years. To evaluate benefit of EC and EAS application pediatric speech discrimination test were performed in four conditions (Acoustic only, Electric only EC or EAS and Best aided) in quiet and noise after at least one year post implantation.

Results: Speech discrimination in EC or EAS and Best aided condition was proven to be superior in comparison to electric or acoustic stimulation only.

Conclusions: Application of electrical complementation - EC end electric acoustic stimulation - EAS is an effective means of speech discrimination development in children with Partial Deafness.

S43 Genetics & gene therapy

S43-1

Clinical application of genetic testing for cochlear implantation candidates

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Background: Genetic factors are the most common etiology in severe to profound hearing loss as well as one of the major factors in determining the outcome of cochlear implantation (CI). Satisfactory auditory performance after CI (including Electric Acoustic Stimulation: EAS) in patients with specific genetic mutations suggests that genetic testing can be useful for selection of appropriate treatment. Knowing whether the etiology locates within the cochlea or not is also important when predicting CI outcomes. Individual differences in residual hearing and progression also present difficulties when selecting candidates for EAS. Children often have residual hearing, so it is important to be able to evaluate the residual hearing and estimate the progression. But in very young children, the evaluation of residual hearing in the low frequencies is difficult. Genetic testing, however, gives us the ability to predict whether hearing loss will be progressive or not in individual patients.

Methods: We evaluated the genetic background of pre-lingual as well as post-lingual deafness patients who received CI or EAS as well as reviewing the post-CI auditory performance.

Results and conclusion: Mutations in several genes, including *GJB2, SLC26A4, MYO15A, TECTA, CDH23*, *TMPRSS3, ACTG1, TMC1* and the mitochondrial 1555A>G and 3243A>G mutation were found in these patients. These patients had relatively good auditory performance with CI or EAS, suggesting that genetic background is among the factors that can be used for prediction of post-implantation performance. Patients with *CDH23, TMPRSS3, ACTG1,* and mitochondrial 1555A>G mutations had residual hearing in the lower frequencies, and therefore carriers of these mutations would be good candidates for EAS. We confirmed that residual hearing was successfully preserved in patients with these mutations and that they had good outcomes with EAS. Combined with the ability to preserve residual hearing, the ability to predict future hearing level by the use of genetic diagnosis should facilitate early intervention with CI or EAS.

S43-9

Anatomical and functional effects of hearing preservation and neurotrophin gene therapy in ears with cochlear implants

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Introduction: The condition of the auditory nerve is believed to affect the quality of information transferred by cochlear implants. This is one motivation for using surgical procedures that promote hearing preservation. In addition, a number of studies are attempting to reduce the degeneration of the nerve in damaged ears using neurotrophins. The objective of the current study was to determine the functional and neuroanatomical effects of hearing preservation and neurotrophin gene therapy procedures in guinea pigs with cochlear implants.

Methods: Mature male guinea pigs were trained to perform psychophysical stimulus-detection tasks. Some animals were implanted in a hearing ear (n=20). In others, neomycin was infused bilaterally into the scala tympani, intended to destroy hair cells and supporting cells leaving a flat epithelium in the organ of Corti. The neomycin-treated experimental group (n=16) was then inoculated in one ear with AAV.*NTF-3* and the cochlea was then implanted. The control group (n=5) was treated in a similar fashion except that the inoculation was with an empty AAV. Psychophysical multipulse integration and temporal integration of pulse trains and ECAP and EABR amplitude-growth functions were then recorded. Animals were then euthanized and the cochleae were processed histologically.

Results: Spiral ganglion neuron (SGN) survival was generally best in ears with preserved hearing. In the 16 neomycin injected, AAV.*NTF-3* inoculated, implanted ears, SGN survival ranged from near normal to poor across animals and across cochlear turns. In contrast, SGN survival in the 5 animals in the neomycin injected, AAV.empty inoculated, implanted animals was poor in all cases, similar to ears treated with neomycin but no inoculation. Steepness of EABR and ECAP amplitude growth functions correlated with the degree of nerve survival over a wide range of SGN densities. In contrast, good psychophysical multipulse integration and temporal integration were seen only in cases with surviving inner hair cells and very high SGN densities.

Discussion: The functional measures affected by neural preservation procedures are correlated with speech recognition in humans reinforcing the importance of neural preservation in treating deafness. These psychophysical and electrophysiological measures could be useful for identifying the strongest and weakest stimulation sites when programming an individual's processor map.

Conclusions: Hearing preservation surgeries and neurotrophin gene therapy procedures can be very effective in long-term preservation of SGN neurons in mature implanted ears, but additional work is needed to reduce variability in outcomes. Electrophysiological and psychophysical measures provide useful tools for noninvasively assessing the effectiveness of these procedures.

Learning outcome: Surgical and tissue-engineering procedures that promote nerve survival can result in improved performance of cochlear implants.

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S44 Support & aftercare in assistive listening devices growing populations

S44-1

10-year outcomes from a high-level satellite CI center

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Access to cochlear implants continues to be a significant obstacle to patients living distant to CI centers. In the United States, market penetration for CI is estimated to be between 9-14%. In an effort to expand CI audiology services to Alaska, we started an outreach in partnership with Northern Hearing Services in Anchorage, Alaska in 2003. The partnership began with the local audiology group identifying patients and sending them to Seattle, Washington for surgery and programming (roughly a 4 hour flight). As the competency of the outreach site increased, we expanded their responsibilities and now the audiology team in Alaska identifies patients and determines candidacy. The patient comes to Seattle for surgery only and is then programmed and followed longitudinally in Alaska. All school support is provided by Northern Hearing Services. We report on 198 patients implanted since 2003 in the Alaska Cochlear Implant Network. Cochlear, MED-EL and Advanced Bionics devices are offered to patient choice. All evaluation is done in Alaska by local ENT surgeons, who also have been trained to manage minor complications. Our tertiary center provides regular support to the audiology team in Alaska as needed. Surgical complication rate is below 2%. We report on patient satisfaction, management of device failures and the expansion of hearing services overall in Alaska due to the efforts of this local consortium.

S44-2

Review of demographic characteristics of the cochlear implant recipients at an established cochlear implant program in Riyadh, Saudi Arabia

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Objective: To evaluate the demographic characteristics of the cochlear implant (CI) recipients under the CI Program at an established tertiary hospital in Riyadh, the capital city of Saudi Arabia.

Method: the demographic information of 135 CI recipients from 2008 till 2013 was analyzed descriptively. Among others, the evaluation was focusing on gender; the age of diagnosis, hearing aid (HA) fitting and CI surgery; geographical location of recipients; and unilateral and bilateral CI.

Results: There was no significant difference between the number of male and female recipients. The majority of the recipients were below 18 years old with congenital hearing loss. The recipients' age when they were first implanted was as young as 9 months old up to 78 years old. The age of identification of hearing loss also varies in which out of the 101 recipients below 18 years of age, only 22 recipients were diagnosed before 6 months old despite the availability of Universal Newborn Hearing Screening Program (UNHS); 27 were diagnosed before 1 year old; and 25 before the age of 2. Out of the 22 recipients who were diagnosed early, only 10 were fitted with hearing aids before 6 months of age. Age of implantation for children was also found to be late with only 31 recipients were implanted before the age of 2 and the majority was implanted between the ages of 5 to 10 years old. The majority of the adult recipients had acquired non-progressive hearing loss. They were mostly diagnosed in different hospitals without comprehensive audiological services, causing the gap between the time of initial diagnosis to CI surgery ranging between a year to 33 years, pending on where they were diagnosed and managed. 47% of 135 recipients were from outside Riyadh 78% of recipients had unilateral CI and out of the 22% of recipients with bilateral CI, 26 had simultaneous CI and 5 were sequential.

Conclusion: More CI Programs need to be introduced throughout Saudi Arabia. Early Hearing Detection and Intervention (EHDI) should be established in every hospital. Public Awareness on the needs for EHDI and the availability of interventions that include CI should be intensively carried out.

S44-5

Cochlear implant self-fitting

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Cochlear implants have shown to provide great improvement in the quality of life of cochlear implant recipients. Because of this recipients are highly dependent on their implants. Any disruption in sound perception through their implant can be devastating. It is important to ensure that each recipient receives the best possible outcome with their cochlear implant with no discontinuity in sound perception. Currently, Cohlear along with many service partners offer direct support to recipients where a recipient can contact the support center and get advice on troubleshooting of their device. This relieves the clinician from spending time on performing troubleshooting activities and lets them focus on their core capability of fitting, evaluating etc. This is also great benefit for the recipients as they can get greater access for troubleshooting support and quicker resolution for the issues. When the troubleshooting requires replacement of parts like the battery, cable or coil the service center is able to send the part direct to the recipient. However, when a sound processor needs to be replaced, then the service center needs to obtain the maps for the recipient from the CI clinic. This often requires the clinic to email the recipient's CDX file to the service center. Cochlear Connect is a new technology developed by cochlear that enables automatic exchange of data from the clinic to Cochlear so that when a replacement processor is required to be sent by the service center, the latest maps for the recipient can be obtained instantaneously. Cochlear Connect synchronizes the database at the clinic and sends it to a secure server that can be accessed by Cochlear. Due to the connectivity to Cochlear's systems Cochlear Connect can also in future enable other services like automatic registration of implants and sound processors and also enable automatic data sharing between clinics for clinics performing remote programming or with Hub spoke setup. The presentation will cover the technology involved in Cochlear Connect and explore the potential applications of this technology in future to enhance clinical care. Preliminary experience with Cochlear Connect at few CI clinics with regard to the impact for recipients and clinical efficiency will be discussed.

S44-7

Rehabilitation, inclusion and inclusive education of children with hearing impairment in developing countries and supportive projects

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Inclusion and inclusive education of children with hearing impairment in developing countries and supportive projects. Worldwide there are about 650 million people with a disability and 360 million people worldwide have disabling hearing loss. 80% of them live in developing countries. Most of children with a disability have a lack of access to different services, care and education. Many children with hearing impairment are not going to school and don't have access to rehabilitation either. The lecture will explain the situation of children with hearing impairment worldwide, impact of the hearing loss, inclusion and inclusive education possibilities, education placements and integration options for HI child and will inform about the support of Pink Crocodile Charity organization to this group of children.

S45 Endoscopic cochlear implantation

S45-1

The feasibility of endoscopic transcanal approach for insertion of various cochlear electrodes

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Objective: To determine the feasibility of inserting various types of electrode arrays using an endoscopic transcanal approach into the cochlea via the round window membrane (RWM).

Surgical technique: The external ear canal was injected with lidocaine 1% with 1:100.000 epinephrine. Cortical mastoidectomy until visualization of the incus was performed in all 13 cases. A 6 o'clock vertical incision was made in the meatal skin, and a posterior tympano-meatal flap was elevated transmeatally to expose the ME cavity using a rigid 0 degree endoscope 3 mm in diameter and 14 cm in length held manually, and then transposed anteriorly. The chorda tympani nerve (CTN) and body of the incus were exposed. The RWM was incised, and the electrodes were passed through the tunnel from the mastoid to epitympanum, medial to the CTN and lateral to the incus into the RW in 7 cases. The tympano-meatal flap was repositioned, and the external auditory canal was filled with Gelfoam® soaked in ear drops containing antibiotics. The surgical procedure was modified in the other 6 procedures: instead of inserting the electrodes through a tunnel, an open groove was drilled starting superiorly and laterally to the CTN and ending in the mastoid region. The electrodes were passed through the groove medially to the CTN and laterally to the incus into the scala tympani through the RW. The groove was filled with bone dust that had been collected during the drilling of the implant bed, and covered with a large piece of fascia prior to repositioning of the tympano-meatal flap, aiming to prevent extrusion of the electrode array into the external auditory canal or tracking of the canal skin into the mastoid with cholesteatoma formation.

Results: Nucleus 24 Contour Advance, Concerto and HiRes90K devices were implanted in 7, 5 and 1 ears, respectively. Complete electrode insertion via the RW was achieved and the CTN was preserved in all cases. There were no postoperative complications. Fully endoscopic CI was more feasible for insertion of Concerto electrode followed by HiRes90K and Nucleus 24 Contour Advance. An assistance of another surgeon was required for removal of stylet in the "off-the-stylet technique" utilized for implantation of the latter electrode.

Conclusion: Endoscopic transcanal implantation of different cochlear electrodes through the RW is feasible in both children and adults and can be used as first surgical option or as a complementary to the traditional posterior tympanotomy approach.

S45-2

Cochlear implant surgery through natural orifices

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Introduction: CI surgery usually involves a PTM.Most of the times practiced in normal temporal bones. It’s a surgical contradiction to destroy healthy tissues, when the objective is to replace a severe hearing loss, and the anatomical structures must be preserved not only to avoid injuries, but also to reach better functional results (e.g. EAS) Soft surgery must include not only the cochlea, but the all temporal bone as well. The best manner to reach this objective is to use anatomical orifices as a natural access to middle and inner ear. As endoscopic ear surgery (EES) and endomeatal approach (EMA) does.

Material and methods: The technique was developed and practiced in fresh temporal bones and then it was applied in patients. This surgery has an endomeatal first stage, which begins with a stapedectomy-like tympanomeatal flap. This flap allows an easy access to scala tympani via round window membrane. The internal part of a groove is drilled on the posterior wall of the EAC. The groove is parallel to the EAC axis and starts in its inner border. Once the endomeatal stage is completed, a standard retroauricular approach is performed, in order to make the receptor-stimulator well and to complete the groove externally, until it connects the middle ear with the external mastoid surface. A flat second well is drilled in front of the first one to lodge the remaining electrode lead. In small children this well is deepened. The electrode array is introduced in the scala tympani through the RW and located into the groove. The electrode is covered and fixed inside the groove with bone paté. The extra length of the electrode lead is located in the second well and the receptor-stimulator is fixed in its well. The ground electrode is placed under the periosteum, the retroauricular incision is sutured, the tympanomeatal flap is restored and a dressing is placed into the EAC.

Results: Surgical time was significantly shorter than in standard approach. Electrode insertion was easy. A multicenter study was conducted over 200 cases compared EMA to others techniques was realized and index of complications were similar and functional results adequate.

Conclusions: The goal of this approach is to avoid antromastoidectomy and posterior tympanotomy, which are replaced by the EAC groove. It is simpler and safer, eliminating the risk of facial nerve injury. It also allows a better access to the round window, with a less traumatic electrode insertion, suitable for “soft surgery” performing. It may advantageously replace the classical transmastoideal approach.

Learning outcome: Soft surgery concept must include the all temporal bone and not only the cochlea itself. To preserve healthy tissues, depends on natural orifices access. In that sense endoscopic ear surgery and EMA can complement each other, in order to overcome their own limits.

S45-3

Report of endoscopic cochlear implantation

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Objective: To report patient outcomes after transcanal endoscopic cochlear implantation for sensorineural hearing loss.

Patients: Males and females more than 9 years old with sensorineural hearing loss (confirmed with audiological studies) were selected. CT imaging was used to rule out any anatomical anomalies of the temporal bone. Smaller pediatric patients whose canal might still be growing and who might have a higher incidence of otitis media and otitis externa were excluded. Obese adults whose canal skin was too thick to allow good access down the ear canal were also excluded.

Intervention(s): Surgical (therapeutic). Endoscopic cochlear implantation using a transcanal approach.

Main Outcome Measure(s): Implant position and function. Post-operative complications specifically related to transcanal approach and use of the endoscope.

Results: Twenty-five endoscopic cochlear implantations were performed on 11 females and 10 males aged 7-65 years. All implants were fully inserted into the scala tympani and 16 functioned normally with appropriate thresholds. One implant (model N5) failed shortly post-operatively and was replaced endoscopically with no further problems. Mean time of follow-up was 11 months (SD ± 8.5). The chorda tympani was sacrificed in 2/25 procedures, 12 EAC/TM tears occurred which healed by the second follow up visit. One 2 mm marginal perforation was repaired with a fat graft. No injury to the facial nerve was observed. One postoperative wound infection resolved with 1 week of antibiotics. Implant array was visible through the EACs skin, but not exposed in 3/25 patients.

Conclusions: Endoscopic cochlear implantation may become a viable, safe, and feasible alternative to the standard open transmastoid approach.

S45-4

Endoscope assisted cochlear implantation via the suprameatal approach

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Introduction: The classic technique for cochlear implantation includes mastoidectomy followed by posterior tympanotomy, and the electrode array is inserted through a cochleostomy over the promontory adjacent to the round window niche, or through the round window niche to access the scala tympani of the cochlea.

Recently, the suprameatal approach (SMA) has gained popularity because of its simplicity and better safety concerning the facial nerve. In difficult cases, such as prominent sinus, ossified cochlea, temporal bone and facial nerve malformations, small mastoid bones, previous surgeries, posterior tympanotomy gets very difficult to achieve and surgeon can face more risks compared to the SMA. When we incorporate the endoscope in such difficult cases, visualization and maneuverability get much better and offer the surgeon tremendous help to achieve his goal in a much better way with less risks or complications.

Objective: To report the results of cochlear implantation via SMA using endoscope assisted surgery in 20 patients operated in the department of otolaryngology, University of Alexandria, Egypt; and to discuss the details of the technique and difficulties as well as report complications.

Results: Endoscope assisted surgery using the SMA approach proved a reliable and safe approach for soft surgery cochlear implantation. Visualization of the round window and insertion of the electrode under endoscopic control was significantly reliable and successful in all cases. Postoperative CT scan of the temporal bone was performed to document electrode insertion for all the patients.

Conclusion: the endoscope assisted SMA technique for cochlear implant is simple, safe and reliable approach. It avoids any risks to the facial nerve and offer excellent visualization to the round window niche. Additionally, endoscope enables visualization of the cochlear inside structures facilitating atraumatic insertion of the electrode array into the scala tympani.

S46 Bimodal hearing

S46-1

The bimodal benefits of cochlear implantation for unilateral deafness

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Patients with unilateral deafness lack the benefit of binaural hearing. They usually report difficulties understanding speech in presence of background noise and speech coming from the side of hearing loss and poor sound localization. In addition, a large number of these patients suffer from tinnitus that cannot be treated by conventional masking devices. This study aimed to investigate the benefit of cochlear implantation on speech perception, tinnitus suppression, and sound localization in these patients. Twenty-eight subjects with unilateral post lingual sensorineural profound hearing loss, with and without tinnitus, were recruited for this study. The patients had unilateral hearing loss greater than a 4-frequency pure tone average (0.5-4kHz) of 70dBHL and contralateral hearing was ≤ 30dBHL. All patients were implanted with a Flex soft electrode array and received an Opus 2 speech processor (MED-EL, Austria). Speech perception was assessed using the BKB-SIN in three spatial configuration: speech and noise from the front; speech from the front and noise from the hearing ear; speech from the CI side; and noise from the hearing ear. Subjective benefits were assessed using the Speech, Spatial and Qualities of Hearing (SSQ) questionnaire and the APHAB (Abbreviated Profile of Hearing Aid Benefit). Localization abilities were also evaluated. Tinnitus was assessed using the Tinnitus Reaction Questionnaire. Analysis of the results reveal a significant improvement in signal to noise ratio in all spatial configurations as well as on the localization abilities, SSQ and APHAB scores. Cochlear implantation is a viable treatment option for unilateral deafness, providing an improvement in hearing performance, decrease of tinnitus perception and high subjective acceptance of the implant. Auditory training appears to be a key factor for successful rehabilitation.

S46-5

Speech perception performance in a group of post-verbal adults with bimodal stimulation

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Objectives: Patients with a cochlear implant in one ear and a hearing aid in the other side commonly achieve the highest speech-understanding scores when they have access to electrically and acoustically stimulated information at the same time. The aim of the study is the evaluation of speech perception advantages using the combining stimulation

Design: The subjects were 18 bimodal listeners with a cochlear implant (CI) in one ear and an acoustic hearing aid (HA) in the other side. All participants were adults with a post-verbal hearing loss, oral language users, had open-set speech understanding with the cochlear implant only, sufficient residual hearing for amplification in the contralateral ear, a good experience with hearing aids prior to surgery and a stable cochlear implant MAP for the past 3 months. All patients were submitted to audiometric thresholds (500-4000 Hz), speech-understanding scores (two-syllabic and tri-syllabic words, sentences and confusion phoneme matrix with speakerphone and voice recorded) in quiet and in noise condition (signal-to-noise level of +10 dB SNR). All tests were performed with CI and HA only and in combined stimulation, the follow-up was conducted in pre-implantation time and after 6 and 12 months after auditory rehabilitation.

Results: Significant improvement of speech perception tests were found when the acoustic and electric stimulation were combined simultaneously. The bimodal stimulation ensured an improvement of speech perception in quiet but especially in noise condition. Benefit was significantly correlated with the audiometric thresholds and with the speech understanding performance in the hearing aided ear before implantation.

Conclusions: Data obtained from our first analysis confirm the efficacy of the use of Hearing Aid in the contralateral ear to CI when is possible.

These initial data support the hypothesis that the improvement is significantly better in noise condition.

S47 Outcomes in adults

S47-1

Adult cochlear implant candidacy: Revised indications clinical trial results

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Intro: The objective of the IDE clinical trial was to evaluate a broader indication for use among postlingually deafened adults.

Methods: Inclusion criteria for the multi-center clinical trial included postlingual adults who presented with preoperative aided CNC word scores in quiet that fell between 10% and 40% in the ear to be implanted and ≤ 50% in the contralateral ear. In addition, audiometric data had to demonstrate bilateral moderate to profound hearing loss in the low frequencies (up to 1000 Hz) and profound sensorineural hearing loss in the high frequencies (3000 Hz and above). Subjects were evaluated preoperatively as well as initial activation, 3, 6, and 12 months post-activation. Outcome measures included hearing sensitivity, speech understanding in quiet (CNC words) and in noise (AzBio sentences, 5 dB SNR) as well as pitch perception.

Results: Twenty subjects with a mean age of 70.6 years (range 32.8 to 88 years) were implanted at 10 institutions. Results demonstrate significant gains in performance for speech understanding for CNC words (P = < 0.001) at all intervals post activation and in noise using AzBio sentences at 12 months post activation (P = 0.003). No significant difference was observed in pitch perception preoperatively to 6 months post-activation.

Discussion: Results confirm that adult candidates who exceed the currently approved FDA guidelines benefit from cochlear implantation.

Conclusion: Current candidacy criterion does not adequately identify those in need of a cochlear implant; revised indications are needed. The data collected within this clinical trial as well as within published research support the opinion that the current candidacy criteria for adult cochlear implantation are set conservatively.

Learning outcome: Attendees will be able to apply more appropriate test measures and counsel their adult patients on the outcomes associated with cochlear implantation.

S47-4

Mental health and cochlear implantation in postlingually deafened adults

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Postlingually deaf individuals experience mental distress, particularly depression, with significantly higher intensity. Although medical intervention, such as cochlear implantation in adults who lost their hearing, is widespread, there are still only a few studies concerning mental health of these patients. The aim of this study is to compare the postlingually deafened CI users with hearing individuals from the general population regarding their self-esteem and areas in which they experience mental distress. Additionally, a question has been asked whether the socio-demographic variables such as gender, age, marital status or occupational status, and deafness-related variables such as duration of deafness, length of CI experience and CI satisfaction may be predictors for mental distress and self-esteem. The study involved 77 postlingually deafened individuals CI users. Mental distress, including somatic symptoms, anxiety, social dysfunctions and depression, has been measured using the GHQ-28 questionnaire, and self-esteem using the SES Rosenberg scale. It turned out that the postlingually deafened women using CIs experience mental distress significantly more intensively, including somatic symptoms, anxiety, social dysfunctions and depression, compared to male CI users, while in comparison to normally hearing women they have more intensive depression symptoms and lower self-esteem. Postlingually deafened male CI users are different from normally hearing men only in lower self-esteem. Increased psychological distress may be expected in the postlingually deafened women using CIs, and in the individuals with lower CI satisfaction levels. In relation to self-esteem, it turned out that its predictors are being married (or in partnership) and CI satisfaction. Results of the study show that risk of the mental health problems (depression) concerns particularly the postlingually deafened women using CI, while we should expect to find the low self-esteem in all postlingually deafened individuals, regardless of their gender, particularly if they have no partner. Program of rehabilitation of patients with postlingual deafness before and after cochlear implantation should include an offer of psychological intervention, psychotherapy and other forms of psychological support.

T2 Medical documentation: ear and cochlea implant database – why the clinician needs a scientific database and the scientist needs a clinical database

T2-1

Ear and cochlea implant database - why the clinician needs a scientific database and the scientist needs a clinical database

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Introduction: Nowadays most ENT Departments have to implement an electronic medical record system. Rarely physicians are asked to evaluate or even design a user friendly data recording system, but the hospital administration has already made their decision. All academic teaching centers are keen to publish clinical and research topics and rely on tracing patients data. Every otologist should be enthusiastic to constantly evaluate his own results and learn from his failures. The ENT*statistics* database was designed by otologist and may fulfill these needs.

Material and methods: Over the last 7 years a clinical and research otology and cochlear implant database was developed in collaboration with innoForce Est. The prerequisite was not to replace existing medical recording systems but to complement them. Caring for cochlear implant patients, a team approach is needed and all members of the team do need access to import and retrieve data.

Results: Whereas digital information from the hospital database (e.g. audiograms, personal patient's data) are automatically imported, each CI team member has his own task to complete the dataset. Starting with a preoperative checklist to summarize the preoperative testings and results, the audiologist, surgeon, engineer, speech therapist and secretaries add their values to complete the follow-up of each patient. The results of surgery and rehabilitation have to be analyzed on a regular basis to improve the outcome of our patients.

Conclusions: The requirements to run a user friendly database and the impact on clinical and scientific work is summarized and demonstrated using the cochlear implant program of the ENT*statistics* database.

T2-2

The Munich^{LMU} Otologic Database - ENT*statistics,* ©by innoForce Est

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Introduction: Objective results in otology are easy to achieve and measureable in most cases. However, reliable data of the surgical outcome (mostly audiometric data) and the exact surgical procedure (i.e. which prosthesis) is crucial for surgical benchmarking. An almost 100% follow up rate is as desirable as a standardized audiometric protocol. Hence, an easy access and user-friendly otologic database is mandatory for the faithful ear surgeon. The ENT*statistics* database designed by innoForce is such a tool.

Material and methods: All middle ear surgeries with all follow up examinations of the past four years were retrospectively included in the database. Every hearing test created with the Avantgarde 4.0 audiometry software (Ingenieur Nuess) at Campus Großhadern and Innenstadt is automatically migrated to the new Munich^{LMU} Otologic Database.

Results: The various possibilities of analysis and benchmarking will be demonstrated live and directly in the session in real time. Tough and unvarnished data will be shown to all different kinds of middle ear surgeries and different prosthesis. A vivid discussion is expected about the sense and non-sense of quality management in ear surgery.

T3 Electrophysiology and cochlear implants

T3-2

Acoustic neural response telemetry: The equipment and methodology needed to measure residual hearing

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Introduction: In recent years criteria for indication for cochlear implantation has been broadened to include patients with residual hearing in the low frequencies (< 2KhZ). Patients with residual hearing can benefit from electroacoustic stimulation by means of hybrid speech processors provided that the residual hearing is preserved. Here we present a method of measurement of residual hearing using a modified Nucleus NRT® software.

Methods: Before draping the patient for surgery an insert earphone is placed in the ear canal of the ear to be implanted. The earphone is used to deliver sound during measurements. When the receiver stimulator is placed in the periosteal pocket the speech processor coil is placed over the receiver stimulator coil under the drapes. The modified NRT software delivers a synchro signal to the sound source and a code to the receiver stimulator to acquire any acoustically evoked auditory nerve response. Measurements can be made during the insertion of the electrodes, following the full insertion of the array and at any time during the use of the implant.

Results: Ears with residual hearing have been tested during the insertion of the array, at full insertion of the array and during the use of the implant.

Conclusions: A simple adaptation of the neural response telemetry software with addition of an acoustic input allows accurate measurement of residual hearing.

T6 Instructional course: Assessment of auditory performance according to minimal outcome measurements in cochlear implantation

T6-2

Instructional course: Assessment of auditory performance according to minimal outcome measurements in cochlear implantation

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The objective of this instructional course for young clinicians and researchers is to learn about the recent formulated guidelines on minimal outcome measurements for cochlear implantation. Assessment and reporting of CI performance is important to evaluate CI efficacy in the individual patient as well as for CI in general. However, to date, many different assessment tools are used in order to determine this level of auditory performance. Due to the wide variety of test materials and test levels reported results with CI are difficult to compare. In order to facilitate multicenter research, meta-analysis, and studies in large cohorts of patients and in order to improve comparability of reported results the minimal outcome measurements (MOM) were established. The MOM testing is an international consensus stated by the HEARRING network of CI centers. These guidelines contain recommendations on test material, speech levels, calibration, test moments etc. The MOM can be used as a protocol for clinical and scientific data collection and reporting and for the establishment of a CI registry. The MOM may enhance the quality of clinical assessment and reporting and increase multicenter research collaboration opportunities.

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WS1Peripheral models and their use in developing coding strategies

WS1-2

Conceptual and computational models of temporal coding by electrical stimulation of the auditory nerve

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In the cochlear implant (CI) literature, interpretation of psychophysical and evoked-potential data is often based on the assumption that auditory nerve (AN) fibers can very faithfully encode electrical pulse trains, with the only limitation being very short refractoriness (< 1 ms). However, recent physiological data suggest that a number of different types of temporal interactions can occur in AN fibers, as well as refractoriness that can extend out to at least 4 ms. In the first part of this talk, I will discuss conceptual models of *refractoriness*, *accommodation*, *adaptation* and *facilitation* to describe the types of temporal interactions that are observed in the physiological data. Second, I will explore some potential biophysical mechanisms behind the different forms of temporal interaction and describe computational models that are being developed to evaluate the possible biophysical causes. Preliminary simulation results suggest a number of different voltage-gated ion channels could contribute to the variety of temporal response properties measured in the physiological data. Furthermore, it appears that the ion channel locations and the site of action potential generation on the AN fiber may additionally contribute to the observed heterogeneity of temporal interactions in the data.

WS1-5

A phenomenological model to reproduce the latency distribution and threshold of the electrically stimulated auditory nerve fibre

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Biophysical models have been developed which accurately reproduce the response statistics of the electrically stimulated auditory nerve fibre (ANF). However, these models are difficult to parameterize and are computationally demanding, making them inconvenient for studying population coding. We present a novel, computationally inexpensive, phenomenological model of the electrically stimulated ANF that has been verified using monophasic and biphasic stimuli in isolation. The main contribution of the model lies in its ability to reproduce statistics of the ANF response (mean latency, jitter, and firing probability) under both monophasic and excitatory-leading biphasic stimulation, without changing the parameters of the model. In both cases, the response statistics of the model depend on stimulus level, reproducing trends observed in the ANF. In the case of biphasic stimulation, the response statistics of the ANF depend on the interphase gap (IPG) of the stimulus pulse, an effect that is qualitatively reproduced by the model. The model is fitted to ANF data using a procedure that uniquely determines each model parameter. Our work extends the stochastic leaky integrate and fire (SLIF) neuron, a well-studied phenomenological model of the electrically stimulated neuron. The SLIF neuron is capable of reproducing the strength-duration and input-output functions of the ANF in response to monophasic stimuli. However, the SLIF neuron responds to stimuli immediately and with almost no temporal variability (~1 µs standard deviation), where-as the response of the ANF is delayed by between ~0.4 and ~1.2 ms, with standard deviation (jitter) between ~5 and ~300 µs, depending on stimulus level. Further, the SLIF neuron does not reproduce the increase in threshold that is observed in the ANF response to excitatory-leading biphasic stimuli, relative to monophasic stimuli. We extend the SLIF neuron so as to produce a realistic latency distribution by delaying the moment of spiking. During this delay, spiking may be abolished by inhibitory current. This reduces the probability of biphasic stimuli evoking a response, relative to monophasic stimuli. By introducing a minimum wait period that must elapse before a spike may be emitted, the biphasic threshold may be adjusted relative to the monophasic threshold, and thus, the model may be parameterized to reproduce the differences in threshold observed in the ANF. Because of the ease with which the model may be parameterized, it is possible to simulate large populations of neurons, reproducing for each response statistic the distribution of values observed in the ANFs. The model is thus useful in the investigation of population coding with cochlear implants, and may facilitate in the development of cochlear implant stimulation strategies that evoke responses which closer mimic those observed in the auditory nerve of the normal-hearing ear.

WS1-6

Making use of auditory models for better mimicking of normal hearing processes with cochlear implants: the SAM coding strategy

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Mimicking the human ear on the basis of auditory models has become a viable approach in many applications by now. However, only a few attempts have been made to extend the scope of physiological ear models to be employed in cochlear implants (CI). Contemporary CI systems rely on much simpler filter banks and simulate the natural signal processing of a healthy cochlea to only a very limited extent. When looking at rehabilitation outcomes, current systems seem to have reached their peak potential, which signals the need for better algorithms and/or technologies. In this presentation, we introduce a novel sound processing strategy, SAM (Stimulation based on Auditory Modeling), that is based on physical and neurophysiological models of the human ear and can be employed in auditory prostheses. It incorporates active cochlear filtering (basilar membrane and outer hair cells) along with the mechanoelectrical transduction of the inner hair cells, so that several psychoacoustic phenomena are accounted for inherently. The presentation elaborates on the following topics: signal processing in SAM, key aspects of the software implementation, computational evaluation, comparison with other strategies, results of the pilot study with CI users, and simulation studies (keywords: auralization, localization, speech perception). Furthermore, an overview of ongoing enhancement work and of possible future directions will be given. Results of the studies so far show that many aspects of normal cochlear processing that are missing in common strategies can be replicated by SAM. This, we suppose, can improve overall CI user performance without changing the electrode setup of current CI systems.

Reference: T. Harczos, A. Chilian, and P. Husar, “Making use of auditory models for better mimicking of normal hearing processes with cochlear implants: the SAM coding strategy,” *IEEE Transactions on Biomedical Circuits and Systems*, vol. 7 (4), DOI: 10.1109/TBCAS.2012.2219530, pp. 414-425, 2013.

WS2 Peripheral models and their use in developing coding strategies (continued)

WS2-1

Towards coding strategies for cochlear implants based on neural excitation measurements and models

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Sound coding for cochlear implants traditionally relies on signal properties and concepts developed for communications systems. The detailed capacity of electrically stimulated neurons to convey spatio-temporal information on an individual basis, however, has not been fully taken into account in practical applications. One way of tackling this problem is to combine a signal processing strategy with a model of auditory nerve fiber population responses to electrical stimulation. A simulation model for auditory nerve responses to constant or time-varying electrical pulse train stimulation was implemented in MATLAB and used to reproduce animal (literature) and human (own measurements) data. The model includes refractory and stochastic membrane properties of neuronal excitation and allows varying the electric field distribution along the basilar membrane.

Two variations of an excitability controlled processing model were integrated into a coding strategy, implemented in Matlab/Simulink and evaluated in pilot experiments. The first strategy, called Refractory State Coding (RSC), is effectively able to reduce both spatial and temporal clustering. Initial laboratory tests involving recognition of VCV logatomes with RSC with 9 CI listeners demonstrated that RSC was not significantly poorer than the listeners´ standard ACE strategy. The second strategy, called Excitability Controlled Coding (ECC), encodes the signal intensity on a given channel into the stimulation rate instead of the stimulation level. ECC therefore encodes loudness by varying the stimulation rate, while keeping the stimulation level constant. One aim of ECC is to minimize channel interaction arising from the electric field spread, since the stimulation level, which is assumed to be the primary parameter related to electric field spread, will not increase with increasing signal intensity. Currently, parametric variations of the two strategies are being evaluated in psychophysical experiments and compared to model predictions.

WS2-2

Cochlear implant stimulation strategies based on neuroscience

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Cochlear implants are up to now the most successful man-made interfaces to the neural system. The auditory nerve is stimulated electrically which leads to a partial restoration of hearing and auditory perception for persons with severe hearing impairment. Speech understanding of cochlear implant (CI) recipients in quiet environments can be very good, but considerably worse in more real-life and adverse listening situations. Although modern CIs use up to 22 stimulation channels, the information transfer is still very limited for the perception of fine spectro-temporal details to allow the perception of music and speech communication in common real-life auditory scenes. The limitations have become clear after years of research. One approach in research on cochlear implant stimulation strategies, is to enhance spectro-temporal features in the signal. Examples will be given of enhanced representation of these features in the signal coding based on neuroscience rationales and leading to improved directional hearing and speech perception in challenging listening scenes.

WS3 "Binaural hearing with electric stimulation – the “Munich Center for NeuroSciences – Brain and Mind" session"

WS3-1

Binaural cochlear implant: Models and issues

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Modeling work that describes neural responses to stimulation from binaural cochlear implants will be presented and reviewed. Issues that are addressed include the adaptive shunting of low-threshold potassium channels, the loss of binaural synchrony in stimulation of binaural neurons, and the consequences of weak interaural sensitivity. Single-neuron models are used to describe measured responses to electrical stimulation at multiple levels within the ascending auditory pathway. The resulting neural patterns are interpreted in terms of their ability to code useful binaural information. Effects of stimulation parameters on perceptual ability to make use of binaural information will also be discussed.

WS3-2

Improving sensitivity to interaural time differences with cochlear implants at high stimulation rates: Insights from neural data

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Poor sensitivity to interaural time differences (ITDs) constrains the ability of human bilateral cochlear implant (CI) users to listen in everyday noisy acoustic environments. Perceptual ITD sensitivity to periodic pulse trains degrades sharply with increasing pulse rate, but can be restored at high pulse rates by jittering the interpulse intervals in a binaurally coherent manner or by amplitude modulating the pulse train (Laback & Majdak PNAS 105:814; Noel & Eddington JASA 133:2314). With the goal of devising new processing strategies to deliver ITD information more effectively, we investigated neural coding of jittered and amplitude-modulated pulse trains by recording from single inferior colliculus (IC) neurons in bilaterally-implanted, anesthetized, deaf cats. The neural basis of the jitter effect was studied by measuring responses to trains of biphasic pulses as a function of pulse rate, jitter, and ITD. High-rate periodic trains evoked only an onset response in most IC neurons, but introducing jitter increased ongoing firing rates in about half of these neurons. Neurons that had sustained responses to jittered high-rate pulse trains showed ITD tuning comparable to that produced by low-rate periodic pulse trains. Action potentials tended to occur reproducibly at sparse, preferred times across repeated presentations of high-rate jittered pulse trains. Spike triggered averaging of such responses revealed that firing was triggered by very short interpulse intervals. Thus, it may be possible to restore ITD sensitivity to high-rate periodic carriers simply by inserting short interpulse intervals at select times. Neural ITD coding of high-rate, amplitude-modulated pulse trains was studied using stimuli in which both the repetition rate and the width (or attack time) of each envelope cycle could be varied independently so as to represent the diversity of envelope shapes contained in natural sounds. Neural ITD coding was generally enhanced by insertion of silent intervals between bursts of sinusoidal modulation. In some neurons, ITD coding was best for low repetition rates with minimal dependence on envelope width. In others, coding was best for brief envelope bursts (high attack slopes) with lesser sensitivity to repetition rate. Future CI processing strategies that enhance envelope attack slopes and maximize silent intervals are likely to improve ITD coding. Where such processing would excessively distort the envelopes of natural sounds, insertion of short interpulse intervals may provide alternative means of transmitting ITD. Thus, our neural results suggest complementary strategies for improving ITD coding for natural stimuli, including speech.

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WS3-3

A bilateral cochlear-implant sound coding strategy inspired by the medial olivocochlear reflex

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In healthy ears, cochlear sensitivity and tuning are not fixed; they vary depending on the state of activation of medial olivocochlear (MOC) efferent fibers, which act upon outer hair cells modulating the gain of the cochlear amplifier. MOC efferents may be activated in a reflexive manner by ipsilateral and contralateral sounds. Activation of the MOC reflex (MOCR) is thought to unmask sounds by reducing the adaptation of auditory nerve fibers response to noise. This effect almost certainly improves speech recognition in noise. Furthermore, there is evidence that contralateral stimulation can improve the detection of pure tones embedded in noise as well as speech intelligibility in noise. The unmasking effects of the MOCR are unavailable to current cochlear implant (CI) users and this might explain part of their difficulty at understanding speech in noise compared to normal hearing subjects. Here, we describe a bilateral CI sound-coding strategy inspired by the MOCR. Compared to two independent sound processors, the proposed MOCR-inspired processor enhances inter-aural output differences, reduces noise within and across channels, and improves within-channel amplitude modulations.

WS4 Improving speech perception with cochlear implants using model-based approaches

WS4-1

Towards a model based coding strategy for cochlear implants using spectral contrast enhancement

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Introduction: Considerable variation in speech intelligibility outcomes when comparing two sound coding strategies has been seen in many clinical studies, even if the study participants were postlingually hearing impaired adults and had at least 2 years of experience with their cochlear implant. One possible reason that might explain this variability is the electrode nerve interface of each individual which has an impact on the spectral resolution of a Cochlear Implant. Spectral resolution has been reported to be closely related to vowel and consonant recognition in CI listeners (1). One measure of spectral resolution is the spectral modulation threshold (SMT), which is defined as the smallest detectable spectral contrast in the spectral ripple stimulus (1).

Methods: In this study we hypothesized that an algorithm which is able to improve SMT might also be able to improve vowel recognition, and consequently produce an improvement in speech understanding. For this purpose we implemented an algorithm termed Spectral Contrast Enhancement (SCE) that is able to emphasize peaks with respect to valleys in the audio spectrum (2;3). This algorithm can be configured with a single parameter, the Spectral Contrast Enhancement (SCE) factor. Additionally, we investigated whether the “SCE factor” can be individualized for each CI user to maximize their vowel identification scores.

For this purpose we developed a peripheral model of the neural activity evoked by CI stimulation. The model has been individualized to the electrode nerve characteristics of each study participant, for example using information about their cochlear size, electrode position and impedance measurements. Next, the parameters of the model were adjusted using a pattern recognition algorithm to match the SMT of each subject. Finally, the model was used to predict the performance produced by the SCE algorithm with two different “SCE factors” in a vowel identification task.

Results: In 7 CI users the new algorithm has been evaluated using a SMT task and a vowel identification task in noise. Audio signals were processed with and without the SCE algorithm and presented to the CI users through the nucleus research interface at an equivalent level of 65 dB SPL. The task was performed for SCE factors of 1 (no enhancement), 3 and 5.

6 out of 7 CI users obtained an improvement in the SMT task corresponding to their improvement in vowel identification scores with an SCE factor of either 3 or 5. The mean improvements obtained by the SCE algorithm for the SMT and the vowel/consonant identification task were 1.9 dB and 5% respectively. The individualized cochlear implant model was able to predict the optimal “SCE factor” for all study participants.

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WS4-2

Anatomical and physiological parameters cause inter-individual variances in the neural representation of speech in cochlear implant users

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Cochlear implant (CI) users show a huge variation in performance. It is therefore likely that they would benefit if their coding strategy could be adapted to their individual strengths and weaknesses. The studies published by Nelson et al. (2008, 2011) show huge differences in the spread of excitation (SOE) across CI users. Some subjects even show large variations in SOE for different electrode locations, where variations in SOE lopes between 0.5 dB / mm and 2.5 dB / mm are not uncommon. However, the development of strategies that are able to compensate individual differences requires a deep understanding of the physiological causes which limit performance in each patient. To tackle this question, we have developed a model framework, which allows us to study how physiological variations in the implanted cochlea impact speech coding in the auditory nerve. The study presented here focuses on inter-individual differences observed in channel cross talk. This study investigates possible reasons that lead to SOE variations based on an electro- anatomical model (EAM) of an idealized human cochlea. The most important anatomical, physiological and operational parameter variations were covered and their influence on SOE evaluated. For the quantitative analysis of neurophysiological variations, such as the distribution of the nerve fibers and the formation of „dead regions zones" (DRZ) (Moore and Glasberg 1997), this EAM model was combined with a nerve population model in which the number and the distribution of spiral ganglion cells along the cochlea was varied (Nicoletti, 2013). The type I spiral ganglion neurons are modelled with single- or multi-compartment models with Hodgkin-Huxley like ion channels, which are also found in cochlear nucleus neurons (HPAC, K_{HT}, K_{LT}). Their large time constants might be responsible to explain adaptation to electrical stimulation (Negem & Bruce 2008). Conductance's and time-constants were corrected to a body temperature of 37°. The differential equations were solved in the time domain with the Crank-Nicolson method and an exponential Euler rule. The model predicts that SOEs differ between near and far field (Briaire 2000) and shows which parameters influence SOEs most. Furthermore, the model quantifies the impact on the neural representation of speech. It demonstrates that with a decreasing number of nerve cells the probability of DRZs increases. With more than 5,000 nerve cells the cochlear spiral is covered sufficiently homogeneous with ganglion cells to represent spectral components relevant for speech coding. For cell count of less than 5,000 randomly distributed nerve cells along the cochlea, the probability for the formation of DRZ increases, which is consistent with observations from Blamey et al. (1997) and Khan et al. (2005). Finally, our model shows that not the absolute number of spiral ganglion cells is important for the performance of a CI-user, but also how they are distributed across the cochlea.

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WS4-3

A model of speech intelligibility in cochlear implant users

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Cochlear Implant (CI) users show a large variability in speech-in-noise recognition performance. While some CI users obtain speech reception thresholds (SRTs) that are close to those of normal-hearing listeners, others show SRTs of +10 dB SNR or higher, which implies a strong limitation in their ability to communicate in acoustically adverse conditions. In order to better understand the large variability found in CI users, a functional model predicting speech intelligibility based on individual characteristics of the CI user would be desirable, which can be used to evaluate and optimize speech processing and coding strategies. As a first step towards this goal, this contribution introduces a functional spiking model of the electrically stimulated auditory system applied to model speech recognition in CI users. The model consists of a series of stages that (1) generate the electric stimulation pattern from the acoustic speech+noise input, (2) mimic the spatial spread of the electrical field in the fluid, (3) model the stochastic behavior of a series of auditory nerve cells in response to electric stimulation and (4) mimic central processing, as well as different degrees of deprivation of the central auditory pathway. A speech recognizer is used for classifying the so-computed internal representations, which contain all those speech cues that the CI user has access to. This approach is used to predict SRTs for a sentence test in noise.
In the first part of the talk, we will show how specific parameter changes in the model systematically affect estimated speech recognition performance. Reducing the number of auditory nerve cells while increasing the spatial spread function resulted in poorer speech recognition. Furthermore, a reduced cognitive performance showed an additional negative impact on the speech recognition, especially if only a few auditory nerve cells were available. A physiologically plausible variation of model parameters resulted in a SRT range that was also quantitatively observed in clinical studies with a large CI user population.
In the second part of the talk, we will outline some applications of the model and show some first results. One application is to use the model to predict SRTs of individual CI users for which the spatial spread of the electric field is known and for which the deprivation of the auditory pathway is estimated from anamnesis data and cognitive abilities. A second application is to use the model to predict speech intelligibility benefits of a noise reduction algorithm. A third application is to extend the model with a low-frequency acoustic component to predict speech intelligibility of hybrid electroacoustic users.

SNAPSHOT PRESENTATIONS

KN2 Middle ear implants

KN2-6

Experiences of VSB (Vibrant Soundbridge®) in twelve cases with moderate to severe mixed hearing loss

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In Japan, the clinical trial of VSB (Vibrant Soundbridge®, MED-EL) implantation has just been completed recently. Twenty-seven patients were enrolled in the trial so far at 13 different medical centers and the data concerning on the effectiveness and the safety of VSB implantation has been collected and is under the systemic analyses at present. In our institute, twelve patients received VSB implantation, of which 11 patients were enrolled in the clinical trial and received the VSB on either the right or left side for the first time. Round window vibroplasty was completed in ten patients and oval window vibroplasty was performed in one patient. While the remaining one patient received the second VSB on the right side after removing the BAHA (Bone-anchored hearing aid®, Cochlear) on the same side. Surgical techniques and hearing performances before and after the surgery should be shown and discussed.

KN2-7

Low frequency amplification with direct inner ear stimulation - new possibilities with VSB

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Objective: To date, normally the Vibrant Soundbridge (VSB) applications have managed to stimulate the inner ear indirectly. The systemic problem is the limited gain in the low frequencies. Our objective was to find out whether direct inner ear stimulation is suitable to overcome this problem.

Patients: Five patients with previous middle ear surgery and moderate-to-severe ipsilateral, mixed hearing loss.

Interventions: Intracochlear vibroplasty for direct acoustic cochlear stimulation. The oval window coupler was attached to the floating mass transducer (FMT). Then, the stapes footplate was perforated, and the tip of the FMT-OW-Coupler assembly was advanced approximately 1 mm into the inner ear. A silicon ring was placed around the tip to prevent it from slipping deeper into the inner ear.

Results: Inner ear vibroplasty resulted in an average functional hearing gain of 36.1 dB (range, 24.2-47.5 dB). Although the greatest amplification was observed in the higher frequencies, there also was a significant improvement in the lower frequencies. The surgery was not related to any difficulties; vertigo, or further complications did not occur. Nevertheless in one patient an inner ear trauma occurred.

Conclusion: We present a new method for direct intracochlear stimulation using an active middle ear implant. The results show that direct inner ear stimulation with VSB is a promising option for treating moderate and severe hearing loss, even in challenging cases with previous middle ear surgeries or fixed stapes footplate and reduced inner ear function in low frequencies.

KN2-10

First European multicentric analysis of the use of a new semi-implantable hearing device: Ototronix Maxum System

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The Ototronix Maxum System is a semi-implantable hearing device with FDA approval and CE mark. The implant consists of a rare earth magnet encased in a titanium canister that is attached to the ossicular chain by positioning a collar around the neck of the stapes without separation of the incudostapedial joint. The external processor has a custom-made earmold coil assembly inserted deeply into the ear canal. The processor sends signals to an electromagnetic coil located in the ear canal near the tympanic membrane, thereby directly stimulating the magnetic implant and thus the ossicles. This arrangement eliminates the use of sound energy in the canal and thus could offer several possible advantages over hearing aids (no occlusion effect, reduced distortion, improved functional gain without precipitating feedback). The digital processor incorporates directional microphones, noise cancellation, and wide dynamic range compression. The first European multicentric analysis was conducted with four tertiary referral centers (Basel, Rome, Antwerp, Béziers) where a total of 12 devices were implanted in patients with moderate-severe to severe high-frequency sensorineural loss, particularly high-frequency ski-slope hearing loss. The first results at 6 months after activation will be presented including the statistical analysis of data as: pre-and postoperative air and bone conduction thresholds, functional PTA gain (at different frequencies), speech discrimination, subjective measures of feedback, occlusive effect, perceived aided benefit, patient satisfaction, and device preference when compared with the patient´s optimally fitted hearing aid.

KN2-11

Evaluation of the benefits of the MAXUM system on bimodal hearing in patients with severe sensorineural hearing loss, wearing a cochlear implant in the contralateral ear

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Introduction: The purpose of this study is to evaluate the effectiveness of a partially implanted hearing device (MAXUM system) in patients with a cochlear implant (CI) in one ear and residual hearing in the opposite ear, as compared to a traditional hearing aid.

Methods: Six adult patients with a CI in one ear, residual hearing in the opposite ear (>20% Hearing in noise test [HINT]), and an ear canal large enough to fit the MAXUM system were enrolled. Insertion of the MAXUM magnet was performed under general anesthesia via a transcanal approach in an ambulatory operating room setting. Pre and post-operative evaluations included unaided and aided audiometry and soundfield testing (Consonant Nucleus Consonant [CNC], HINT in quiet and noise, AzBio). Post-operative testing was performed at activation (6 -8 weeks after surgery) and 6 weeks post-activation. Each subject had visits at 1, 3, 6, 12, and 18 weeks post-implantation to evaluate their healing process. Quality of life measures were assessed using the Abbreviated Profile of Hearing Aid Benefit (APHAB), Hearing Handicap Inventory (HHIE), and the Hough Ear Institute Profile (HEIP) surveys.

Results: One patient required explantation due to middle ear granuloma formation and was not included in data analysis. Four-frequency PTA was 78.75 dB HL unaided, 36 dB HL with a hearing aid, and 47.8 dB HL with the MAXUM at activation. Soundfield discrimination scores (% correct) using the CI and hearing aid, versus the CI and MAXUM, were 70.33 and 73.6 (CNC), 98.8 and 93.33 (HINT in quiet), 77.8 and 87.67 (HINT in noise), and 78 and 79 (AzBio) respectively. Average APHAB scores were 69% preoperatively, and 70.5% at 6 weeks after MAXUM activation. Average HHIE emotional score was 30.5 preoperatively, and 23 at 6 weeks after MAXUM activation. Average HHIE situational score was 30.5 preoperatively, and 22.5 at 6 weeks after MAXUM activation. Three out of five patients reported better sound quality, less feedback, and higher level of satisfaction with the MAXUM on the HEIP survey.

Discussion: Binaural stimulation has been proven to be more beneficial in patients with bilateral sensorineural hearing loss as compared to monoaural CI stimulation. Although audiometric testing did not show superiority of the MAXUM over the patients' power hearing device, more patients preferred the MAXUM for its high fidelity sound and less feedback. HHIE emotional and situational scores improved by 7.5 and 8 points, respectively.

Conclusion: Based on our preliminary results, the MAXUM implant may play a role in the aural rehabilitation of patients with a CI in the contralateral ear, who are unable or unwilling to undergo bilateral cochlear implantation.

Learning outcome: Bimodal stimulation using a CI with a middle ear implant device is a viable option for patients with bilateral severe sensorineural hearing loss.

KN2-12

The PowerMax middle ear implant for mixed hearing loss

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In chronic ear disease surgery it has always been a challenge to improve the postoperative hearing. Not only must the pure tone average improve, but the SNHL component must be improved as well. In the past, this challenge has been relegated to hearing aids (HA). Unfortunately, it is not possible for a hearing aid to produce enough functional gain to accomplish this goal. The conductive component of the mixed loss has been addressed in the past with the use of TORPS and PORPS. The results have been less than stellar. There are several reasons for this failure. The prosthesis must be interspersed between the stapes superstructure or the stapes footplate and the tympanic membrane. Even when the middle ear is packed with gealfoam, the prosthesis is subject to the effects of gravity. Not only that, but the SN component is not addressed. So, how is the best way to deal with this situation? The solution must include a method to improve the conductive as well as the SN component. It has been well established that direct driving the stapes or the stapes footplate will result in improvement of both a conductive loss as well as a sensorineural one. That would imply that the solution to this problem lies with a combination of a middle ear prosthesis and a Maxum magnet. This devise is referred to as a PowerMax. By attaching the device to the EAC at the annulus with a special anchor it is possible to negate the effect of gravity. The power of the magnet attached to the prosthesis will drive the stapes of stapes footplate directly overcoming both the conductive as well as the SN component of the hearing loss. This course will describe the surgical process and give laboratory data obtained on fresh temporal bones to prove the validity of the concept.

KN2-13

Surgical experience with BAHA Attract

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The aim of the study was to asses surgical procedure with BAHA Attract as well as audiological feedback. The recommended cut is U cat with distance from 15 to 20 mm from magnet plate. That procedure was used in 8 patients. The group consists of 10 patents implanted in 2013. We modified surgical approach due to possibilities of lack of feel in skin area after surgery for more conservative, It doesn't influence for audiological results. It as well allows to make less bleeding during surgery. Baha Attract is recommended in surgeries with lack of space in mastoid due to congential malformation or anatomic conditions. It gives a little less audiological feedback that standard BAHA, but it is preferable by patients from cosmetic point of view.

KN2-14

Bonebridge and CI surgery under local anesthesia

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Introduction: The Bonebridge (BB) system and the cochlear implants are a remarkable solution for certain types of conductive hearing loss or unilateral hearing losses with head shadow effect and sensorineural hearing losses, respectively. The aims of this article are to describe the surgical technique under local anaesthesia with the use of both systems.

Material and methods: 6 patients were selected for this new procedure with the BB implant. 5 suffered from a chronic otitis media (COM) and they had antecedents of failed tymplanoplasties. The sixth patient was surgically intervened of a left acoustic neuroma. A CT scan processed with the 3DSlicer software allows us to accurately plan our surgery by digitally placing the BC-FMT on the selected area according to the skull thickness. Two patients underwent cochlear re-implantation surgery. For the local anaesthesia, we use a combination of lidocaine and 2% epinephrine. A specially designed surgical cover was used to avoid a claustrophobic effect. To mask the drilling sound, we used a mp3 player with a headphone on the contralateral ear.

Results: All patients tolerated the surgery without complication and were intervened under local anaesthesia and the BCI and CI were placed satisfactory.

Conclusions: Implantation of the BB and revision surgery of CI with local anaesthesia is a safe and feasible procedure.

KN2-15

Systemic review to evaluate the safety, efficacy and economical outcomes of the Vibrant Soundbridge for the treatment of sensorineural hearing loss (SNHL)

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Firstly introduced in the late 90's, the active middle ear implant Vibrant Soundbridge is nowadays largely used for hearing rehabilitation in patients with mild to severe sensorineural hearing loss unable to tolerate conventional hearing aids. Implantation involves a surgical procedure, which usually requires general anaesthesia. In experienced hands the implantation is fastly done, safe and highly standardized. Here we present a systematic review after more than 15 years of Incus Vibroplasty application to determine the efficacy/effectiveness and cost effectiveness as well as patient satisfaction with the VSB active middle ear implant in the treatment of mild to severe SNHL. The systematic search of electronic databases resulted in a total of 1640 papers. At the end of a Cochrane based study search procedure 24 studies remained to be systematically reviewed. It shows that VSB Implantation is a safe procedure with no loss of threshold during surgery and surgical complications that are seen during routine middle ear surgery. Explantation rates due to device failure are low compared to other MEI.The functional gain of VSB is significantly higher compared to conventional hearing aids being used prior to surgery and as compared to the unaided situation. Speech perception in quiet and noise was difficult to evaluate as the number of available testing tools outweighs the results. Taken all studies together the VSB was found to provide a functional gain ranging 25 dB HL to 33 dB HL.Seven different self-assessment scales were used with the most frequent ones being the APHAB and the Glasgow Benefit Inventory (GBI). In general the VSB is described as much more comfortable, clearer in sound perception and less events of unease are reported.

Considering the economic benefit of VSB implantation is difficult as there is only little information on economic impact of MEIs in general. In comparison to Willingness To Pay (WTP) threshold Data middle ear implantation with the Soundbridge is cost effective.

RT2 Chinese-German friendship

RT2-1

Deaf patients are sensitive to 'hear sound photo': Evidence from event related potentials

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Backgrounds: It's considered that deaf patients are sensitive to visual stimulus; however, the neural mechanism for this is unclear. In our study, we aided to use event related potentials (ERPs) to find out the mechanisms of visual processing in deaf subjects.

Methods: 10 bilateral moderate to severe post-lingual hearing loss patients were recruited, and 10 normal hearing volunteers were for control. ERPs were test based on their responses to the visual stimulus (sound photos Vs. nonsound photos), the waveform (N1, N2 at FC3 and FC4, P170 at Pz), topomapping and source location were analyzed.

Results: Deaf subjects had higher N2 amplitudes and faster N2 latencies at both FC3 and FC4. And the response to 'sound photos' in deaf had faster N1 latencies and N2 amplitudes than that to 'nonsound photo'. Topomaping showed that the difference between the response to 'sound and nonsound photo' in deaf subjects was mainly in the right frontal and temporal areas, from around 200ms to 400ms. And further LAURA source location showed that the difference was in around Middle Frontal Gyrus, Frontal Lobe (BA10).

Conclusions: Deaf patients are sensitive to 'hear sound photo', and this function can attribute to the right frontal and temporalcortex in a late process in around 200~400ms.

Key words: Hearing loss, visual compensatory, event related potential, neural mechanism

RT2-2

Establishment and rudimentary application of the method of recording EMLR in cochlear implantation

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Purpose: Establishment of the pre-operative electric evoked auditory middle-latency response (EMLR) detection method for the first time,.

Method: Choose February 2010 to February 2011 in our hospital company Nucleus 24R multi-channel cochlear cochlear implant surgery. Preoperative objective audiometry showed no residual hearing of 26 cases of patients as the experimental group, with residual hearing 26 patients as a control group; The normal control group (acoustic stimulus): Select 6 normal hearing healthy subjects, the line short sound stimulates the auditory middle latency evoked potentials (auditory middle latency response, AMLR) test. Electrical stimulation experimental group and the control group electrical stimulation: intra-operative EABR test with the same device is connected, select EABR mode, using monopole stimulation. Calculation leads to rates, the wave amplitude, latency thresholds and grading. 1 month after surgery in patients after boot collection T, C values; boot 12 month after hearing behavior grading standards (categories of auditory performance, CAP) score. Correlation of the ECAP threshold, EABR threshold, EMLR threshold and boot T, C values ; correlation of EMLR grading and boot 12 month CAP score. Statistical analysis of the difference between the two groups' EMLR threshold, postoperative CAP score difference.

Results: 6 cases of normal hearing subjects AMLR waveform can be recorded to an average response threshold (12.5 ± 8.6) dB nHL, close to the threshold for behavioral audiometry (10.8 ± 7.3) dB HL. EMLR waveform is similarity to AMLR ,The remaining 49 cases were elicit meaningful EMLR waveform (in Pa wave as a reference), the experimental group EMLR detection rate and detection rate consistent EABR (88.46%), higher than the ECAP detection rate. Experimental group EMLR mean threshold (151.32 ± 14.31) CL below ECAP mean threshold (172.11 ± 16.78) CL, the difference was statistically significant ($P < 0.01$), EMLR threshold and boot T, C value (correlation coefficient $r = 0.905$, $r = 0.862$) with significant correlation numerically closer to the value of T. Graded according EABR waveform classification for EMLR, is divided into four, boot 12 month CAP score (6.52 ± 0.98) and intra-operative EMLR grading (3.5 ± 0.80) high correlation (spearmen: 0.673); experimental group EMLR threshold (151.32 ± 14.31) CL control group (140.68 ± 12.84) CL, statistically significant difference between the two groups; EMLR classification between the two groups (U-test: $P = 0.588$), postoperative 12 month CAP score (U-test: $P = 0.179$) compared no statistically significant difference.

Conclusion: This study successfully established preoperative EMLR detection method, which can detect the physiological function of the primary auditory cortex, preliminary estimates postoperative hearing ability and speech rehabilitation according to EMLR classification results.

RT2-3

Pre-processing with microphone array and noise reduction for electroacoustic stimulation of cochlear implant simulation on Chinese speech recognition in noise

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Introduction: Recent studies have shown that hearing impaired persons benefit on speech recognition with electro-acoustic stimulation (EAS). In addition, fundamental frequency and periodic information of speech signal are important for Mandarin speech recognition. The purpose of this study is to investigate the pre-processing with microphone array and noise reduction for electroacoustic stimulation of cochlear implant (CI) simulation on Chinese speech recognition in noise.

Methods: We used advanced combination encoding as the speech processing strategy to simulate the cochlear implant and a low-pass filter with the cut-off frequency of 500 Hz for the hearing aid (HA). Four pre-processors (two different microphone arrays, Mic. and these two microphone arrays plus two noise reduction strategies, Mic.+NR) were implemented in this study. There were 10 adults (9 males and one female) with normal hearing participating in the experiment. We used disyllabic words and sentences combined with speech-shaped noise (SSN) as test materials (signal-to-noise ratio, SNR of -5dB and 0dB) in all experiments. All the subjects attended two experiments: one is CI only and the other, CI combined with hearing aid (CI+HA).

Results and discussion: In the CI only experiment, average speech recognition rates of the test materials (word and sentence) with pre-processing (word: 50%, sentence: 42%) and those without pre-processing (word: 17%, sentence: 22%) were significantly different ($p< 0.001$). Additionally, there were significant difference ($p < 0.001$) between the average speech recognition rates of the test materials with pre-processing (word: 93%, sentences: 97%) and those without pre-processing (word: 61%, sentences: 79%) in the CI+HA experiment. The average speech recognition rates between CI+HA and CI only showed significant differences ($p < 0.001$) between CI+HA and CI only irrespective of the test materials and the pre-processing strategies. However, average speech recognition rates between pre-processors with microphone arrays and microphone arrays plus noise reduction strategies showed no significant differences ($p > 0.05$), no matter under the experiment of CI only (Mic.: 47%, Mic.+NR: 44%) or CI combined with HA (Mic.: 95%, Mic.+NR: 95%).

Conclusion: In summary, our results implied that there are significant differences between the speech recognition rates of the test materials with pre-processing and those without pre-processing in both experiments. However, our data also showed that noise reduction strategies are used to improve listening comfort for the subjects instead of improving speech recognition rates.

RT2-4

The effect of cultural differences on timbre perception

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Objectives: To assess the timbre perception ability in musical activities for Chinese and foreign normal hearing people, to investigate the effect of cultural differences on music perception.

Methods: Forty adult Chinese and foreigner participated in this study respectively, whose music experience and age were matched. Instrument identification and instrument number detection measurements in Musical Sounds in Cochlear Implants (MuSIC) test battery were used to assess the timbre perception.

Results: Foreigner subjects achieved 96.7% correct in instrument identification test on average, which was better than Chinese subjects`(89.4%)（P< 0.05）. Confusion matrix revealed that it was difficult to distinguish the oboe and trumpet for Chinese normal hearing people; The average score of instrument number detection test for foreigner was 82.5%, which was higher than Chinese subjects`(73.3%)（P< 0.05）. When playing four or five kinds of musical instruments at the same time, subjects were more difficult to identify the number of musical instruments, especially for Chinese subjects.

Conclusion: Chinese normal hearing people performed significantly poorer in timbre perception tasks relative to foreign normal hearing people. Cultural differences have a significant impact on timbre perception.

RT2-5

A case report of the cochlear implant electrode array misplacement into vestibular and superior semicircular canal

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Intro: In general, the electrode array of a cochlear implant is inserted through a cochleostomy or the round window. The misplacement of the electrode array has been reported rarely, which can result in serious complications. Here, we report an unusual case of the misplacement of a cochlear implant electrode array.

Methods: Case report.

Results: A 5-year-old male with a history of progressive bilateral profound sensorineural hearing loss was referred for cochlear implant evaluation. Preoperative CT scan of the temporal bones demonstrated bilateral large vestibular aqueduct and Modini malformation (IP-II). Surgery was performed via round window approach technique, and full electrode (COCHLEAR NUCLEUS CI24RE CA) insertion was achieved. Intraoperative impedance results were normal. However, neural response telemetry (NRT) showed absent responses except one basal electrode. The patient felt dizziness after surgery. A radiograph in Stenver's view and CT temporal bone revealed that the electrode array entered the vestibule and then taking an upward course into the superior semicircular canal. During revision surgery, the round window was enlarged to visualize the round window membrane, the electrode array was inserted fully. Intraoperative NRT and impedance measurements were normal. In addition, an intraoperative X-ray imaging confirmed electrode placement within the cochlear. After 1.5 years follow-up, the patient have demonstrated no complications and good hearing and language ability.

Conclusion: Cochlear implant surgeons should be aware of the possibility of the misplacement of electrodes. Abnormal intraoperative NRT should be paid attention, and intraoperative X-ray imaging in Stenver's view can confirm whether the electrode placement is properly positioned.

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RT5 The beauty of the cochlea

RT5-6

On human Round Window anatomy, “hook” structure and cochlear implantation - is the human Round Window really round?

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Background: The true shape of the human RW has been divisive since its description in 1772 by Antonio Scarpa. Introduction of novel surgical strategies in recent years have raised its significance. The most advantageous admission of an electrode array in hearing preservation surgery is tentative. Here, human RW size and shape variations were documented in micro-dissected human temporal bones. In addition, we assessed intra-cochlear trauma caused by differently prepared cochleostomies.

Material and methods: The variational anatomy of the “hook” region was analyzed in 23 human, micro-dissected temporal bones. RW rim could be delineated and photographed from the labyrinthine aspect and its topography assessed. Impacts of various cochleostomies (conventional anterior, antero-inferior/inferior and enlarged-RW) on intra-cochlear structures were also examined.

Results: Human RW is seldom round but ovoid or orthogonal, skewed and non-planar (saddle-like). Membrane is fan-shaped or conical with an antero-inferior and a postero-superior part. Mean longest diameter was 1.90 mm and smallest 1.54 mm. The mean diameter from the crista fenestra was 1.31 mm. The mean area of the RW was 2.08 mm^2 which varied between 0.99 mm^2 to 3.20 mm^2. The crista fenestrae of the anterior component forms a “doorstep” that may limit the entry to the scala tympani from the RW niche. There were surprising size variations of the “hook” region influencing the accessible area of drilling. Cochleostomies resulted in trauma to essential intra-cochlear structures in most cases (spiral ligament or spiral lamina). An inferior approach may preserve these structures but instead challenges the patency of the inferior cochlear vein.

Conclusion: The alternate anatomical features of the human RW may influence its surgical access and designs of implants aimed at targeting this region. Cochleostomy techniques, in either form, cause frequent inner ear damage. A contributing factor is the unpredictable variations in human inner ear anatomy. This modus operandi is therefore not recommended in patients with substantial residual hearing. Instead a RW approach is endorsed.

RT7 New indications

RT7-5

Conception and long term results of hearing rehabilitation by cochlear implantation in single sided deafness after translabyrinthine approach to the skull-base

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Intro: The treatment of tumours of the inner ear canal and cerebellopontine angle by a translabyrinthine resection has to face beside others the problem of deafness on the surgical treated ear. Single side deafness (SSD) is perceived as a significant loss in quality of life by most of the patients. Not least for this reason rehabilitation of hearing in cases of single side deafness has become meanwhile part of cochlear implant (CI) programs. We will demonstrate that the rehabilitation of SSD by cochlear implantation after a translabyrinthine approach can be successful.

Methods: We report about our concept and results in patients, treated in tertial referring setting, who underwent translabyrinthine resection of a temporal bone pathology (e.g. acoustic neuroma) and consecutive cochlear implantation on the same ear.

Results: So far 7 patients have been provided with a CI. The removal of the tumor was complete in all cases and the cochlear nerve could be anatomical preserved. In two cases the CI was implanted simultaneously. In most of the cases an open speech understanding on the implanted ear could be achieved after 6 months of use and kept stable. The longest follow up interval is now 4 years. The personal feedback with regard to the hearing impression in daily life situations is very positive in nearly all patients.

Discussion: In comparison with other methods, e.g. bone anchored or CROS hearing aids, only a CI is able to restore bilateral hearing. As well a progressive obliteration of the cochlea is possible in consequence of the operation procedure. Considering this a quick implantation is maybe needful to preserve the chance of bilateral hearing with a CI. On the other hand this approach has disadvantages concerning MRI compatibility for tumor control and additional diagnostic imaging for other reasons. However, so far no method is available to guaranty the functional integrity of the hearing nerve and herewith the success of hearing. This all should be taken into account to provide the patient with adequate information during the counseling process.

Conclusion: In summary in certain circumstances cochlear implantation can be a good solution to restore hearing in SSD after translabyrinthine approach to the skull-base.

Learning Outcome: To be aware of the possibility to provide patients with a cochlear implant who underwent translabyrinthine resection of acoustic neuromas or other pathologies of the temporal bone.

RT7-7

Ipsilateral simultaneous cochlear implantation in vestibular schwannoma resection with normal contralateral hearing

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Introduction: Vestibular schwannoma patients represent a challenge both from surgical and audiological point of view. Whichever modality of management is chosen, the chances of completely losing the hearing in the affected ear are considerably high. When dealing with sporadic VS with normal contralateral hearing, the audiological impact of this disease centers on the loss of binaural hearing. The purpose of this study was to assess the hearing results of cochlear implantation performed simultaneously to tumor resection in VS patients, when contralateral hearing is normal. A secondary objective was to identify predicting factors for CI outcomes, either patient, surgery or tumor related.

Methods: Ten patients affected with VS were consecutively selected for cochlear implantation simultaneously to VS resection. Inclusion criteria were patients with VS with useful social contralateral hearing tumor size intrameatal or grade I from the Kanzaki Classification. Postoperative auditory performances were assessed in the auditory only condition in both closed set (Vowel idenfitication-VI) and open-set (dissyllabic word recognition-DWR, sentence recognition-SR, common phrases comprehension-C) formats with monitored live voice through the sound field at a level of 70 dB SPL. Binaural hearing was tested has previously in three different spatial configurations as previously done by others (Wesarg, 2007).

Results: A total of 10 patients were implanted, mean age was 54 years. All patients had ipsilateral preoperative hearing, therefore there was no deprivation time for these implants. Regarding tumor size, nine tumors were intrameatal in two cases and grade II in the remaining cases Postoperatively, mean pure tone averages (PTA) on the implanted side were 48, 53, 53, 60, 71 and 76dB for the hearing frequencies 250, 500, 1000, 2000, 4000 and 8000 Hz. Results for speech discrimination were: VI: 93%, DWR: 68%, SR: 68% and C 80%. Two patients had poor results achieving only closet set discrimination.Binaural hearing benefits: There was a mean improvement of 1.57dB, 1.42dB and 0.42 dB for the different spatial configurations tested. Sound localization was improved from 30% of correct answers in unaided condition to 39% in aided condition.

Conclusion: Our study demonstrates that cochlear implantation can be safely performed simultaneously to VS resection with good hearing results, provided that the cochlear nerve is anatomically and functionally preserved. The most controversial aspect is the lack of a reliable intraoperative monitoring for the eight cochlear nerve to determine if, after VS resection, this nerve will be suitable to conduct electrical stimuli provided by a cochlear implant. CI offered binaural benefit in all the condition tested. These results must be interpreted with caution, and may probably improve on longer-term follow up.

RT7-8

Ipsilateral cochlear implantation in patients with NF 2 and sporadic vestibular schwannoma in the only hearing ear

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Introduction: Patients with neurofibromatosis type 2 (NF-2) and patients with sporadic vestibular schwannoma (SVS) in the better or only hearing ear represent challenging situations for the neurotologic teams, as progression towards profound deafness is expected. These patients are considered candidates for auditory brainstem implantation (ABI). Unfortunately, audiological results of ABI in NF-2 patients are generally limited to sound awareness and enhanced lip reading, with open set discrimination achieved in less than 20% of the cases. Cochlear implantation has recently emerged as a reasonable therapeutic option for patients with bilateral VS or SVS in the only or better hearing ear, when anatomical integrity of the cochlear nerve during tumor excision is maintained. The aim of this study is to present the combined experience of three tertiary referral centers with ipsilateral CIs in patients with VS, including decision making, surgical aspects, and outcomes.

Material and methods: A multi-institutional, multi-national retrospective study was conducted in 3 tertiary referral care centers. A systematic chart review was carried out on all patients affected by NF-2 with bilateral VS and patients affected by sporadic VS in the only or better hearing ear that underwent cochlear implantation as part of their management protocol. Data included patient demographics, tumor size, treatment modality, preimplantation audiometric performance scores, and hearing outcomes after implantation. Preoperative audiologic measurements included pure tone audiometry (PTA) and maximum speech discrimination score (SDS). For both the implanted and the contralateral side, hearing classes according to the modified Sanna classification. Postoperative auditory performances were assessed in the auditory only condition in both closed set and open-set (dissyllabic word recognition) formats with monitored live voice through the sound field at a level of 70 dB sound pressure level.

Results: A total of 15 patients were implanted . Eight patients (53%) where NF-2 and 7 patients had a VS in the only or better hearing ear. One patient was explanted for CSF leak. The other 14 patients obtained sound detection , 60% of them achieving open set discrimination and 80% achieving closed set discrimination. Three patients are able to use the telephone. At the last follow-up 10 patients (67%) were using the CI.

Conclusion: Our study confirms literature data reporting that cochlear implantation in the same side of the tumor, may offer at least the same results as ABI with much less morbidity, as long as anatomical cochlear nerve integrity is preserved. Sound detection was initially possible in all patients, with 60% and 80% of them achieving closed and open-set speech discrimination respectively. The results of cochlear implantation in patients with bilateral VS or VS in the only or better hearing ear compare favorably to those obtained with the auditory brainstem implant.

RT7-9

Hearing preservation and hearing rehabilitation in Acoustic Neuroma

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Progress in microsurgery of Acoustic Neuroma allowed to extend the goals of treatment to preservation and or rehabilitation of hearing. The role of wait and scan (observation) and radiotherapy were also considered and only seldom applied to their lack of mid-term success. Cochlear implant demonstrated to be a valuable method of rehabilitation in deafness due to surgery of acoustic neuroma. We implanted a total of 7 cases with cochlear nerve preserved after removal of acoustic neuroma. There were 2 cases of sporadic acoustic neuroma with contralateral severe or total hearing loss and 5 cases of NF2, as follows. Two cases with deafness after attempted hearing preservation surgery and normal contralateral hearing. One case of severe hearing loss and contralateral deafness and one patient with bilateral cochlear implant submitted to failed hearing preservation surgery on one side, and removal of the tumor in severe hearing loss on the other side. The expertise achieved in hearing preservation surgery seemed to correlate with fitness to, and quality of hearing rehabilitation with, cochlear implant. Our experience with hearing preservation surgery (HPS) with retrosigmoid approach allowed us to focus on preserving the cochlear nerve with the double goal of hearing preservation and rehabilitation. This objective was applied to both retrosigmoid approach and the non-hearing preservation translabyrinthine approach. The principles of total removal of tumor irrespective to its extent to the fundus of internal auditory canal as well as of preserving neurovascular structures will be outlined. In our experience, there is reciprocal advantage in hearing preservation surgery and the translabyrinthine techniques. The anatomo functional quality of the preserved cochlear nerve is reflected in the rates of success of preserved and rehabilitated hearing. Details about surgery and technical refinements are discussed.

RT7-10

Cochlear implantation and simultaneous labyrinthectomy in Meniere´s disease

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Active Meniere´s disease may be both invalidating for his fluctuating vestibular function, poor hearing. and sometimes invalidating tinnitus. The patients suffering unilateral Meniere´s disease may present with normal hearing or with sensorineural hearing loss in the non-affected ear. Bilateral cases of Meniere´s disease may be more challenging. Medical management and intratympanic therapies allow us to cure with efficacy most of the cases; conservative surgical therapy as endolymphatic sac surgery or surgical vestibular ablation as vestibular neurectomy permit a better control of vertigo but may fail control of ear pressure and tinnitus with their fluctuations. In selected cases a single surgery with simultaneous labyrinthectomy and cochlear implantation may provide a cure of the main Meniere´s symptoms and a hearing rehabilitation of the same ear. Indications and surgical management of simultaneous labyrinthectomy and cochlear implantation are discussed and clinical cases are presented.

RT7-11

Outcomes following cochlear implantation for patients with single sided deafness, including those with recalcitrant Ménière's disease

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There has been an increasing amount of interest from patients with single-sided deafness (SSD) seeking rehabilitative options to regain binaural auditory function. Currently, a cochlear implant is the only opportunity for this population to restore hearing to both ears. The purpose of this study is to compare the pre and postoperative performance in patients undergoing cochlear implantation (CI) for SSD. Thirty patients have undergone CI for SSD. SSD was due to end-stage Ménière's disease (MD) in 10 subjects. In these patients the CI was placed simultaneous with a labyrinthectomy. CNC word and AzBio sentences in quiet are being administered via DirectConnect. Spatial hearing was evaluated in quiet and noise. A multiple-loudspeaker sound localization and an adaptive speech perception in noise test are being collected in the better-ear only and bilateral listening conditions. Data has been collected pre-operatively and 3, 6, 12 months post-operatively with post-operative data currently available for most. Additionally, a tinnitus handicap questionnaire was administered pre- and 12 months post-operatively. Averaged results show that CNC word and AZ Bio sentence scores significantly improved in the implanted ear. Sound localization appeared to improve in an experience dependent fashion in most patients. Speech perception in noise outcomes was variable. Most patients reported diminished tinnitus following cochlear implantation. All patients undergoing labyrinthectomy experienced resolution of vertigo attacks and were the most satisfied with the CI. A CI restores binaural auditory function individuals with a unilaterally deafened ear. Additionally, the binaural input appears to improve sound localization and speech perception in noise for most patients. Most patients experience a reduction in their tinnitus handicap after receiving a CI. These functions cannot be restored using bone conduction hearing devices or cross hearing aids. In patients with severe hearing loss and recalcitrant vertigo attacks due to MD, simultaneous labyrinthectomy and CI effectively relieves vertigo attacks and improves auditory function. Listeners will have a better understanding of the outcomes associated with patients who have SSD.

RT7-12

Is "no response" on diagnostic auditory brainstem response testing an indication for cochlear implantation in children?

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Introduction: Histrically, children with congenital hearing loss and a no- response (NR) result on auditory brainstem response (ABR) testing are fit with hearing aids based on ABR predicted threshold estimates and use of a prescriptive formula for estimating gain and output. Reliable behavioral audiometric testing is then used to confirm pure-tone thresholds more precisely between 6-8 months of age and hearing aid adjustments are made as needed. For those that do not make appropriate progress in communication skills development, despite good compliance with well-fit amplification and auditory-based intervention, a cochlear implant (CI) is recommended. When uncomplicated, this process should result in cochlear implantation by the end of the first year of life. This paradigm is consistent with the goals and recommendations of the Joint Committee on Infant Hearing (JCIH)

The purpose of the present study was to report behavioral pure tone audiometry and clinical tracking to CI among a group of children with NR responses on ABR testing.

Methods: Following IRB approval, a retrospective review of pediatric patients who underwent multi-frequency ABR testing in a 5 year span. Total of 1143 pediatric patients underwent ABR testing during the study period and 105 (9.2%) were identified as bilateral NR based on absent responses to both click and tone burst stimuli. For the NR children, various clinical parameters were evaluated as these children progressed through the CI evaluation process. Children were grouped based on whether they underwent ABRs for diagnostic or for confirmatory purposes.

Results: Of the 105 children that met inclusion criteria, 94 had sufficient follow up to be included in this analysis. Ninety-one (96.8%) of 94 children with bilateral NR ABRs were ultimately recommended for and received a CI. Three (3.2%) children were not recommended for implantation based on the presence of multiple co-morbidities. No child (0%) had enough usable residual hearing to preclude CI. For those that had diagnostic ABRs, the average time at ABR testing was 5.4 months (SD 6.2, range 1-36) and the average time from ABR to CI was 10.78 months (SD 5.0, range 3-38).

Conclusions: CI should tentatively be recommended for children with a bilateral NR result on multi-frequency ABR, assuming confirmatory results on behavioral audiometric testing. Amplification trials, counseling, and auditory-based intervention therapy should commence but not delay surgical intervention, as it does not appear to change the eventual clinical course. Children not appropriate for this “fast-tracking” to implantation might include those with significant co-morbidities, auditory neuropathy spectrum disorder, and unreliable or poorly correlated results on behavioral audiometric testing.

RT8 Bilateral cochlear implants

RT8-3

The effect of sequential or simultaneous bilateral cochlear implantation on speech reception thresholds and spatial listening abilities in children born with profound hearing impairment

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Introduction: Policies regarding the provision of bilateral cochlear implants to children vary internationally. There is growing evidence that early and closely spaced procedures may lead to better spatial listening abilities for children born with a profound hearing loss. However no studies published to date have directly compared groups of sequentially and simultaneously implanted children. Evidence regarding the outcomes for these groups would help to inform future policy makers and service providers. We therefore aim to compare the speech discrimination and spatial listening outcomes of profoundly, congenitally hearing impaired children as a function of sequential or simultaneous cochlear implantation.

Methods: Children over 4 years of age, assessed at 12, 24 or 48 months post 2^{nd} implant, were categorised as sequentially implanted (n = 47; mean inter-implant interval = 54 months) or simultaneously implanted (n = 16). Speech reception thresholds were measured using the McCormick Toy Discrimination Test monaurally in quiet and binaurally in noise. Words were presented from 0° and noise from 0°, +90° and -90°. Spatial release from masking was calculated from speech reception thresholds in noise. Sound-source localisation was assessed using two tests: three loudspeakers separated by 60° and five loudspeakers separated by 30°. RMS errors were calculated. Statistical significance was tested with t-tests for speech outcomes and multiple linear regression analysis for localisation outcomes, controlling for age at test and time since second implant.

Results: For the sequentially implanted group the first-implanted ear had significantly better speech reception thresholds in quiet than the second-implanted ear and spatial release from masking was significantly greater if noise came toward the side of the second implant ($p < 0.05$). Results were symmetrical for simultaneously implanted children. The sequential group had an RMS error 11.7 degrees greater than the simultaneous group for the 3 choice localisation test ($p = 0.05$). Results for the 5 choice test were not statistically significant.

Conclusions: Simultaneous implantation led to more symmetrical speech discrimination outcomes and better sound-source localisation than sequential implantation for these children born with profound hearing loss.

Learning outcome: To appreciate the potential benefits of simultaneous rather than sequential cochlear implantation with regard to spatial listening, for children born with profound hearing loss.

RT8-4

Bilateral implantation in children: Hearing in noise and localization benefits

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Aim: This study aimed to evaluate speech reception and sound localization abilities for a group of bilaterally-implanted children.

Material and methods: 23 children implanted with Neurelec Digisonic SP devices were tested for speech perception tests in quiet and in noise. Localization was assessed by lateralization tasks adapted to age (90° or 30°). Progress in speech and language development and subjective assessment of benefit were assessed using several rating scales and questionnaires.

Results: Children scored significantly better in bilateral conditions rather than in unilateral conditions, both for speech quiet and in noise. Lateralization tasks showed a mean score of 86% in bilateral condition, and chance level for both unilateral conditions.

Conclusions: These results suggest that paediatric bilateral cochlear implantation is more beneficial than unilateral implantation both for speech recognition and localization, even for very young patients. However, a prospective study with a control group could confirm these encouraging results.

RT8-5

Comparison between binaural and bilateral recipients for speech intelligibility and sound localization abilities

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Purpose: The Digisonic® SP Binaural is a device that allows electrical stimulation of both two deaf ears within a single device. The purpose of this study was to compare a group of binaurally-implanted and bilaterally-implanted patient in terms of speech reception in quiet and in noise, but also sound localization abilities.

Methods: 7 binaural and 6 bilateral patients were included in the study. Bilateral patients were users of standard monaural Neurelec Digisonic SP implant. Tests included speech intelligibility in quiet and in cocktail-party background, and sound localization over 5 loudspeakers regularly spaced between -90 and 90 degrees.

Results: Results showed a non-significant small benefit of binaural over bilateral on average. Statistically, speech intelligibility in quiet and in noise, and sound localization were performed identically for both groups.

Conclusion: This device can be implanted in a safe procedure, and it provides similar benefits in speech recognition and sound localization as bilateral cochlear implants, but for a much lower cost.

RT10 Auditory brainstem implants (ABI) & beyond

RT10-2

Auditory brainstem implant in NF2 and other indications: A report of 68 cases

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Objective: To evaluate the auditory brainstem implant (ABI) performances in neurofibromatosis type 2 (NF2), and other otologics indications.

Material and methods: Between 1996 and 2013, 65 patients (68 ABI, three bilateral) (age: 2 to 72 years) have been implanted with ABI (Cochlear, MED-EL, Neurelec). Cases were: NF2 (n=53), ossified cochlea (n=6), vestibular schwannoma with controlateral lesions (n=4), or auditory pathway malformation or tumor (n=5). The preoperative evaluation included clinical, radiological, lipreading, and psychological status. A translabyrinthine or retrosigmoid approach was chosen. The auditory perception with the ABI was evaluated by PTA, testing the words recognition in open-set lists, and the speech understanding with usual sentences.

Results: Mean follow up was 36 months for NF2 patients, and 48 months for non NF2 patients. In NF2 patients, best results (defined as the ability to communicate without lipreading or major improvement with lipreading) were obtained in 29 cases. Negative prognostic factors were elderly, the duration of total hearing loss (>10 years), the tumor size (>3 cm), difficulties in electrode array placement, complications during post-operative course, and the number of active electrodes (< 10). In cases of postmeningitis ossified cochlea, 2 patients have been first implanted with cochlear implant, with transitory or no auditory benefit. Results with ABI in these 6 cases, demonstrated a good benefit reaching those obtained with cochlear implant in postmeningitis deafness. Twenty two patients are non-user of ABI, or ending of follow up, due to NF2 evolution. Revision of ABI was necessary in three cases due to tumor growth with decreasing of hearing benefit. Activation of electrodes is recent in one child case with cochlear nerve aplasia.

Conclusion: These results show a clear benefit of ABI in NF2 patients, with or without previous tumor removal, in case of small tumor with a short duration of hearing loss. Long term follow up is necessary due to NF2 evolution. In case of postmeningitis ossified cochlea, results potentially reach those of cochlear implants.

RT10-3

Auditory brainstem implantation in young children-UNC clinical trial

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Intro: Jackler & Luxford (1987) recognized cochlear implants to be contraindicated in children with evidence of cochlear nerve aplasia or deficiency (CND). Since 2001, Colletti et al has placed auditory brainstem implants (ABI) in children with CND with success. In the United States however, the ABI has only been approved by the Food and Drug Administration (FDA) for individuals with NF2 >12 yrs of age. Moreover, the receptiveness and plasticity of the naive auditory system remains to be more clearly defined. The present study investigates the safety and effectiveness of ABI in young children (>18 mo) with CND.

Methods: Following approval by an investigational device exemption (IDE) from the FDA (Aug 2012) and the local IRB, a single arm trial of ABI in children with CND with or without previous cochlear implant was opened. Implantation is carried out via a retrosigmoid craniotomy and is followed by intensive auditory training. Surgical, audiological and electrophysiologial outcomes for the first 5 children are reported.

Results: ABI is possible in children as young as 21 months of age. No major complications have been encountered, but postoperative pseudomeningocele and aseptic meningitis has been observed. Examples of intraoperative, implant-induced auditory brainstem responses (eABR) and postoperative cortical potentials (eCAEP) will be shown. Electrically-induced cortical auditory evoked potentials (eCAEP) were used to clarify thresholds and differentiate auditory vs non-auditory responses in some instances. To date, sound awareness and improved speech perception has begun to emerge.

Discussion: Cochlear implantation can be transformative for deaf children, but is contraindicated in those children with cochlear nerve aplasia. ABI offers electrical stimulation of the cochlear nucleus, but carries increased surgical risk and less well defined benefits. The results of the present trial show meaningful sound detection and emerging speech understanding, following ABI in young children with CND. Complications were self-limited.

Conclusion: These results support the previous work of Colletti et al and others that suggest that the auditory system remains permissive despite congenital CND. The findings that eCAEPs may be used in children with ABIs to identify thresholds and non-auditory stimulation is worthy of further exploration.

Learning outcome: This presentation will detail the initial experiences in one US center with ABI in young children.

RT10-4

Histological study of the cochlear nerve in a case implanted salvage ABI after CI

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Intro: Histological study of the resected cochlear nerve in a case which implanted CI but was not effective.

Methods: A case of 67 y/o male who suffered from meningitis and profound deafness at age of 50. PTA showed totally scale out at all frequencies and the promontory test was negative bilaterally. CT showed bilateral partially ossified cochlea. He received a cochlear implant at another hospital at age of 61. However, he could not obtain sound sensation via his CI at all and had been non-user for 6 years. Received an implant of MED-EL Combi 40+ABI on the CI side with sub-occipital approach.

Results: Performance of ABI showed 88% in closed set words and 21% in open set sentences with auditory alone.

Discussion: Histological examination of the resected cochlear nerve showed severe atrophy with cavity formation and disappearance of axons.

Conclusion and Learning outcome:

1. The reason why the CI is not useful in some case with ossified cochlea can be explained with the presence of severe atrophy of the cochlear nerve.
2. Indication of CI should be discussed carefully, if the patient is suffering from meningitis, the cochlea is strongly ossified, and the promontory test is negative.

RT11 Challenging situations for middle ear implants

RT11-2

Round window Vibroplasty in open cavities: long term audiological and surgical issues

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The aim of this study is to evaluate the long-term outcomes in adults with open cavities implanted with the Vibrant Soundbridge™(VSB) middle ear implant placed in the round window.

Twelve adult patients with conductive or mixed hearing loss, with previous unsuccessful functional surgery and persistent air-bone gap, underwent round window vibroplasty. The middle ear was entered in previous canal wall down mastoidectomies. Two patients underwent subtotal petrosectomy in addition to the VSB placement. Compound action potential thresholds were assessed during surgery, and vibrogram values were calculated. Subjective benefit was also evaluated using the Nijmegen Cochlear Implant Questionnaire (NCIQ), Glasgow Benefit Inventory (GBI) and Hearing Implant Sound Quality Index (HISQUI) tests.

Mean follow-up was 36 months, ranging from 18 to 65 months. Main surgical complication was cable extrusion, which occurred in 4 cases. One patient required reimplantation due to infection of the internal receptor. At the last follow-up all but one patient were using the device. There was no significant change in bone conduction following surgery. Aided hearing thresholds and word recognition in quiet were significantly improved (mean gain of 34.3±12.9 dB HL).The SDS shifted from 31.7±38.8% to 82.9±21.6%, and SRT changed from 85.4±36.4 to 40.4±15.4dB SPL. All subjects completed the intraoperative electrocochleography (ECoG) evaluation. Vibrogram values were similar at the different interval measures. Subjective questionnaires revealed significant changes after implantation. NCIQ: basic sound 30.3±20.1 to 93.6±11.1; advanced sound 64.8±13.5 to 91.7±9.8; speech production 48.0±25.2 to 93.9±7.2; self-steem 47.4±19.0 to 78.6±9.1; activity 60.9±26.3 to 91.1.9±7.7; social 48.2± to 81.3±10.4, preoperatively vs postoperatively. GBI: all patients had a positive overall GBI score (range +8 to +61, mean 35.0±17.0). HISQUI mean score was 152.8±28.0; on average the quality of sound was defined as very good. For appropriate candidates with open cavities suffering from mixed hearing loss, VSB represents a predictable treatment option. Intraoperative ECoG and vibrogram values may be considered of significant help to check the coupling of the floating mass transducer to the inner ear. The main complication in this series was cable extrusion. Subtotal petrosectomy with external ear canal closure may be considered as an alternative surgical technique to prevent this complication. Understand the mechanisms of active middle ear implants to improve hearing in patients with mixed hearing loss following open surgery for cholesteatoma. Learn the different approaches to place the VSB in an open cavity depending on the anatomical situation, including direct placement on the round window and interposing cartilage, fascia or perichondrium.

RT11-3

Retrosigmoid implantation of the Bonebridge™ bone conduction implant in patients with chronic otitis media

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Percutaneous bone conduction implants have several complications including skin reaction, wound infection, growth of skin over the abutment, and implant extrusion. In recent years, transcutaneous systems as the Bonebridge™ Bone Conduction Implant have been developed to overcome these disadvantages. This device may be either placed in the mastoid cavity or the retrosigmoid area. As many patients suffer from chronic otitis media, the retrosigmoid approach avoids any contact of the device with the pathological ear. The aim of this study is to describe our experience with the Bonebridge™ in patients with chronic otitis media using the retrosigmoid approach. Seven patients with conductive hearing loss due to chronic otitis media underwent Bonebridge™ implantation. Other indications and approaches were excluded for this study. The implant was positioned in the retrosigmoid area in every case. No local or general complications occurred in this series. In every patient the dura was exposed and retracted. Different grades of retraction were needed. Aided thresholds demonstrated a significant benefit, with a mean improvement from 68 dB to 25 dB. Speech discrimination scores improved a mean of 35 dB. All patients use the device daily. The Bonebridge™implant is an effective transcutaneous bone conduction implant for patients with conductive hearing loss. Retrosigmoid implantation is an excellent option for patients with middle ear diseases or previous surgery. Understand the mechanisms of transcutaneous bone conduction implants to improve hearing in patients with conductive hearing loss due to chronic otitis media. Learn the surgical technique, as well as the main pros and cons of the retrosigmoid approach for Bonebridge™ implantation.

RT13 Severe otosclerosis: stapes surgery or CI?

RT13-2

Otosclerosis and cochlear implants: Technical features, medium and long-term results

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Otosclerosis is a relatively common cause of acquired severe to profound bilateral deafness and represents 7-10 % of cochlear implants indications in adults. However, the presence of otosclerosis remains classically considered a poor prognostic factor in terms of functional outcomes of cochlear implantation, particularly in cases of advanced peri-cochlear lesions witch may complicate electrode array insertion. The objective of this study is to present our experience and medium and long-term results on 38 patients with otosclerosis implanted in University Hospital of Bordeaux. Quality MRI and thin-section CT imaging is essential to take stock of the lesions and provide any surgical difficulties, especially near the round window and basal turn of the cochlea. The choice of implanted side partly depends on this radiological diagnosis. In our experience, surgical difficulties are often minimal, and a posterior tympanotomy with round window approach allowed full insertion of the electrode array in 31 cases out of 38. In case of obstruction of the basal turn of the cochlea, milling 3 to 4 mm deep into the basal turn usually can remove the obstacle. The functional results are quite comparable to those of other etiologies of deafness receiving cochlear implants. In our series, more than 70% of patients with otosclerosis have achieved good or very good audiometric results 18 months after cochlear implantation. When possible, bilateral cochlear implantation further improves performance, primarily for sound localization and speech understanding in noisy environments.

RT13-3

Cochlear implant in far advanced otosclerosis. Performance-complications-long term results

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Objective: To evaluate clinical outcomes of these patients, complications, and observation of the benefits of implants to medium and long term.

Design: Retrospective.

Material and method: 32 adult patients, range age 50 years old, 22 women and 10 men, with profound neurosensorial hearing loss and otosclerosis far advanced, were treated with implants multi-channel cochlear implants (CI). 3 patients had initially stapedectomy in the same ear of the cochlear implant. All patients had a previous otological medical examination, psychological, audiometry and 0% of speech discrimination with well fitted hearing aid, CTS (4 of them with RMI) in order to determine hypodensity or morphologic changes within the cochlea.

Results: CTS with morphologic changes in the cochlea in 24/32 patients (Rottevel´ s grading): 12 had type 2 (localized retrofenestral disease), 6 types 3 (retrofenestral diffuse). Full insertion inside the cochlea in 28/32 cases, where in 6 patients it was necessary to drill the bone in 4 to 6 mm in the tympanic basal turn of the cochlea. 4 patients had partial insertion of electrodes, one of them with 2 electrodes in the IAC and leakage of CSF (otosclerosis Type 3). 2 with stimulation of the facial nerve (FNS) (otosclerosis type 3) and was managed with deactivation of the offending electrodes and resetting the current levels for comfort level. 4 patients experienced diminution of the auditory skill in the time by failures of the device, where 3 were reimplanted, with upgrade of the same brand and they obtained improvement of the performance. Auditory diminution and presence of sudden episodes of tinnitus, with sensation of resounds, were observed in 5 patients (otosclerosis type 3), where in 1 the tinnitus diminished with fitting. Good discrimination in the speech in 26/32 patients. Mediocre performance in 5/6 patients (otosclerosis type 3) being good in one of them.

Summary: Patients with far advanced otosclerosis demonstrated good performance with CI in 26/32 cases. In the cases with otosclerosis type 3, 5/6 patients had more difficulty in the insertion of electrodes, 1 of them with 2 electrodes within the IAC and leakage of LCR, and 5 of these recipients with tinnitus and poorer auditory outcome, with greater number of calibrations and adjustments in levels T and C. Only two patient, 2/32 had FNS and were in otosclerosis type 3 with straight electrodes. None with perimodiolars electrodes.

RT13-4

Far advanced otosclerosis: Stapedotomy or cochlear implantation

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Objectives: To describe the hearing outcomes in a group of patients with far-advanced otosclerosis managed with either stapedotomy, cochlear implantation or both, and to identify the best initial approach based on preoperative speech discrimination, Air-bone gap and radiological classification.

Study design: Retrospective chart review

Setting: Academic neurotology tertiary referral center

Inclusion criteria: All patients with an air conduction threshold below 85 dB (HL) and a preoperative dissyllabic word recognition score between 0% and 100% at 70 dB (HL) with maximal hearing aid, and a positive CT Scan.

Results: Overall, 61 patients fit the inclusion criteria and were divided into 3 groups: A- stapedotomy alone (n=28) B- stapedotomy followed by cochlear implant (n=24) C- Cochlear implant alone (n=9). Lesions were classified into 3 Stages: I - isolated lesion involving the footplate and/or pericochlear lesion without endosteum involvement; II - pericochlear lesion with endosteum involvement; III - Complete obliteration of the round window and/or pericochlear lesion with ossification of the basal turn. Changes in word recognition scores were compared between the three groups after a minimum of 12 months follow up; surgical difficulties and postoperative complications were described, and statistical analysis was performed to identify predictive factors for success.

Conclusion: Based on this study the authors will try to give an algorithm for the management of patients with far-advanced otosclerosis.

RT13-5

Active middle ear implants: an alternative to improve hearing in advanced otosclerosis

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Introduction: The advanced otosclerosis produces severe mixed hearing loss, and this condition is very difficult to resolve. Usually these patients require stapedectomy and after surgery, they need fitting a hearing aid to improve the bone thresholds. On the other hand, many patients with stapedectomy, many years later suffer from the deterioration of neurosensorial thresholds, needing hearing aids.

Aim: Establish the useful of active middle ear implants in the advanced otosclerosis or in reinterventions, and describe the different surgical alternatives.

Methods: 5 patients were implanted with active middle ear implants (Vibrant soundbridgeTM). Different surgical techniques were used. The first option was estapedectomy and VSB's collocation simultaneously. This situation was elected in patients without previous surgery and AB gap more than 30 db. The second alternative consists to place directly onto the round window, without revision of the previous estapedectomy. Other option is in a patient with previous estapedial surgery, with functional prosthesis and VSB on round window.

Results: The mean preoperatory audiometric thresholds (500, 1000, 2000 and 4000 Hz) was 73 dB. (All patients have air bone gap superior to 30 db.), while the postoperative thresholds reaches 19,1 dB. Therefore la functional gain was of 53 dB. Regarding to the speech discrimination test reached 97% at 65 db.

Discussion: The active middle ear implants could improve the hearing impairment due to otosclerosis. Stapedial surgery and hearing aids can be replaced for this kind of active prosthesis in one surgical step or to improve the deafness, when the sensorineural thresholds are affected.

Conclusion: The active middle ear implants improve the severe mixed hearing loss produced by otosclerosis.

Learning outcome: Show other alternative in cases of advanced otosclerosis

RT14 Siebold memorial session – Japanese-German friendship

RT14-2

Estimation of the cochlear duct length for MED-EL standard electrode arrays

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The standard electrode array of MED-EL is 31.5 mm long and that covers almost full length of the cochlear duct when fully inserted. According to the MED-EL company, this full coverage of the cochlear duct contributes to better hearing by stimulating an entire cochlea. In contrast, the length of human cochlear duct is variable. The anatomical analysis of human temporal bone specimen revealed that the cochlear duct length (CDL) in human varied from 25.2 to 35.5 mm and 29 out of 69 cases have CDLs less than 31.5 mm (Hardy et al., 1938). This result suggests that full insertion of the standard electrode array from MED-EL is impossible at least in some cases even if the cochlea does not have any malformation.

Actually, one case could not obtain full insertion of the electrodes among 24 cochlear implantation cases with normal cochleae using MED-EL standard electrode array in Kyoto University hospital from 2007 to 2012.

In this study, we retrospectively estimated the CDLs of standard electrode array cases using preoperative CT scan images and tested if it is possible to predict the full insertion, in other word CDLs, preoperatively. 21 out of 24 cases, where CT data with DICOM format were available, were included in this study. CDLs were estimated using double-oblique paracoronal reformatted images of cochleae (Escudé et al., 2006). A measurement in the images from the round window to the opposite wall of the basal turn through the midmodiolar axis (distance A) (Escudé et al., 2006) was used to calculate CDLs. We used two different equations that are calculating the CDLs along lateral walls (LW) (Escudé et al., 2006) and organs of Corti (OC) (personal communication with Dr. Claude Jolly). Distance A ranged from 6.75 to 10.07 mm (average: 8.62 mm, median: 8.62 mm) and estimated CDLs ranged from 27.9 to 41.5 mm (average: 35.6 mm, median: 35.6 mm) for LW and from 24.1 to 37.9 mm (average: 31.9mm, median: 31.9 mm) for OC. The estimated CDLs for OC were almost comparable to CDLs reported by Hardy et al. (25.3 - 35.5 mm, average: 31.5 mm). The CDLs for the case that full insertion was not obtained were 27.9 (LW) and 24.1 (OC) mm. In the case that has the second shortest estimated CDLs (LW: 33.0 mm, OC: 29.3 mm), full insertion was difficult in re-implantation after hard failure. By the CDL estimation based on LW, all but one case had CDLs longer than 31.5 mm, which is consistent with the results of full-insertion achievement. In contrast, eight cases had estimated CDLs shorter than 31.5 mm by the estimation based on OC length.

These results suggested that estimated CDLs along LW are more preferable to predict the CDL for MED-EL standard electrode array. This may be due to the position of MED-EL electrode arrays that sit near the lateral wall of the cochlea. Although 28 mm electrode array is more popular choice currently, the estimation of CDLs based on preoperative images is still important because some cases have CDLs less than 28 mm.

RT15 Tinnitus and non-auditory side effects

RT15-2

A consideration about the tinnitus suppressing effect by cochlear implant

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Introduction: Tinnitus is often a debilitating disorder affecting approximately 15% of people of all ages who perceive it continuously, and in about 3% of the population it seriously affects the quality of life[1)]. There are about 1,073,630,000 people with tinnitus world-wide (as of Jan. 2014), and about 214,720,000 people are seriously suffering from severe tinnitus. However, there is as yet no significant cure or antidote. It is well known that sound therapy with TRT (Tinnitus Retraining Therapy) and hearing aids are effective for some specific patients, but, this treatment is ineffective for most of patients with severe tinnitus that are hard hearing where the output of TCI (Tinnitus Control Instruments)and the hearing aid cannot overcome the loudness level of the tinnitus. We investigated the effectiveness of Cochlear Implant (CI) for these severe tinnitus patients through the use of a questionnaire. Furthermore, from my own personal experience[2)] as both a doctor (CI surgeon) as well as a CI patient, I added some practical first-hand knowledge about the effectiveness of CIs in dealing with tinnitus.

Methods: We provided patients using CI and visiting our Center for mapping and rehabilitation after CI with a questionnaire containing the following questions. 1; Do you have tinnitus?, 2; If you do, which side is it on?, 3; What does your tinnitus sound like?, 4; How long does your tinnitus typically last?, 5; Does your tinnitus subside after wearing your speech processor (SP)? 6; How troublesome is your tinnitus when you remove your SP? Describe using a VAS. 7; How troublesome is your tinnitus when put on your SP? Describe using a VAS.

Results: Reviewing the data we've collected up to this point, tinnitus is present in 14.3% of the 56 cases ranging in age from infancy to adulthood.

Amongst these patients, the rate of reported tinnitus was 6.0% in children who are congenital or pre-lingual and 100% in post-lingual adults. For all the adult patients, the tinnitus could be strongly attenuated by wearing a CI. We will continue collecting further data and report on it, while paying attention to the following conditions that may affect tinnitus, such as 1; Why is there very little tinnitus for the pre-lingual hearing loss?, 2; Why can tinnitus be controlled well in those with post-lingual hearing loss through the use of a CI?

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RT15-3

Moment-to-moment variability of the auditory phantom perception in chronic tinnitus

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With a prevalence of about 70%, the majority of patients that undergo cochlear implantation also report a perception of tinnitus prior to operation. Following implantation, some patients report an improvement of tinnitus while the tinnitus worsens in other cases. Subjective tinnitus, in general, is defined as an auditory perception in the absence of any physically identifiable source for it. The patients typically report a constant ringing, buzzing or hissing in the ear, which can lead to serious psychological distress including depression, insomnia and anxiety.

Several evidence exists, that the perception of tinnitus is not constant during the everyday life and rather fluctuations from one moment to the other and that the amount of fluctuation relates to the generally perceived tinnitus-related distress. For example, electrical stimulation of the cochlea can change this perceptual variability leading to longer and more episodes where the tinnitus is ´off´. In order to measure this moment-to-moment variability of tinnitus perception, we developed an experience sampling application running on smartphones that is able to track the individual tinnitus perception and distress during the day under real world conditions. The longitudinal data collected by the app might also be helpful for the adjustment of the CI settings. Additionally, we assessed the moment-to-moment variability of brain activity in the auditory cortex using magnetoencephalography. Chronic tinnitus is usually associated with a decrease of the alpha frequency oscillatory power in temporal areas. Here we show, that also the moment-to-moment variability of the alpha activity is largely reduced in chronic tinnitus. Most importantly, it can be shown that this neuronal variability is associated with the tinnitus duration. Subjects with a longer history of tinnitus show less alpha variability in auditory regions. Whether these changes in neuronal variability relate to the perceptual variability remains to be seen.

RT15-4

Cochlear implantation in patients with tinnitus

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Introduction: Tinnitus remains a problem for many people. Treatment efficacy is low despite the variety of pharmacological and psychotherapeutic techniques and physiotherapy. Hearing aids are used to correct tinnitus in patients with impaired hearing. Cochlear implantation is the most effective method of rehabilitation in patients with profound hearing loss.

Aim: To assess the dynamics of tinnitus severity in patients after cochlear implantation.

Methods: We examined 172 patients (aged 14-67 years) with profound sensorineural hearing loss and complaints of tinnitus. Cochlear implantation was performed in all the cases. The severity of patients' tinnitus was assessed by visual analogue scale survey completed on 4 occasions: 1) prior to implantation, 2) 7 days after implantation, 3) at first fitting of the speech processor, and 4) 6 months after first fitting.

Results: At 7 days after implantation, 11% of patients' tinnitus disappeared completely, 34% of patients' tinnitus decreased but did not disappear, 46% of patients' tinnitus was unchanged, and 9% of patients' tinnitus increased. At first fitting, 27% of patients' tinnitus disappeared completely, 54% of patients' tinnitus decreased but did not disappear, 17% of patients' tinnitus unchanged, and 2% of patients' tinnitus increased. At 6 months after first fitting 4% of patients' tinnitus disappeared, 85% of patients' tinnitus decreased but did not disappear, 10% of patients' tinnitus remained unchanged, and 1% of patients' tinnitus increased.

Conclusions: Although further research is needed, cochlear implantation reduces the severity of tinnitus in patients with profound sensorineural hearing loss. This reduction can be attributed to several factors: the effect of habituation, acoustic masking, direct stimulation of the auditory nerve, and perhaps the reorganization in auditory areas of the cerebral cortex.

RT15-5

Systematic review of cochlear implantation and tinnitus

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Objective: The objective of this study was to systematically review both the quality of the evidence and tinnitus outcomes following cochlear implantation (CI).

Data Sources: A structured search strategy was applied to the following biomedical databases from inception to May 2013: PubMed, CINAHL, EMBASE (Ovid), PsycINFO, Scopus, Academic Search Premier, The Cochrane Library, The Centre for Reviews and Dissemination and Clinicaltrials.gov.

Study Selection: Two researchers independently assessed publications against the following inclusion criteria: English, human, multichannel implant, any validated tinnitus outcome described and level 1-2 evidence.

Data Extraction and Synthesis: Data was systematically extracted using a standardized, pretested data form which was crosschecked. The form assessed patient population, study design, outcomes and generalizability. Data was pooled to compare study populations.

Conclusions: This is the first systematic review in the world literature on the subject - 17 studies with 1267 adult patients met the inclusion criteria. There is a 71% prevalence of tinnitus in cochlear implant candidates with moderate levels of clinically significant handicap/distress. After CI, 40% of patients have complete elimination of tinnitus, 91% have complete or partial suppression (and reduction of handicap/distress). Tinnitus remains unchanged for 16%, worse in 9%, and induced in 8% of CI patients. Second side CI still has positive benefits on tinnitus outcomes but slightly increased risk of tinnitus exacerbation in 16% and induction in 20% of patients. This systematic review provides the evidence base for a new indication of cochlear implantation as an effective, durable treatment for patients with single-sided deafness and severe/intractable tinnitus.

S1 Development of rehabilitation concepts

S1-4

The development of ´Sound Success´. A new online speech reading and speech perception resource to support hearing rehabilitation for adults and adolescents

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Introduction: Sound Success is a self-directed, online resource (computers, iPads, iPhones) aimed at adults with hearing aids or cochlear implants. It focuses on building confidence and skills to speech read and follow speech without speech reading cues. Clients select from six speakers, varying in clarity of speech, accent, pace and difficulty for speech reading. Clients work at their own pace through British English hierarchically structured listening activities. The 'Getting Started' section provides closed set activities. The 'Up & Running' section challenges listening skills and auditory memory through open questions and conversation pieces. Background noise can be added to increase difficulty. Scores can be recorded for clinicians to monitor progress. The rationale behind the development and the effectiveness of Sound Success will be presented.

Method: Clients at two UK audiology centers had access to the resources test site from home for a minimum of four weeks. The clients then completed a questionnaire. The clients consisted of profoundly deaf adults/adolescents at different stages post cochlear implant switch-on or with hearing aids. A group of rehabilitation professionals from implant centers around the UK also reviewed the resource prior to its general release.

Discussion & results: Client and professionals responses will be presented in detail. The responses were generally positive indicating Sound Success enables adult patients to independently practice listening and speech reading, post-amplification. Sound Success can be easily integrated into the speech perception rehabilitation programs offered to clients. The framework for Sound Success could be adapted for use in other languages.

S1-5

A visual-syntactic method for improving reading comprehension of cochlear implanted students

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Introduction: Hearing loss during the critical period of language acquisition restricts spoken language input. such restriction may affect language skills including reading comprehension. This study aims to examine the effects of visual identification of wh-questions according to the syntactic structure of Persian interrogative sentences on reading comprehension of cochlear implanted students.

Methods: Seven Cochlear Implanted students aged between 8 and 10 attended this study. All students had profound pre-lingual hearing loss. Subjects were asked to read a story, and answer the questions. they were taught how to visually identify wh-questions according to the syntactic structure of Persian interrogative sentences. After two weeks, subjects were asked to read the story and then answer the questions. After collecting the answers, they classified into four categories based on their understanding of who-questions. The data collected from the tests were analyzed by SPSS 18.0.

Results: The comparison of the data before and after teaching the concept and location of wh-questions show that there is a significant difference in the scores of two categories of answers.

Conclusion: Reading comprehension improved after wh question´s identification and understanding; also students demonstrated more fluency, suitable pauses and intonation voice patterns in reading.

Keywords: Cochlear Implanted Students, Syntax, Visual Identification, Wh-Questions, Reading Comprehension

S1-7

Oral communication of hearing impaired children treated with cochlear implants or hearing aids

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Universal Newborn hearing screening, improved pedaudiological diagnostic measurements, safe cochlear implantation techniques or hearing aids suitable for children and appropriate early intervention lead to a nearly age-appropriate development of oral speech and language development. In a multicenter study the German version of the questionnaire „Functioning after Cochlear Implantation“ (FAPCI) was filled in by parents. It includes 23 questions with regard to typical oral communication in everyday life. They cover speech and language production and comprehension. Influence of age at diagnosis and treatment with hearing aids or cochlear implantation and degree of hearing loss were analyzed Preliminary results illustrate that hearing age of the child is a factor for development rather than age at beginning of treatment and that different rehabilitation measures such as cochlear implants or hearing aids yield comparable outcome. This presentation discusses the possibilities and limitations of a questionnaire addressing communicative skills in hearing impaired children and their possible clinical implications.

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S1-8

Cochlear implant centers: Experience with children with complex needs

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Introduction: Children with complex needs have been studied relatively little in the literature, and outcomes may be challenging to measure. For cochlear implant teams, their assessment is also challenging, and referrals may not be timely. This study explores the experiences of cochlear implant teams in assessing and managing children with complex needs and the issues they consider need addressing.

Methods: A questionnaire was designed and piloted in the UK and the Netherlands, designed to investigate the numbers of children being referred and assessed for implantation, the timeliness of referrals, the assessment process, and its length and challenges, and the changes observed in these children. The questionnaire was sent out to all centers in the UK and in the Netherlands, using Survey Monkey, and providing for both quantitative and qualitative data.

Results: The results, currently being analyzed, will be presented considering the numbers and ages of those being implanted, challenges in referral, the length and challenges of the assessment process, parental involvement, multi-professional involvement, decision making, implantation and device management issues, long-term care, educational management, and protocols for this group.

Discussion: While it is now accepted that a predictor of better outcomes from implantation is early age at implantation, it is becoming apparent that these children are likely to be referred for implantation later, and thus possibly doubly disadvantaged. Outcomes for the group require different protocols and measures of benefit to those traditionally sought in the speech and language domains, with more subtle measures of benefit such as changes in communication, and quality of life becoming more important.

Conclusion: This study, in reviewing current practice in two European countries, will share challenges in managing this group, and provide evidence to develop more equitable processes and decisions. It will incorporate the views of parents with the professionals in the centers to suggest changes in referral, assessment and management protocols which will support cochlear implantation in this complex group of children.

Learning outcome: Attendees will understand the issues re the challenges for cochlear implant teams in managing this population, and the groups which are considered most suitable for implantation. They will understand more fully possible outcome measures which will be suitable, and ways in which the long-term management can be facilitated.

S1-9

Therapy intensity as an influence factor for speech comprehension in children after sequential bilateral cochlear implantation

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A lot of children get sequential bilateral cochlear implantations (CI). The results of both implantations show high variability. Retrospective analysis can search for predictors and influence factors for the results in every single side. The data of 251 congenital deaf children aged between 4 and 18 years were analyzed. All children got their devices between 1995 and 2011 at Medical University of Hannover. The inter-implant-interval is between 2 month and 14 years. The patients were required to have experience with the second CI for at least one year. All patients get Hearing- and Speechtherapy in Cochlear Implant Centers. Depending on their age they get early intervention at home and some children get additionally physiotherapy or/ and ergotherapy. So, all patients got different therapy depending on their needs. The most recent data for each implanted side were evaluated.

The performed statistically tests (performed) were one factor analysis of variance (ANOVA) followed by the Scheffé Post-Hoc-Test, the Wilcoxon test followed by Bonferroni correction and the Spearman´s-Rho correlation coefficient. The mean results in monosyllabic speech understanding (FET) are 66% in the first implanted side, in the second side 44%. Mean results in the HSM-sentence test are 75% in the first side and 45% in the second side. The mean results in HSM sentence test in noise are in the first side 30% and in the second side 14%. Depending on the therapy form the intensity differs and shows correlations to the speech test results. After implantation second side hearing therapy intensity is in mean almost half of the first side. Further analyses will show the correlation between quality of speech understanding and the inter-implant-interval, duration of wearing the speech processor and will be presented.

S1-10

The efficiency of patient's rehabilitation after bilateral cochlear implantation

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Aim: To evaluate the efficiency of rehabilitation process after bilateral cochlear implantation (CI).

Methods: The subject pool contained 33 patients who were implanted in the Center in 2011-2013. 9 patients were bilaterally implanted simultaneously, 5 of them were after reimplantation of the 1st ear and implantation of the 2nd one. 24 patients were after sequential bilateral CI, the period between 2 surgeries was less than 1 year in 14 patients and more than 1 year in 10 patients. At the time of cochlear implantation 23 patients were in the age from 1 to 3 years, 8 - from 4 to 16 years. 2 patients were adults. In our assessment we used the free field (FF) tonal audiometry and the FF speech audiometry. Patients were also tested by speech therapist.

Results: During the switch-on of the speech processor after the 1st surgery all patients were able to hear sounds of musical toys at the distance of about 3 m according to the speech therapist's examination. During the switch-on of the 2nd speech processor (after the 2nd surgery) they were also able to hear conversational speech in addition to sounds of musical toys both at the distance of 5 m. After 7 months of using 2 speech processors those patients who had sequential CI during the period of less than 1 year had good speech and whisper recognition at the distance of 6 m. Those patients who were implanted after 1 year from the 1st surgery achieved the similar results only after 1 year of using 2 speech processors. During the switch-on of the speech processors after the simultaneous CI all patients had perceptions of the sound of the musical toys at the distance of 3 m and right after 3 months had good speech recognition in situation of limited choice. It should be noted that during the switch-on of the speech processors in the patients, who underwent simultaneous reimplantation of the 1st ear and implantation of the 2nd ear, the reactions in the reimplanted ear were better than in newly implanted ear. Speech and whisper recognition had appeared after 3 months of using CI-system. The FF tonal audiometry was performed in all patients, and all of them were classified as patients with the mild hearing loss (26-40dB).The FF sound perception thresholds in bilaterally implanted patients with 2 active speech processors were significantly better than those who used 1 active speech processor. Binaural summation was found in all cases. The FF speech audiometry was performed in adult patients. Their Speech Discrimination Scores (SDS) at the presentation level of 45-55 dB was about 100%. At the level of 25 dB SDS deteriorated abruptly.

Conclusions: The decreasing of the time frame between the 2 surgeries provides the reduction of the hearing perception differences between 2 ears and improved sound localization. According to the FF tonal audiometry the binaural summation was confirmed. The results were better in the earlier implanted ear despite of the lack of auditory nerve stimulation in case of reimplantations.

S1-11

Verbal working memory training in cochlear implanted children

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Introduction: Working Memory (WM) has a central role in learning. It's the brain system for temporary storage and manipulation of information. WM includes a central executive that controls and coordinates the operation of two subsystems: the phonological loop and the visuo-spatial sketchpad. The phonological loop is the part of working memory that deals with spoken and written material. Verbal Working Memory (VWM) is the ability to store and manipulate symbolic representations of verbal information, while working on the information at the same time. Deaf Children represent a group of subjects with a WM deficit.

Aims: The aim of the present study was to evaluate the effects of training on VWM ability, speech production and auditory perception.

Methods: A randomized study using an intervention group (n=9) and a control group (n=7) of cochlear implanted children, with mean age of 8.7 years was conducted. An intensive and adaptive training of verbal working memory tasks was used. Training was presented 2 times per week for 3 months. Assessment of VWM was performed using the word List matching, word List recall, listening recall, counting recall and backwards digit recall. The CAPII and SIR were utilized to assess speech production and auditory perception.

Results: The results indicated that performance on VWM tasks and speech production were significantly improved by training.

Conclusion: Training has significantly positive impacts on VWM and speech production in cochlear implanted children.

S1-12

Using data logging as a counseling tool with adult cochlear system 6 recipients

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Intro: Data logging is now available for system 6 recipients. Data Logging provides information about the amount of time the cochlear implant recipient has used their speech processor in different listening environments, including time spent listening to music. This level of detailed feedback can provide useful information for the cochlear implant recipient and clinician if it is used sensitively.

Methods: Data logging has been available for cochlear implant recipients at the Yorkshire Auditory Implant Service since October 2013. Information provided by data logging is now being used routinely in rehabilitation appointments with adult cochlear implant recipients.

Results: Through the use of data logging more information about how cochlear implant recipients are using their implants has been available. This has allowed appropriate guidance and targeted support. Examples are:

- An adult cochlear implant recipient with learning difficulties was identified as having difficulty keeping their coil in place in their home environment. Without data logging this problem may not have been identified.
- A prelingually deaf adult was struggling to adjust to listening through their implant. Data logging showed that they spent the majority of time in a completely quiet environment. Counseling was used to facilitate an increase in their exposure to sounds and speech.
- A cochlear implant recipient was very disappointed in how music sounded. Analysis clearly identified that their exposure to music was a lot less than they had thought. Through collaborative discussion they identified how they could increase their time spent actively listening to music to see if they could enhance their music appreciation.

Discussion: Through the careful use of questioning and reflecting the clinician and cochlear implant recipient can work together to discover the best route to achieving benefit from cochlear implantation through increasing listening opportunities.

Conclusion: Information obtained through data logging offers useful information into the cochlear implant recipient´s use of their processor. It can reveal why a cochlear implant recipient may not be making expected progress and in many cases can be used as a motivational tool. However, insensitive handling of data logging information could potentially result in a poorer outcome than if no data logging information was available.

Learning outcome: Clinicians can use information from data logging to facilitate an increase in opportunities for listening practice, leading to better performance outcomes for cochlear implant recipients.

S2 Intraoperative/objective measurements

S2-3

Time evolution of comfort levels based on electrically evoked stapedius reflex thresholds in children with CI

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Intro: In clinical application the electrically evoked stapedius reflex threshold (ESRT) serves as a robust estimator of maximum comfortable loudness levels required for fitting of cochlear implants. Postoperative ESRTs are typically obtained from acoustic impedance measurements using appropriate ear probes. These measurements are possible whenever the middle ear function of the patient is normal, which is the case in about 90% of the patients. Up to now it is not known how much the ESRT values change over time with regular implant use. This information is particularly important for the refitting of cochlear implants in children based on objective methods.

Methods: In the present retrospective study the time evolution of ESRTs has been studied. 36000 ESRT measurements, which have been collected over a period of 12 years for 40 children supplied with MED-EL cochlear implants, have been analyzed at the common time intervals used for fitting. As reference the change of maximum comfort loudness levels over time was evaluated in an independent sample of 10 adult CI patients fitted with conventional behavioral methods.

Results: The postoperatively determined ESRTs show considerable changes within the first year of cochlear implant use for all children tested. On average a change of maximum comfortable loudness levels based on ESRT of 22% is observed. For the majority of implants an increasing trend of charge levels was observed. Though a small fraction of implants showed decreasing ESRT levels and hence a common trend cannot be stated. Maximum comfort loudness levels stabilized after about one year of implant use in all patients. The change of maximum comfort loudness levels based on conventional loudness scaling was ranging within comparable limits.

S2-4

Intraoperative monitoring in cochlear implantation for hearing preservation

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Intraoperative monitoring during cochlear implant surgery may provide the surgeon with online feed-back to modify surgery and reduce the trauma for increased preservation of residual hearing. Furthermore, it can intra-operatively monitor the extent of the damage to the residual hearing function with different electrodes and surgical strategies. We present data obtained with a new technique from adult patients who underwent CI with pre-operative measurable auditory thresholds in the low-mid frequencies. All patients had intraoperative compound action potentials measured to assess cochlear function during surgery. In those patients surgery was modified according to the intraoperative feedback. Monitoring cochlear function provides real-time feedback to the surgeon during CI surgery providing objective data to modify his or her surgical technique in ways that can improve the rate of short-term hearing preservation.

S2-5

An algorithm for intraoperative monitoring during cochlear implant surgery

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Introduction: Various methods including impedance, telemetry and radiologic studies are used during cochlear implant surgery in an attempt to assess device functioning. In this study, our purpose was to examine the various methods and generate an evidence-based algorithm for the use of intraoperative testing during cochlear implantation (CI).

Methods: Our subjects included 277 children (aged 6 mo to 17 yr) and adults 18 years and older with normal cochlear anatomy who underwent primary and revision cochlear implantation with the Nucleus device at our institution. Intraoperative testing included the following: 1) individual electrode impedance measurements; 2) neural response telemetry (tNRT) levels for electrodes E20, E15, E10, and E5; and 3) plain film radiograph assessment of electrode position.

Results: No patient demonstrated abnormalities on all 3 modalities. Open or short electrodes on impedance testing were found in 6% of patients; half of these normalized when remeasured. Absent tNRT responses on 1 or more electrodes occurred in 14% of patients, although complete lack of response was rare (1.4%) and did not correlate with a dysfunctional device. Intraoperative radiography identified tip-rollover and extracochlear electrode placement in all cases and prompted the use of the backup device.

Conclusion: Immediate intraoperative determination of device functionality and optimal electrode placement is advantageous. Of the modalities tested, including electrode impedance, tNRT, and plain radiograph, only the radiographic results impacted intraoperative surgical decision making and led to the use of the backup device. While intraoperative objective measures provide important information for device programming, etc., radiographic information provides immediate feedback regarding device integrity.

Learning outcome: Whenever possible, it is advisable to obtain plain film radiograph prior to leaving the OR.

S2-6

Relation between the etiology of deafness and electrically evoked auditory brainstem response recorded during cochlear implantation

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Background: DIGISONIC SP® cochlear implants (CI) use variable time-pulse for sound coding between comfort and threshold levels. Accordingly, we previously described the impact of modulating phase duration on auditory brainstem responses at different site of the cochlea.

Objective: In this study we aimed to investigate the relation between the etiology of deafness and electrically Evoked Auditory Brainstem Responses (eABR) recorded at the time of cochlear implantation.

Design: Auditory brainstem responses evoked by a biphasic pulse train, at increasing phase duration (pulse width, T-pulse), were recorded in 188 subjects at the time of cochlear implantation. All patients were fitted with a NEURELEC CI device, initially DIGISONIC® then DIGISONIC SP® (2004-2006).

Result: The mean age at implantation was 22,9 years, ranging from six months to 80 years. Clinical evaluation in that population allowed identification of a causative or precipitating pathology in 55% (104/188). Eighty-eight patients (46,8%) became deaf before the first year of life (Early onset deafness). In this group, the implantation age was 2,9 ± 1,4 years. Forty-two subjects (22,3%) were genetically predisposed; nineteen (10,1%) GJB2-related deafness were identified (12 were homozygote carriers of the 30delG mutation). stimulation by the CI resulted in reliable wave III and V eABR waveforms (wave V 4.28±0.42 ms and 2.23 ± 0.38 ms for wave III (Mean ± SD)) with latencies following an apical to basal gradient (0.32 ms increase in mean eV latency and 0.12 ms for eIII latency).

Conclusion: We report the result of eABR registered during cochlear implantation of Neurelec CIs using a single set of stimulating parameters. We describe our results with emphasis on early onset deafness and GJB2-related deafness.

S2-7

Remote intraoperative support during cochlear implantation

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Introduction: The Russian state cochlear implant (CI) program has grown from less than 100 surgeries in the year 2000 to more than 1000 surgeries in the year 2013. With the increasing number of patients, specialists need new methods of pre-operative examination, intra- and post-operative fitting, and CI testing. Usually intraoperative testing is performed by the audiologist in the operating theater. In theater testing leads to significant time loss. The audiologist cannot carry out other responsibilities while in theater. The primary objective of this study was to compare the time needed by an audiologist to perform in-theater intra-operative testing compared to the time needed to perform remote intra-operative testing.

Methods: 50 subjects were enrolled in this prospective, open label, 2-arm study. Remote testing was developed and performed at our clinic. The operation room was equipped with a videoconference connection to connect in-theater medical staff online with external staff. During the test session an audiologist had visual access to the screen of the computer installed in the operation theater, the view from the microscope, and full control over the CI testing procedure. Routine intra-operative tests: Impedance Field Telemetry (IFT), Auditory Nerve Response Telemetry (ART), and the Evoked Stapedius Reflex Test (eSRT); were performed at surgery. The time taken to perform the intra-operative tests was recorded. A questionnaire was administered to the remote expert and the local host, and a different questionnaire was administered to the local expert after the test procedure.

Results: Using standard in-theater testing it took more time overall to perform intra-operative testing (Table 1). It took less time to get to the operating theater and perform IFT with remote testing. eSRT and ART took longer when performed remotely. According to the questionnaire administered the extra time taken by the standard procedure was caused by connection interruptions. The overall time spent per patient was longer using standard intra-operative testing because of the time taken to get between rooms.

Table 1.

	Time to get to theater	IFT	eSRT	ART	Total (hh:mm:ss)
Standard testing	360	35	120	240	755 (00:12:35).
Remote testing	0	26	180	300	506 (00:08:26)

[Average time per patient (n=50) (seconds)]

Conclusion: Remote intra-operative testing session takes less time than a local intra- operative measurement session.

S2-10

Automated ECAP classification in objective measure software

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ECAPs are an objective measure of the peripheral neural response with cochlear implant stimulation, which can be recorded by back-telemetry. It is commonly used in clinical routine for assessing the auditory nerve functionality at the end of surgery or during later fitting sessions, in particular using ECAP thresholds. Efficient use of ECAPs require that most of the complexity of stimulation and recording configuration as well as data analysis be done automatically, so that presence of an audiologist expert on objective measures to supervise the measurements is not necessary. Automated ECAP algorithms aim to deliver regular ECAP function outcome 'by single-click' without the need of parameterization of the stimulation and recording settings and without the need for evaluation by highly trained experts. Automated ECAP-functions decide on which current-unit to set the stimulation of the next trace depending on ECAP response classification as containing or not a neural response. This way the stimulation level is in- or decreased until a satisfactory ECAP-threshold is obtained. ECAP classification is a critical step in automated ECAP functions: it should be made as accurate as possible. Here, a comparison was made between automatic and visual rating of a dataset of 18,375 ECAP traces. These traces were originally obtained with RSPOM 1.3 using Smart-NRI for a loudness growth function with alternating polarity paradigm (1490 functions, 9969 traces), and recovery functions (496 functions, 4837 traces) as well as spread-of-excitation functions (256 functions, 3569 traces) with masker and probe paradigm. The two criteria retained for automatic ECAP classification was the absolute voltage difference of N1-P1 and the signal-to-noise ratio, estimated by the ratio between root-mean-square over the section where the neural response was expected and over last 42 samples where neither neural response nor artifact was expected. Altogether, a high degree of correct ECAP classification was achieved using the combination of +5 dB-SNR and 50 µV: it produced the best compromise between high true-positives and -negatives and reasonably low level of false-positives and -negatives. A distinction appeared between Smart-NRI on one side and Recovery / Spread of Excitation on the other side, thought to be due to better quality traces obtained with forward-masking compared to alternate polarity (used in Smart-NRI). These observations are implemented in the automated functionalities of the new objective measures software VOLTA, which provides more flexibility than the SoundWave NRI module. VOLTA enables measuring a variety of NRI paradigms, including spread-of-excitation and growth functions for threshold measurements. All measurements are either manually configurable or automated (NRI-Express).Data may also be retrospectively analyzed or exported to Excel. In demo-mode, CI professionals with less experience can simulate measurements based on real NRI data.

S2-13

Comparison of electrically evoked compound action potential growth function and loudness growth function

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Typically, the levels for the upper and lower stimulation, i.e., M-Levels and T-Levels, are fitted based on feedback of the CI user and, thus, require active cooperation and reproducible responses of the CI user. Further on, it is common practice to concentrate fitting and mapping of the acoustic level on the upper and lower stimulation levels but spend less effort on the mapping within the electric dynamic range. To have a time efficient approach and especially in case of young or uncooperative CI users, objective correlates for the loudness and loudness growth are highly desired. A potential objective measure might be derived from electrically compound action potentials (ECAPs). In this study ECAP amplitude growth functions were measured in 15 Advanced Bionics CI users and compared to the loudness growth functions with direct electric stimulation at the same electrodes and similar pulse width. ECAPs were recorded using RSPOM (Research Platform for Objective Measures) and amplitude growth functions were evaluated offline. A linear regression was performed in the linear part of the growth function, i.e. noise floor and saturation were omitted. Loudness growth was derived from a loudness scaling procedure with an adaptive approach in categorical loudness units. In the majority of measurements (>95%) a reasonable linear regressions could be performed for ECAP amplitude growth functions as well as loudness growth functions. In the data set available so far, no correlation between the slope of the ECAP growth function and loudness growth function was found. Further on, the ECAP threshold derived from the linear regression of ECAP amplitudes does not correlate with threshold derived from loudness scaling. Reasons for not being able to obtain a linear regression were a too small ratio between the ECAP amplitude and noise floor, too high stimulus artifact which overlays the ECAP response or a too small number of recordings with a monotone amplitude growth, for example in case of limitation of the stimulus intensity in the upper dynamic range by compliance of the current source or loudness.

S2-14

Intracochlear impedance matrix test for the nucleus cochlear implant

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Introduction: A new telemetry-based function test for the Nucleus cochlear implant, known as the CS19 Intracochlear Impedance Matrix (IIM) was used to establish reproducibility (test-retest reliability) and normative ranges. The IIM test introduces new ways to record and display impedance measurements, using measurements between every possible electrode combination. The purpose of this study is to describe the aims and function of the IIM test and to present outcomes from a large number of users of the Nucleus CI24M, CI24R, CI24RE and CI500 series implants.

Methods: Six European clinics collected IIM data from a total of 192 devices (180 subjects). 31 unselected devices were tested on two occasions in order to test reproducibility. Data from a subset of 46 devices with no identifiable abnormalities were analyzed in order to establish normative ranges.

Results: The IIM test measures bipolar impedances between all electrode pairs and employs a normalization procedure based on common ground impedances in order to provide several graphical displays which are able to identify abnormal current paths among electrodes. Successful recordings were achieved in all devices. Reproducibility was very high, with a correlation of $R = 0.99$ between initial and repeat measurements. The normative analysis demonstrated narrow ranges among devices after normalization of impedance data. Examples of results obtained with relatively straightforward electrode open circuits and low impedance current shunts are also provided.

Conclusions: The IIM test was found to be straightforward to perform clinically and demonstrated reproducible data with narrow ranges in normally-functioning devices.

Learning outcome: The IIM is able to identify abnormal current paths which are not evident from standard impedance telemetry.

S2-15

Evaluation of cochlear implant patients having no electrically evoked compound action potential

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Introduction: Objective measures are a widely used and valuable tool in the field of cochlear implants. One objective measure of the auditory nerve´s response to electrical stimulation is the Electrically Evoked Compound Action Potential (ECAP). This response is allows the clinician to directly measure auditory nerve potentials on patients with Cochlear implant. In analyzing the physiological response to the electrical stimulation transmitted by the implant, information can be obtained regarding the expected and actual function of the peripheral nerve. Reliable response can be obtained in most cases of adults and children. However, in some cases no intra-operative response or reliable response is obtained. We report adult cases that had no ECAP response.

Materials and methods: Out of 644 cases which received cochlear implants between 1985 and 2013 at Tokyo Medical University Hospital, we investigate 10 adult cases which did not show ECAPs in intra-operative measurement. Measurement of ECAPs was carried out using Neural Response Telemetry (NRT™) software (electrode 4, 12 and 20) for Cochlear devices and the Auditory Nerve Response Telemetry (ART™) feature of the MED-EL MAESTRO system software (electrode 1, 5, 9, and 12) for MED-EL devices.

Results: The cases having no ECAP were 10 cases (2 males and 8 females). mean age 57 and range 32-79 years old. The etiologies of deafness were otitis media in 3 cases, meningitis in 2 cases, drug-induced in one case, Meniere's disease in one case and unknown in three cases. Among 10 cases, 6 cases received Cochlear devices and 4 cases received MED-EL devices. Devices used were CI24RE(CA) (5 cases), CI24M (1) and CI422 (1) from Cochlear Co. and PULSAR (4 cases) from MED-EL Co. Four cases received more than one operation including those who had the first operation at the other hospital. Speech perception was evaluated in audition only in Japanese, and the average was 37.2 % (0～84 %) in word and was 52.2 % in sentences.

Discussion: The reaction rate of ECAPs is generally more than 80% and becomes higher especially at intra-operation measurement. The rates of 96% for Cochlear devices and 86.6% for MED-EL devices have been reported. However, some cases of no reaction were observed, we investigate these cases in this study.

The reasons for no ECAPs are considered to be meningitis in two cases, otitis media or flap infection in one case and side effect of aminoglycoside drug in one case. There is also a bad example listening performance, but discretion is necessary because there is also a good example.

S2-16

Efficacy of objective ESRT fitting method to generate audio processor programs for young CI users

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Background: Objective fitting methods are preferred, particularly when the cochlear implant (CI) user is not able to provide unambiguous feedback on loudness or perform to electrical stimuli. Objective methods tend to be faster than subjective methods and as results are definitive, fewer follow up fitting sessions are required. This is important for CI clinics with busy schedules. Maximum comfort level (MCL) can be set on each electrode at electrically elicited stapedius reflex threshold (ESRT) level and threshold (THR) can be set at 10% of MCL. Live ESRT testing indicates 'loudness' of generated program, global MCL changes may ensue.

Objective: This study aims to demonstrate the efficacy of ESRT fitting method by reporting: performance of CI users fit using this method; frequency of fitting sessions and uniqueness of user's programs. Performance will be reported in terms of sound field thresholds and auditory maturity as measured using aided cortical assessment (ACA) and the MED-EL LittlEARS Auditory Questionnaire (LEAQ).

Method: This is a retrospective study. Data was collected from files of >30 unilateral MED-EL CI users, implanted under the age of 30 months, with at least 18 months CI experience. All children are fitted using the ESRT fitting method and followed up by authors. ESRT's are mostly measured while the child is awake but are sometimes done during natural sleep. Sound field implant thresholds are measured after fitting. Whenever possible, aided cortical assessment is done after the 1st,2nd,3rd and 4th fitting session using the Fonix® HEARLab System by Frye. CI users progress is also assessed using the LEAQ.

Results: Typically, these CI users have aided cortical responses to speech tokens /M/, /G/ and /T/ presented at 55 dBSPL, with normal P1 latencies with just 3 months of CI use. They have implant sound field thresholds of 30 -35 dBHL across frequency range 250 to 6KHZ. They tend to achieve 35 points on the LEAQ with just 12 months of CI use representing auditory maturity similar to that of a hearing 2 year old. These findings demonstrate adequate access to sound with programs generated from ESRT's. Most CI users are only fit 5 to 6 times in 18 months. Some users have some electrodes deactivated and charge on adjacent electrodes maybe different. Measuring ESRT's on individual electrodes allows for a precise fit and consequent access to all speech sounds at quiet conversational level.

Conclusion: The objective ESRT fitting method enables clinicians to provide young CI users with accurate audio processor programs which access the child to quiet conversational speech.

S3 Development of surgical techniques

S3-1

What did we learn from single channel cochlear implants (1983-2003)?

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During the period of twenty years, we have performed over one hundred single channel implants. The models used included 3M-House, All-Hear, and MED-EL. The results will be discussed in answering the following questions: is speech understanding possible and predictable, electrical versus acoustic hearing, effect on tinnitus and residual hearing, hardware vs software differences, breakdowns and battery consumption, programming and follow-ups, surgical issues, and possible new indications in the future.

S3-5

Small incision and drilling technics using custom made skin protector

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Incision shorter than the maximum width of the receiver-stimulator device (approximately 30mm) can be used, as the skin and subcutaneous tissues stretch. We currently use a 25-30mm long incision. A spoon-like skin hook (Li-Han instrument) is designed in order to position the receiver-stimulator device within the limitation of the minimal incision (figure 1,2). The main purpose of using this skin hook is to give adequate release of soft tissue and facilitate elevation of the scalp flap when drilling the well for the receiver-stimulator pedestal. Enlarging the well safely to the required diameter and smooth-off the edges is feasible.

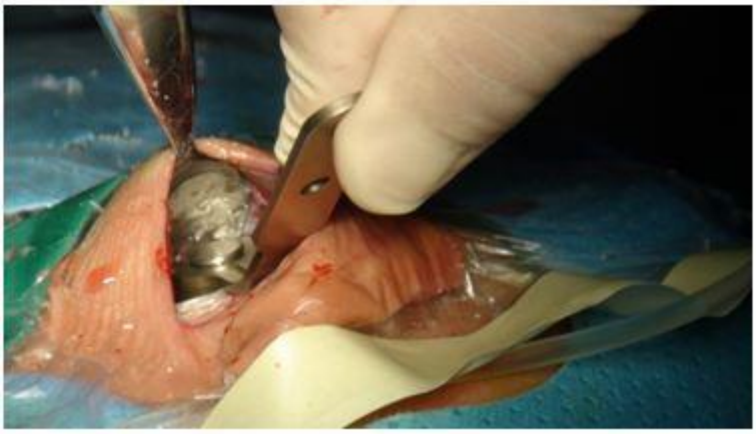

Figure1. Using a spoon-like skin hook to lift up the skin flap during the operation

[Fig.1]

Figure2. Spoon like skin hook (Li-Han instroment)

[Fig.2]

S3-6

Transcanal minimal invasive technique for cochlear implantation (overview of 1000 cases done in 15 years, using all implant systems)

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The conventional or the classic technique uses a mastoidectomy & posterior tympanotomy approach to the middle ear & the cochlea. Though it is a successful technique it is more time consuming & prone to various complications specially in small children with a small Facial Recess, anomalies of the cochlea, cochlear rotation, etc. In the era of Minimal invasive techniques & need for better accessibility (of the cochlea in this case) the Trans-canal or the Veria Technique is very helpful. This technique is very easy and getting more acceptable, particularly the ease with which it can be done in children. I have done over 1000 cases by this technique, in my center and in centers around India and SAARC countries including Pakistan & Bangladesh, with no surgical complications till date and with very good post-op results, in patients, ranging from 9 months to 79 years, both pre-lingual & post lingual. In this case, a Trans-canal Tunnel is created, with a special “Perforator” in the cortex of the posterior canal wall, which enters the middle ear through the facial recess. A tympano-meatal flap is elevated to do the Cochleostomy & insertion of the electrode in the scala-tympani. Varity of cases with Middle ear cleft Variations /Anomalies like Cochlear Rotation, seen commonly & normally in small children, Dehiscent high jugular bulb, Anteriorly placed sigmoid sinus; Small & Sclerotic Mastoids, Cochlear anomalies like Mondini & Single cavity cochlea; Cochlear dystrophies (osteogenesis imperfecta); Cochlear ossification, etc. were done. Situations like Intra-op CSF Gusher's were dealt, with ease.

The results using all the Implant systems are compared. In any surgery its paramount to have minimal complications with maximum effectiveness. This can be achieved with good visibility and accessibility to middle ear structures in all cases of cochlear implantation using this technique which provides complete smooth insertion of electrodes.

S3-7

Cochlear implant surgery with local anaesthesia and sedation: about 18 cases

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Objectives: Cochlear implantation is performed under general anaesthesia in almost all cases. However, for some elderly patients with comorbidities, there is a risk to perform a surgery under general anaesthesia and the immediate recovery after the surgery can be more symptomatic. So for these patients, the feasibility to perform the cochlear implant surgery under local anaesthesia can be useful. Few studies have described this procedure under local anaesthesia with sedation. The purpose of this study is to evaluate the possibility of performing cochlear implant surgery under local anaesthesia and sedation. Then, we discussed our results with the literature.

Design: Consecutive case reports

Patients and method: Eighteen adult patients with bilateral sensorineural profound post lingually deafness were included in this study. Patients were aged between 43 and 87 years. The comorbidities were cardio-vascular (9 cases) and chronic respiratory pathology (3 cases). In 9 cases, the patients had no comorbidities. Retroauricular infiltration was performed with lidocaine-epinephrine 2% and sedation with sublingual or intravenous midazolam in 16 cases, hydroxyzinedichlorate in one case and remifentanyl in one case. We analyzed the efficacy of the anaesthesia, the per-operative symptoms, hospital stay and auditory results during the fitting.

Results: A retroauricular incision was performed for all the patients. Ten MEDEL® implants were done, 5 Neurelec® and 3 Cochlear®. During per-operative period, no complication was noticed, no vertigo occur during the cochlear insertion of the array. A standard procedure (mastoidectomy, posterior tympanotomy, round window approach) was performed in 16 cases, in one patient had an open cavity and in one case the implant was placed after a canaloplasty without mastoidectomy. Most of the procedure was an hospital stay of 2 days (n=14). The procedure was ambulatory surgery in 2 cases. The maximum hospital stay was 3 days for one patient. After a minimum follow-up of 12 months, the auditory results increased during the fitting and no complication was reported.

Conclusion: Realization of the cochlear implant surgery under local anaesthesia with sedation is feasible without increasing the rate of complication. It allows cochlear implant surgery even in elderly patients with comorbidities.

S3-8

Middle fossa approach for cochlear implantation

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Classic approach to the cochlea through the mastoid and facial recess may not be suitable for patients after open ear surgery for cholesteatoma. Those patients are difficult to manage because of the risk of cholesteatoma recurrence and extrusion of the electrode. In 1998 Colletti presented a technique to bypass the middle ear, and insert the electrode through the middle cranial fossa approach. The cochlear implant program in Poznan started in 1994 and includes 1076 Nucleus devices implanted. We present two consecutive successful implantations via middle cranial fossa approach. Two adult patients with chronic otitis media were implanted several years ago. Due to recurrence of chronic otitis media both of them needed the explantation. After temporal bone trials we have performed in these patients another surgeries using middle fossa approach. A middle cranial fossa craniectomy was performed. Then a carful dissection of the dura was carried out to expose the arcuate eminence and the greater petrosal nerve. Using a diamond burr the basal turn of the cochlea was discovered and the cochleostomy was done. In one case the electrode was inserted in the apex direction and in the other backwards. Surgery was twice longer than a standard procedure. There were no complications. Hospital stay was 6 days. Postoperative CT showed correct position of the intracochlear electrode. At the moment one patient uses the speech processor since several weeks and has appropriate level of communication and does not require hand writing. Second patient will be switch-on in a few weeks.

S3-9

Keyhole implantation techniques

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Objective: To date, cochlear implant (CI) surgery has employed open access or minimalist approach techniques. In contrast, a very limited “keyhole' approach has been used in Brisbane employing a small incision in the posterior auricle. The technique was employed to avoid wound sites close to the implant or overlying the electrode arrays and therefore to avoid infection or wound tension in the vicinity of the implant body. The technique has been successfully employed for some 400+ CI cases and has more recently been extended to include Vibrant Soundbridge (VSB) and Bonebridge cases. The technique also has other applications in postaural myringoplasty and labyrinthectomy.

Methods: The surgery employs a 2.5-3.0 centimetre diameter 'C' incision on the posterior auricle, widely undermined postaural skin (which effectively “mobilizes” the wound for better access), a pinna based periosteal flap and a pericranial pocket to retain the implant body. The 'C' incision is enlarged when the VSB / Bonebridge device is employed, to permit use of the drill hole guidance dummy implant. Soft tissue trauma and exposure is minimal. Cochlear exposure is achieved via a limited mastoidotomy.

Clinical Useage: The technique considerably simplified the cochlear implantation process, with surgical times in the region of thirty minutes. Slightly longer times are required for VSB or Bonebridge procedures. The surgery has been free of infection. Occasional cochlear implant body displacement was noted in very young children, due to the curvature of the skull and delicacy of overlying tissues, which caused some instability. This was overcome using a percutaneous soluble stay suture at the implant-electrode junction to temporarily stabilize the devices, whilst tissue fibrosis provides long term stability.

Conclusions: The technique is brief, atraumatic and with few complications. It is readily taught to training staff and has been proven over a period of seventeen years.

S3-10

The role of subtotal petrosectomy in cochlear implant surgery: Report of 61 cases and review on indications

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Introduction: Subtotal petrosectomy (SP) in association to cochlear implantation (CI) was first described for cases with chronic otitis media or in the presence of a previous radical cavity. It has also been used in cases of cochlear malformations, and as a salvage procedure for repeating meningitis. The aim of this surgical technique is to create an environment with less risk of infection and higher possibilities for sealing off any CSF leakage. In addition, it provides a better access and visibility during surgery.

Objective: To report and review 61 cases of subtotal petrosectomy (SP) in cochlear implant (CI) surgery and to define the indications and contraindications for this procedure .

Material and methods: Retrospective case review undertaken in a terciary referral skull base center. The database of CIs performed in our Department from 2004 to 2013 contained 60 patients treated. The surgical technique consisted on subtotal petrosectomy with blind sac closure of the external auditory canal, closure of Eustachian tube, and abdominal fat obliteration in combination with cochlear implantation. All patients were scheduled for a control CT scan at 1, 3, 5, and 10 years to monitor the development of residual cholesteatoma in the obliterated cavity.

Results: Indications for SP in CI surgery were the following: chronic otitis media (n = 12), previous radical cavity (n = 18), previous subtotal petrosectomy (n = 6), ossification of the cochlea (n = 7), malformation of the inner ear (n = 4), temporal bone fracture (n = 5), combined skull base approach (n=9). One patient was simultaneously bilaterally implanted; two cases were revisions. All procedures were performed in one stage. In five cases (8.6%), complications were encountered (one subcutaneous cerebrospinal fluid collection, two array extrusions, one temporal lobe abscess and one abdominal fat infection). Only in one case the complication was related to the SP procedure. None of them needed explantation. No cholesteatoma has been found in this population until now. Mean follow-up was 52 months (range 8 - 113 months).

Conclusion: Subtotal petrosectomy combined with cochlear implantation is a procedure required in specific situations and lowers the risk of repetitive ear infections, CSF leakage and meningitis by eliminating all connection with the external environment. Additionally, it gives excellent visibility and access in difficult anatomy or in drill-out procedures. Preservation of residual hearing can be considered the only absolute contraindication as an open external meatus is necessary for use of electroacoustic stimulation.

Additional risks of the combined SP + CI procedure are infection of the abdominal fat, breakdown of the blind sac closure, and entrapped cholesteatoma.

S3-11

Experience and evolution of surgical technique over 1st 100 independent cochlear implant surgeries

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Introduction: Posterior tympanotomy approach for cochlear implantation is a very well established surgical technique. However complexity of anatomy, proximity to facial nerve and lack of training opportunity confines this surgical practice to only select centers worldwide. Inspite of available detailed description and videos, there are many aspects of this surgical technique that the surgeon needs to evolve on his own, especially with respect to some steps like exposure of incus, posterior tympanotomy, cochleostomy and electrode insertion. Various different types of descriptions are available for all these steps in literature but there is no substitute to evolution with personal experience.

Method: Retrospective study

Results: This paper attempts to describe surgical practice and how it changed over the course of 1st 100 independent surgeries carried out by the author.

Conclusion: The study attempts to identify significant though subtle changes in surgical procedure that allowed surgery to complete in significantly shorter duration of time with more objectivity and confidence.

S3-13

Scala vestibuli dislocations: Which consequences and how to avoid them?

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Intro: This study aimed to evaluate the impact of scala vestibuli dislocations on speech recognition scores and to identify their underlying mechanisms

Methods: 106 unilateral cochlear implanted adult patients were included in this prospective study. Speech recognition scores (dissyllabic words and MBAA sentences in quiet, MBAA sentences in noise with +10 and +5dB signal to noise ratios SNRs) were collected before implantation, and then three months, six months and one year post-operatively. The intra cochlear position of the electrode array was systematically assessed after implantation using CT scan imaging or Cone Beam computed tomography with specific trans modiolar reconstructions. The number and position of dislocated electrodes were collected. Auditory performance of patients with scala tympani insertions was compared to that of patients with a dislocation from scala tympani to scala vestibuli, after control of other potential prognostic factors (profound deafness duration, pre-operative residual hearing, aetiology, age).

Results: Our preliminary results involved 70 patients, categorized between two different groups: 53 were included in the first "scala tympani" group while 17 displayed a dislocation from scala tympani to scala vestibuli (included in a second "dislocation" group). Comparative analyses showed that speech recognition in noise tended to be better in patients with strict scala tympani insertion. Indeed, for a +5dB SNR, the mean recognition score was 68,4% (±20.8) for the "scala tympani" group versus 59.2% (±19.1) for the "dislocation" group (p=0.08). So far, speech recognition in quiet was not influenced by the intra cochlear position of the electrode array.

Discussion: Our preliminary analyses suggested the importance of the implant design (straight or perimodiolar) and insertion technique on dislocations, but also on speech recognition performances. Indeed , a perimodiolar electrode array is more likely to dislocate if no specific insertion technique, such as Advance Off Stylet, is used. The design might also influence speech recognition.

Conclusion and learning outcome: Dislocations of the electrode array into the scala vestibuli might have a negative impact on speech recognition abilities after cochlear implantation. Manufacturers and surgeons should pay specific attention to both design and insertion technique of the electrode array to optimize patients´ performance.

S3-14

The novel method of cochlear implant fixation

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A number of authors suggest that implant fixation is mandatory but time-consuming and sometimes complicated part of the cochlear implantation (CI). Different techniques were offered to facilitate fixation from periosteal pocket to titanium screws and anchors. The novel Concerto pin device is the first implant for reliable minimally invasive surgery, especially useful in children there the drilling of bed and holes for sutures can cause rare but life-threatening complications like epidural hematomas. Since the October, 2011, 750 children between 7 months and 16 years old (mean age 4.6) were consecutively implanted unilaterally with the Concerto pin device. In all cases the bony bed was not drilled. The surgical technique included classic mastodectomy/posterior tympanotomy approach and holes for pins only have been created in the cortical layer of the flat bone just behind the squamous suture. The bone thickness was assessed in every case during routine computed tomography. The measurements obtained were similar to those made for osseointegrating devices. Every stage of surgery was estimated and timed. The mean time of surgical procedure with Concerto pin was 33 ± 7.3 min. The full insertion of electrodes of previously chosen length has been achieved in 746 cases. In 91.9 % of CIs the electrode array was inserted through the round window membrane. The follow-up period vary extremely from 1 to 27 months. No major complications occurred after CI till this time. The implants present stable and absolutely immobile in every child. No evidence of device migration or its rotation was observed. Minor complications included hematomas, two cases of acute otitis media on the implanted ear with the total rate less than 3 per cent. Specially designed questionnaires completed by parents after surgery revealed that the size of postoperative scar is of greater importance than the device prominence behind the ear. Despite this fact the cosmetic outcome was estimated both by parents and specialists as satisfactory in all 750 cases. The outcome of hearing rehabilitation for children with Concerto pin seems similar to that of children with devices implanted with other techniques. Thus the Concerto pin device could be used for minimally invasive CI even in very little children without risk of serious complications, although further research is needed with the follow-up data collection.

S3-15

Cochlear ossification and implantation in patients with profound hearing loss following bacterial meningitis

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Objective: To investigate the pre-operative occurrence and degree of cochlear ossification in CI implantees with bilateral profound hearing loss following bacterial meningitis. To determine the correlation between pre-operative imaging and per-operative findings, as well as electrode insertion success.

Methods: Forty-seven cochlear implantations were performed in 34 consecutive candidates suffering from bilateral profound hearing loss following bacterial meningitis. A retrospective review of patient files and preoperative CT and MR images was performed.

Results: Cochlear ossification occurred in 35% of patients and 26% of ears on CT.

S.pneumoniae meningitis caused ossification more frequently than N.meningitidis, whereas age at infection had no impact. Overall, normal per-operative findings occurred in 72% of the implantations and full electrode insertion was achieved in 83% (complete failure in 2%). In 36% of ears with CT pathology, normal findings occurred at surgery. Full electrode insertion was achieved in 73% of ears with a pathological pre-operative CT, partial insertion in 27%. Cochlear ossification/fibrosis was found in 17% of ears with a normal pre-operative CT/MR. Full electrode insertion was achieved in 86% of ears with a normal CT, whereas partial insertion occurred in 11% and complete failure in 3%.

Conclusion: Cochlear ossification following bacterial meningitis is related to causative pathogen, but not age at disease. Full electrode insertion is achieved in the majority of cases, even in case of partial cochlear ossification.

S3-16

Stenting: A viable option in ossified cochlea

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Objective: To assess the hearing outcome in patients of cochlear ossification after stenting and to compare the auditory outcome of the stented patients with those who have been stented immediately post meningitis. Partial or complete obliteration of the cochlear lumen is found in patients suffering from deafness post meningitis. These are the cases which require implantation at the earliest. But, in our region finances is the main constraint and people spend lot of time procuring money and land up with complete obliteration of the cochlear lumen. These patients then require a drill out procedure during implantation. Hence, we have developed a technique where in we use a depth gauge as a stent, to keep the lumen patent. This prevents further ossification of the cochlea, thus making implantation easier. Once the funds are arranged we remove the stent and replace it with cochlear implant.

Study Design: A retrospective study, included a group of patients implanted post meningitis immediately and a group who was stented initially and implanted at a later date.

Conclusion: The stent helps to keep the cochlear lumen patent and so makes it easier to place the implant in the cochlea. We encountered no difficulties while operating on stented patients. The patient gets time to arrange for his finances and a hope to gain hearing. The hearing outcomes of the stented group is comparable with those who were implanted immediately post meningitis.

S3-17

CI in cases with cochlear dysplasia: surgical technique and auditory outcome

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Objective: To validate classification for CI cases with cochlear dysplasia, and to estimate influence of cochlear dysplasia to auditory outcome after CI.

Method and subject: Basing on image of temporal bone high resolution CT, 650 cases were diagnosed as bilateral cochlear dysplasia from 3351 CI cases. According to embryologic development stage, above 650 cases were classified into 5 types. Type I was identified by morphologically normal basal turn and a cavity fused by middle and top turns (Fig 2), type II by normal basal turn but top and a part of middle turn absent (Fig 3), type III by only a part of basal turn present (Fig 4), type Ⅳ by suspected a part of basal turn which usually formed common cavity with vestibule (Fig 5), type V without morphological cochlear but only a globular cavity formed by vestibule and lateral semicircular canal (Fig 6). Residual cochlear tissue maybe found in the inferioanterior part of globular cavity. Basing on cochlear morphology, several types of electrode array were decided for above cases.

Result: 419 cases were identified as type I, 124 as type II, 81 as type III, 15 as type IV and 5 as type V. Facial recess approach was applied for cases of type I, II and III. Lateral semicircular canal fenestration was used for electrode array insertion in cases of type IV and V. All operations were completed successfully, proper placement of electrode array in inner ear was confirmed and no complication was reported. Satisfying auditory test results were obtained in cases of type I, after CI activation, average hearing threshold in sound field was 30dB, result of speech test including initials and finals was 99%. It was 35 dB and 80% in type II, 55 dB and 70% in type III, 65 dB and 40% in type IV, 75 dB and 10% in type V. In further details, difference between result of initials test and finals test was present in cases with severe cochlear deformity. Average score was 100% in initials test and 40% in finals test in cases of type III, 80% and 10% in type IV, 40% and less than 5% in type V.

Conclusion: Different surgical approaches should be decided for specific type of cochlear deformity. Auditory performance especially speech capability after CI was affected negatively by severity of cochlear dysplasia.

Keyword: cochlear dysplasia; cochlear implant

S3-18

On influence of cochlear modiolus dysplasia to CI auditory outcome

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Objective: to study correlation between cochlear modiolus dysplasia and result of speech recognition test after CI, and define classification system for modiolus dysplasia cases.

Methods and subjects: Based on high resolution temporal bone CT, 685 cases with bilateral inner ear dysplasia were identified among 3503 CI cases (438 cases diagnosed as LAVS, 215 as Modini deformity, 18 as common cavity, 13 as IP-III deformity). 2 types of cochlear modiolus dysplasia were identified among above 685 cases: type Ⅰ with partial modiolus present and type Ⅱ with totally modiolus absent. Refer to methods applied for auditory performance evaluation 3 months after CI activation, pure tone audiometry and mandarin speech recognition test including initials and finals list were chosen for subjects older than 3 years. For subjects younger than 3 years, auditory performance evaluation was conducted 12 months after CI activation. Evaluation was conducted in standard sound field, in further details, initials including /a/, /e/, /i/ and finals /g/, /k/, /h/, /j/, /q/, /x/, /z/, /c/, /s/ were chosen for test.

Result: 102 subjects were defined as type Ⅰ of modiolus dysplasia. Among this population, 52 cases were identified from 438 LAVS cases (13%) and 45 from 215 Mondini deformity. 201 subjects were defined as type II, which included 170 cases from 215 Mondini deformity cases (79%), 18 from 18 common cavity deformity (100%) and 13 from 13 IP-III deformity (100%). Relative satisfying evaluation score was obtained in population of type I: Average hearing threshold in sound field was 30 dB, recognition scores were 99% in finals test and 78% in initials test. For population of type II, hearing threshold was 65dB, scores were 70& in finals test and 10% in initials test.

Conclusion: Influence of cochlear modiolus dysplasia to auditory and speech performance after CI was indicated. For patient with totally modiolus absent which was classified as type II, relative limited auditory benefits was found, which was usually followed by poor capability of speech communication.

Keyword: cochlear modiolus dysplasia; cochlear implant

S3-19

CI re-implantation

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Introduction: Previously, the common belief is that once a cochlear implant is implanted, it is implanted forever. However, contrary to beliefs, re-implants are inevitable. Markets only require the reliability of cochlear implants to be 98.5% in order to be put on sale. Even if manufacturers proclaim their products to be 99% reliable (or more), in a pool of 1000 patients, there will still be a few “hard failure” exceptions. Furthermore, head trauma and hermetic problems would potentially increase the number of hard failures. Apart from hard failures, other causes for re-implants include cholesteatomas, wound infections and flap problems. Recently, even with no technical problems with their cochlear implants, patients have requested to replace their old CI models for newer models with updated technology.

Method: In cases of re-implants, doctors have often encountered fibrosis and new bone formation. These would surround the electrodes messily, causing the removal of the electrodes to be difficult. The standard method of removing electrodes is to cut the electrodes in half, and extracting them separately. However, the separate halves cause electrode troubleshooting to be hard. To reduce such problems, we do not drill the cortical bone, but harvest a piece of cortical bone with a chisel. Before the closure of the wound, we cap the bone piece back to its original place.

Result: This would prevent random bone growth and fibrosis growth into the mastoid cavity. During re-implants, we discovered that this method causes a significant decrease of fibrotic tissue in the mastoid cavity.

Discussion: This allows the cable to be more visible, allowing the surgeon to extract the cable as a whole. Because the cable can be explanted harmlessly, not only that multiple re-implantations are made possible, but also that residual hearing can still be well-preserved after the re-implant. Statistics show that there is only a 5 dB loss of residual hearing 30 days after the operation.

S3-20

Well design in cochlear implants - a forgotten art?

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Most surgical workshops concentrate on small incisions, alternate techniques, round window exposure and atraumatic insertion of cochlear implants. But if you analyze the failure data of cochlear implants, a sizeable proportion is attributed to implant migration, movement and fractures of the devices which happens over time. Is it the fact that surgeons are spending less time on a proper well creation that is leading on to these events? At MESIARC, our cochlear implant center, we have always followed a meticulous technique for well creation. For all kinds of implants, we create a large well with a central bony island and dural exposure, not damage, all around with tie down holes to ensure that the top of the implant is flush with the bone even in very young children. Properly done, this does not take much time but securely and effectively fixed the implant so that further movement and potential for skull trauma to damage the implant is greatly reduced. We evaluated our series of over 700 implant and found that we had only one fracture of the implant and no electrode migration at all, even in malformed cochlea. The technique of drilling a proper well even in small incisions is adequately emphasized which not only prevents implant migration but also protects against trauma. The technique has to be fine-tuned to prevent any dural injury. Surgeons need to focus more on long term survival of the device than on speed of surgery.

S3-21

Bilateral round window VSB implantation via subfacial approach

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Objective: To report on experience regarding bilateral round window VSB implantation via subfacial approach and discuss the efficacy and safety of this novel surgical approach.

Patient: A 16-year-old boy presented with bilateral microtia and osseous atresia, after the reconstruction of the outer ear.

Methods: The bilateral round window VSB implantations were performed sequentially with a 31-month interval(the left first, and then the right, the interval time) . During the operations of both sides, the facial nerves were found displaced inferiorly and anteriorly, causing difficulty in exposing promontory and round window niche. Accordingly, the sub-facial approach was taken in both sides to get the fully exposure of Round window membranes (RWM) and place the FMT on the surface of RWM. The safety and efficacy of the technique and intervention were evaluated by perioperative observation, and auditory follow up.

Results: After VSB fitting of the left side for 36 months and the right side for 5 months, there is no perioperative or long term postoperative complication observed. The mean aided threshold of four audiometric test frequencies(0.5k, 1k, 2k, 4 kHz) was 42dB(HL) post-operatively compare to 101 dB(HL) pre-operatively on the right side, 30 dB(HL) post-operatively compare to 85 dB(HL) pre-operatively on the left side, and 26 dB(HL) bilateral post-operatively compare to 70 dB(HL) bilateral pre-operatively. Speech discrimination of monosyllable/disyllable/sentence in quiet conditions and sentence in noise(S/N=+10 dB) with the left and bilaterally activated was 100% at 65 dB(SPL), and 80% with only right activated.

Conclusion: We reported the first case of bilateral round window VSB implantation via subfacial approach with satisfactory outcome and long term safety. Our practice offered an alternative procedure to such patients with microtia and osseous atresia and severe aberrant facial nerve.

Key Words: bilateral VSB implantations, subfacial approach.

S3-22

Cochlear implantation in open cavities

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Cochlear implantation (CI) used to be considered inappropriate in chronic otitis media patients. Gradually, otologists ventured into this field and various management protocols were proposed to reduce the risk of infections in CI. Herein, we are presenting our experience in CI candidates with open cavity mastoidectomies which had previously been performed to eradicate cholesteatoma. Risk of developing recurrent cholesteatoma and prosthesis extrusion are two major concerns in radical mastoidectomy cases. In this technique pieces of cartilage are used to cover the prosthesis in the cavity so that the prosthesis is not in close contact with the cavity epidermal lining. There is no need to oversue the external ear canal and the cavity is readily accessible for watchful follow-ups in case of recurrent disease.

S4 Implant hardware & new implant technology

S4-2

Optical stimulation of the cochlea - electrophysiological responses of irradiated spiral ganglion neurons in vitro

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It has been shown that the inner ear can be stimulated in vivo by laser pulses resulting in cochlear potentials corresponding to auditory evoked signals [1]. Optical stimulation can be very site specific which coincides, due to the tonotopy of the cochlea, with a very frequency specific stimulation, possibly overcoming the limitations of conventional hearing aids as well as of electrical cochlea implants. To investigate the basic effects and mechanisms of the optical stimulation of the cochlea, single cell measurements were performed. Spiral ganglion neurons, isolated from the cochleae of P3 - P6 Sprague Dawley rats, were stimulated with 5 ns laser pulses. Their electrophysiological reactions on different laser parameters such as pulse energy and wavelength were detected by means of the whole cell patch clamp technique. The irradiated cells show inward currents at resting potential, depending linearly on the pulse energy of the laser light as well as the absorption coefficient of water. These reactions are clearly elicited by the laser beam and can be observed in voltage clamp measurements as current spikes on a timescale of less than 0.3 ms. Current clamp experiments demonstrate slight depolarizations of the membrane potential due to the irradiation with laser light. With a magnitude of less than 2 mV the depolarizations were not sufficient to generate action potentials. The laser-induced temperature change was less than 1.5 °C. The results show that the thermal effects of laser irradiation with pulse durations in the nanosecond range lead to cellular responses, but do not suffice to generate action potentials. In combination with in vivo experiments demonstrating positive stimulation results, performed with similar laser parameters (1), this suggests that direct stimulation of spiral ganglion neurons is not the main mechanism of optical cochlear stimulation. The results rather support the theory that the optical stimulation of the cochlea is based on an optoacoustic effect for the investigated laser parameters.

Reference:

[1] Wenzel et al. Green laser light activates the inner ear. J. Biomed. Opt. 144, 044007 (2009)

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S4-3

Excitation patterns in the Inferior colliculus point to an opto-acoustic mechanism of intra-cochlear infrared laser stimulation

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Laser stimulation of the cochlea has attracted attention as a potential, more focused, alternative for conventional cochlear implants or hearing aids. The absorption of pulsed laser energy also induces sound waves in the absorber, an effect e.g. applied in optoacoustic imaging. We utilized two pulsed laser sources (variable wavelength source: 434 - 1961 nm, 5 ns, 6µJ; constant wavelength source: 1860nm, 20µs - 20 ms, 6 - 500 µJ) to perform in-vivo and ex-vivo experiments in stress and thermal confinement. Multiunit responses in the inferior colliculus (IC) were recorded in-vivo from normal hearing, ketamine anesthetized guinea pigs. An optical fiber was positioned into a cochleostomy of the basal turn for intra-cochlear stimulation. A 32-channel Neuronexus-probe was stereotactically inserted into the IC along the tonotopic axis and characteristic frequencies were determined with tonal stimulation prior laser stimulation. Additionally, acoustic resonances caused by the absorption of pulsed laser light in a closed small volume (tympanic bulla) were investigated ex-vivo. An optical fiber was inserted into the bulla of a macerated skull through a bullotomy. The laser beam was directed towards the basal cochlear turn. A calibrated Bruel&Kjaer microphone placed on the outer ear canal was used to record the sound generated during laser pulse emission. Spectral analyses of the opto-acoustic effect recorded ex-vivo indicated resonance maxima at frequencies of 4.5 kHz (resonance of the bulla) and to a lesser extend at 8 and 12.5 kHz. Similar frequency characteristics could be shown for all wavelengths. The IC activation by inner ear laser stimulation was strong at units with characteristic frequencies mostly below 10 kHz for intra cochlear laser stimulation. The general activation pattern in the IC did not depend on wavelength, pulse duration or intra-cochlear fiber orientation. Yet each of these parameters had a modulatory effect on the response strength. No responses to laser stimulation could be recorded from the IC of completely deafened animals, but the IC remained responsive to electric intra cochlear stimulation at normal thresholds in all cases tested.

The results suggest an opto-acoustic effect causing a sound activation of the cochlea rather than a direct neuronal or hair cell excitation. We propose residual hearing as the most likely explanation for any response of the auditory system to laser pulses in the cochlea. Hearing status has to be precisely controlled for in laser stimulation experiments, particularly at low frequencies. Laser induced sound within auditory structures seems to have strong low frequency content due to resonance, even though the short pulse duration could suggest otherwise.

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S4-5

A low-power custom integrated circuit vector matrix multiplier for an implantable vestibular prosthesis

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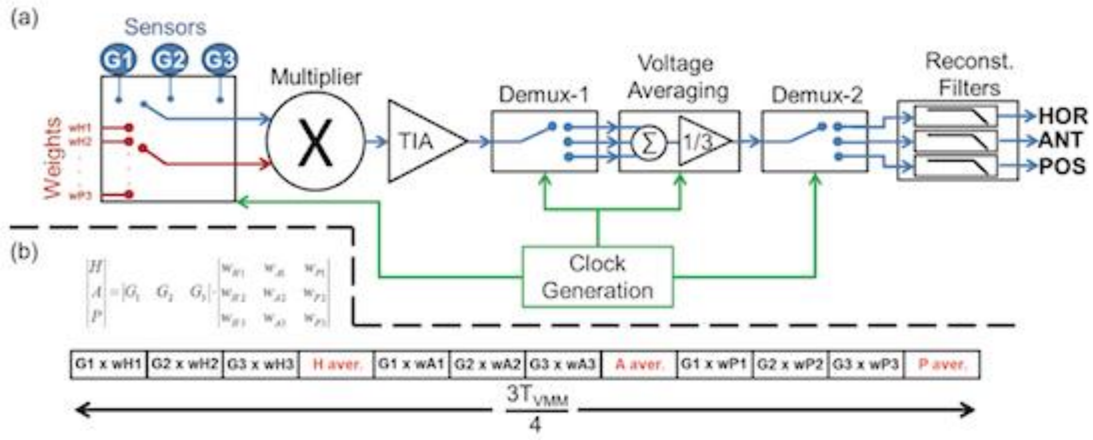
Intro: A Vestibular Prosthesis (VP) is an emerging therapeutic option for individuals suffering from bilateral vestibular hypofunction. By providing electrical stimulation to target vestibular neurons, a unilateral VP may enable individuals to potentially achieve function similar to unilateral vestibular hypofunction patients undergoing rehabilitation. Existing VP technologies enlist inertial sensors to capture angular and linear head motion and encode motion as electrical stimulation pulses for delivery to target neural elements innervating the ampullary and otolith organs. While VP devices have demonstrated efficacy in animal models and in humans, a significant challenge remains to their efficacy; namely, spurious excitation of non-target neural elements. Caused by stimulation current spread, this effect can be mitigated by adjusting the amount of current delivered to each of the three canals. In addition, misalignment between implanted angular rate sensors and the natural vestibular labyrinth can also be offset through a vector matrix multiplier.

Methods: Analog circuitry was designed specifically for 3D human semicircular canal function. An output voltage from each of three gyroscopes is mathematically transformed to a stimulation signal for each of the three canals. More specifically, a 3-by-3 vector matrix multiplication (VMM) occurs with the weighting ideally determined during an initial, and potentially periodic VP fitting, session(s). By designing the circuitry in the subthreshold analog domain, the needed VMM operations occur with minimal consumption. Moreover, by time division multiplexing the VMM operations fewer devices are needed thereby reducing system size and also minimizes calculation errors.

Results and discussion: The TSMC 0.35µm CMOS fabrication process was employed to fabricate the custom circuitry yielding an footprint of 2300µm x 500µm. The VMM circuit transforms 3 gyroscope voltages, magnitude ±250mV (±500º/sec max.), bandwidth < 1.25 kHz, in less than 1msec and consumes 4.98µW of power,

Conclusion: We demonstrate low-power VMM circuitry to ultimately precompensate for suboptimal electrical stimulation provided by a VP. The VMM can be readily integrated with existing VP technologies. Looking ahead, a similar VMM can be designed for otolith organs to convey sensation of 3D linear motion.

Learning outcomes: A realizable, state-of-the-art solution exists to improve the efficacy of electrical stimulation provided by a VP.



VMM. (a) Block Diagram. (b) The 3-by-3 VMM representation and the order of each arithmetic operation, where T_{VMM} is the VMM completion time. *HOR*, *ANT*, and *POS* are the corrected signals for the horizontal, anterior, and posterior canals, respectively. G_1, G_2 and G_3 denote the output signals from the gyroscopes and w_{ji} denotes the weight voltage corresponding to the canal type j and multiplying the signal from the gyroscope number i.

[VMM]

S4-6

Reduction of eddy current losses in inductive transmission systems with ferrite sheets

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Intro: There is a continuing trend to reduce the size of inductively coupled systems in industrial and biomedical applications, such as active implantable systems. As a consequence, metallic surfaces, for example the housing of a battery, will be in close proximity to the transmitter or receiver coil. Thus, eddy currents will be induced which influence the system parameters and lead to a reduction of the energy transfer efficiency. This work will show that this problem can be overcome by placing a thin ferrite layer between the metallic object and the coil of the inductive transmission system, effectively creating a mirror for the magnetic field.

Methods: The effect of single and double layer substrates consisting of ferrite and/or copper on the inductance and coupling of planar spiral coils was analyzed. Specifically, the dependence of these parameters on the distance between the emitter and receiver coils was studied, as this is important for the application in active implantable systems. All calculations have been done analytically with a model based on an infinite substrate and verified both experimentally and with finite elements (FEM) simulations.

Results: The results show that ferrite foils with a thickness of about 0.5mm and a size comparable to the outer radius of the coils are capable of efficiently shielding the metallic substrate from unwanted influences. An adaptation of the number of coils allows restoring the original inductances, coupling strength and transfer efficiency. Analytical results are in excellent agreement with FEM simulations and with the experimental results.

Conclusion: Thin layers of ferrite can be used as a mirror for unwanted magnetic fields and are thus able to efficiently shield unwanted effects of metallic surfaces in the close proximity of inductively coupled systems.

S4-7

Micro computed tomography imaging of a silicone coated thin-film polymeric electrode array in the feline cochlea

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Intro: Although cochlear implants have been remarkably effective in providing functional hearing to nearly 200,000 individuals worldwide, there remains significant variation in speech perception, difficulty in understanding tonal languages, understanding speech in noisy environments, and appreciating music. Solutions to overcoming these challenges include improving the spectral and temporal resolution of stimulation, more effectively engaging the cochlea's surviving neural population, and reducing surgical trauma introduced during array insertion. One promising alternative is a polymeric thin-film intracochlear electrode array. Such microfabricated arrays demonstrate high mechanical flexibility, the ability to place electrode sites with sub-micro resolution, as well as in high-density configurations. However, one limitation these arrays face is reliable insertion into the cochlea given their thin nature and fragility.

Methods: We report a simple method for tailoring the robustness of a thin-film polymer electrode array for electrical stimulation. Using a pneumatically driven dispensing system, an average 232 ± 64 µm (mean ± SD) thickness layer of silicone adhesive coating was applied to stiffen the underside of polyimide multisite arrays. Additional silicone was applied to the tip to protect neural tissue during insertion, and applied along the array to improve surgical handling. Each array supported 20 platinum sites (180 µm-dia., 250 µm-pitch), spanning nearly 28 mm length and 400 µm width.

Results and discussion: Sized for a shallow insertion into the scala tympani via a round window approach, an average intracochlear stimulating current threshold of 170 ± 93 µA to evoked an auditory brainstem response in 7 acutely deafened cats were measured. To visualize placement of such arrays, and validate the adhesion of the silicone to the array, micro computed tomography (micro-CT) imaging with 50 µm resolution was performed on the resected temporal bones of 2 cats euthanized after array insertion. Distances ranging from 100-565 µm from the cochlea's central modiolus were measured for one subject. Two coated arrays were imaged independently ex-vivo to measure silicone coating thickness. Top-side coating thickness measured at 1-1.5 mm intervals averaged 357 ± 81 µm. Bottom-side coating, under the sites, measured at 500 µm intervals averaged 232 ± 64 µm. Integrity of the arrays was also corroborated with post-stimulation impedances within acceptable range. In another subject exhibiting facial nerve activation, micro-CT confirmed appropriate intracochlear placement of the array.

Conclusion: The micro-CT studies served as an integral tool to validate our thin-film devices enhanced with a silicone coating. Further studies will include a histological analysis of neural tissue as impacted by surgical insertion of such arrays.

Learning outcome: Micro-CT imaging of polymeric thin-film arrays can provide the necessary resolution for assessing array placement.

S4-8

Micro magnetic stimulation of the feline cochlea

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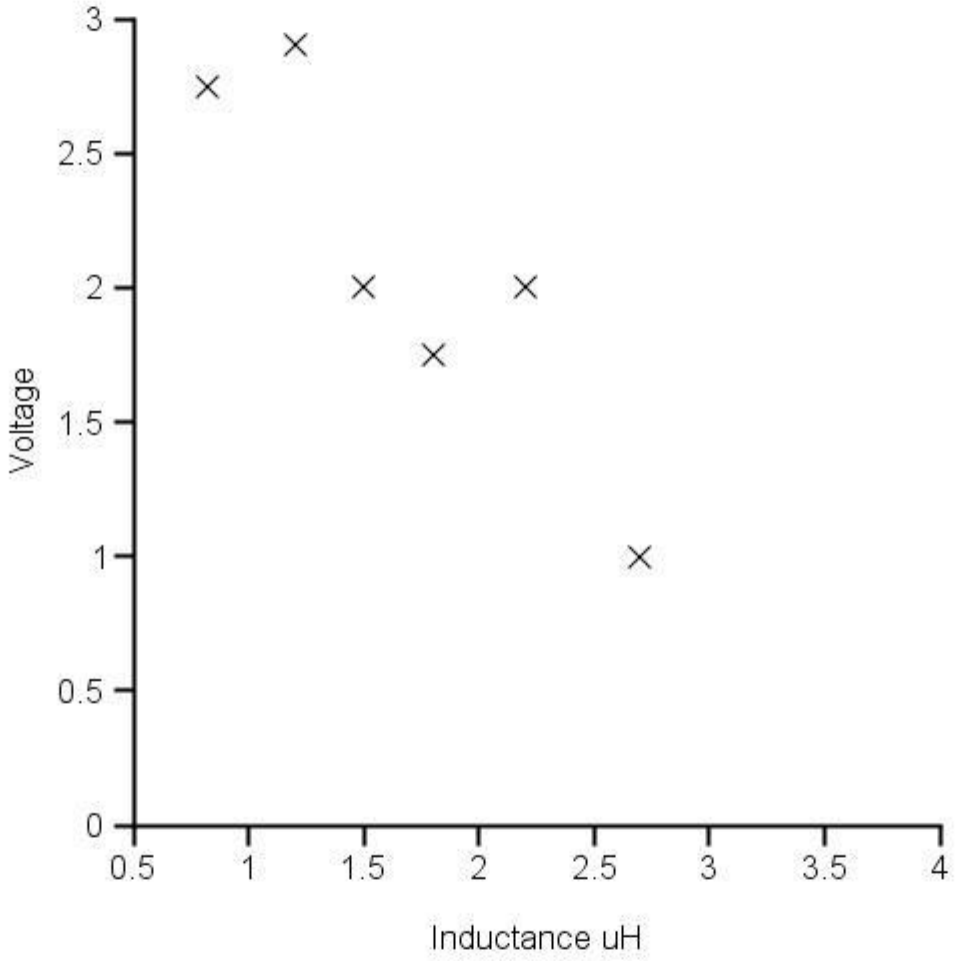
Intro: Cochlear implants provide prosthetic sound to 70,000 new people each year. Their performance is limited by the number of effective channels stimulated, and also by the necessity of adjusting stimuli for each electrical contact based on efficacy in eliciting a response. The efficacy varies as a function of distance from the modiolus, tissue response, and the tissue:electrode impedance. To provide an alternative to intracochlear electrical stimulation with potentially enhanced control of neural activation and reduced tissue response, this paper explores neural activation of auditory tissue induced by an implanted magnetic coil.

Methods: Guided by recent work of others validating micro magnetic stimulation of rabbit ganglion cells in-vitro, we developed a series of magnetic coils (magtrodes), spanning the nano to micro Henry range. Each coil, encased in a cylinder of silicone 8 mm long and 0.8 mm diameter, was introduced into the basal portion of the feline cochlear scala tympani. Stimuli were applied as 20 µSec pulses with rise and fall times of 7 µSec. Artifact was eliminated by using stimuli that alternated in polarity before averaging. Auditory brainstem responses (ABRs) were measured as the potential difference from vertex to ipsilateral bulla. ABR threshold was determined as the minimal stimulation voltage that reliably elicited an auditory brainstem response.

Results: Very low inductance coils appeared to activate neurons through capacitative coupling. Increases in inductance were not related to changes in the threshold to cause an ABR. For larger inductance coils (above 1 µH), increases in inductance were linearly related to decreases in voltage necessary to trigger an ABR. At ABR threshold with the largest inductor (2.7µH) each pulse was measured as 7 microjoules of energy.

Discussion and conclusion: While we have observed that the implanted magtrodes can modulate neuronal activation, further studies are necessary to understand the relationship between stimulation parameters including coil size, coil orientation, distance from neural elements, and neuronal activation. Furthermore, projections based on inductors that meet size requirements show that magtrodes may be comparable to electrodes for power consumption in activating the cochlea.

Learning outcome: Direct micro magnetic stimulation of auditory neural tissue may prove to be an effective alternative, or potentially a compliment, to contemporary intracochlear electrical stimulation.



[ABR threshold vs. inductance]

S4-9

Perilymph proteomic imprint using a new tool with a nanoporous silicon chip.

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Introduction: The physiopathology of hearing loss and intimate mechanisms of degeneration of the inner ear structures is still largely unknown. Hence, 25 % of sensorineural hearing loss is currently unexplained. The in vivo exploration of the cochlea is a new challenge in attempt to get new insights into the oxidative stress and mitochondrial metabolites inducing apoptotic pathways in noise-induced hearing. Specific perilymph sampling is impossible in vivo without contamination of cerebrospinal fluid. Due to the small size of the entrance gate of the cochlea represented in vivo by the round window, nanotechnology aims at circumventing the technological barrier to reach the desired intracochlear target. Our objective is to design a molecular imprint tool using nano chips of silicon to analyze perilymph with mass spectrometry.

Material and methods: A nanoporous silicon chip (2 mm length, 300 µm width) is fixed on a medical polyether ether ketone (PEEK) base with an inox extension cable. The device is surrounded by a retractable Teflon sheath with a sharp distal tip to protect the silicon chip and penetrate the round window membrane.

The surgical procedure was managed on 30 WISTAR rats, 15 healthy rats and 15 rats exposed to ototoxic dose of gentamicin (160 mg/kg/j) during 5 days. We exposed the tympanic bulla by a ventral approach and drilled the bone capsule to have an access to the round window. Then an imprint was done, applying our tool through the round window membrane and insert the silicon chip in cochlea. The silicon was examined in a MALDI-TOF (Matrix-assisted laser desorption ionization - time of flight) mass spectrometry.

Results: Our preliminary results show a proteinic enrichment of the nanoporous silicon chip instead of a standard surface of analysis. The use of a nanoporous surface allows a peptidomic and metabolomic analysis of our perilymph sample. Imprint realization was done easily using our device. We identified specific metabolites of perilymph and concentration gradient in our ototoxic model.

Discussion and conclusion: This new tool allows a specific perilymph protein analysis. Perspectives are the characterization of the perilymph proteome, the discovery of hearing damage biomarkers and potential treatments, in particular in cochlear implant surgery.

S4-10

Towards a self-adapting, smart softening cochlear implant with high channel density

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Histopathological studies have shown that insertion of standard cochlear implant (CI) arrays cause trauma of both the basilar membrane and lateral wall of the cochlea resulting in an inflammatory response which ultimately leads to fibrosis and neo-ossification. In consequence, this trauma can limit achieving hearing outcomes with CIs. Current electrode arrays have up to 22 intracochlear electrodes. However, functionally, implant users do not make full use of all 22 electrodes. A study investigating speech recognition performance in CI users as a function of the number of electrodes demonstrated average performance dramatically improves as electrode count is increased from 1 to 2 to 3 to 4 electrodes. However, there was no added benefit when increasing to 7, 10, or 20 electrodes. Furthermore, if all 22 of the currently available channels were used and speech understanding were improved, experiments with normal hearing subjects have revealed that at least 32 are required to appreciate music. In this work we present the design and fabrication of a novel thin-film cochlear implant. Thanks to the use of shape memory polymers technology, CIs have the ability of altering its shape during the insertion process and take the shape of the cochlea's anatomy (figure 1). During the implantation the smart substrate lowers its mechanical modulus to improve biocompatibility and reduce damage to the lateral wall. This dynamic geometry allows an intimate contact between the implant and the cochlea, opening a new window of opportunity for large count electrodes. Electrode materials like nanostructured titanium nitride, Iridium oxide and platinum had been integrated to improve charge transfer efficiency, lower energy consumption and miniaturization of electrodes. The thin-film cochlear implant is fabricated using full photolithography and other semiconductor processing technologies. This enables not only an increment in the channel count in the implant but also the integration of active devices like: transistors to matrix address electrodes and/or organic light emission diodes.

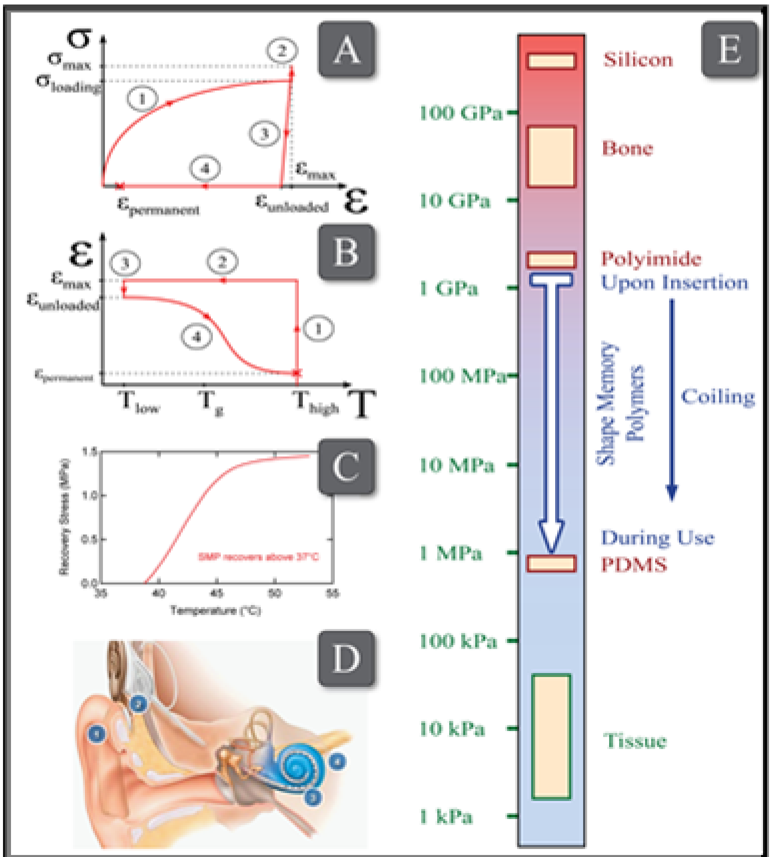

Fig. 3. The shape memory cycle is shown (A) stress-strain and (B) strain-temperature regimes schematically. *Step (1)* is isothermal loading above T_g to induce deformation; *Step (2)* is cooling to fix a metastable shape; *Step (3)* removes the applied load; and *Step (4)* is shape recovery. (C) Constrained strain recovery indicates recovery just above body temperature. (D) A CI schematic from Cochlear Ltd. is shown. The electrode (3) will be replaced with our self-coiling flexible electronic device. (E) The shape memory effect allows for stiff insertion of cochlear implants that soften and coil during implantation and are ultra-flexible chronically.

[Figure 1]

S4-11

Release of BDNF from a nanomatrix induces neurite outgrowth in spiral ganglion cell

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Introduction: Auditory function in severe hearing loss or deafness can be restored to some extent by a cochlear implant (CI). A cochlear implant stimulates the auditory nerve electrically, functionally mimicking lost inner ear sensory cells. The spatial distance between the electrode array in scala tympani and the stimulated auditory neurons hinders highly specific stimulation of small groups of neurons. To bridge this distance one approach is to initiate growth of dendrites of auditory neurons onto or near the CI electrode. As neurons need substrate to grow on, we screened commercially available 3-D nanomatrices that may provide scaffolds for outgrowing neurites and also serve as a reservoir for growth- and guidance factors.

Methods: The screening was performed in a murine bioassay. Native spiral ganglion explants from postnatal day 3-5 mice were employed as a standard technique. Spiral ganglion cell explants were placed in 8-well culture slides containing droplets of distinct 3-D nanomatrices. Cultures were maintained at 37°C for 96 hours. Neurites (NF200) and glial cells (GFAP) were immunostained and analyzed using a laser scanning microscope (LSM) that allows a 3-D reconstruction of the specimen and nanomatrix. Sprouting of neurites was quantified after stimulation with brain-derived neurotrophic factor (BDNF) in the medium.

Results: Multiple candidates of commercially available nanomatrices were evaluated for their stability, toxicity and ability to serve as reservoir for neurotrophic factors. Most of these were formed stable gels under culture conditions and were tested in the murine bioassay for neurite outgrowth. Six of these nanomatrices were stable during the time of explant culture. Eight of nine 3-D nanomatrices tested, allowed neurite outgrowth in the culture slide and along and on the surface of the nanomatrix droplets. Thus, these nanomatrices possess no obvious toxic properties inhibiting neurite growth. Dissolving growth factor (BDNF) in the nanomatrices led to improved neurite outgrowth demonstrating release of sufficient BDNF from the matrix into the culture medium.

Conclusion: The postnatal mouse spiral ganglion explant model allows to evaluate 3-D nanomatrices regarding their ability to allow neurite outgrowth. Furthermore, nanomatrices can be tested regarding possible toxic effects, their ability to form fiber networks, and their ability to serve as a repository for neurotrophic factors.

S4-12

The present and future of cochlear implants

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Intro: Much has changed since the invention of Cochlear implants in the 70s. At present, an external speech processor filters sound into different frequency bands and extracts the envelope within each of them or, more recently, the fine structure of the signal. The corresponding electrical stimulus is sent in sequence to 8 to 22 electrodes implanted in the cochlea. However, there are still situations where CI users are still far from hearing like normal-hearing individuals, such as in noisy environments or music appreciation. This has led to the development of many new approaches in the field that range from new coding strategies, to alternative forms of stimulation, such as optical or piezoelectric. Therefore, the aim of this study is to provide an overview of the state of the art regarding the most novel approaches in cochlear implants, covering not only commercially available technology, but also promising prototypes in early stages of development.

Methods: extensive literature research was conducted in the fields of: 1) sound coding strategies; 2) coupling configuration patterns; 3) electrode contact design 4) totally implantable devices; 5) optical stimulation; 6) piezoelectric based devices; 7) regenerative medicine. The potential of each discovery was assessed based on its feasibility, potential applicability, current technological limitations and state of development.

Results: The literature research reveals that the areas with the strongest research focus are novel coding strategies. Extensive research is also being conducted in the fields of totally implantable devices, with some models currently being available on the market. Optical stimulation on the other hand seems to be a strong bet for the future, with important companies now funding such projects. Finally, other creative approaches include piezoelectric artificial cochleae and 3D bioprinting ears, although these are in a much earlier stage of development.

Conclusion: This is an exciting moment for cochlear implant research. Many aspects of such devices are subject to improvements. Due to the speed at which technology evolves, previously inconceivable solutions are now the subject of serious and promising research. Interdisciplinary collaborations have led to remarkable achievements. It is thus important to gather everything that has recently happened and to see the whole picture, which spans much farther than one might think.

Learning outcome: This review will provide a broad view of the current state of the art in the field of cochlear implants and their likely evolution in the future.

S4-13

Laser and chemical surface modifications of titanium grade 2 for applications in middle ear implants

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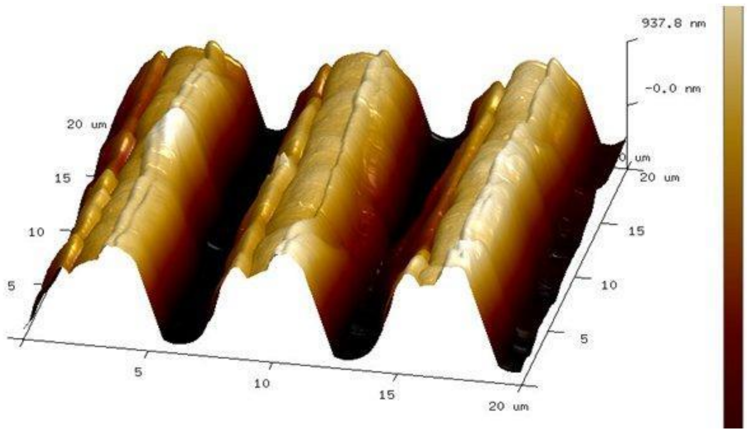
The surface topography of implants is a key parameter for both inducing and suppressing osteointegration mechanism. It is commonly accepted that modification of prosthesis roughness allows for enhance implant-bone adhesion and stimulate cell proliferation. However, optimal topography of the implants surface is still discussed with the latest reports of favorable results obtained for multiscale (from nano- to micrometers) geometric features [1]. In this work we present two approaches for functionalization flat and curved surfaces of titanium middle ear implants. The presented methods include topography modifications with the double laser beam interference technique and chemical etching. The used methodology allows for obtain clear and smooth Ti surface as well as periodic striated topography with the roughness range from nano- to micrometers (Fig. 1.). The obtained structures have been characterized in terms of shape, roughness, chemical composition, mechanical properties and microstructures of substrate material. In order to achieve all information, numerous of research methods have been used: scanning electron microscopy, atomic force microscopy, optical profilometery and microhardness measurements. Demonstrated methodology can be used as an effective tool for manufacturing periodic surface structures with variable geometrical parameters e.g. width, height of stripes and distance between them. The future studies of in vitro cells growth on the surfaces with controlled topography will be also highly valuable for precise description of the relation between implant surface structure and osteointegration phenomenon.



[Figure 1]

Fig. 1. AFM (atomic force microscopy) image of example striped structure obtained with double laser beam interference technique

Reference:

[1] D. Khong, J. Choi, Y-M Im, Y-J Kim, J-H Jang, S.S. Kang, T-H Nam, J. Song, J-W. Park, *Biomaterials,* 33 (2012) 5997.

S5 Electric-acoustic stimulation

S5-3

Influence of insertion angle on speech perception after cochlea implantation

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Cochlear implantation in terms of hearing preservation is performed in patients with residual hearing within the low frequencies. The aim is to use electric and acoustic stimulation (EAS) after surgery, but what happens if hearing cannot be preserved? Is the reduction of insertion depth accompanied by reduced speech perception compared to full cochlear coverage? 93 patients were implanted with Flex electrodes (MedEl Innsbruck, Austria) of different lengths and with variations in insertion depth resulting in different insertion angles postoperatively. After at least one year of cochlear implant use speech perception results for monosyllables were tested in best aided condition (CI only/DUET). Radiological insertion angles were measured postoperatively using the stenvers view x-ray. Speech perception was then evaluated in relation to insertion depth. The group of patients with the shallowest insertion angles showed best results for speech perception when using the combined stimulation strategy (EAS). Within the group of patients who use only electric stimulation a slightly, though not significantly better, speech perception is evident when comparing 540° insertion to 630/720°-insertion. A limited insertion angle is beneficial to patients with residual hearing within the low frequencies who use EAS postoperatively, therefore every effort should be made to preserve residual hearing in these patients. For candidates who are unlikely to use EAS after surgery an insertion angle of at least 540° should be aimed for. Future prospective studies will help to further evaluate the influence of insertion angle on outcome.

S5-5

Tolerable processing delay in electro-acoustic stimulation

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Introduction: Recent studies using modern cochlear implant (CI) devices prove that the majority of subjects can integrate electrical and acoustic stimulation either on the same or on different ears. This bimodal hearing offers potentially complementary information that, when appropriately integrated in the brain, could allow for improved speech perception in noise. In order to enable integration of ipsilateral electric and acoustic stimulation (EAS), however, the delay between the electric and acoustic component may play a crucial role. While there are no clear-cut research results available on maximum tolerable delay between electric and acoustic signals, investigations by Stone & Moore [2003] indicate that delays up to about 10 ms are acceptable for acoustic hearing. Depending on the devices, the difference in group delay between CIs and HAs can range from 0 ms up to 15 ms. Another important parameter for subject acceptance and sound quality of the EAS fitting seems to be the amount of electro-acoustic spectral overlap. In order to optimize sound processing and fitting for EAS, more data on tolerable delays between electric and acoustic signal paths for different filterbank settings is needed.

Method: Eight CI-users with aidable residual hearing in the low frequencies on the implanted side participated in three experiments. Experiment 1 investigated the just-noticeable delay between electric and acoustic stimulation for five different stimuli. In Experiment 2, speech understanding in noise was measured for different delays below and above the individual just-noticeable delay. Finally, subjects had to choose their preferred filterbank setting (overlapping or non-overlapping) in Experiment 3. To be able to control the delay between acoustic and electric stimulation, all stimuli were presented via direct audio input (DAI) to hearing aid (HA) and CI separately.

Results: The just noticeable delay varied substantially across individuals, but was in all cases clearly above the values which are typical for state-of-the-art signal processing in HA and CI. Speech turned out to be the most sensitive stimulus. Speech scores were not significantly affected by variations of the delay up to the just noticeable threshold. For larger delays, however, speech recognition is degraded. While speech scores generally were better with the non-overlapping filterbank, subjective preference varied highly across individuals.

Conclusion: The differences of processing delay in state-of-the-art acoustic and electric signal processing seem to be tolerable for ipsilateral electro-acoustic hearing. However, patients with residual acoustic hearing in mid and high frequencies may be more sensitive to delay differences than the group in this study.

Reference:

Stone MA, Moore BC, 2003: Tolerable hearing aid delays. III. Effects on speech production and perception of across-frequency variation in delay. Ear Hear 2003; 24: 175-183.

S5-6

The role of map parameters on hearing preservation and speech perception outcomes with EAS

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Intro: The utilization of combined acoustic and electric stimulation (EAS) in an ipsilateral listening condition is dependent on postoperative hearing preservation in the surgical ear. Modified electrode arrays and surgical insertion techniques may preserve residual hearing intraoperatively, however, studies have documented the continued progression of hearing loss in some recipients. The goal of this project was assess the relationship between mapping parameters, the preservation of residual hearing, and speech perception outcomes with EAS.

Methods: Thirty (30) adult subjects participated in the EAS clinical trial at the study site. Test intervals included: preoperative, initial cochlear implant activation, initial EAS activation, and 3-, 6- and 12-months post-initial EAS activation. Unaided residual hearing was assessed bilaterally at each interval prior to speech perception assessment and mapping. The test battery consisted of CNC words in quiet and CUNY sentences in steady-state noise. Mapping parameters were recorded to assess the relationship with hearing preservation and aided speech perception outcomes.

Results: Variability in hearing preservation was noted, including loss of residual hearing prior to cochlear implant activation, and complete hearing preservation throughout the 12-month trial. All subjects experienced an improvement in speech perception abilities with EAS as compared to preoperative results with conventional amplification and maintained this higher level of performance through the 12-month test interval. There was a weak relationship between mapping parameters, hearing preservation and speech perception results.

Discussion: Further investigation into potential influences of the variability in postoperative hearing preservation rates is needed.

Conclusion: Subjects with postoperative residual hearing experience an improvement in speech perception abilities with EAS. Evaluations of how to preserve residual hearing over the long-term is needed.

Learning outcome: The participant will understand the variability in postoperative hearing preservation rates and speech perception, and role of map parameters.

S5-7

EAS and residual hearing with positive genetic background

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Intro: The proof of positive genetic mutation encourages patients to receive an earlier intervention. Furthermore, it has been proved to predict the future pattern of deafness to some extent from the sub type of mutations. Such information will be useful even for EAS surgery with resuidal hearing.

Methods: Genetic screening test for deafness has been already approved in Japan and can be covered with public insurance system. Responsible 13 genes and 46 mutations can be checked using *Invader assay* (Usami , Abe: 2008) in deafness patients. The carrier diagnosis without deafness is not permitted ethically.

Results:

1. Results of genetic screening test in patients with deafness

Since March 2009 , this test was applied to 106 patients with profound deafness at Toranomon Hospital, and responsible mutations were detected in 46 patients (43.4%). Some patients with *GJB2, SLC26A4*, *mit1555, mit3243, KCNQ4* mutation thought to be candidates for EAS from the standpoint of audiological criteria.

2. A case report

A 6 Y/o girl passed NHS, but she showed bilateral progressive asymptomatic hearing impairment. Her parents had normal hearing and no other person with severe hearing problem in her family. Pre-operative PTA showed residual hearing bilaterally. Audiological assessment with HA (Naida V) using mono-syllable test showed 5% in right ear and 25% in left ear, word test for infant showed 20% in right and 76% in left.Her blood genetic test showed that she had *mit3243A>G* mutation (heteroplasmy 2%). This meant her hearing will take a turn for the worse. Her parents hoped to get better speech results with hearing preservation on the worse right ear, and they agreed to receive CI (PULSAR FLEX24) operation in the right ear. After 17 months, the residual hearing in the low frequencies is preserved and the mean deterioration was 6.8dB. Post-operative audiological assessment using word test for infant showed 100% in the right EAS. The hearing thresholds using original EAS and DUET2 were compared. Hearing thresholds using DUET2 showed better results than using original EAS (CI+HA).

Discussions and Conclusions: As a genetic background, patients with *GJB2, SLC26A4*, *mit1555, mit3243, KCNQ4* mutation can be candidates for EAS from the standpoint of audiological criteria. The proof of positive genetic mutation encourages patients to receive an earlier intervention including EAS. Furthermore, it is possible to predict the future progressiveness of deafness and will also contribute to select the electrode length.

S5-8

Clinical evaluation of the Nucleus® CP900 series processor in Hybrid mode: Comparison of speech perception scores with and without the acoustic component in the Midlands hearing implant program - children's service, UK

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Introduction: The benefits of electro-acoustic stimulation (EAS) are well known in patients who have residual low frequency hearing. The Nucleus CP900 series sound processor has the capability to add an acoustic component and this can easily be trialled and subsequently removed if there is no clinical benefit. This was not practical in a paediatric population with previous EAS systems produced by Cochlear.

Methods: Five paediatric unilateral Nucleus CI users were identified within our paediatric population as possible candidates for a Hybrid fitting. If these children are deemed suitable, they will trial the CP910 sound processor with and without the acoustic component. Their performance and acceptance of the processors will also be compared.

Measures will include the Automated Toy Test in quiet and in noise and the Brief Assessment of Parental Perception, which is a measure created by the UK Cochlear Implant Psychology Group, currently undergoing validation. This is a quality of life measure appropriate for routine clinical practice in the paediatric population.

Results and conclusions: Two of the five unilateral users were candidates for a Hybrid fitting. Results and conclusions of the two hybrid fittings and their performance with and without the acoustic component will be presented.

Learning outcome: Based on previous research we predict that the children will accept and prefer the additional acoustic input made possible through the Hybrid mode on the CP900 processor.

S5-9

Long term outcomes in cochlear implant adult subjects with pre-implant low-frequency residual hearing

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Introduction: A chart review from our Cochlear Implant (CI) center indicates that recent adult candidates to cochlear implantation have potentially useable, low frequency hearing in the implanted and as well the opposite ears. The clinical issue is to evaluate performance of the implanted ear compared to that obtained in the pre-implant aided ear, and to compare such findings with subjects who previously had scarse pre-implant unaided residual hearing.

Materials and methods: Study group was composed of 10 subjects with slowly progressive hearing loss, with pure tone threshold over the range 125-1000 Hz less than 70 dB; Control group A patients with slowly progressive hearing loss, with pure tone threshold over the range 125-750 Hz equal to 70-85 dB; Control group B with profound hearing loss, > 85, with no hearing aid benefit. Speech perception was assessed in quiet and in noise at SNR +10, primary signal and noise at 0° azimuth, with bisyllabic words and PB sentences.

Results: Hearing threshold for study, control A and Control B groups at the range 125-1000 Hz was respectively: 69.7%, 81.2% and 96.2%. Hearing threshold for study, control A and Control B groups at the range 2000-4000 Hz was respectively: 98.4%, 101.7% and 101.8%. Speech perception in quiet was on average 80-90% for all three groups and not significantly different. Speech perception in noise was higher in Study group than in controls A and B both for words (83.7%, 75.7%, 75%) and sentences (85.8%, 70%, 62%).

Discussion: Although results are not statistically significant, better speech perception both in quiet and in noise was obtained by patients with low-frequency residual hearing compared to their pre-implant condition and to control groups with severe-profound deafness. Implications for bimodal hearing and underlying hearing loss etiology will be discussed.

S5-10

Localization and speech intelligibility in bilateral and EAS cochlear implant users

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Two groups of cochlear implant (CI) listeners were tested and compared on tests designed to task binaural hearing. The EAS group (n=12) combined electric and acoustic stimulation in the same ear, and had low-frequency acoustic hearing in the ear contralateral to the CI ear. These EAS users had access to interaural timing difference (ITD) cues but not to interaural level difference (ILD) cues. The second group (n=11) wore bilateral CIs and had access to ILD cues, but not ITD cues. At issue was the value of having access to one cue, ITD or ILD, in the absence of the other cue, for localization and for speech perception when the target and speech maskers were separated in space. In Experiment 1, the two groups of CI listeners were tested for sound source localization in the frontal, horizontal plane. The stimuli consisted of low-pass, high-pass, and wideband noise bursts randomly presented from a 13 loud speaker array spanning an arc of 180 degrees. Forty-five normal hearing (NH) listeners were tested and served as a reference. For the NH listeners, the mean RMS error for localization was 7 degrees, for the bilateral CI listeners, 20 degrees, and for the hearing preservation listeners, 23 degrees. The scores for the two CI groups did not differ significantly. Thus, both CI groups showed equivalent, but poorer than normal, sound source localization abilities. This outcome using filtered noise bands for the NH listeners suggests that ILD and ITD cues can support equivalent levels of localization. For Experiment 2, the bilateral CI and EAS listeners were tested for speech recognition in a simulated 'cocktail party' environment where the target and maskers were spatially separated. The target was in front and informational maskers were on both sides of the listener. At issue was whether either CI group would show evidence of binaural hearing indicating the ability to 'unmask' speech in a complex listening environment. Binaural advantage was calculated and compared (i) the better CI ear to bilateral CIs allowing access to ILD cues when the poorer CI was added, and (ii) the bimodal condition to the combined condition (bilateral acoustic hearing + CI) when the preserved hearing was added allowing access to ITD cues. Both CI groups showed a significant binaural advantage (a combination of squelch and summation). Group mean scores were equivalent with the bilateral CI listeners improving18 percentage points and the EAS listeners obtaining a 17 percentage point advantage. Results show that either cue - ITD or ILD - allows similar levels of performance when unmasking speech in complex listening environments.

S5-11

Nucleus 6 Hybrid Sound processor in patients with residual hearing

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Cochlear Implant (CI) patients with a common electrode and residual hearing within the low frequency range before and after surgery can benefit from an additional acoustic component. Aim of the study is, to investigate the benefit from Nucleus 6 Hybrid Sound processor for experienced CI users with residual hearing. The Nucleus 6 Hybrid Sound processor can deliver electrical as well as acoustic stimulation in the low frequency range via an acoustic component on the same ear. The improvement in speech understanding and the correlation between the degree of residual hearing and the benefit was determined. Additionally a CI sound processor added with a conventional in-ear hearing aid was tested. After four weeks the speech comprehension in quit and in noise was analyzed. First results show that there is an improvement in speech understanding for the combination of CI sound processer and conventional hearing aid as well as for Nucleus 6 Hybrid Sound processor. It becomes apparent that the improvement with the Hybrid sound processor is larger. Furthermore the degree of residual hearing seems to affect the degree of improvement in speech understanding, though CI users with small residual hearing benefit from the additional acoustic supply too.

S5-12

Relationship between speech discrimination and spread of excitation profile width in simulated CI speech processor - comparison of electric only and PDT EC hearing

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Background/Purpose: To investigate if there is a correlation between the Spread of Excitation (SoE) profile and achieved speech understanding after cochlear implantation, the MATLAB model of CI signal processing was built

Method and Material: Various widths of SoE were used as a model's parameters. The acoustic stimulations of monosyllabic words were prepared using developed model with three different widths of SoE profile The study group consisted of 20 normally hearing adults. Prepared simulations were presented to them in free field chamber. The amount of correct recognized words were calculated

Results: The correlation between understanding of simulated words and simulated SoE profile width was found as highly significant. Nevertheless simulated width of SoE as well as width of SoE measured from CI patients differs significantly from the width of the excitation pattern for normal hearing, used for low frequency by PDT EC patients.

Conclusion: Achieved relationship between width of SoE profile and speech understanding could explain differences in hearing benefits of CI users as well as could be one of the explanations of superior results of PDT patients.

S5-15

The impact of a cochlear implant electrode array on middle ear transfer function - a temporal bone study

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As a treatment for partial deafness with residual hearing in the lower frequency range the combined acoustic and electric stimulation of the cochlea has become widely spread. The acoustic stimulation is provided by a hearing aid's air-borne sound and the electric stimulation by a cochlea implant electrode array, which may inserted through the round window or a cochleostomy. With regard to a most efficient acoustic stimulation of the cochlea this study investigates the influence of an electrode array as well as its insertion path on middle ear sound transmission. Furthermore the influence on inner ear fluid dynamics have been evaluated in 6 non fixated human temporal bones. Therefore the stapes footplate and round window membrane movements were measured with laser vibrometers in response to an acoustic stimulation at the tympanic membrane. The results show a small trend towards an increase of the oval window net volume velocities with a present cochleostomy. The footplate rotational component along the long axis increases independent of electrode array geometry and insertion path while the volume velocity ratio of round and oval window remains unchanged within standard deviations of measurements. The presence of an electrode array in the cochlea may change the middle ear sound transmission properties and the perception of air-borne sound. These results may contribute to further improvements in combined cochlear stimulation.

S5-16

Vibro-EAS: A proposal for advanced electroacoustic stimulation

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Introduction: Electric acoustic stimulation (EAS) uses both cochlea implant (CI) technology to restore severe-to-profound hearing loss in high frequencies and acoustic amplification for mild-to-moderate hearing loss in the low-to-mid frequencies. More patients with residual hearing become candidates for EAS surgery due to the improved techniques for hearing preservation. Most patients with partial deafness fulfill the audiological criteria in low and mid frequencies for the active middle ear implant Vibrant Soundbridge® (VSB). This active middle ear implant - originally designed to treat mild-to-severe sensorineural hearing losses - is a potential device for the acoustical stimulation in EAS. The aim of this study was to evaluate the acoustic potential of the Floating Mass Transducer (FMT) driving a EAS CI electrode for intracochlear fluid displacement as acoustic stimulation.

Materials and methods: A subtotal mastoidectomy and a posterior tympanotomy were performed in seven fresh human temporal bones. As a control for normal middle-ear function, the tympanic membrane was stimulated acoustically and the vibration of the stapes footplate was measured by laser Doppler vibrometry (LDV). Fixation of a FMT to the long incus process (standard coupling) was compared with an FMT fixation on a 20 mm inserted standard cochlea electrode array (31.5 mm) via the round window (Vibro-EAS).

Results: Intracochlear fluid movements using a FMT driven EAS electrode lead to stapes displacements comparable to acoustic stimulation. Velocity responses of the Vibro-EAS lead to 30 to 42 dB lower amplitudes at frequencies up to 4 kHz in comparison to standard coupling. The mean ratio ranges between -25 dB and -35 dB.

Conclusion: Intracochlear combined electrical and acoustic stimulation may be a viable technique to achieve advanced electroacoustic stimulation. A reliable technique for attachment or integration of the FMT to the cochlea electrode array has yet to be developed.

S5-17

Inferences and metaphoric comprehension in unilaterally implanted children with adequate formal oral language performance

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Objectives: To assess skills in inferences during conversations and in metaphors comprehension of unilaterally cochlear implanted children with adequate abilities at the formal language tests, comparing them with well-matched hearing peers; to verify the influence of age of implantation on overall skills.

Methods: The study was designed as a matched case-control study. 31 deaf children, unilateral cochlear implant users, with normal linguistic competence at formal language tests were compared with 31 normal hearing matched peers. Inferences and metaphor comprehension skills were assessed through the Implicit Meaning Comprehension, Situations and Metaphors subtests of the Italian Standardized Battery of "Pragmatic Language Skills MEDEA". Differences between patient and control groups were tested by the Mann-Whitney U test. Correlations between age at implantation and time of implant use with each subtest were investigated by the Spearman Rank correlation coefficient.

Results: No significant differences between the two groups were found in inferencing skills (p=0.24 and p=0.011 respectively for Situations and Implicit Meaning Comprehension). Regarding figurative language, unilaterally cochlear implanted children performed significantly below their normal hearing peers in Verbal Metaphor comprehension (p=0.001). Performances were related to age at implantation, but not with time of implant use.

Conclusions: Unilaterally cochlear implanted children with normal language level showed responses similar to NH children in discourse inferences, but not in figurative language comprehension. Metaphors still remains a challenge for implant users and above all when they haven´t any reference, as demonstrated by the significant difference in verbal rather than figurative metaphors comprehension. Older age at implantation was related to worse performance for all items. These aspects, until now less investigated, had to receive more attention to deeply understand specific mechanisms involved and possible effects of different levels of figurative language complexity (presence or absence of contextual input, degree of transparency and syntactic frozenness). New insight are needed to orient programs in early intervention settings in considering and adequately responding to all these complex communicative need of children with hearing loss.

S6 Music and CI I

S6-4

Childhood Assessment of Music Perception Skills (CHAMPS) in children with cochlear implants: A new test and pilot data

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Intro: Existing studies on music perception on prelingually deafened children (5-10 years old) with cochlear implants (CIs) are limited in the elements of music perception examined. The study purpose was to develop, for use in children (5-10 years old) with CIs, a computerized music perception test that assesses a range of musical perception elements.

Methods: The Childhood Assessment of Music Perception Skills (CHAMPS), developed using *Finale* music composition software (the timbre subtest was generated using live recordings), was presented via an Apple computer, and was played through a Jawbone Jambox (in a sound-treated audiometric booth) to boost intensity. The rhythm subtest has six 4-5 beat instrumental woodblock-generated phrases. The task is to clap the rhythm. Each response is scored as 0 (not close to task), 1 (close but not perfect) or 2 (perfect). The pitch same-different subtest has 20 piano-generated tone sequence pairs (semitone distance = 0-14). Listeners are asked “Were the sounds the same (point) or different (point)?” The response card shows 2 apples versus an apple and banana. The pitch direction discrimination subtest comprises 16 pairs of ascending or descending piano-generated tone sequences (semitone distance = 1 - 12). Listeners are asked “did the music go up (point) or down (point). The response card shows 2 arrows (1 up, 1 down). The closed-set melody (4 melodies for the younger children, 8 melodies for the older children) recognition subtest has piano-generated musical phrases from common melodies. The task is “Show me the picture of the song” and, upon repeat presentation, “Sing the song”. The response card illustrates the melodies plus a dummy foil. Scoring is done separately for the point and sing responses. For the closed-set timbre test, live recordings were generated for 5 instruments for a scale ascending 1 octave then descending back 1 octave. The recordings were stored as audio files. The response card shows photos of an individual playing each instrument. Listeners are asked “Which one of these did you hear?” The subtest order of presentation was counterbalanced.

Results: CHAMPS testing was done on 4 children with CIs {3 binaural, 1 monaural (no hearing aid in the contralateral ear)], age range = 5.1 - 6.1 years, years of CI experience = 2.6-4.1.Scores (%) were as follows:

	Rhythm	Pitch same/different	Pitch direction	Timbre	Melody (point)	Melody (sing)
Range	4-83	40-95	44-63	20-90	38-100	0-50
Median	45.5	67.5	53	50	50	0

[CHAMPS Data]

Discussion: The CHAMPS is easily administered within 20-25 minutes and is appropriate to use with young children. The spread of scores was wide.
Conclusion: The CHAMPS can be used successfully and easily to test several elements of music perception in young children with CIs.
Learning outcome: Listeners will be able to describe, in young children with CIs: (a) various music perception test measures (including the CHAMPS); (b) performance on these measures.

S6-5

Music engagement: The potential of the singing voice - An initial investigation of a group therapy approach

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Intro: Music engagement as an active expression of making music seems to be a very promising training for CI users. Music is quite multifaceted and singing is one possibility. Singing is a musical activity where the innate natural instrument of humans is used. Singing combines music and speech. Furthermore clinical research has shown physiological, neurological and emotional benefits of singing.

Methods: Hearing implant users were invited to participate in a voice and singing workshop for adults. Overall eight participants, all with different types of hearing implants attended. Six meetings were scheduled over the next three months and each meeting took about 1 to 1 ½ hour. The goal was to raise their awareness of the relation between listening and expression. More specifically to make them more familiar with their own voice, teach them some possibilities to make them more sensitive listeners, to improve their ability to be expressive and to increase self-confidence.

Results: Beside the fact that the participants had much fun during the workshop and felt highly motivated and encouraged to further engage with musical activities, some reported that people they interact with on regular basis noticed an improvement in their speech understanding in difficult listening situations. By the fourth meeting the group was able to sing multiple parts of a song (singing in two voices) without problems, which was an unexpected result.

S6-6

A comparison of music style identification abilities between cochlear implant and hearing aid users: Setting realistic expectations for cochlear implant recipients

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Intro: Test of music perception for cochlear implant (CI) recipients have traditionally involved rhythm, pitch, melody and instrument identification assessments; it is well accepted that adult CI recipients are poorer than normally hearing listeners for the latter three assessments. As yet, there are no published results on the music style identification abilities of CI or HA users.

Methods: A music style identification test developed and validated in an earlier study (Looi, King & Kelly-Campbell, 2012) was administered to 17 adult CI users and 11 adult HA users on two occasions, approximately 3 months apart. The test incorporated 8 different styles: i) Classical-Solo; ii) Classical-Group; iii) Jazz; iv) Modern/Pop (1990s onwards); v) 1960s-1980s; vi) Old-time music (pre 1960); vii) Country & Western; and viii) Eastern. Closed-set identification was required, with a score out of 32.

Results: At the first administration, mean style Identification scores for the CI group was 54.61% (SD: 17.55), and 72.46% (SD: 15.61) for the HA users. At the second administration, mean scores were 53.94% (SD: 20.30) and 71.31% (SD: 14.78) for the CI and HA groups, respectively. Mann Whitney U tests showed no significant difference between the 2 administrations for either group, with the HA scores being significantly better than the CI scores (p=0.006). Spearman's rho analyses showed no significant correlations for the HA group between identification scores and the variables of speech perception, pre- or post- hearing loss music listening, formal music training, or music enjoyment. For the CI group, the only significant correlation was between style identification scores and post-implant music listening (rho = 0.492; p= 0.045). Normally hearing participants scored over 90% correct; significantly better than both the CI and HA groups.

Discussion and conclusion: The results indicated that although HA users were significantly better than CI recipients, HA users were not as good as NH listeners. This is an important consideration for counseling CI recipients. Most of the current published research compares CI recipients to normally hearing listeners; this may not be a fair or appropriate comparison given that HA users with lesser degrees of hearing loss than CI recipients do not perform equivalently to normally hearing adults.

Learning outcome: Delegates will have a better understanding of the music style identification abilities of both CI and HA users. Evidence will be provided to challenge the traditional research methodology of comparing CI users to normally hearing listeners for music perception, and setting realistic expectations in counseling.

Reference:

Looi, V; King, J & Kelly-Campbell, R. (2012). A Music Appreciation Training Program Developed For Clinical Application With Cochlear Implant Recipients And Hearing Aid Users. Seminars in Hearing. Vol 33(4), pp. 361-380.

S6-7

The impact of cochlear implantation of music appreciation

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Intro: Existing research has shown that adult cochlear implant (CI) recipients report lower levels of music appreciation and listening, compared to normal hearing (NH). However given that CI recipients have a significant sensorineural hearing loss (SNHL), which results in physiological changes as well as psychoacoustic abnormalities, is must be asked whether NH is a realistic or justifiable comparison of music outcomes for adult recipients? When evaluating speech outcomes, a 'good' outcome is reported if a recipient's post-surgery scores are better than those recorded in pre-implant evaluations (i.e. when the recipient had a significant SNHL). Audiologists do not consider a 'good' outcome only to be when post-implant speech results are equal to, or better than, NH. The purpose of this study was to evaluate the music appreciation levels of adults who met the audiological criteria for standard implantation- i.e. a moderately-severe to profound bilateral SNHL.

Methods: The Music Quality Rating Test Battery (MQRTB) [Looi et al., 2011], along with a music questionnaire [Looi et al., 2008] was administered to all adults who met the audiological criteria for a CI at a large clinic in Australia. This paper is part of an ongoing study, with the MQRTB to be re-administered 3, 6 and 12 months post-implant in a CI-only listening condition.

Results: Results are also compared to existing publications of CI recipients evaluated using the same MQRTB. It was hypothesised that music appreciation levels would be higher post-implant than pre-implant, as the CI should provide more of the higher frequency information that contributes to timbre perception, when compared to having a moderately-severe to profound bilateral loss and using hearing aids.

Discussion and conclusion: These results have significant implications for clinical practice in terms of counseling and setting realistic expectations for prospective as well as new recipients. It also has implications for future research studies; are comparisons of CI recipients to NH listeners a fair or appropriate comparison? Learning outcomes: This presentation will highlight the difference between music appreciation and music perception will be given, and the need for separate assessments for these two independent issues. Delegates will have a better understanding of the impact of cochlear implantation on music appreciation, as well as the need to compare 'like with like'. That is, comparing results with the CI to those obtained just prior to implantation, as opposed to comparing CI outcomes to NH performance. The application of these results in clinical practice will be discussed.

References:

Looi, V., McDermott H. J., et al. 2008. Music perception of cochlear implant users compared to that of hearing aid users. Ear Hear. 29, 421-434.

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S6-8

Music perception and appreciation in young adults with cochlear implants

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Intro: Studies largely show diminished music enjoyment associated with impaired music perception in adults with cochlear implants (CIs). This finding, however, may not apply to young adults with CIs, as the importance of music is heightened in young, hearing adults. The study purpose was to examine music perception and appreciation in young adults with CIs.

Methods: Participants (18-26 years old) comprised 10 prelingually deafened users of CIs (5 binaural, 5 monaural without a hearing aid in the contralateral ear; 7-19 years of CI use) and 12 listeners with normal-hearing sensitivity (NH). The following were administered in counterbalanced order: 1. The computer-administered Clinical Assessment of Music Perception (CAMP) (Nimmons et al., 2008) in sound field at 65 dBA in a sound-attenuating booth; 2. A 4-question survey on music listening habits and enjoyment (5-point scale with 1 being the least frequent, important, or enjoyable and 5 being the most frequent, important, or enjoyable)

Results: Results of the 2-sample Wilcoxon Rank Sum test revealed significantly poorer median performance ($p < .05$) on all music perception measures (except pitch at 226 and 391 Hz) in the CI group than the NH group. Median scores were as follows:

	Pitch direction discrimination threshold (semitones)	Timbre recognition (% correct)	Melody recognition (% correct)
CI group	0.9-1.2, depending on frequency	25	14
NH group	0.6-1.1, depending on frequency	85	67

[Table 1]

Chi-square testing revealed no statistically significant difference ($p>.1$) between groups for music-listening frequency, music importance, music enjoyment, or most common music listening mode; median scores were moderately high to high on these measures in both groups.

Discussion: Despite the marked divergence on most music perception measures, no significant differences occurred between groups on any parameter of music listening habits and enjoyment. Thus, music appreciation and music listening frequency was moderately high to high in both groups. In contrast, the results of studies on adults who are 26+ years old have shown significantly poorer music appraisal in persons with CIs as compared with NH adults.

Conclusion: CIs have significant limitations in transmission of sound percepts because of wider and a reduced number of auditory filter bandwidths that adversely affect frequency selectivity and ultimately yield impaired music perception performance, particularly for timbre and melody. Nonetheless, enjoyment of music, frequency of listening to music, and importance of music remains are moderately high to high in young adults with CIs as well as young NH adults.

Learning outcome: Listeners will be able to describe (a) pitch, timbre, and melody perception in prelingually deafened young adults with longstanding CIs and in young NH adults; (b) music listening habits and appraisal in young adults with CIs as compared with young NH adults; (c) contrast music perception and music appraisal in younger versus older adults with CIs.

S6-9

Research of Apical Effect on Music Perception - preliminary study

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Introduction: Cochlear implant (CI) has been known to significantly improve recipients' speech perception in quiet environments. However, it is still unknown about the apical effect of CI with regard to music perception. The aim of the study is to investigate the CI with long electrode arrays from MED-EL were studied in order to see if music perception ability is affected with long electrode arrays that reach the apical end of the cochlea.

Methods: All participants take diatonic scales discrimination test (DSDT) which includes four experimental treatments: all electrodes activated (ALL), apical electrodes deactivated (A), basal electrodes deactivated (B), and interval electrodes deactivated (I). Participants need to distinguish in total 392 pairs of diatonic scales between due to si (14 scales). They need to tell which one scale is higher than the other. Apart from diatonic scales discrimination test, we proceed sound field test and word discrimination score (WDS). All experiments data are examined in statistics.

Results: In DSDT, the group of ALL is better than the other three groups with statistic significant. Though the group of B has the worst performance within these three groups (A, B, I), it doesn't reach the statistic significant level. In WDS, it is the same that the group of ALL has better results than the other three groups with statistic significant. Then, the group of I has better performance than these two groups of A and B with statistic significant level. Further, there is no difference between groups of A and B deactivated on their WDS performance.

Discussion: According to the data we collected, it shows that reducing the electrodes effects the performances, no matter on DSDT or WDS. In DSDT, it seems that the group of B performs worse than the group of A. In other words, there is no apical effect in this experiment. As a result of the basal electrodes deactivated, it effects the perception of high frequency; it may make participants lose the clues of harmonics, which will make them difficult to make discriminations. Further, this research is unable to access the parameters setting of MED-EL fitting software. Therefore, it may be possible that the parameters setting of MED-EL fitting per se make no differences among three electrodes deactivated groups. Then in WDS, the group of I performs better than the group of A and B. However, comparing to the group of ALL, the group of ALL still performs the best with statistic significant level. Thus, when implant has problems, we still need to sort it out as soon as possible, and keep tracking recipients' speech perceptions.

Limitation and Suggestion: Owing to the limited access to the parameters of MED-EL software, we suggest that future studies shall have better access and control of all parameters of software. Additionally, it is also possible to include other melody discrimination test in further experiment and to investigate the wrong patterns.

S6-10

Fine structure contributions to discrimination of musical simuli

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Appreciation of music is often unsatisfactory for cochlear implant users. While rhythm is typically recognized, fine structure components of musical stimuli such as timbre are poorly perceived. To investigate musical elements contributing to timbre perception, and the potential limitations of cochlear implant processing strategies to perceiving timbre, we manipulated the temporal and spectral envelopes of musical notes and tested perception of these novel stimuli on normal hearing and implanted subjects. The first study examined the ability of cochlear implant users (n=25) to identify and discriminate musical instruments in several conditions affecting the envelope and fine structure of the stimuli. These included the most characteristic pitch range of the instrument, the pitch normalized to playing a G4-G5 scale, the attack of the note removed, the release of the note removed, and the attack and release of a note removed. While CI subjects had significantly poorer performance than normal hearing controls regarding the ability to identify an instrument ($p < .05$), there was no significant difference in discriminating the musical stimuli as same or different. Further, spectral and temporal information was important for both identification and discrimination, and was used similarly by normal hearing and CI subjects. The second study also examined fine structure and tested the ability to discriminate notes in which the attack and release were removed leaving only the harmonic spectrum of the note. One task was to discriminate whether the stimuli were from the same/different instrument. There were some instrument pairs in which CI subjects (n=25) performed as well as normal hearing subjects but several instruments (i.e., clarinet vs flute vs saxophone) in which there was significantly more difficulty ($p=.01$ to $p=.047$). The second experiment used stimuli from the same instrument but with the 1st and/or 2nd harmonic removed; subjects were tested for discrimination of native from modified sounds. Removing both the 1st and 2nd harmonic of a musical note greatly improved the ability of CI subjects (n=15) to discriminate stimuli despite overall performing significantly worse than normal hearing subjects ($p < .05$).These experiments show that many spectral and temporal cues important in timbre perception are heard by CI users. While CI users may not be able to use these cues to identify what instrument is playing, they are able to use these cues to distinguish one instrument as being different from another. This suggests that some fine structure, but not necessarily all fine structure, is being perceived by CI users. Training is a potential intervention to enable CI patients to better use the information being perceived to recognize the source of a musical note. These experiments also indicate that changing the harmonic structure of a sound, such as what could be done with new processing strategies, can help CI users distinguish between similar musical stimuli.

S6-11

Association of music recognition and speech perception in children with bilateral cochlear implants: Effects of music training, implanted side and binaural hearing

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Introduction: It has been said that music recognition by cochlear implant (CI) is difficult, however, a recent study has shown that children with CI can enjoy music, sing and also have the ability to identify well-known music using sheet music. In our study, when children were exposed to and also actively listened to music at home starting at a young age with CI, this resulted in higher word recognition scores. In this presentation, we compare performance on speech perception tasks in musically trained and untrained bilaterally implanted children and teens. We will also examine effects of implanted side on speech perception tasks.

Materials and methods: Twenty three children or teens with CI were tested on their recognition of familiar melodies sung using only the syllable 'la' with the music being played by a piano. Twelve were taking or had taken music lessons pre- or post-operatively and eleven had no formal musical training. We performed music recognition test (see Nakata, et al. in this proceeding for the procedure). Furthermore, we evaluated word recognition scores (WRS) and speech discrimination scores (SDS) under silent & noisy conditions on 23 children with bilateral CIs who had already acquired language.

Results: There was a main effect of musical training for SDS at 60 dB without noise indicating that child and teen CI users with musical training outperforming untrained counterparts ($p < .001$). Furthermore, *t*-tests revealed significantly higher performance by musically trained than untrained child and teen CI users in some speech perception tasks. On WRS, musically trained children and teens outperformed their non-musically trained counterparts at 60 dB SPL when tested with bilateral CIs ($p < .02$). For monosyllabic SDS, again the musically trained group outperformed their non-musically trained counterparts at both 60 dB when tested with 1st CI ($p < .05$), and 70 dB with bilateral implants as well as 1st CI, (*p*s < .02). Bilateral performance was significantly better than 1st CI and 2nd CI when the test was done with the presence of noise ($p < 0.001$). Four children who received their 2nd CI at the age 6 or younger and started to enroll in music lessons at age 3 had perfect scores on the music recognition test. Furthermore, those four children excelled in speech perception tests. Their scores revealed 100% at 60dBSPL and 96-100% at 70dBSPL on WRS, 90-100% at 60dBSPL and at 70dBSPL on SDS and 75-85% on SDS under the noise (S/N=80/70). Overall, children and teens with musical training recognized melodies significantly better than those with no musical training. We are hopeful in also expecting improvement of in the pitch recognizing ability and in the phoneme speech perception of children with CI with the help of music lessons and binaural hearing strategy.

S6-13

Electrophysiological evidence for semantic processing of music by cochlear implant-recipients

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Background: Postlingually deafened patients with a cochlear implant (CI) often report long-term limitations in music perception abilities. Unfortunately, their subjective perception cannot be validated sufficiently. However, in normal hearing participants, electrophysiological measurements provide objective evidence of music perception by tracking the semantic processing of words preceded by musical excerpts (*Koelsch et al., 2004, Nature Neuroscience*). The current study examines, whether these musical-semantic associations of complex musical excerpts can be perceived by CI-patients.

Material and methods: Thirty-eight postlingually deafened and fifteen pre- or perilingually deafened patients supplied with a cochlear implant for at least five months as well as matched controls participated in the study. They listened to complex musical excerpts (presented via loudspeakers) which were followed by a visually presented word. This word was either semantically congruent or incongruent to the prior musical excerpt as evaluated in several pretests with normal hearing participants (see *Koelsch et al., 2004*). Event-related brain potentials on the word stimuli were averaged separately for congruent and incongruent conditions. Differences in ERPs related to congruency provide information about the musical-semantic associations perceived by the participants.

Results: Incongruent stimuli elicited a more negative ERP on central electrode positions than congruent trials (N400 effect) in the postlingual as well as in the control group. In contrast, no such congruency effect was seen for the pre-/perilingual group. The amplitude of the congruency effect in the postlingual group correlated with time post implantation as well as with some musical discrimination abilities. However, the congruency effect was not related to either language comprehension abilities with CI, musical training with CI or musical experience prior to implantation.

Discussion: Postlingually deafened CI recipients are able to extract meaningful information from complex musical excerpts similar to normal hearing controls despite reduced discrimination abilities. Onset of hearing loss (pre-/peri- vs. postlingual) had a large impact on the conceptual processing of music. The present paradigm allows an objective validation of semantic processing of complex musical excerpts by CI recipients.

S6-14

Improving learning ability by music & different aspects of music on CI users

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Aim: In this study we have reviewed the feasibility and results of teaching music for implanted children. Music is found to affect the process of learning and thinking. Music develops a positive attitude in the listeners and provides them with motivation.

Material and methods: In a longitudinal study, all the children who have been undergone cochlear implantation are potential candidates for this training program compared with CI control group.

Results: All children who have entered the music training programs, have significant improvements in their daily communications as well as the desired endpoints.

Conclusions: learning ability will be improved for this group of children. Music training can be, and should be, a part of habilitation programs. We have introduced this approach 14 years ago, and know it is completely incorporated in our routine habilitation program and also in many centers in the world.

S6-15

Association of musical training and music recognition by children and adolescents with bilateral cochlear implants

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Objectives: While available research indicates that cochlear implant (CI) users typically have difficulty recognizing music without lyrics, there are anecdotal reports on children and teens with musical training showing flawless performance on such tasks. The goal of this study is to examine whether children and teens with bilateral CIs with musical training show enhanced ability in recognizing familiar music.

Design: Twenty three children or teens with bilateral CIs were tested on their recognition of familiar melodies (M = 5.8 songs, range = 3 songs to 10 songs) sung with lyrics, sung with ´ra´, and played by piano. Twelve were taking or had taken music lessons pre- or post-operatively (congenital age: M = 11.3 years, range = 6.5 to 16.4 years, years of music training: M = 5.7 years, range = 1 to 12 years) and eleven had no formal musical training (congenital age: M = 12.4 years, range = 6.10 to 16.5 years). Melodies were presented in a fixed order for side of implant and song type. Side of implant was in order of 2nd implant, 1st implant, and bilateral implants. For each implant side, song type was presented in order of normal lyrics, monosyllabic, and piano versions. Within each set, order of songs was randomized.

Results: Because the number of songs on which child and teen CI users were tested varied, accuracy score was computed by correcting the observed proportion of correct identification by the proportion of correct responses expected by chance. Analysis of variance revealed a strong main effect of musical training with musically trained group recognizing melodies significantly better than musically untrained group ($p = .001$). More specifically, a significant music lesson by song type interaction effect ($p = .001$) indicated that while accuracy scores were high (> .80) regardless of musical training type for normal lyrics version, musically trained group outperformed untrained group for monosyllabic and piano versions (> .70 for musically trained group and < .45 for untrained group). A main effect of the side of implant ($p < .001$) revealed higher accuracy scores by the first CI and bilateral CIs than the second CI, but difference between 1st implant and bilateral implants was not significant. Also a main effect of song type indicated that performance increased in order of lyrics, piano, and monosyllabic versions ($p < .001$).

Conclusions: Child and teen bilateral implant users with music training can identify familiar songs without lyrics. Association of piano timbre with music may have played a role in superior performance in piano version than in monosyllabically sung version. Further study with random assignment of musical conditions can uncover causal effect of musical training on various musical and spectrally demanding tasks for users of CIs.

S6-16

Influences that musical activities by acoustic musical instrument bring to cochlear implant recipients - feeling the articulation of music

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Introduction: Most majority of the Cochlear Implant Recipients (CIs) are content of carrying communication in quiet but have difficulty listening in noisy environment. And, it's difficult for them to enjoy listening music because they have difficulty recognizing musical notes. As a result, many of the CI's tend to keep themselves apart from music. The further they keep themselves from music, more difficult it becomes for them to involve with music. Our team have kept musical activities with CIs for more than ten years so they could enjoy music in some ways. Through those activities, we found that the recognition tasks involved with pitch or harmonies were tough for them, but we also discovered that having themselves playing musical instruments made them really willing to listen to music, not necessarily percept pitch, harmonies or melodies. They can play acoustic instruments, feel the emotions out of music through the activities.

Objectives: Introducing our musical activities aiming to have CI's feel the articulation of music.

We have held music concerts with CIs annually for the last ten years, so our activities should be introduced.

Methods:

1. Using acoustic musical instruments and have the CI's play following therapists.
2. Assess the below in the range from 1 to 10, how well they could imitate the therapist.
    1) Rhythms 2) Dynamics 3) Breath 4) Intonation
3. Have musical activities according to their abilities measured above.
4. Using acoustic instruments, and feel the music articulation that is conducted by the others, to perform the tunes ensemble. The state of the capability to take in articulation was investigated.
5. Practice playing musical instruments considering their skills observed above.
6. Conducting the same tasks above with normal hearing participants and compare with CI's.

Results and discussion: We surmise that these musical activities would help them improve their perception among the musical feelings. Once they start to begin to improve on these abilities, they should start to feel some kind of satisfaction while listening to music. The CI's could feel the musical emotions - they don't have to give it up.

S6-17

Differences in the perceived music between normal hearing, monolateral and bilateral cochlear implanted adults by EEG

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To now, the perception of music by cochlear users remains limited with severe deficits observed in the perception of the tone and the pitch of the music. The fruition of music falls inside the context of the perception of complex stimuli. In this field, one of the main problems is that the evaluation of the pleasantness strictly depends on the listening. Different research relies on the use of psychophysical tests to assess the users´ perception of music. However, such psychophysical tests are not useful to create an objective indices that allow a better assessment of the perception of music by patients. The aim of this study is to investigate whether it is possible to describe the pleasure of the listen of musical stimuli in a population of patients with monolateral (MCI) and bilateral (BCI) implants by using electroncephalographic recordings (EEG). Previous observations on healthy subjects have shown that changes in EEG of the prefrontal areas are correlated with the pleasure experienced as a result of the perception of stimuli (approach - withdrawal theory). In particular, we used the variation of the unbalance of the power spectra activity of the EEG between left and right frontal cortical areas as an index of the appreciation of the music by two groups of 7 MCI and 3 BCI patients against a group of 6 normal-hearing controls (CTRL). All the groups analyzed viewed the same short movie (5 min) with no sound (MUTE), with the original sound (NORM) and with a distorted sound (DIST) in a random sequence. The results Analysis of Variance results show that the pleasantness index returns a statistical significant differences for the three populations across the different stimulations (NORM, DIST,MUTE). In particular, for MCI population with a $F(2,118)=12.941$, $p = 0.0001$, for the BCI ones with a $F(2,118)=0.152$, $p = 0.859$ and for the CTRL with a $F(2,118)=4.5101$, $p = 0.013$.Summarizing the statistical results related to the neuroelectrical index of pleasantness of the music perceived by the groups it can be stated that: i) the appreciation of the music for the CTRL and the BCI patients are similar across the stimulations employed (NORM, DIST, MUTE);ii) the MCI population has a proper profile across the stimulations in which the event of the MUTE presentation of the video generates a strong unpleasant reaction. The reason could be due to the evocation of the memory of deafness as reported by patients recorded. Indeed, these findings support the hypothesis that the MCI population could perceive worse the music when compared to the CTRL subjects and the BCI patients.

S7 Language acquisition and speech production after CI

S7-1

Multi-center longitudinal study of oral language development in children after cochlear implantation: Results of growth in narrative language skills from the childhood development after cochlear implantation (CDaCI) study

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Introduction: Longitudinal studies of language development and factors associated with post implant language growth trajectories in children with cochlear implant provide important insight to inform implant candidacy and post implant habilitation strategies.

Methods: Longitudinal study of oral language development 4 to 8 years after cochlear implantation was conducted using data from the Childhood Development after Cochlear Implantation (CDaCI) Study. The CDaCI Study enrolled 188 children with severe to profound sensorinueral hearing loss (SNHL) who received cochlear implant before 5 years of ages at study baseline. Language samples were obtained from 161 of the 188 implanted children at their 48, 60, 72, 84, and 96 months of follow-up after implantation Narrative retell language samples from 155 of these children were analyzed for language skills including mean length of utterance in morphemes (MLUM: gross morphosyntax), number of different words (NDW: lexical diversity), and words per minute (WPM: verbal productivity) using the Systematic Analysis of Language Transcripts program.

Results: At 4-year after implantation, the mean (standard deviation) was 5.6 (2.2) for MLUM, 65.7 (36.4) for NDW, and 57.5 (26.5) for WPM. The growth of oral language skills between 4- and 8-years after implantation varied as a function of age of implantation, with children implanted earlier showing faster language growth than those implanted later. However, the language growth of implanted children were highly variable, and on average lagged behind the language skills of typically developing, age-matched children. Several baseline variables were found to be associated with oral language development after implantation to a varying degree. Verbal comprehension scores at baseline predicted MLUM, NDW, and WPM between 4- and 8-years of post-implant follow- up, while residual hearing, measured as 4-frequency pure tone average at baseline in the better ear, predicted only MLUM outcomes during the same follow-up period.

Discussion: Age of implantation impacts children´s language development. For children implanted at the same age, greater verbal comprehension prior to implantation is associated with improved development of language skills over time.

Conclusion: Timely and effective intervention for children with SNHL who are eligible for cochlear implantation is critical to their subsequent language development.

Learning outcome: At the conclusion of this activity, participants will be able to

1. describe the post implant language growth of implanted children relative to the language skills of typically developing children.
2. explain the impact of age on implantation on language growth post implantation across several oral language skills.
3. identify some important pre implant factors that are associated with language growth post implantation across several oral language skills.

S7-2

Effects of age on speech abilities in young cochlear implanted children

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Introduction: According to the literature one of the most important factors which can influence on the communications skills in paediatric cochlear recipients is age at the time of implantation. But, it is not possible to predict the outcomes of cochlear implantation prior the intervention. In the field of achievement in the cochlear implanted children still exist large variability. In this article we analyzed the improvement in speech recognition and language skills as a function of age at the time of implantation.

Methods: We analyzed the results of 42 implanted children. In all cases we performed cochleostomy, in 12 cases we used trans-canal approach (Veria) and in 30 cases we used classic technique (with posterior tympanotomy). After classic technique we switched on implant after 6 weeks and after trans-canal approach after 4 weeks. All of them used only oral communication. We divided participants in the 2 groups by their age at time of implantation, C1 (cochlear implantation prior the 2 years of age) and C2 (cochlear implantation between 2 and 5 years of age). All children in our study have profound bilateral sensorineural hearing loss without additional handicap. We applied a battery of different test prior the implantation, and every 6 months postoperative for at least 3 years. The child responses are scored as the percent of key words or sentences correctly identified and repeated. In the last measuring we used testing in the background noise.

Results: All children demonstrated significant improvements in their ability to recognize words from a closed-set with increased time of device use without significant influence of the age at the time of implantation. For the open-set testing score ranging from 45% for C1 to 40% for C2 group one year after implantation. Following 2 years of device use, the open-set score ranged from 85% for C1 to 80% for C2 group. There was no interaction between age at the time of implantation and length of device use. For both groups word recognition score improved over the time. For both groups the results of open-set word recognition were lower up to 20% in the presence of the background noise.

Conclusions: In summary, our investigation demonstrated that young children with cochlear implant achieve significant improvement in their verbal communication skills over the time. Early implantation (before the 2 years of age) can have a significant impact on the word recognition and language development, but may not be crucial for the speech abilities.

S7-6

Rehabilitation of the late cochlear implanted adolescents with prelinguistic deafness: The benefits of Persian Cued speech

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Introduction: The purpose of the current study was to assess the effectiveness of using Persian Cued Speech as the rehabilitation tool for the late cochlear implanted prelingually deaf adolescents. Cued Speech is a system which can make language completely accessible for deaf persons.

Method: Patients were late cochlear implanted adolescents who had failed from all the oral rehabilitation programs after receiving their devices except Cued Speech. First narrative competence skills were assessed then after participating in one- hour Persian Cued Speech intervention sessions twice a week for eight weeks the test assessed again and compared with each other.

Results: Results revealed significant differences between all pre and post testing measures. All the narrative macrostructure (Topic maintenance, Event Sequencing, Main information)(P< 0/01) and microstructure (Referencing (P< 0/05), Mean Length of Utterances(P< 0/01)) items were significantly improved There is no significant differences in two of microstructure items (Conjunction Cohesion, Syntax Complexity)

Conclusion: Our results demonstrated that using Cued Speech can be so effective in the rehabilitation programs of late cochlear implanted adolescents.

Keywords: Cued Speech, Pragmatic skills, Narrative competence, Deaf, Cochlear implant, Late implanted

S7-10

Acoustic properties of vowel production in prelingually deafened children with cochlear implants

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The present study examined the acoustic features of vowels in Mandarin-speaking children with cochlear implants (CIs). The subjects included 14 native Mandarin-speaking, prelingually deafened children with CIs (age 2.9-8.3 years old) and 60 age-matched, normal-hearing (NH) children (age 3.1-9.0 years old) as control. Each subject was recorded producing a list of Mandarin monosyllables which contained seven Mandarin vowels: /a i u y ɤ ʅ ɿ/. Midpoint formant values (F1 and F2) of each vowel token were extracted and then normalized to eliminate the effects of different vocal tract sizes. Results showed that CI children produced significantly longer vowel durations and less compact vowel categories than did NH children. The CI children's acoustic vowel space was reduced due to a backward distribution of the vowel /i/. The vowel space area showed a strong negative correlation with age at implantation (r =-0.80). Additionally, the analysis of acoustic distance between the CI and NH children showed that CI children produced peripheral vowels such as /a u/ similar to NH children whereas other vowels such as /ʅ ɿ/ considerably different. These findings highlight the importance of early implantation and have implications in guiding clinical aural habilitation in young children with CIs.

S7-11

Acoustic structure of voice in children with partial deafness (PD)

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Introduction: Congenital or acquired in early age hearing disorders have significant impact on the development of the larynx and voice production. Hearing disorders acquired with time in every age give rise to voice disorders called audiogenic dysphonia.

Aim: The aim of this study was assessment of acoustic structure of voice in children with partial deafness.

Material and method: Material included 137 children in the pre-school and school age, from 4-12 y.o. with diagnosed sensorineural hearing loss within high frequencies - over 1000 Hz - which is defined as partial deafness (PD). All children were subjected to the phoniatric and laryngological examinations as well as subjective and objective voice assessment. All children went through the phoniatric and laryngological examinations to exclude possible pathologies (palate dysplasias, cleft palate, mental deficiency, asthma, craniofacial congenital defects) that could influence the quality of voice and phonation in the larynx. All children were examined with impedance audiometry, tonal audiometry and ABR. Voice was assessed subjectively considering the following features: character, production, regulation, intensity. Voice was recorded directly on a hard drive using CSL 4300B KAY Digital measurement interface, all generally approved studio conditions were provided for the recording. Prolonged phonation on the vowel „A” was recorded by each patient. Results of the acoustic research were analyzed.

Results: All patients used grammatically correct language. In 65 % of cases articulation disorders were observed, in 30 % of children speech was not fluent, almost 30% of them had problems with understanding of complex commands. Listening assessment of children voices in over 73% revealed that voices were not correct. Voices of the children were: dull, unstable, too high, harsh and of high volume. Results obtained in MDVP analysis showed that voices of children suffering from PD differ from voices of normally hearing children within most ranges of acoustic parameters. In the research group we observed different values of parameters describing disturbances of frequency, amplitude, voice vibration and parameters informing about the presence of noise elements in voice comparing to the control group.

Conclusions: Acoustic structure of voice in children with partial deafness is different than in children hearing normally. Acoustic features of voice change with age, thus it is justifiable to compare voice in the same age groups. More significant perturbations of acoustic voice structure were observed in school children, that can be an issue of growing need and requirements from hearing organ in the learning period. Acoustic analysis of voice may constitute a sensitive indicator of hearing improvement in PD children after application of cochlear implant treatment.

S8 New trends in electrode development & new technologies

S8-2

New approaches to improve performance of cochlear implant electrode arrays

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Objective: Improvements in outcomes for cochlear implant patients over the past two decades have primarily been due to improvements in speech processing. Although changes have occurred in materials or structure of the implanted receiver-stimulator, relatively few changes have been made to the electrode array for cochlear implants or to the electroneural interface. This study reports on the application of new technologies and materials to improving the capacity and function of the electroneural interface for cochlear implant electrode arrays.

Study Design: A range of materials and processes for surface modification of silicone rubber, and for incorporation of molecules such as corticosteroids into the surface of the electrode array were evaluated. In particular, studies investigated means of controlling the timing of release of therapeutics into the cochlear environment. In addition, studies have investigated the potential benefits of application of electroporation techniques.

Results: Results showed that surface modifications using polymer technology can provide for significantly varied release times and profiles for therapeutics into the cochlear environment using both passive and active dissolution methods. Direct application of these materials into the cochlear environment may be an important element for preservation of residual hearing, or in the future, for improving the capacity and functionality of the electro-neural transmission.

Conclusions: Application of new technologies and processes may improve transmission of electrical signals, and thereby, significantly improve the performance of future designs of cochlear implant electrode arrays.

S8-3

Concept and development of a new Shape Memory Cochlear Implant Electrode

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Introduction: For residual hearing preservation (RHP) different thin, mostly straight electrodes have been developed. In contrast to the precurled and therefore perimodiolar positioned electrodes, the straight electrodes are typically positioned at the lateral wall of the cochlea with more space between electrode and spiral ganglion cells. Perimodiolar position has been found to result in improved battery life and means a more efficient stimulation closer to the spiral ganglion cells when compared to lateral wall placement resulting in improved speech performance.

Another unwanted effect of the lateral wall placement of the current RHP electrodes is the shorter insertion depth comparing to the same length of the electrode if positioned in perimodiolar position. The coverage of the Cochlea and the ganglia cells is therefore reduced in lateral wall positioned electrodes.

Material and method: For achieving a final perimodiolar position with a straight electrode insertion, we aimed to include an initially straight inlay of shape memory alloy into a conventional electrode carrier of the Hybrid L electrode (Cochlear Ltd., Sydney, Australia). After insertion the straight shaped electrode is designed to then curl by shape memory activation at body temperature. A CAD-based design of a new electrode with an inlay made of Nitinol was used to fit the geometry of an average human cochlea. Different shaped Nitinol-wires with varying diameter and different alloys were produced to achieve the final perimodiolar position after activation of the shape memory effect. An iterative process for finding the best shape and alloy for the Nitinol Inlay has been followed. Experiments were performed in a water bath with controlled temperature (20°C to 45°C). The first version of the Nitinol inlay had a good ability of the electrode to transform into the memorized curved shape above the transformation temperature of approx. 37°C. However these electrodes armed with the Nitinol inlays began curling even before insertion. Cooling the electrodes beforehand did not prevent this issue. With the second iteration of the inlay a different Nitinol alloy with an increased transformation temperature have been utilized. The premature transformation into the curled shape could be prevented, thus the insertion process was straightforward. However, the thermal characterization demonstrated an incomplete recovery of the electrode curved shape at 37° C. Only when heated up to approximately 43°C full curvature could be achieved. Further refinement of Nitinol thermal response characteristics, trained shape and electrode mechanical properties is required.

Conclusion: By replacing the stiffener of a conventional Hybrid-L electrode with a shape memory actuator made of Nitinol, a more perimodiolar position within the cochlea could be achieved with an initially straight electrode.

S8-5

Mondini dysplasia: A new electrode designed for cochlear implantation

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Introduction: Incomplete partition type II (Sennaroglu classification) is the type originally described by Mondini cochlea. The triad is: modiolus defect in the apical part of the cochlea and its corresponding septum intercalar, minimally dilated vestibule and enlarged vestibular aqueduct. It could be presented with Gusher, a profuse clear liquid output by opening the inner ear by a defect of variable size between CAI and ear malformations. According to literature gusher incidence malformation in case of inner ear is between 40 - 50%.

Material and method: We report the case of a 2 year old girl diagnosed with bilateral profound hearing loss with bilateral incomplete partition type II. The extensive bone defect at the bottom side of the Internal Auditory Canal (IAC), predicted a profuse surgical Gusher. We present this case of bilateral cochlear implant surgery using a new electrode specially designed to minimize the risks of surgical Gusher. Sennaroglu recently designed a special electrode to prevent leakage of cerebral spinal fluid after insertion of the electrode. The electrode has the feature of having a silicone plug where the insert ends. The electrode is designed to block preventively and effectively the outflow (Gusher) in cochleostomy.

Results: We described surgery and implantation technique for this particular electrode. During surgery there was a very heavy gusher. We did a small cochleostomy to the right size to fit the diameter of the silicone plug and enhance its effectiveness. We used small grafts of fascia to achieve the highest possible hermeticism seal. The result was favorable

Conclusions: The gusher is the result of a bone defect in the bottom side of the IAC. When is profuse, often presented a wide communication between subarachnoid space and the inner ear, which has a higher risk of postoperative meningitis. Although conventional electrodes can get a proper seal, we consider laudable any attempt innovation and improvement of the surgical technique or the design of the electrodes in order to minimize this risk.

S8-6

Electrodes loaded with corticoids for cochlear implantation: impact on residual hearing.

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Introduction: Today, in cochlear implantation, the challenge is to preserve residual hearing. To the challenge, adapted cochlear implants are now proposed as well as soft surgery. A new area of research is the use of corticoids to further reduce insertion trauma. The aim of this study is to compare dexamethasone-loaded and unloaded electrode-arrays in terms of hearing preservation using an animal model.

Material and methods: 30 normal-hearing gerbils were implanted with a dexamethasone-loaded array on one ear, and unloaded array on the other ear. Hearing thresholds were determined preoperatively and 4-6 weeks to one year postoperatively.

Results: Better hearing preservation were observed on the loaded array side on the short term at 500 (p=0,0030), 1000 (p=0,0349), 4000 (p=0,0038) and 16000 Hz (p=0,0008). These results were confirmed after one year for 16 000Hz (p=0,0103), but need further control for lower frequencies.

Conclusion: This new type of electrode allows for better preservation of residual hearing. In addition, it does not alter the classic surgical approach. A study by confocal microscopy is currently underway to support the hypotheses that could explain these results, particularly in terms of cell survival.

S8-9

Concept of implanted probes for continuous ESRT measurements

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It is a well-known fact that thresholds for electrically elicited stapedius reflexes (ESRT) are strongly correlated with the comfort level of listening (C-level). Thus, such thresholds may be used as a tool for setting the speech processor. There are different ways of recording ESRTs, such as visual observation intra-operatively, or by measuring impedance changes using tympanometry post-operatively. Our goal is to establish a method allowing the measurement of ESRTs at any time, which may be used for a control circuit for setting the speech processor. This could be achieved by electromyography via a needle electrode inserted in the stapedius muscle. We report our results with such systems. Furthermore alternative methods are discussed.

S8-10

Using an electro anatomical model of the human cochlea as a current spread predictor and implant positioning diagnostic tool

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Objectives: To investigate the impact of electrode design and placement on current spread in the cochlea using a physiologically accurate Electro Anatomical Model (EAM). Using the model predictions of current densities at the location of the Spiral Ganglion Cells (SGCs) for different array designs are calculated and compared.

Study design: A 3D volume conduction model was generated from a spiralling shape based on human cochlear geometry, incorporating the three scala, Rosenthal's canal, osseous spiral lamina and surrounding cochlear bone. A potential field is then simulated due to a current source placed within the conduction model, this field is calculated by using the finite difference technique in combination with the preconditioned conjugate gradient method. From the potential field solution, current densities at the locations of the SGCs are calculated, the SGCs are defined in positions equally spaced between the basal and apical tip on a path defined within Rosenthal's Canal. A range of intracochlear arrays were generated in ProEngineer and implemented in the EAM, these arrays were placed within the scala tympani, comparing the effect electrode positioning on current spread at the SGCs. Modeling of electrode complications during insertion then simulating voltage tomography captured along the electrode array in the EAM was also investigated. A series of theoretical voltage profiles that are expected to be observed by implant software can be generated for real time comparison during insertion.

Results: Plots of current density at the SGCs relative to the cochlear angular rotation have shown differences in peaks for different scala positions. Complications in implant positioning can also be modelled with a very distinct set of voltage tomography profiles being generated.

Conclusion: computational modeling is crucial to aiding the design process of cochlear implants, this EAM has been used to determine the effect of electrode position on current spread observed at the SGCs against angular rotation within Rosenthal's canal. This model can also be used to potentially characterize different voltage profiles in cases of electrode positioning complications during insertion, which may potentially be used as a reference for real time measurements for diagnostic feedback during surgery.

S8-11

A longitudinal study of frequency specific electrical stimulation levels in cochlear implant users

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Background and Objectives: The purpose of the study was to evaluate the changes in electrical stimulation levels, i.e. threshold (T) levels, comfortable (C) levels, dynamic range (DR), and electrode impedance values (EIVs) during the first year in cochlear implant users.

Subjects and Methods: The maps of 49 cochlear implant users (at least 1 year mapping), using the Nucleus device, were examined at the time of initial connection, and at 6 and 12 months post-initial stimulation. T levels, C levels, DR and EIVs were analyzed according to three frequency levels.

Results: During the first 6 months of implant use, C levels and DR increased significantly whereas T levels were stable. EIVs of current carrying electrodes decreased significantly from the connection to the 12-month visit. The changes of electrical stimulation levels did not differ among three frequency levels during the entire follow-up.

Conclusion: During the first 6 months of implant use, C levels and DR increased significantly. Thus, an appropriate mapping in the first 6 month is critical to setup hearing capacity in implant users. The mapping should be performed under the best communication environment between the audiologist and the patient, and it makes correct setting of T levels from the initial connection period.

S8-13

Further results with the HiFocus Mid-Scala electrode

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With every new developed electrode care has to be taken to assess electrode positioning and intracochlear trauma in temporal bones and in human implantation. We performed a temporal bone (TB) study with n=20 TB`s to analyze intracochlear placement following cochleostomy or round window membrane insertions b 3d-digital volume tomography and histology. Results following human implantation were analyzed by 3D-digital volume tomography and audiological follow-up. Within the TB study, results were very encouraging with minimal intracochlear trauma. Human implantation revealed the possibility of scalar dislocation. Auditory results will be analyzed as well. Insertion of the HiFocus Mid-Scala electrode appears reliable without major intracochlear trauma. Compared to other perimodiolar electrodes the dislocation rate in human implantation is low. Initial auditory results of this ongoing study are encouraging.

S8-14

Simultaneous bilateral implantation of freedom and 422 in children: Is there equipoise between the devices?

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Background: Currently there are two Cochlear Corporation devices approved for use in children: the well-established pre-curved Freedom cochlear implant electrode array, which sits within the cochlea in a perimodiolar position, and the newly developed thin and straight 422 array, designed to sit along the lateral wall of the cochlea. Although there are theoretical benefits of each of the designs with respect to the preservation of cochlear structure and, ultimately, hearing, the superiority of either electrodes is not yet clear.

Purpose: We sought to compare the 422 array to the Freedom perimodiolar array implanted in the same child to assess: 1) device function and 2) preservation of residual hearing.

Methods: Measures of device efficiency and auditory function were collected in 18 children with severe to profound hearing loss who were bilaterally implanted simultaneously with a Freedom array in one ear and a 422 in the other ear at 3.7 ± 1.3 years (mean ± SE). All devices were inserted via a drilled cochleostomy approach using 'soft' surgical technique. Measures included implant electrode impedance, auditory nerve thresholds (eCAPS), behavioral thresholds to current, evoked middle ear reflexes (eSRTs) and implant power consumption. Residual acoustic hearing thresholds were measured in 6 of these children (implant age: 4.4 ± 2.9 years).

Results: The 422 array had significantly higher impedance and required higher levels to elicit the eCAP and eSRT ($p < 0.05$); however, these 422 values remained within a clinically acceptable range. Behavioral threshold and power consumption were similar for both devices. Changes in acoustic thresholds varied considerably across children: Freedom (0 - 20 dB), with a mean ± SE of 4.0 ± 5.4 dB, 422 (0-11 dB), 6.7 ± 1.9 dB.

Conclusions: No clinically significant differences were found between the 422 and Freedom devices. Although required stimulation levels were higher for the 422, this did not impact power consumption. In this initial cohort of children with severe to profound hearing loss, the impact of implantation on acoustic hearing thresholds was not influenced by type of electrode array.

S9 Intraoperative/objective measurements II

S9-2

Correlations in objective measures for adult CI users with the MED-EL Flex electrode receiving a hearing preservation surgical technique

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Intro: The purpose of this study is to examine whether correlations exist between objective measures at different levels of the auditory system in adult patients receiving a hearing preservation surgical technique. To be considered are the electrically evoked compound action potential (ECAP), which reflects the integrity of auditory nerve function, and cortical auditory evoked potentials (CAEPs), which are used to trace a sound stimulus through the ascending auditory pathway from the cochlear nerve to the auditory cortex.

Methods: 18 cochlear implant recipients, (9 male, 9 female), ranging in age from 43 to 76 years were included. All participants had pre-operative audiometric thresholds better than 80dB HL at 125 and 250Hz, and better than 90dB HL at 250 and 500Hz. ECAP testing was completed at CI activation, 1 month, and 3 months. CAEP measurements were conducted at 3 months post activation. Participants also completed detailed speech and audiometric testing at all-time points.

Results: Preliminary results indicate that shorter P2 latencies of the CAEP waveform are associated with higher ECAP thresholds measured at all-time points ($p< 0.05$). The P2 wave of the CAEP is elicited from the primary auditory cortex and shorter P2 wave latencies are indicative of better auditory processing. Larger ECAP thresholds are associated with better auditory nerve status and better implant performance.

Discussion: Hearing preservation is a benchmark for atraumatic implantation. Preservation of acoustic hearing using modified surgical techniques has thus gained a great deal of importance and research focus. Currently, the primary outcome measure for hearing preservation is the audiogram. Preservation of low frequency residual thresholds are associated with better speech perception. However, it is possible that the effects of hearing preservation may also be gleaned through objective measures of auditory function. Our preliminary findings suggest a correlation between the objective measures of ECAP and CAEPs. The protection of neural substrate, encouraged through hearing preservation techniques, may lead to advantageous outcomes within the auditory system that are tangible through objective testing. Such findings lend support to the on-going use of hearing preservation techniques in clinical settings.

Conclusions: The P2 wave of the auditory evoked potential is correlated with higher ECAP thresholds for adult patients who have received hearing preservation CI surgery.

Learning outcome: To explore whether hearing preservation surgery is supported by the results of objective measures testing.

S9-3

Correlation between cognitive *Auditory* evoked *Potentials* and speech perception tests in cochlear implant users

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Introduction: Hearing loss deeply affects individual quality of life, entailing major limitations in oral communication and social interaction. Cochlear implant (CI) is a device that aims to improve auditory speech perception in people with severe to profound hearing loss. However, hearing and specially speech performance among cochlear implant users still present a very large variability. Analysis of electrophysiological aspects of auditory processing may provide better understanding of these differences.

Objective: To evaluate the correlation between behavioral tests of speech perception and the measurement of cognitive auditory evoked potential P300 in individuals with cochlear implants.

Method: The study evaluated 10 consecutively implanted patients due to post-lingual hearing loss. The tests were conducted at least 12 months after regular use of CI (mean = 47.9 months). The age of participants ranged from 14 years to 67 years (mean = 43 years). To assess speech perception a test with 25 monosyllabic and two lists of 10 sentences were used. The sentence lists were present in silence and in noise (signal / noise ratio + 10 dB). The P300 potential was elicited using tone burst stimuli (1000 Hz x 2000 Hz) and speech (/BA/ x /DA/). The values of amplitude and latency of P300 potential in both modalities were correlated with speech perception tests.

Results: The mean percentage of correct answers in monosyllables test was 41.6%, 82.2% in sentences in silence and 19.18% in sentences in noise. The mean latency P300 potential with tone burst stimuli was 328.7 ms and amplitude 7.79 uV. Mean latency of P300 potential with speech stimuli was 309.8ms and amplitude of 9.45uV. No correlation could be observed between the results in behavioral tests and P300 measurements. On the other hand, significant positive correlation was observed between monosyllables test results and sentences in silence test ($r = 0.800$, $p = 0.005$) and between sentences in silence and in noise tests ($r = 0.805$, $p = 0.005$).

Conclusion: Positive and significant correlations were found between behavioral tests (monosyllables / sentences in silence and sentences in silence / sentences in noise). Latency and amplitude of P300 elicited by tone burst and speech stimuli presented no correlation with speech perception tests used in this study.

S9-4

Correlation between per- operative electrically evoked auditory brainstem responses and auditory performance in adult cochlear implant users

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Objectives: Retrospective study that evaluates correlation between several electrical evoked auditory brainstem responses (eABRs) preoperatively measured and auditory performance along user follow up, in post-lingual adults cochlear implant users.

Material and methods: 29 post-lingual adult subjects were included. They were all implanted with Neurelec device. During surgery, after cochlear implantation and under general anesthesia, several eABR measures were performed. Latencies and amplitudes of wave III and V were collected on several stimulation levels, using a basal, a medium and an apical electrode. All collected parameters were correlated to speech intelligibility results measured on disyllabic words, after at least 1 year of follow-up.

Results: Across all tested correlations, wave III and wave V latencies on basal electrode showed significant correlations, with R= -0.676 and R=-0.477 respectively.

Conclusion: It was shown in previous studies that eABRs are a good indicators of residual spiral ganglion neurons and auditory pathway functions. It is then consistent to find a correlation with auditory outcomes, even though a larger number of subjects could be used to confirm those results. Routine peroperative eABR measures advantages are double: on one hand, the evaluation of the implant functioning in place, and on the other hand, to identify patients with poor responses in order to offer them a more intense speech therapy follow-up.

S9-5

Value of per and post-operative ECAP recordings in cochlear implanted children : correlations with fitting and performance

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Introduction: Electrical Compound Action Potentials (ECAP) can be recorded intra- and post-operatively in cochlear implanted children, however the use is not yet systematic in this population due to the time required. The aim of our study was to investigate the feasibility of systematic recordings in children and the correlations with fitting parameters and long term performances.

Materials and methods: Seventy-seven children were implanted with Advanced Bionics implant 90K between September 2008 and March 2013 and were prospectively included. ECAP recordings (NRI) were obtained intraoperatively using RSPOM 1.3 software with three paradigms (I/O function, spread of excitation and recovery function) and postoperatively using the fitting software Soundwave. For each child, the recordings were made on four different channels. Thresholds, I/O slope and correlations with performance at 1 and 2 years were investigated. Performances were evaluated using the APCEI profile.

Results: Intraoperative NRI responses were obtained in all children and in 66% of cases for all tested channels. Spread of excitation and recovery function were obtained in respectively 75 and 66 %. T-NRI thresholds correlated well with the C-levels at 3 months ($P < 0.001$). A significant correlation was found between APCEI scores at 2 years and the initial I/O slope ($P < 0.04$), the recovery period ($P < 0.003$) and the T-NRI levels ($P < 0.005$). No correlation was found between performances at 2 years and width of SOE.

Conclusion: Intra and post-operative ECAP measurements are particularly useful in children because they help to confirm the responsiveness of the cochlear nerve fibres, correlate well with the first settings parameters and could indicate future good performers.

S9-6

Correlation postoperative electrically evoked auditory brainstem responses correlation with subjective most comfortable levels in pediatric cochlear implant users

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Introduction: Postoperative electrically evoked auditory brainstem responses (eABR) can be a good assistant method in cochlear implants speech processors fitting, especially in difficult cases. eABR unfortunately are not included in routine practice due to unproven techniques and variability in results. The purpose of the study was to find the correlation between the calculated eABR threshold and subjective MCL. We are looking for the predicting MCL range based on eABR data. We suppose that using the eABR thresholds may predict sound processor fitting map.

Methods: Postoperative eABR was performed on 12 CI users aged 2 to 8 years (mean 4,5) with MED-EL cochlear implants. 2, 5 and 10 channels were used for stimulation in all subjects. eABR was conducted using ABR registration system and synchronized with the MED-EL DIB II. We used the standard parameters for ABR registration and electrode installation. Stimulation consisted of a single run of 2000 two-phase incentives with a negative initial phase of alternating polarity, 30mks duration at a 17Hz stimulation frequency. To build amplitude growth function stimulation amplitude varied in steps by ± 10%, 20%, 30% from the subjective MCL. The subjective MCLs were taken from patients speech processors fitting maps. Amplitude growth function linear regression was used to determine the eABR thresholds. As an eABR threshold stimulation level with calculated zero response amplitude was taken.

Results: Linear correlation coefficient by Pearson was determined to identify correlations between eABR thresholds and subjective MCLs. The coefficient value was r = 0,856, indicating a strong correlation . Student stats showed that the probability of significant differences correlation coefficient from zero is P> 0.999. Regression analysis gave the linear regression equation in the form :MCL (qu) = 7,7596 + 1,0414 * eABR TH (qu). Coefficient r2 = 0,7328 indicates a high degree of reliability of approximation of this equation to the experimental data.

Conclusion: We propose to use the linear regression method for calculating fitting map MCLs through eABR thresholds. Using other than described above stimulation parameters, especially another stimulation frequency, can lead to changes in the V peak amplitude. At all these cases linear regression formula coefficients clarification is required. We suppose that using the calculated eABR thresholds may predict sound processor fitting map MCLs. And it may be the only base for sound processor fitting in difficult situations. Further studies are required to specify the possibilities of this method.

S9-7

Cochlear implant programming considerations for older adults or alternative methods for programming CI in older adults

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Intro: Certain populations of cochlear implants users can be difficult to program by traditional behavioral measures. As such, electrically evoked stapedius reflex thresholds (ESRTs) have been used as an objective means of setting MCL (maximum comfort loudness level). As the possibility of age-related changes in cognition become a factor in cochlear implant programming, the option of programming MCL based on objective measures may become more widely used. The purpose of this study is to determine whether ESRT or ART measures pose a viable option for objectively setting MCL in the older adult population of MED-EL cochlear implant users. Correlation of these measures will be cross-checked with speech perception scores and the results of a cognitive screener.

Methods: To be considered for the study, participants must meet all inclusion criteria: at least 60 years of age, implanted with MED-EL CONCERT or SONATA or PULSAR cochlear implant, normal impedances for electrodes 1, 2, 5, 6, 10, and 11, minimum of twelve months experience using a Fine Structure coding strategy, normal middle ear function as demonstrated by tympanometry, normal otoscopic examination, English as primary language, willing and available to comply with all procedures as defined in the protocol. The following tests were completed for this single visit study: Montreal Cognitive Assessment (MOCA©), tympanometry, telemetry, CNC words in quiet, behavioral MCL measurement, ESRT measurement, and ART measurement.

Results: The relationship among behavioral MCL, ESRT, and ART will be analyzed. Additionally, the relationship between MCL and ESRT or MCL and ART will be correlated to speech perception outcomes on CNC words. The same analysis will be completed looking at differences in behavioral and objective measures of threshold compared to pass/fail scores on the MoCA. Data analysis has not been completed at this time as study enrollment is ongoing.

Discussion: Anticipated outcomes may include a difficulty in obtaining ESRT in this population of patients, a high rate of failing scores on the MoCA, and poor to fair word recognition scores.

Learner outcome: Understand if ESRT or ART measures pose a viable option for objectively setting MCL in the older adult population of MED-EL cochlear implant users

S9-8

Mismatch negativity (MMN) as a measure of central processing in children with CIs

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Introduction: The primary goal of pediatric cochlear implantation is to provide critical speech information to the child´s auditory system and brain to maximize the chances of developing spoken language. It is not clear how C.I enables children to reduce or overcome auditory cognitive deficits associated with hearing impairment. MMN is an attractive tool : it provides an electrophysiological index of auditory learning and perceptual accuracy and it is elicited even without the subject's attention to the auditory stimuli.

Objectives:

1. To assess the effect of CI on auditory processing in children.
2. To study the correlation of MMN measures with behavioral data in CI children.

Methods: 33 children implanted with Nucleus implants and full insertion was achieved. They had congenital or early onset hearing loss with average IQ and no other abnormalities. Outcome was assessed using aided warble tone response and aided Arabic speech perception tests together with Arabic language test.Mismatch negativity test was conducted using Oddball paradigm where the standard stimulus (Ba) was presented for 80% and deviant stimulus (Ga) was presented for 20% of the stimuli.

Results and discussion: MMN was identified in 24 out of 33 CI children (72.7%) .The mean latency was delayed compared to latency in normal children for similar paradigm while the amplitude recorded were similar to the normal hearing children. Latency of MMN was significantly correlated with duration of CI use and speech perception measures especially for more difficult open set tests. Children failed to demonstrate MMN had worse performance on speech tests and language scores.

Conclusions:

1. CI is successful in the majority of profoundly deaf children to improve central processing of basic auditory information (auditory discrimination skills) & provides maturation of the neuro-physiological mechanisms that generate MMN.
2. MMN test could be used as predictive tool for behavioral performance especially for early implantation.
3. Implanted children failed to demonstrate MMN possibly had adverse central processing deficits and need more innovative training and rehabilitation.

S9-11

Use of acoustic change complex to estimate spectral discrimination thresholds on cochlear implant users with a single channel EEG approach

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The ability of a cochlear implant user (CI) to resolve spectral changes within sounds has been correlated to their speech perception performance in quiet [Won, J.H., et al. JARO-Journal of the Association for Research in Otolaryngology, 2007. 8: p. 384-392.]. Electroencephalography metrics (EEG), such as the mismatch negativity (MMN) and the acoustic change complex (ACC), have been used in research to obtain an objective estimate of the spectral discrimination [Won, J.H., et al. JARO-Journal of the Association for Research in Otolaryngology, 2011. 12(3): p. 375-393.]. However, their clinical use is limited due to high density of EEG electrode arrays required to effectively attenuate the CI artifact [Gilley, P.M., et al. Clinical Neurophysiology, 2006. 117(8): p. 1772-1782.]. Previous work by this group proposed an artifact attenuation strategy that allows single channel EEG recording of cortical auditory evoked potentials [Mc Laughlin et al. Hearing Research, 2013. 302: p. 84-95]. Here we investigate extending this approach by using the ACC response as a method for spectral discrimination.

Single channel EEG recordings were acquired from ten adult CI users and two paediatric CI users, while listening to complex sounds. The 2000ms stimuli contained a spectral change at the midpoint. After artifact attenuation, ACC responses were identifiable in the recordings. A decrease in the ACC amplitude was observed in the responses elicited to stimuli with a smaller spectral change. The point of no spectral discrimination was defined at the moment where an ACC response was not present in the recording. Behavioural spectral ripple discrimination thresholds were determined via a single interval psychoacoustic test. Preliminary results suggest that a clear ACC response were not present in all adult CI subjects (six subjects did not show a reliable ACC response). Both paediatric CI subjects showed a measurable ACC response (see Figure 1). When the ACC response is present, comparing behavioral data with electrophysiological data suggests that it is possible to objectively estimate spectral discrimination thresholds in CI users via ACC responses without the use of a dense array of EEG electrodes. An objective metric for spectral discrimination may provide audiologists with an extra tool when examining hard-to-test CI users such as infants.

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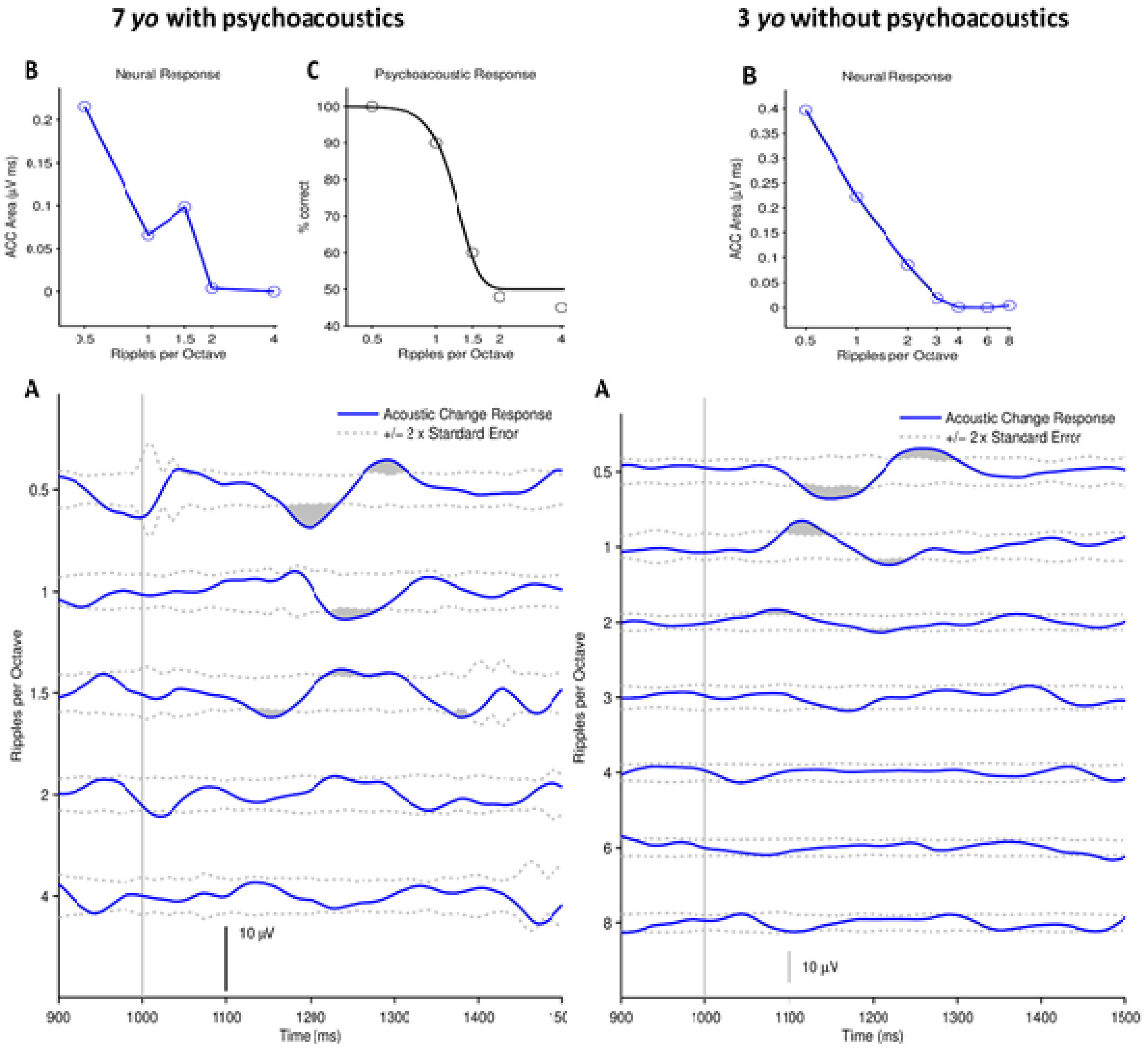

Figure 1 Objective assessment of spectral ripple discrimination threshold in paediatric CI users. A- Acoustic change complex responses to an incremental sequence of spectral ripple stimuli. B- Spectral discrimination threshold tracking based on the acoustic change complex responses. C- Spectral discrimination threshold tracking based on psychoacoustic testing.

[ACC responses in paediatric subjects]

S9-12

Telemetry changes over time in cochlear implant patients

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Aim of the work: The Value of the intra-operative telemetry measurements in predicting cochlear implant recipient performance, and determine the reliability of intra-operative neural telemetry, especially in predicting postoperative psycho-electric parameters. 40 patients had cochlear implant were evaluated retrospectively regarding the impedance and neural telemetry and its comparison with the psycho-physical measurements and its effect on language perception. The relation overtime of the neural telemetric findings were assessed, and the language evaluation as an outcome of the results.

S9-13

The use of ASSR in the evaluation of the hearing preservation in cochlear implantations

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Introduction: Recently designed cochlear implant electrodes aim to preserve the residual hearing during implantations, succeeding in most cases. For the remaining cases the question arises whether the impairment is caused by the intrinsic surgery or by processes initiated postoperatively. Therefore the usefulness of Auditory Steady State Responses (ASSR) shall be investigated.

Methods: Within the implantation routine of devices aiming to preserve the residual hearing Auditory Steady State Responses (ASSR) were registered intraoperatively. Therewith the hearing threshold was evaluated under anaesthesia directly before and after surgery. Up to now registrations were done with 107 subjects (41 m, 66 f, Ø 54.8 yrs). 12 of them received a MedEl Flex electrode, 34 of them were implanted with a Nucleus Hybrid-L device and 61 of them with a Nucleus SRA device. The obtained ASSR thresholds were compared with each other and with the pre- and postsurgically measured behavioral thresholds.

Results: On average, the difference between pre- and postsurgically measured behavioral thresholds was 11.4 dB ± 14.8 dB (mean ± standard deviation), the difference between pre- and postsurgically obtained ASSR thresholds was 5.0 dB ± 13.1 dB, the difference between presurgically obtained behavioral and ASSR thresholds was 17.2 dB ± 14.5 dB and the difference between postsurgically obtained behavioral and ASSR thresholds was 15.0 ± 20.4 dB.

Conclusion: The ASSR thresholds were found to be highly reproducible before and after surgery. Thus, the method can be applied for the desired purpose.

S9-14

Otoacoustic emissions in various degrees of partial deafness

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Click evoked otoacoustic emissions (CEOAEs) are known to be good indicators of hearing function when used in the frequency range of 1.5-4 kHz. The aim of this study was to assess the diagnostic value of otoacoustic emissions (OAEs) in identifying the residual hearing of subjects with partial deafness (PD). Here PD cases characterized by steep audiograms with normal thresholds up to certain frequency and almost total deafness above were considered. CEOAEs and tone-burst evoked otoacoustic emissions (TBOAEs) were measured in subjects with severe-to-profound sensorineural hearing loss, in subjects with various degrees of PD, and in subjects with normal hearing (NH). Each subject was also tested with pure tone and impedance audiometry. There were many cases in which no response to clicks was observed, but the use of tone bursts did produced OAEs. Additionally aspects related to stimulus and acquisition window length, number of averages and broadband vs band parameters were discussed.

S9-15

Cortical auditory evoked potentials in cochlear implant users with auditory neuropathy spectrum disorder with normal and cochlear nerve deficiency

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Introduction: In the routine of cochlear implant centers, diagnostic imaging involving computed tomography (CT) and magnetic resonance imaging (MRI) is essential for characterizing the status of the cochlea and auditory nerve. In patients diagnosed with auditory neuropathy spectrum disorder (ANSD), findings include normality, hypoplasia or agenesis of the auditory nerve, the latter contraindicating cochlear implantation (CI). Several studies showed poor results after CI in children with auditory nerve hypoplasia while others reported benefits. Due to this variability of results becomes important to understand the acoustic signal processing in these individuals.

Objective: To characterize the P1 cortical auditory evoked potential (CAEP) in patients with ANSD users of cochlear implant, correlated with speech perception.

Methods: This study was conducted in the cochlear implant department of the Audiological Research Center, Hospital for Rehabilitation of Craniofacial Anomalies, University of São Paulo with the approval of the Ethics Committee under Case No. 181/2004. The study included 12 patients diagnosed with ANSD users of cochlear implant, aged 5-12 years, with pre-lingual hearing loss, being six patients with auditory nerve hypoplasia (cochlear nerve deficiency - CND), and six patients with normal auditory nerve, confirmed by MRI analyzed by two medical specialists. The groups were matched for chronological age and age at implantation. The P1 CAEP testing was conducted in response to the speech stimulus /da/, presented at 70 dB HL in free field, and latency and amplitude of the P1 component were analyzed, when present. Speech perception was assessed using the Meaningful Auditory Integration Scale (MAIS) or the Infant-Toddler Meaningful Auditory Integration Scale (IT-MAIS).

Results: The P1 component was identified and analyzed in all patients, indicating cortical activity after CI. Patients with CND presented higher values of P1 latency than children with normal auditory nerve, which indicate an abnormal redirection of the cortical auditory structures in patients with CND. A similar behavior was observed in speech perception, which proved to be better in patients with ANSD and normal auditory nerve. Only one patient with CND reached P1 component latency within normal limits for age, and score of 95% at IT-MAIS. This patient´s MRI showed a mild hypoplasia, differing from the others of CND group. Therefore, the analysis of anatomical conditions related to CND seems to be important in predicting the benefits of the cochlear implant.

Conclusion: The P1 CAEP component is characterized by higher latencies in children with CND when compared to children with normal auditory nerve, which is reflected in auditory speech perception performance. The importance of this differential diagnosis is reflected in the orientation for the family, especially regarding the expectations on the results to be obtained after CI, especially in patients with CND.

S9-16

The effect of steroids on hearing preservation cochlear implantation - a tertiary implant center randomized controlled trial

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Intro: Hearing preservation cochlear implant surgery has become the standard approach for patients with residual hearing. There have been several methods proposed to improve the rate of hearing preservation, including the use of corticosteroids. Intraoperative steroids given preoperatively for otoprotection have become more popular due to evidence in animal studies and its use in otologic emergencies. However there are currently no published randomised controlled trials of steroid use in cochlear implantation. The aim of this study is to determine if preoperative steroids can improve hearing preservation rates and if its effects can be measured electrophysiologically.

Methods: 31 patients with low frequency residual hearing undergoing cochlear implantation with a MED-EL Flex 28 electrode were enrolled in a tertiary academic center. Surgeons were blinded and round window insertion was performed in all cases. Patients were randomised to receive dexamethasone transtympanically one day prior to surgery, oral prednisolone 6 days prior to surgery, or a control group. Post-operative outcome measures were performed at 1 week, 1 month, 3 months, 6 months and 12 months after switch on. These included pure tone audiometry, speech discrimination in quiet and noise, ECAPs (electrically evoked compound action potentials), and CAEPs (cortical auditory evoked potentials).

Results: Preliminary outcomes of the first 18 patients show that the oral steroid group have a greater mean ECAP slope than control at progressively more basal electrodes over time. The oral steroid group also had a greater mean ECAP slope than the transtympanic steroid and control group at basal electrodes ($p < 0.05$). Both steroid receiving groups had higher ECAP thresholds compared to control ($p < 0.05$), and higher MCLs (maximum comfort levels) and larger DRs (dynamic ranges). The transtympanic steroid group had the lowest impedances compared to control up to 6 months post surgery ($p < 0.05$). Higher ECAP slopes and thresholds have been shown to correlate with greater neuronal survival. CAEPs showed no differences between the groups, confirming the local effect of steroids. The outcomes including hearing and speech discrimination will be presented for the remaining patients.

Discussion: The preliminary outcomes indicate that steroids have clear effects on the ECAPs and electrode impedance, particularly in the basal portion of the cochlea. This finding correlates with our animal study showing that systemic and transtympanic steroids have primarily basal effects. This has implications for future steroid delivery techniques, targeting the apical region of the cochlea.

Conclusion: We present the outcomes of the first randomised control trial for steroid use in hearing preservation cochlear implantation.

Learning outcome: To discuss the role of preoperative steroids in hearing preservation cochlear implantation

S10 CI in the elderly

S10-4

Increase of postop vestibular loss in elderly?

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Background: Cochlear implant candidacy has been significantly changed during the last decades. A relaxation of degree of deafness resulted - compared to the 80's - in a growth of CI candidates with significant residual hearing and - in principle - without restrictions of maximum age. Thus, the number of contraindications for cochlear implantation has also been reduced. However, this relaxation of criteria might involve some surgical risks, such as postoperative degradation of residual hearing or of vestibular function. The present study gives an update of the state-of-art regarding possible risk factors that might induce vestibular loss after cochlear implantation. Furthermore, our and other previous studies will be addressed and compared to the most recent data obtained from a large group of adult CI users (n>900).

Methods: Besides standard audiological assessment and MRI, objective electronystagmographical (ENG) data was preoperatively obtained in all CI candidates. Only those subjects with significant functional vestibular reactivity (evoked by rotary chair and caloric irrigation testing) in the ear that would receive a CI, were included in the study. In this group, caloric irrigation testing was repeated postoperatively to assess functionality of horizontal semicircular canals of the implanted side. Additionally, presence of possible postop asymmetry was evaluated by velocity step testing to verify central adaptation. Postoperative vestibular function was analyzed in relation to age at implantation, cause of deafness, surgical procedure, type of electrode, surgeon, and postoperative deterioration of pure tone thresholds. Subjective evaluation was assessed using the Dizziness Handicap Inventory comprising functional, physical and emotional domains.

Results: More than 20% of CI subjects show a vestibular deterioration after cochlear implantation; some of them completely lost their vestibular function, resulting in unilateral areflexia. Regression analyses show that older candidates are more susceptible to postoperative vestibular deterioration than younger CI candidates. Our data also show that the other variables do not seem to play a significant role. Rotational chair data reveal that the presence of a postoperative central adaptation is in agreement with behavioral DHI results. In contrast, no relationship was found between objective caloric test and subjective responses. The restraints and pitfalls of vestibular testing will be discussed in relation to frequency-specificity. A protocol will be proposed to efficiently evaluate vestibular function in elderly.

Conclusion: Age at implantation is a significant factor that should be taken into account during preoperative counseling. The increasing number of older CI candidates and users demands adequate preop counseling and postop short- and long-term evaluation with respect to possible future degradation of vestibular function.

S10-5

Which ear should we choose for cochlear implantation in the elderly: "worse" or "better"? Audiometric and quality of life results

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Cochlear implantation (CI) in elderly patients is becoming more popular in recent years. As life expectancy is usually shorter than in the general population, the election of the ear to be implanted may be a dilemma in this group. Theoretically, implantation of the "better" ear provides the best audiological outcomes. However, implanting the worse ear permits contralateral acoustic stimulation if there is residual hearing. To define the "better" and "worse" ears different criteria have been considered. This study aims to determine whether choosing the "better" or the "worse" ear for CI influences audiometric and quality of life outcomes in older patients.

73 adults (aged 60-80, mean 68.2) with more than 6 months of unilateral CI experience were enrolled. Subjective benefit was evaluated with the Glasgow Benefit Inventory (GBI). Patients were divided in 2 groups ("better" vs "worse" ear implanted) depending on different criteria (C).

- C1, Chen et al (2001): "better" ear when only this ear had worn hearing aid, and "worse" when the nonimplanted ear was aided before surgery.
- C2, modified from Howard (2005) and Lazard et al (2012): "better" the best PTA (0.5-2KHz) of both ears. To compare both ears the ranges used were 40-49, 50-59, 60-69, 70-79, 80-89, 90-99 and ≥100dB.
- C3, modified from Rubinstein et al (1999): maximum SDS prior to surgery

Audiometric testing included warble tone thresholds (PTA4, mean threshold 0.5-4KHz), dissyllables (DS) and sentences (S) recognition in quiet. 58 out of 73 elderly answered the questionnaire (78.4%). Duration of deafness was similar in both groups (mean 25.6 years). Considering the C1 criteria, comparing patients with "better" ear vs "worse" ear implanted, the mean total GBI score was 36.4 vs 37.8, PTA4 was 38.6 vs 38.9, DS was 68.2% vs 80.8%, and S was 93.5% vs 95.3%, respectively. No statistical difference was found when comparing both groups of patients. Regardless of the criteria chosen (C1, C2, C3) the results in all evaluated fields were similar.

1. Elderly patients perceive a significant benefit in their daily life, regardless of the choice of the implanted ear. The quality-of-life (QoL) improvement is comparable among the different groups.
2. Implantation of the "worse" ear in deafened adults ≥60y does not prognosticate poorer postoperative performance. This finding recommends implanting the worse ear, especially in patients with a contralateral hearing aid.
3. Theoretically, a perfect comparison of the "better" vs. "worse" ear could be only carried out in bilateral implantation. Further studies are required to take into consideration more individual factors as duration of deafness, device type, processing strategy, gender, and etiology of deafness.

Participants will learn that the choice of the poorer or better ear to be implanted in the elderly does not have a significant impact on hearing or QoL outcomes. The importance of QoL measures in this population will be emphasized.

S10-6

Comparison of outcomes in postlocutive patients treated with cochlear implants before and after 60 years of age

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Introduction: Stimulation with cochlear implants in people older than 60 years old with profound bilateral hearing loss in postlocutive stage offers the possibility of studying a deprivation model in an aged auditory system. The objective of this work is to analyze the factors that influence in the results paying special attention to which may be related to the mechanisms of auditory cerebral plasticity in the elderly.

Material and method: A total of 64 patients over 60 years old of age received a CI, being the average age of implantation 61,81 years and an average time of auditory deprivation of 11,7 years. The recognition percentages of disyllabic words and phrases in CID were analyzed after 3 years of follow-up. It was compared with the percentages achieved by a group of implanted patients under 60 years old with a time of auditory deprivation of 14.4 years.

Results: Showed a significant statistically correlation between the age of implantation and the results achieved after 3 years of follow-up. Comparing the results in patients older and younger than 60 years of age, a significant difference was appreciated in the percentage of disyllabic word recognition (p< 0,05) and phrases in CID (p< 0,01) in favor of the implanted group under 60 years old. In the group of patients older than 60 years old worse results in disyllabic word recognition were observed as the implantation was performed later. However, in this group the results obtained after the implantation did not suffer a setback throughout 7 years of follow-up.

Conclusion: The age of implantation plays an important role in the prognosis of CI in postlocutive implanted population. The results in implanted people above 60 years old showed the ability to discriminate in an open context.

S10-7

Cochlear implantation for elderly patients

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Background: Cochlear implantation in elderly patients seems to be not cost effective, due to belief that elderly patients perform poorly in the postoperative audiological rehabilitation procedure for degenerative processes in the auditory system.

Methods: This retrospective study entails the analysis of 16 postlingually deaf patients over 60 years of age, who underwent cochlear implantation in our clinic between 1996 and 2013. The average age of 9 female and 7 male patients was 65 years at the time of implantation (range 60 to 82 years) with an average duration of deafness of 13 years (range 2 to 36 years). The hearing loss was caused by a sudden or progressive sensorineural hearing loss, meningitis and/or trauma. Prior to cochlear implantation all patients received a conventional hearing aid on both ears, in use for at least three months. Patients were analyzed with an open-set speech perception test using multi- and monosyllabic word recognition (75 dB in quiet). The data of the elderly patients were compared to a control group of postlingually younger adult recipients.

Results: The surgical procedure was well tolerated by all patients. The speech perception was recorded 1, 3, 6 and 12 months after implantation. There was a significant improvement of disyllabic words and sentence scores. We found no significant differences in the results of the multi- and monosyllabic word test (open-set) in the study group of elderly patients and the control group of younger patients.

Conclusion: Cochlear implantation is feasible in elderly patients without higher risks or costs in comparison to younger patients. No significant differences in speech perception between senior and younger recipients could be recorded in our study. Cochlear implantation leads to a higher quality of life in elderly patients.

Learning outcome: *C*ochlear implants have a positive impact on quality of life in elderly patients.

S10-8

Elderly cochlear implant candidates maintain performance scores over long term follow-up: The Sunnybrook experience

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Intro: As our population ages and cochlear implant candidacy expands, a growing number of elderly adults are undergoing cochlear implantation. Previous research at our center has demonstrated that elderly cochlear implant patients have similar benefits when compared to our younger cohort within a year of implant activation. However it is unclear whether this benefit in elderly patients is sustained over a long-term period of time especially when the potential of developing additional serious health issues is extremely likely.

Methods: Prospective quality of life and hearing in noise test (HINT-Q) test scores were collected from patients greater than 60 years old when initially implanted. One-year, 2-year, 5-year and 10-year post cochlear implant activation data was collected and analyzed.

Results: Eight-two patients over the age of 60 years old were implanted between 2002 and 2012. The average age at implant was 68 years old. Fifty patients were between 60-70 (young elderly) at time of implantation and 32 patients were over the age of 70 (older elderly). The average HINT-Q score at 1 year post-activation was 78%. At 2, 5 and 10 years post-activation, the HINT-Q scores were 80%, 80%, and 90% respectively. When divided into young elderly and older elderly the HINT-Q scores at 1 year post-activation were 82% versus 72% respectively which were not statistically significant. At longer time durations, the HINT-Q scores in the young elderly and older elderly were 81% versus 77% at 2 years post-activation, 82% versus 77% at 5 years post-activation and 94% and 84% at 10 years post-activation. None of these values between the young elderly and older elderly group were statistically significant. Quality of life scores also demonstrated excellent improvement post-implantation and were maintained over the long term.

Discussion: Elderly cochlear implant patients have excellent benefit from cochlear implantation and this benefit is maintained over a long-term duration. Patients in the young elderly and older elderly groups do not demonstrate any statistically significant difference at any time point between time of activation to up to 10 years post-activation.

Conclusion: Cochlear implants should be made accessible to this large and growing segment of our population. We have demonstrated this group of elderly patients perform very well over the long-term and subjective quality of life improvements are also maintained.

Learning outcome: Discuss the long-term performance and subjective outcomes of elderly patients who underwent cochlear implantation.

S10-9

Development & validation of a cognitive screening test for the severely hearing impaired

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Introduction: With the aging of our population, we are increasingly encountering patients with mild cognitive impairment (MCI). It is unknown how patients with MCI would respond to cochlear implantation. However, all current and commonly utilized validated screening tools for cognitive testing rely on the ability for the patients to follow auditory verbal instructions. No clinical screening test for MCI is available for patients with severe hearing loss. Development of such a test would be invaluable in our initial patient assessment for cochlear implantation in the elderly. Our objective is to validate a modified version of the Montreal Cognitive Assessment (MoCA) for use in patients with hearing impairment (MoCA-H).

Methods: Older-aged subjects were recruited from outpatient Otolaryngology clinics. Patients who volunteered for the study first underwent a battery of cognitive screening tools. Patients who passed the screen were then administered the MoCA-H. The MoCA-H was performed on 55 normal hearing subjects and 50 subjects with severe-to-profound hearing loss (HL). The regular MoCA was retested 6 months after MoCA-H was administered in a subset of normal hearing subjects.

Results: The average score of patients who underwent the MoCA-H was 26.6 (SD = 2.04), consistent with the accepted normal cutoff of ≥26/30. No significant difference was demonstrated between the MoCA-H scores in those with and without HL. Similar scores were noted between the MoCA-H and MoCA in the subset of normal hearing subjects that were retested. Further subanalysis of results of the individual questions revealed small differences between the MoCA-H and MoCA. Initial testing at our adult cochlear implant center with a sequential cohort of potential cochlear implant candidates over the age of 60 revealed an average MoCA-H score of 26.

Discussion: The MoCA-H results of normal cognitively screen subjects have a high correlation to MoCA results. Larger numbers will be required for subtest analysis. The MoCA-H is the only tool to detect MCI in patients with severe hearing impairment. This test will be an invaluable tool for both screening and serial follow-up testing in future patients with MCI that undergo cochlear implantation.

Conclusion: The MoCA-H can be used reliably to screen severely hearing impaired patients for MCI.

Learning outcome: (1) Discuss the need for a cognitive screening test for hearing impaired individuals and (2) Understand the various components of the MoCA-H test.

S10-10

Auditory-cognitive processing in older adults with cochlear Implants: Electrophysiological and behavioral manifestations

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With the growing number of older hearing-impaired adults receiving cochlear implants (CI) it is clear that substantial benefits can be gained. Nonetheless, variability in hearing performance is high, and inconsistent evidence exists as to whether older CI recipients have similar outcomes as compared to young recipients. Clinically used speech perception tests, though sensitive, to some degree, to the difficulties encountered by older CI recipients, do not tap into the cognitive aspects of speech understanding that affect the amount of attention, effort, and memory resources expended during communication. A potential objective means for assessing the benefits derived from CIs in older adults are objective measures. Specifically, auditory event-related potentials (AERPs) are advantageous as they allow evaluation of the time-course of cortical information processing, from early perceptual to later cognitive, post-perceptual stages. By varying task complexity and degree of cognitive load AERPs may expose processing difficulties of older adults with CI. The goal of the present study was, therefore, too characterize auditory-cognitive processing in older-adult CI recipients by means of behavioral and electrophysiologic manifestations of Stroop tasks. AERPs were recorded from 32 scalp electrodes while post-lingually deafened older CI recipients (age at CI>60 yrs) and age-matched normal hearing (NH) listeners performed Stroop tasks. Participants were required to classify word meaning or speaker´s gender while ignoring the irrelevant (congruent, incongruent) speaker's gender or word meaning, respectively. While data collection is still in progress, preliminary results indicate:

1. A significant behavioral Stroop effect i.e. prolonged reaction time to incongruent vs. congruent stimuli in both groups
2. Similar Stroop effect magnitude and reaction times in both groups
3. Poorer performance accuracy in CI recipients compared to NH listeners
4. Significantly longer P3 latency together with comparable N1 latency, in CI recipients vs.NH listeners.

Taken together, the recording of AERPs together with the simultaneously obtained behavioral measures during higher-order cognitive tasks revealed a differential time-course of auditory-cognitive processing in older CI recipients. Potential implications of the current findings for evaluation and rehabilitation procedures for older adult CI recipients will be discussed.

S10-11

Symptoms of dementia in addition to hearing loss in elderly CI candidates - contraindication for cochlear implantation?

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Severe hearing impairment in old age had been of increasing scientific interest in recent years due to the aging population in industrialized and newly industrializing countries. Dementia symptoms had been a relative contraindication for cochlear implantation (CI). Although recent studies have shown a reduced benefit for older patients compared with younger counterparts, but were able to demonstrate that older and very old patients benefit from a CI. In general, it has been underlined that the investigated elderly collectives showed no cognitive comorbidities. This study examines whether older patients with cognitive impairments also benefit from the cochlear implant and whether they significantly distinguish during rehabilitation. Retrospectively, 46 patients were studied, which had been provided in Halberstadt with a cochlear implant in 2010 and 2011. All patients were 65 years or older. In addition to common audiovestibular testing and radiological examination all elderly patients underwent gerontopsychiatric investigation. The patients were intensively interviewed and examined in term of a screening (Mini-Mental-State-Examination, clock drawing, DemTect) by a geriatric psychologist. Suspicious patients were compared with the inconspicuous with regard to age, gender and hearing before and after Cochlear Implantation. In 11 patients mild or medium cognitive abnormalities revealed. Both groups, with and without pathological psychiatric showed no significant difference in hearing. Essentially all investigated patients benefit from cochlear implantation. Patients with moderate symptoms of dementia in preparation for cochlear implantation should undergo further neuropsychiatric examination to rule out rapid progressing forms of dementia. If that had been done mild symptoms of dementia can be discussed as good reason for and not against a Cochlear Implantation.

S10-12

Objective and subjective performance development of the elderly with cochlea implant

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Objective: Due to rising life expectancy and indication enlargement of cochlea implantation more elderly patients are supplied with an inner ear prosthesis. Beyond doubt is the positive influence of the cochlea implants on the restoration of hearing and the quality of life linked with it. Also, the effects connected to dementia processes as well as on psychovegetative processes are well-known. The following study focuses on the comparison of objective and subjective performance development of older CI user.

Method: A total of 45 CI patients were examined. The average age at the time of the CI rehabilitation was 79.6 years. During the postal-surgical treatment the regular speechaudiological measurements were carried out. In parallel the study participants received a questionnaire to evaluate the quality of life after the CI care. In case studies it shall be demonstrated why within some participants big discrepancies between the objective and subjective performance development emerge.

Results: First interpretations are introduced explaining causes for this course development. The aim of the study should be to reflect the requirements for the CI aftercare with older patients as well as to adapt the therapeutic work to the special needs of this patient group and to introduce, perhaps, new training methods.

Conclusions: In summary, it can be said that the success of the CI rehabilitation of these patients shows a special challenge for all involved professionals. The topical scientific knowledge and technical developments offers new possibilities in the modern and advanced treatment of older people with extreme hearing disturbances.

S10-13

Acute effect of stimulation rate on speech recognition scores in young, middle-age, and older adult cochlear-implant users

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Intro: It has been well-documented that the aging auditory system shows deficits in many auditory processing tasks, including a slowing of temporal processing. The aim of this study is to investigate whether high rates of stimulation have a deleterious effect on speech recognition scores of older, but not younger cochlear-implant (CI) users.

Methods: We are testing participants across the adult age span from 20 - 85 years. Thus far, 10 CI users (mean age: 58.4 years, ranging from 26 to 80 years) were mapped at stimulation rates of 500, 720, 900, and 1200 pulses per second (pps). Speech recognition scores were obtained monaurally at 60 dB SPL in the sound field in quiet and in 10-talker babble (+10 dB signal-to-noise ratio), using both AzBio (Spahr et al., 2012) and Perceptually Robust English Sentence Test Open-Set (PRESTO) (Park et al., 2010) sentence materials. Participants were asked to qualitatively evaluate their performance with each Map, as well as provide sound quality judgments on a scale of 1 to 5. A brief cognitive test battery was also administered including, the Modified Mini-Mental State Exam (Teng & Chui, 1987) to screen for dementia, the Reading Span (Daneman & Carpenter, 1980) to evaluate working memory, and digit symbol coding and symbol search tasks from the Digit Symbol Subtest of the Wechsler Adult Intelligence Scale (WAIS-III) to assess processing speed.

Results: All participants performed best when listening to AzBio sentences in quiet. Scores for AzBio sentences in noise decreased by 34% compared to conditions in quiet. PRESTO sentences yielded scores that were, on average, 20% lower than those obtained with the AzBio sentences in both quiet and noise. Speech recognition scores obtained with different stimulation rates were highly variable across CI listeners; however, some older participants showed substantial effects of rate that were not apparent in the younger participants.

Conclusion: These results suggest that CI stimulation rate may impact speech understanding scores in older adults differently than younger and middle-aged adults.

Learning outcome: Implications for clinical mapping practices and evaluation methods for an older patient population will be discussed.

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S11 Malformed cochlea

S11-1

An abnormally rotated cochlea: A condition diagnosed by studying the cochlear carotid angle on high resolution CT scan

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For optimal cochlear implant performance, not only the proper placement of the electrode into the scala tympani is important, but the insertion vector is crucial to assure complete and atraumatic insertion. The optimal surgical insertion vector should be thought of in all cases of cochlear implantation. The surgeon must attempt to ensure a coaxial insertion by estimating the course of the basal turn by observing its lumen through the cochleostomy. If this direction is not respected, the implant may be incompletely inserted, or the tip of the electrode can be rolled over, or the electrode can pass into the scala vestibuli. The orientation of the insertion vectors also depend on the rotation of the cochlea in the parasagittal plane. A large spectrum of inner ear anomalies are increasingly addressed in the literature, with neglect of subtle orientation changes of the cochlea. This is the case in a posteriorly rotated cochlea, where the round window is more posteriorly and medially directed, and difficult to expose. The variability of orientation of the cochlea can be seen on standard high-resolution axial CT scan, by observing the cochlear carotid angle with the sliding sign serving as a good predictive sign preoperatively. Intraoperatively, various findings can also point to such an anomaly. The angle of the round window overhang with respect to the surgical perspective may serve as a useful guide to the degree of parasagittal rotation. We describe our criteria for diagnosing such a condition pre-operatively as well as intra-operatively, and the instructions to follow to assert proper electrode insertion in such cases.

S11-2

Different CI-mediated auditory brainstem responses observed in different types of the severe inner ear malformations

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Purpose: The purpose of this study is to evaluate cochlear implant (CI)-mediated responses of spiral ganglion neurons (SGNs) and the brainstem auditory system in children with severe inner ear malformations including common cavity deformity (CC) and incomplete partition type 1 (IP-1).

Background: Severe inner ear malformations including CC and IP-1 show a cystic cochlea without a modiolus. In these malformations, the distribution and amount of SGNs are unclear due to the lack of the modiolus which contains SGNs in the normal cochleae. These severe inner ear malformations can be also associated with abnormalities in the central auditory system. The functional abnormalities in the SGNs and the brainstem auditory system may affect hearing outcomes with CI, but have not been revealed well.

Methods: This study includes 5 children with CC, 4 with IP-1, and 6 control patients without malformations who underwent cochlear implantation. CI-mediated electrically evoked ABR (EABR) testing was performed to evaluate the responses in the auditory system and the evoked waves (eII - eV) were compared between CC, IP-1, and control groups.

Results: The reproducible evoked eVs with approximately 4 msec of the latency was observed in all groups, but the proportion of eV-positive electrodes was lower in the CC group than IP-1 and control groups, suggesting the restricted distribution of the SGNs in the CC group. Regarding the evoked waves with a shorter latency than eV, 3 of 4 patients with IP-1 exhibited clear eII, eIII, and eIV and their latencies were similar to those observed in the control patients. On the contrary, some evoked waves including a putative eIII were detected in 3 of 5 children with CC, but their latencies were different from those of eII-eIV in the control group.

Conclusion: Results of EABR testing suggest that developmental abnormalities are usually restricted within the inner ear in the IP-1 group, but the patients with CC may be often associated with abnormalities in the synaptic connectivity and/or the neural network in the brainstem auditory system.

S11-3

Cochlear implantation in children with congenital inner ear malformation

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Introduction: Recently, cochlear implantations for children with severe sensorineural hearing loss have not been rare in Japan. In the literature, 20% of children with sensorineural hearing loss are supposed to show radiological anomalies in the temporal bone. Although the inner ear malformation is not a contraindication to cochlear implantation, there remain some cases with complications or cases that need special consideration for rehabilitation after surgery.

Material and method: There were 532 cases (adults:337, children:195) that received cochlear implantation at Osaka University Hospital from January 1991 to May 2013. Among them, 17 cases had some inner ear malformations in children. We retrospectively assessed the grade of malformation, postoperative hearing results and surgical complications. We used the classification of inner ear malformation that was suggested by Sennaroglu et al. in 2002. We adopted meaningful auditory integration scale (MAIS) to evaluate behavior with sound, and used meaningful use of speech scale (MUSS) to evaluate utterance.

Results: The details of cochleovestibular malformation were as follows; common cavity deformity:2, hypoplastic cochlea:3, incomplete partition type Ⅰ:1, incomplete partition type Ⅱ:6, vestibular aplasia:1, narrowing of internal auditory canal(IAC):2. 11 cases were accompanied with some syndromes. 11 cases had also mental retardation. Three children had severe perilymph/CSF leak during the operation. Three children were re-implanted to opposite side but two of them are not in use now. In one case of narrowing of IAC, facial spasm is evoked when the processor is switched on. Two children were re-implanted in the same side because of device failure. We evaluated hearing results of 12 children who are still using CI now. There was no significant difference due to the grade of inner ear malformation. We found that hearing results were poor in the cases with mental retardation.

Discussion: In the case of narrowing of IAC, hearing results were poor in comparison with other types of malformation. But there was no significant difference among other types of malformation. It seemed that the hearing results depend on accompanied syndromes, especially mental retardation, compared to the grade of malformation. Of course, it is important to be aware of surgical complications, such as CSF gusher, bleeding, abnormal course of facial nerve, but cochlear implant is still useful for the children with inner ear malformation. Therefore, cochlear implantation should be performed for these cases without hesitation.

S11-4

The surgical outcomes of cochlear implantation in children with incomplete partition type I

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Objective: The aim of this study is to compare speech perception of cochlear implantation (CI) in children with incomplete partition (IP) type I with those of CI in age matched children with normal cochleae.

Study Design: Retrospective chart review

Setting: Academic center

Patients: We identified 23 children with IP type I children and selected 384 age-matched deaf children with non-syndromic, normal inner ear underwent CI between Jan 2000 and Jun 2013.

Intervention: CI, speech perception test, high resolution temporal bone (HRTB) CT and MRI.

Main Outcome Measure: Categories of Auditory Performance (CAP), and Meaningful Auditory Interation Scale (MAIS)

Results: The mean age at the CI was 5.3 years (SD, 5.4, range; 0.9 - 17.7). The mean duration of follow-up was 4.7 years (SD, 3.5; range, 1.1 - 11.2). Contralateral lesions were found mostly IP type I in 17 ears (68 %), cochlear aplasia in three ears, common cavity in two ears and normal in one ear. HRTB CT showed widening of the fundus in 20 ears (80%); however fourteen ears (56 %) were showed cerebrospinal fluid gush out during the cochleostomy. Among 25 ears, the cochlear nerve was evaluated in 17 ears by MR and the cochlear nerve hypoplasia in nine ears and normal in 8 ears. Facial twitching was occurred in fifteen ears. In lesser than 3 years old at CI, There were statistical significant difference in CAP and MAIS score at 12 and 24 months between two groups. CAP and MAIS plotted over time show that normal inner ear have higher scores compared with IP I and, however, the CAP and MAIS scores of IP type I catches up those of normal inner ear at 72 and 42 months. In more than 3 years old at CI, mean CAP and MAIS score was not statistically significant different between two groups.

Conclusion: The IP type I was comprised 3 % among 842 of CI. The cochlear nerve hypoplasia was found in 63.2 % of IP type I patients. Regardless of the extent of inner ear anomalies, a CI with careful treatment planning is a valid option for the IP type I inner ear malformation. .

S11-5

Cochlear implantation in children with inner ear anomalies

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In the 28 years since 1986 when the first child was implanted at our center, we have performed unilateral or bilateral cochlear implant surgery on nearly 700 children. A vast majority of these children had normal anatomy based on MRI of their temporal bones. However, a population of patients implanted in our program had various inner ear anomalies. The most common of these anomalies include enlarged vestibular aqueducts (dilated endolymphatic sacs), cochlear dysplasia, cochlear vestibular dysplasia, and hypoplastic cochlear nerves. The presence of these anomalies introduces additional risks of surgery and potential complications. In addition, they may limit the maximal benefit of implantation. Nevertheless, we have found that with careful planning and modification of techniques, patients with inner ear anomalies can safely and successfully undergo cochlear implantation. This presentation will review our experience with cochlear implantation in children with various inner ear anomalies. We will present the prevalence of the various anomalies in the children who have undergone implantation at our center, discuss the special considerations unique to the various anomalies, present technical pearls for implantation with certain anomalies, and review our surgical results, complications, and post-operative outcomes in these patients.

S11-6

Cochlear implantation in children with CHARGE syndrome

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CHARGE syndrome represented a cluster of features including coloboma of the eye©, congenital heart defects (H), atresia or stenosis of the nasal choanae (A), retardation of growth or development and/or central nervous system anomalies®, genital hypoplasia (G), and anomalies of the ear and/or deafness (E). The "E" refers to hearing loss (HL) and malformations of the ear of these patients and they can present with mixed HL, sensorineural deafness, cochlear defects, and vestibular problems. When severe sensorineural HL or deafness is present, cochlear implantation can be a therapeutic option. According to the literatures review, children with CHARGE syndrome in whom the neurologic deficits are extremely severe might not benefit from cochlear implantation, and careful therapeutic decision making and parental counseling must take place. In considering cochlear implantation for patients with CHARGE syndrome, attention must be given to the varied temporal bone anomalies that may be suggested by pre-operative CT/MRI test and be encountered during the surgery. In our institute, six children with CHARGE syndrome underwent cochlear implantation. The radiologic and audiologic records and surgical techniques used should be reviewed.

S11-7

CHARGE syndrome and paediatric cochlear implant outcomes

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Introduction: Charge syndrome is a complex cluster of congenital abnormalities, which can impact on cochlear implant outcomes. Associated factors include hearing loss, abnormal inner ear anatomy, developmental delay and cranial nerve hypoplasias. These children may have absent or hypoplastic auditory nerves.

Method: The Sydney Cochlear Implant Centre (SCIC) data were searched for cochlear implant children with CHARGE syndrome, aged 16 and less. Data were collected regarding clinical history; hearing assessments; MRI and CT scans; transtympanic electrical Auditory Brainstem Response; intraoperative findings; and language outcomes in terms of main language used and Categories of Auditory Performance scores (0-7 ranking).

Results: Nine children were identified. All six prelingual profoundly deaf children had hypoplastic or absent auditory nerves bilaterally on MRI scanning. Intraoperative anatomy and surgery was difficult in half of these cases. Sign language was used as the main mode of communication in all of these children. Two, implanted early, did have spoken language also. CAP scores ranged from 0-5. The three children with progressive hearing loss had better auditory nerve findings on MRI scan. All preoperatively only used verbal language and continued to with their cochlear implants, with CAP scores of 6.

Conclusion: Congenital profound hearing loss in children with CHARGE syndrome is associated with hypoplasia or absent auditory nerves, affecting outcomes with cochlear implants. These children do best with a bilingual early intervention, using sign language and verbal language, to ensure best language outcomes of the children. Progressive hearing loss CHARGE syndrome children did well with cochlear implants.

S11-8

Cochlear implantation in cochlear anomalies and thin cochlear nerves

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Introduction: Although Cochlear implantation has become an established intervention for children with severe to profound deafness, Children with abnormal Cochlea & cochlear nerves present problems in evaluation and management. This Retrospective study is aimed at analyzing the diagnostic challenges, counseling strategies, intra-operative techniques and outcome of Cochlear implantation in these children.

Methods: Of the 234 hearing impaired children who underwent cochlear implantation in our center, fifteen were found to have cochlear anomalies and /or hypo plastic cochlear nerves. Their age at implantation varied from 2 to 7 years. These children underwent audiological, Radiological, Psychological evaluations along with Speech & Language assessment, When cochlear nerve integrity was in doubt, TTEABR was performed to assess the functional integrity of the nerve. Parents were counseled for realistic expectations with Cochlear implant surgery for their child. Parents were made to meet similar children who had cochlear implantation. This helped them to make decisions regarding Cochlear implantation for their child. The surgical technique used in all these children was Mastoidectomy-Posterior tympanotomy and cochleostomy approach. Post Switch on children underwent auditory training with oral aural method or total communication. The outcomes were evaluated periodically and the necessary changes made in the Habilitation strategies.

Results: Out of the fifteen children studied 7 had Mondini deformity. Two had Large Vestibular aqueducts with thin modiolus. One had common cavity with semi-circular canal abnormality and very thin cochlear nerve. Three children had normal cochlea with thin cochlear nerves where as two children had hypo plastic cochlea with thin cochlear nerves. It was difficult to diagnose thin cochlear nerves on routine MRI scans. Whenever in doubt about the cochlear nerve, Transtympanic EABR was done under anaesthesia. In three cases we were able to demonstrate neural response and hence the functional integrity of the nerve was confirmed. Patients with cochlear anomalies underwent CI with straight electrodes whereas children with normal cochlea received Perimodiolar electrodes. The problems faced during surgery like abnormal facial nerve, CSF gusher, difficulty in Cochleostomy and electrode insertion were handled effectively.

Discussion: Rate of progress was slow in children with thin nerve. They began to respond spontaneously to sound only after 6 months. Speech perception was seen after one year in children who showed intraoperative NRT. Implants helped to acquire speech and language & Parents were happy as their expectations were met.

Conclusion: Careful evaluation and Counseling is necessary to get realistic expectations with cochlear implantation in children with cochlear anomalies and hypo plastic Cochlear nerve

Learning outcome: Successful habilitation is possible in these children with Cochlear implantation.

S11-9

Outcomes of cochlear implants in children with anomalous cochleo-vestibular anomalies as compared to those with normal inner ear anatomy

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Aim: To evaluate the efficacy of Cochlear implantation in children with normal as well as abnormal cochleas

Objective: To assess auditory performance and speech intelligibility of each implantee using the categories of auditory perception scale (CAP II) and Speech intelligibility Rating (SIR)

Study Design: Retrospective study

Method: 68 patients, each less than 10 years, who underwent cochlear implant surgery on either the Right or the Left side within the period of April 2008 and January 2012 were included in the study. Amongst these, 52 patients (n=52) had normal cochleo-vestibular anatomy. 16 patients had abnormal cochleo-vestibular anatomy which were as follows: Cochlear ossificans (n=6), Hypoplastic cochlear nerve (n=2), Mondini's dyplasia with large vestibular aqueduct (IP type II) (n=4), common cavity (n=4). Each of the patients was followed up at 3months, 6 months, 12 months and 24 months post-surgery.

Main Outcome Measure: Categories of Auditory Performance (CAP II) & Speech Intelligibility Rating (SIR).

Results: In both groups, the CAP and SIR scores increased with the time of implant usage during follow-up after implantation, and there were no significant differences in the CAP or SIR scores between the two groups at any of the four follow-up assessments.

Conclusions: Cochlear implants are an effective means to improve auditory capabilities in the hearing impaired. Our study showed that even patients with abnormal cochlea-vestibular anatomy developed auditory capabilities, enough to make them self-independent. Hence, inner ear malformations should not be considered a contraindication to cochlear implant surgery.

S11-10

Outcomes of cochlear implantation in patients with Bony Cochlear Nerve Canal malformation

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Methods: A total of 54 ears from 44 patients (10 bilateral CIs) out of 851 CI ears were selected for this retrospective study. BCNC stenosis was considered present when the BCNC was < 1.5 mm in diameter. CN hypoplasia on MRI was defined when the CN was smaller than the facial nerve. To measure the CI outcomes, patients were divided into three groups by age at CI and their results were compared results with those of the age-matched controls. Group A patients (27 ears) underwent CI at < 3 years. Group B patients (21 ears) underwent CI at 3-18 years. Group C patients (4 ears) underwent CI at ≥18 years. The age-matched control groups included 89, 129, and 106 ears, respectively.

Results: In 54 BCNC malformation ears, 28 (51.9 %) had normal cochlear and vestibular structures and 24 (44.4 %) had semicircular canal (SCC) and/or vestibular structural anomalies. Two ears (3.7 %) were of incomplete partition type I. In the 24 ears with SCC and vestibular anomalies, 12 ears showed no development of the three SCCs (8 ears had CHARGE syndrome), 6 ears had the malformation in the lateral SCC (LSCC) and the vestibule, and 6 ears had the malformation only in the LSCC. In the 54 BCNC malformation ears, BCNC atresia and stenosis were present in 15 (27.7%) and 39 (72.2%) ears, respectively. IAC stenosis (< 3 mm) was found in 27 ears (50%). In the evaluation of CN, 16 ears were excluded due to inadequate MR images. In the 38 ears whose CN was evaluated, 30 (78.9 %) showed non-visible CN (NVCN) and 8 (21.0 %) had CN hypoplasia. All eight ears with CN hypoplasia had BCNC stenosis. Regarding postoperative speech evaluation, the category of auditory performance (CAP) score in group A of the BCNC malformation group reached 5 at 48 months, 5.75 at 5 years, and plateaued until 7 years after CI. However, in control group A, the CAP reached 6 at 2 years and 7 at 6 years after CI. In group B, the CAP score was 3.97 at 1 year, 4.50 at 2 years, and plateaued until 7 years after CI.

Conclusions: BCNC malformations were found in 54 ears (6.3%) of 851 CI recipients. In the evaluation of the CN, 30 ears (78.9%) had NVCN and 8 ears (21.0%) had CN hypoplasia. In the outcomes measurement, all the parameters of speech evaluation in the BCNC malformations were worse than control groups. The CN hypoplasia group showed much better outcomes than the NVCN group.

S11-11

Use of special electrodes in malformed cochlea and the application of EABR in the decision of choosing the ear to be implanted

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Malformation of the cochlea poses many challenges to the surgeon and the cochlear implant team. Surgically, it means difficulty in accessing the cochlea, possible injury to the nearby structures and the potential for CSF leak. From the audiological perspective, choosing the side to be implanted need not necessarily mean that the lesser malformed ear is the better choice. Transtympanic EABR is a good tool to decide the side to be implanted and also to possibly predict outcomes. Special electrodes like the FORM electrode help us to achieve a good seal in cases with profuse CSF leaks. We, a primarily pediatric implant center, with experience of over 700 cochlear implantations, evaluated our series of cochlear and cochlear nerve anomalies. The use of EABR in deciding the ear to be implanted or to decide whether it was worthwhile implanting at all was useful, but not fully predictable for outcomes. The type of malformations that were studied included incomplete partition (IP) I, II & III, thin auditory nerves and auditory neuropathy/dyssynchrony spectrum disorder. For the transtympanic EABR, we used a special electrode designed and developed indigenously and was very useful in getting good traces in the assessment period. A risk analysis was then made and issues discussed with the parent. After getting parental consent, the implantation choice was made. In certain cases special electrodes were ordered when profuse CSF leak was predicted. A careful pre-operative study of the imaging was imperative in making this analysis. We found that good pre-operative transtympanic EABR traces were useful in predicting the better ear to be implanted. However, this did not always correlate with the implant outcomes. CSF gushers were managed with proper surgical techniques and use of lumbar drains and medication to reduce CSF pressure, but a strong recommendation is made to use special electrodes. This study points to the benefit of using specially designed electrodes for transtympanic EABR and also the need for special electrodes in malformations. More studies are required to validate these results from different centers to see if there can be a good predictive value for this technique

S11-12

Scalar position and speech perception outcomes of a mid-scala electrode

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Introduction: Speech perception outcomes have shown to be related to both the insertion depth and cochlear trauma created during the insertion. The latter has also been associated with accidental penetration related to the stiffness and dimensions of the electrode array. A mid-scala electrode was developed to cover one and a quarter turn and with the pre-curved design to be less susceptible to variations in individual cochlea dimensions and insertion techniques (Advanced Bionics HiFocus V). We aim to evaluate the results of cochlear insertion radiologically, electrophysiologically, and behaviorally in a consecutive series of patients in our Centre.

Methods: We study prospectively the scalar position and the insertion depth of the HiFocus mid scala electrode in 7 Chinese cochlear implant recipients underwent the AB Advantage implant surgery. Surgical techniques with detailed reference to the manipulation of the round window and insertion time, anatomical variations on the electrode position as determined radiologically, impedance and neural responses of individual electrodes are evaluated pre, peri and post operatively. Residual hearing of the implanted ear was also monitored over 6 months post operatively. Majority of this series of patients received this mid scala electrode as the consecutive 2nd implant, after no less than 3 years of use of their 1st implant. The post 6 months speech perception results, including sentence recognition and lexical tone identification, both in noise and in quiet, with reference to their 1st implant, will also be discussed.

Results and discussion: We present the results of individual variations in the relative electrode position. The mid scala electrode had consistently shown to lie on the scala tympani, and the impedance responses were also shown to be stable and relatively low with atraumatic electrode insertion techniques. Behavioural outcomes with the mid scala electrode stimulation was also found to be stably progressing. Though individual variations were noted, behavioral outcomes of this series of patients are promising.

S11-13

The application of the navigation during cochlear implantation surgery

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Cochlear implantation in patients with middle and inner ear malformations is still remaining difficult in some cases. The difficulties can be obtained during surgical approach to the cochlea. The peculiarities of the inner ear projection on the promontorial wall and temporal bone individual anatomical structures could increase the intraoperative trauma accessing the necessary cochlear region. The analysis results of the surgical stage peculiarities of 2073 cochlear implantations performed in our center from 1991 to 2013 confirmed very rare but possible temporal bone structure malformations which could cause difficulties for finding even normal but displaced cochlea. In one case even the navigation system was used to facilitate the approach to the cochlea. This 6-years old child had abnormal topography of the external ear canal and normally formed cochlea placed higher in comparison with the facial recess. It was impossible to visualize the round window niche in typical place. With the help of the searching probe placed on the promontorial wall it was found the point corresponding to the scala tympani projection in the maximal proximity to the vestibulum. The cochleostomy was performed in this point and the electrode array was inserted totally. The Electrically evoked compound action potentials were registered from all electrodes. The right placement of the electrode array was also confirmed by X-ray. It was demonstrated that the use of navigation system requires minimal additional invasive manipulations. The rehabilitation of this child has already started successfully.

Conclusion: The technique and results of the cochlear implantation with navigation system assistance in patients with the middle and inner ear malformations is very useful and safe, which allow to avoid the complications and increases the chances of the effective rehabilitation in this group of patients.

S12 Drug delivery

S12-3

Evaluation of the systemic and intratympanic application of the selective glucocorticoid receptor agonist Compound-A for ototoxic effects in a Guinea-pig model

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Intro: Glucocorticoid therapy is used for various conditions affecting the inner ear. Because the systemic application of glucocorticoids bears a high risk for side effects like hyperglycemia or osteoporosis - especially if the drugs are given for a longer period of time -, the use of novel pharmaceutical compounds is a way to improve therapy of the inner ear. Selective glucocorticoid receptor agonists like Compound-A are potent anti-inflammatory drugs, but showed a reduction in side effects in various *in-vitro* and *in-vivo* models. As selective glucocorticoid receptor agonists have never been used for the therapy of conditions affecting the inner ear, we evaluated the topical and the systemic application of Compound A for ototoxic effects prior to the application in trauma-models.

Methods: In total, 24 pigmented guinea pigs were used and grouped as follows: 1) Systemic application of Compound A (1,5mg/kg; n=6); 2) systemic application of Compound A (4,5mg/kg; n=6); 3) intratympanic application of Compound A (1mM; n=6); 4) intratympanic application of Compound A (10mM; n=6). Contralateral ears of the topically treated animals were used as controls. Hearing thresholds were determined by the recording of auditory brainstem responses to clicks and tone bursts between 1 and 32 kHz. ABRs were measured before and directly after the application of the compound as well as on days three, seven, 14, 21 and 28. After the final audiometric evaluation, animals were euthanized and temporal bones were harvested for the preparation of organ of Corti wholemounts stained with phalloidin and histological slides, which were H&E stained.

Results: Systemic administration of Compound A (1,5 mg/kg & 4,5 mg/kg) did not result in hearing threshold shifts. In contrast, the intratympanic application of 1mM and 10mM Compound A resulted in statistically significant threshold shifts in the click measurements of 28 and 21dB, respectively, as compared to the control group. The IT application of both concentrations of Cpd A resulted in pure tone threshold shifts, which partially recovered until day 28 and were more prominent in the higher frequencies, reaching up to 50dB at 32 kHz at day 28. The histological evaluation of the inner ears showed, that the application of Compound A via both routes did not result in a loss of hair cells or spiral ganglion cells. In contrast to the systemic application, the intratympanic application caused osseous alterations and could therefore have caused a conductive hearing loss.

Discussion and conclusion: Selective glucocorticoid receptor agonists like Compound A could provide novel therapeutic options for the treatment of inner ear disorders, but extensive testing for ototoxic effects prior to evaluation of otoprotective effects is warranted. As the systemic application of Compound A did not cause ototoxicity, it merits evaluation for otoprotective effects in trauma models.

S12-4

Long-term protective effects of neurotrophic treatment of the auditory nerve in deafened Guinea pigs

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Background: After severe damage to the organ of Corti spiral ganglion cells (SGCs) degenerate as a result of lost neurotrophic support. Our previous research showed that local treatment with exogenous brain-derived neurotrophic factor (BDNF) prevents SGC degeneration up to two weeks after cessation of the treatment. The goal of this study was to investigate the extent of this preservative effect on both structure and function of the auditory nerve on the longer term.

Methods: Guinea pigs were deafened by co-administration of kanamycin (400 mg/kg) and furosemide (100 mg/kg). Two weeks after deafening the animals were implanted with an intracochlear electrode array with a cannula connected to an osmotic pump filled with either plain phosphate-buffered saline (PBS) or BDNF in PBS. Immediately upon implantation electrically evoked compound action potentials (eCAPs) were recorded using the intracochlear electrode array and a MED-EL PULSAR cochlear implant. Four weeks later the treatment was stopped by surgically removing the osmotic pump. Eight weeks later another series of eCAPs was recorded after which the animals were sacrificed for histological analysis of the SGCs.

Results: Either directly or eight weeks after the four-week treatment with BDNF, SGC packing density was similar to that in two-weeks deaf animals (at which time the treatment started), although some degeneration had occurred in the cochlear apex. Packing density in all three groups was 20-30% lower than in normal-hearing controls. In contrast, the 14-weeks deaf PBS-treated controls suffered severe SGC degeneration (up to 75%). In accordance with SGC degeneration, the eCAP amplitude became smaller after deafening, roughly stabilized in response to BDNF treatment, and was much smaller in PBS-treated controls. The slope of the input-output curve followed the same pattern as the amplitude, but there were no significant differences in the eCAP threshold. The eCAP latency became shorter after deafening, and was also shorter for BDNF-treated animals.

Conclusions: The preservative effect of BDNF extended significantly beyond the four-week treatment period. This implies that brief neurotrophic treatment, possibly by activating an autocrine survival mechanism, can permanently put progressive neuronal degeneration to an end. These findings make clinical application of neurotrophic treatment more appealing, since it may be sufficient to administer BDNF for a short time in order to ensure long-lasting auditory nerve preservation.

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S12-5

Adipose tissue-derived stem cell (ASC) application enhances the survival of spiral ganglion neurons in vivo

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Introduction: Cochlea implantation (CI) is very successful in restoring speech perception capabilities in severely hearing impaired or deaf patients. However, there are still limitations in many CI patients during difficult listening situations, particularly in background noise. It is believed that a poor interface between electrode contacts and spiral ganglion neurons (SGNs) may account for these problems, since this leads to a broad spread of excitation and a limitation of effective channels. Adipose-derived stem cells (ASCs) are multipotent stromal cells that can be harvested from adult individuals. In a series of experiments, it was tested if ASC would be potentially useful for improving the bioelectric interface of CI.

Methods: ASCs have been cultivated in various hydrogels and supernatants were analyzed by ELISA. Then, ASCs have been co-cultivated with SGNs and neurite length and SGNs survival were determined. Moreover, ASCs were harvested individually from guinea pigs and were implanted into one inner ear of each animal after bilateral deafening. Histologic evaluations were done after 2-8 weeks.

Results: We found that ASC embedded in different hydrogels produce various amounts of neuroactive substances, e.g. BDNF and laminin. In co-culture with SGN, ASCs promoted survival of SGN and neurite outgrowth significantly. Moreover, *in vivo,* ASC application significantly improved SGN survival after induced hearing loss.

Discussion and conclusion: These results suggest that ASC may improve the survival of SGN in the impaired auditory system and, thus, may improve the bioelectric interface in cochlear implantation.

S12-6

On the way to the inner ear: nanoparticle-loaded thermosensitive drug delivery systems for treatment of inner ear diseases and traumata after cochlear implantation

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Drug delivery to the inner ear to treat inner ear diseases or traumata after cochlear implantation by systemic therapy is limited by anatomic facts such as low blood flow in the cochlea and presence of the blood perilymph barrier. To overcome these limitations and to reach therapeutic relevant drug levels in the inner ear local intratympanic therapy by administration of the drug directly on the round window membrane (RWM) seems to be a beneficial approach. At this, suspensions or solutions of glucocorticoids have been administered on the RWM, but rapid drainage through the Eustachian tube counteracted efficacious drug delivery. Thermoreversible hydrogels, based on the FDA approved Poloxamer 407 (POX 407) are fluid at room temperature but semisolid at body temperature [1] and can be administered directly on the RWM. Because of gelation on the barrier the required prolonged contact time can at least in theory provoke higher drug levels in the perilymph. Nanoparticles (NP) made from biodegradable and biocompatible, FDA-approved Poly-lactic-co-glycolic-acid (PLGA) are supposed to additionally prolong the release and efficacy of glucocorticoids especially considering the size limit of 150nm for permeation through the RWM [2]. To approach this aim, Triamcinolone acetonide (TAAc)-loaded PLGA-NP were prepared and the manufacturing parameters were optimized to downsize their diameter. The TAAc-PLGA NP were used for preparation of thermoreversible micellar hydrogels based on POX 407. To assess the release profile, an in-vitro model was established using cellulose filter-inserts with 0.4 µm pore diameter, artificial perilymph fluid as acceptor medium, and setting the volume ratio between hydrogel and perilymph fluid close to in-vivo conditions. Samples were withdrawn within the first four hours every 60 minutes to estimate the initial rate and after 24 hours. The amount of released TAAc was quantified by HPLC-DAD.

The in-vitro release studies revealed that the highest amount of TAAc was released from hydrogels containing TAAc-PLGA-NP of 109 nm amounting to 4.46% TAAc after 24 hours. For comparison, the release rate from 121.8 nm NP was 2.43%, from 709 nm NP 1.88%, and unencapsulated TAAc of 180 µm particles was 3.53% TAAc within 24 hours. The initial drug release was similar in all preparations. All in all, the particle size significantly influences the in-vitro release rate of TAAc from NP and a higher PLGA content of the NP seems to prolong the release of TAAc. Due to the prolonged release injectable micellar thermoreversible drug delivery systems containing TAAc-loaded PLGA-NP seem to be preferable for intratympanic therapy of inner ear diseases as well as traumata after cochlear implantation.

S12-7

Passive delivery of dexamethasone to the inner ear from a cochlear implant

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Passively eluting active pharmaceutical ingredients from the silicone matrix in the intra-cochlear electrode of a Cochlear Implant (CI) offers a simple, effective and reliable method for servicing the inner ear with dexamethasone (DXB). This treatment may be effective in mediating electrode insertion trauma (EIT) and preserving any remaining acoustic hearing in CI recipients. Several in vitro and non-clinical studies have been conducted to investigate the feasibility of intracochlear drug delivery via an electrode array. In vitro pharmacokinetics was studied under the influence of clinically relevant stimulation levels. The impact of ETO exposure from terminal sterilization was also assessed. The shelf life of a clinical design was validated according to external guidelines by perfoming both purity assay and pharmacokinetic profiling before and after normal and accelerated aging. Non-clinical studies addressed primary patient risks. Histology from the ears of Guinea Pigs implanted with drug loaded devices showed that inclusion of high loadings of DXB in a prosthesis is safe. And a meningitis study in a Rat model concluded that ears implanted with devices loaded with DXB faired no worse than those implanted with substance-free controls. This protocol consisted of innoculation with Streptococcus pneumoniae 5 days after implantation.

S12-8

The NeuEar project: Developing a neurotrophic cochlear implant for severe hearing loss

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NeuEar is an EU-funded consortium bringing together four corporate and academic partners with the common goal of improving the efficiency of the current cochlear implant (CI) technology. By combining the CI with a neurotrophin-releasing medical device, we are addressing the progressive and underlying degeneration of auditory neurons (ANs) that ultimately leads to significant neuronal loss after long periods of deafness. The loss of endogenous neurotrophic factors normally expressed by hair cells, such as brain derived neurotrophic factor (BDNF) and neurotrophin-3 (NT-3), is a strong mediator of AN degeneration. Intra-cochlear delivery of neurotrophic factors with beneficial protective and/or regenerative effects on ANs could significantly improve the CI/patient interface, leading to a better treatment of profoundly deaf patients.

The goal of the NeuEar project is to combine a cochlear implant from MED-EL GmbH, Austria with neurotrophic factor delivery from an encapsulated-cell Brain Repair medical device developed by NsGene A/S, Denmark. Academic partners from the Hannover Medical School, Germany and Karolinska Institutet, Sweden are testing the combination of stimulating electrodes with neurotrophin-releasing devices in cat and guinea pig deafness models, respectively.

The primary objectives of the NeuEar project are to: 1) develop genetically modified cells for encapsulation and long-term overexpression of selected neurotrophins from the Brain Repair device, 2) develop a clinically relevant Brain Repair implant prototype capable of chronic secretion of neurotrophic factors combined with a cochlear electrode array, 3) evaluate and optimize safety and functional effects in *in vitro* and *in vivo* assays and, 4) evaluate the long-term safety and efficacy in a large animal model of a clinically relevant CI/Brain Repair implant. The final project goal is to have an implant prototype with animal safety and functional data available to support further development and clinical testing by the end of the project in the fall of 2015.

We present data from recent studies of deafened animals where animal-specific electrodes were combined with miniaturized Brain Repair prototype devices developed for animal cochlear implantation. The long-term effect of Brain Repair device delivery of the neurotrophic factors GDNF and BDNF was evaluated by periodic measurement of electrically evoked auditory brainstem responses (eABR) during chronic implantation. Treatment benefits were evaluated in the end of the study by the measurement of anatomical neural tissue characteristics such as spiral ganglion cell density and related surface area. The extent of fibrous tissue growth in the scala tympani was also compared to control animals. We report results on the effect of long-term local treatment with neurotrophic factors delivered by the Brain Repair device on cochlear implant performance.

S12-9

Role of antioxidants in saving inner ear anatomy and function

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Objective: to understand the biomechanics of inner ear and the role of Antioxidants.

Method: A review of the literature: up to 2014.

Results:

- ROS lead to pathology of the inner ear and the peripheral and CNS.
- Higher levels of oxidants are in affected tissues and in blood from the same side of ears with idiopathic tinnitus.
- Antioxidant Therapy in Idiopathic Tinnitus: Lead to subjective discomfort and tinnitus intensity and. ROS values corresponding changes at the jugular v. in patients pre-,and post- treatment.
- Low plasma coenzyme: *CoQ 10 %,* Treatment ,lead to significant ROS reduction in tinnitus patients.
- NAC reduced significantly auditory threshold shifts, changes in DPOAEs, and tinnitus in 566 military subjects.
- Mg prevented noise induced SNHL in soldiers. A combination
- Glycerophosphorylethanol,-b-carotene, vitamins C and E. lead to the same in another study.

Discussion: Otologists remained helpless for most of the inner ear ailments. Oxidants are Reactive oxygen species (ROS): they are free oxygen radicals that play an important role in several pathogenic processes. These OXIDANTS damage cellular components, and therefore derange function. This leads to pathologies and manifestations in various organs and neurodegeneration. The endothelium is at major risk especially the microcirculation. Oxidants roles are now taught in pathology in undergraduate courses. A comprehensive micronutrient approach exploits several metabolic pathways, to deliver Antioxidants to be synergistic. They are neuroprotective in vivo and clinically, saving hearing and balance from acoustic trauma and neurotoxicity of drugs as gentamycin.

Conclusion: With new animal and human studies Antioxidants provide useful tools to repair, protect and treat the inner ear function at the molecular level and the microcirculation. AOX are neuroprotective in vivo and clinically, saving hearing and balance from acoustic trauma and neurotoxicity.

Learning outcome: Trials may prove its protective effects for balance and residual hearing in CI and implantable HA.s patients and thus improve sound and life quality for these and other patients.

Abbreviations: AOX : antioxidants; ROS : reactive oxygen species; NAC :Acetylcystiene; CoQ 10: Co enzyme-Q 10

S13 Development of implanted children incl. cognitive and social development & educational aspects

S13-2

The primary triangle: mother, father and infant. What happens when the child is prelingually deaf using a cochlear implant?

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Aim: As an extension of a previous study concerning the feasibility of Lausanne Trilogue Play (LTP) in families with profoundly deaf children, the present research compares communicative and relational modes within families of profoundly deaf children wearing Cochlear Implants (CI) with those relative to a control group of Normal Hearing (NH) children. Specifically, the following aspects were taken into consideration: Stress as perceived by parents, Parenting styles, and Family Alliances.

Material and methods: Study Group consisted of 26 parents and 13 profoundly deaf children with CI, ranging from 12 to 36 months of age; the Control Group consisted of 26 parents and 13 NH children within the same age. No additional problems were present in children. For evaluation of parents' characteristics, the tools used were Parents Preference Test (Westh, 2003), Lausanne Trilogue Play (Fivaz-Depeursinge, 1999) and Parenting Stress Index-Short Form (Abidin, 1995).

Results: The most rilevant findings were as follows:

- Stress Levels perceived by parents of CI children were similar to those found in the NH group, except in the “Difficult Child” domain, where the CI mothers sensed their children as being more difficult to manage both in comparison the CI fathers and to both parents of NH children;
- Parenting Styles: in the NH group parenting styles were seen to vary in that the mothers were more emotional, whereas the fathers were more linked to rules (directive style). In the CI group styles of both fathers and mothers were more consistent since both assumed a directive style, focused on child's behavioral and linguistic regulation;
- Family Alliances: in the CI group, were found significant difficulties in interactions between partners and reluctance to include the other parent when interacting with the child.

Conclusions: LTP, set up initially for the NH family, proved to be a useful tool for the study of CI families too. The study has to be validated over time by a larger study group in order to assess the weight of triadic interactions on the development of language, communication and emotional skills in the implanted deaf child, with the aim of setting up more adequate habilitative strategies.

S13-3

The effect of bilateral/bimodal cochlear implant use on speech perception, language and verbal cognition skills in children

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During this presentation we will focus on several of our research outcomes on children using uni-, bimodal, or bilateral cochlear implants. First of all we will show you the differences in speech perception and preverbal communication skills of deaf young babies and toddlers using unilateral or bilateral cochlear implants. Further on we show you the results in outcomes on vocabulary and narrative skills between these groups. Finally we will focus on the long-term verbal cognition skills, which will show you that there is a huge difference in complex language development and in verbal cognition skills between these groups in favor of those wearing two devices. Regression analyses showed that this is mainly caused by their speech perception of soft speech (45 dB SPL) and speech-in-noise skills. During the last part of the presentation we will focus on the rehabilitation after bilateral implantation. Do these young children receiving two hearing devices at a very young age still need rehabilitation? If so, what kind of rehabilitation do they need?

S13-4

Cognition, perception and language development after three years of implantation for children

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Studies on the development of deaf children with cochlear implants (CI) have emphasized variability in CI outcomes. This variability may be due to multiple factors, even when implantation has occurred in early stages. We therefore propose an exploratory study to investigate the links between cognition, perception and language development of deaf children who had at least three years of experience with a multichannel cochlear implant.

Design: 25 prelingually deaf children between the ages of 6 and 10 years participated. All of them had received a cochlear implant before the age of 4. The independent variables were the socio-demographic and auditory characteristics of the children, the type of therapy intervention and families' scores in a family participation scale. Cognitive variables examined included planning, visual attention, visual, audio-visual and narrative memory. Perceptive variables included monosyllabic words perception (PBK), the Categories of Auditory Performance scale, and an identification test of everyday sounds. For language assessment, variables as speech intelligibility and receptive lexical and syntactic delays were analyzed.

Results: In spite of a large variability, non-linguistic cognitive functions as visual and planning skills were found to be near normal values or even slightly higher. But audio-verbal skills were under the norm which could be either a delay or a specific cognitive development. Moreover, performances in the identification of everyday sounds were low and were not correlated with word perception scores. For the moment, the role of family participation seemed to be the most important factor for the success of CI. These results must be further analyzed in order to profit current rehabilitation interventions.

S13-6

Monitoring language, musical, motor and social- emotional skills using the Musical Journey resource

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Intro: We developed observations scales that allow professionals to monitor the listening, speech, language and music skills that are trained using the rehabilitation resource “Musical Journey”. Moreover, the scales also allow monitoring of early motor, social and emotional development.

Methods: A group of therapists created the observation scales, based on the aims that are mentioned in the music program. They worked with hearing impaired children of different ages, in group and individual sessions, and filled in the lists.

Results: The qualitative and quantitative observations of each skill allow the professional to develop therapy sessions tailored to the needs of the child or adjust the therapy if necessary. This approach also gives parents a better insight in the capabilities of their child.

Conclusions: Music is not only a means to train speech and language skills. It is also an essential part of the human communication and development in general. The current state-of-the-art cochlear implant technology opens the musical world for deaf children, and this has a great impact on their communicative and socio-emotional development.

Keywords: Musical Journey, monitoring, appropriate scale, clear graphic presentation, human communication, socio-emotional development, motoric skills, musical world.

S13-7

Paragraph and sentence reading ability in children with cochlear implants

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Objectives: (1) To investigate different aspects of reading competence in elementary-school Mandarin-speaking students with cochlear implants (CIs) in order to identify their weakness during paragraph reading; (2) to examine the predictive factors of less favorable paragraph reading outcomes, and (3) to assess the replaceability of paragraph reading comprehension test by sentence reading comprehension test.

Methods: Fifty-three students with CIs (20 boys, 33 girls, aged 7.4-12.8 years) participated in this study. They received CIs at a mean age of 3.6±1.7 years and the mean duration of use was 7.4±2.0 years. A Test of Chinese Reading Comprehension was used to test their paragraph reading ability, which included 7 aspects: phonological processing, semantics, syntax, basic facts in the text, main points of the text, comparison and analysis, and inference making. A Test of Sentence Reading Comprehension was used to test CI students' reading ability of sentences. The students' performances on Chinese character recognition, receptive vocabulary and receptive and expressive language were also tested.

Results: Compared with the hearing age mates in the normative sample, 37 (69.8%) CI subjects scored within the average range, 9 (17.0%) above the average range and 7 (12.2%) below the average range. Their performances on the 7 areas of the paragraph reading test were significantly different ($\chi^2 = 54.342$, $p < 0.001$). The result of comprehending basic facts in the text was significantly better than that of deriving main idea from the text and making inferences ($p < 0.001$). Younger age at test, lower sentence reading scores and poorer receptive language could independently predict poorer paragraph reading scores ($R^2 = 0.761$). Sentence reading scores could account for 28.6% of the paragraph reading outcome.

Conclusion: Although most of the elementary-school students with CIs have basic reading ability, they are less capable of deriving the main points of a story and making inferences. Therefore, sentence reading tests may not be enough for assessing reading competence. These reading aspects require special attention in the rehabilitation and training programs.

S13-9

Verbal and visuo-spatial working memory capacities of deaf children with a cochlear implant compared with their hearing peers

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The Cochlear Implant (CI) is a recent electroacoustic device. We still have few information on the development it has for the deaf child and even less on the nature of the representations used by the deaf child to memorize verbal or visuo-spatial information. The CI generally gives excellent results, especially if the child was early implanted. However, being cochlear implanted does not allow acquiring the oral language immediately. Even when the implantation is early, visual information (lip reading and keys of the Cued Speech) improve the perception of the oral language. They provide a phonetic complement in the impoverished signal sent by the implant. This study, implying 14 deaf children with cochlear implant (CI) and 14 hearing children (mated on the real age), has been made to know better the use of the verbal and visuo-spatial working memory and to compare their results to those of Hearing children. The method used to estimate assess the working memory is adapted from the procedure of Cleary, Pisoni and Geers (2001). The children had to memorize series of images or series of locations of points in a grid with various conditions. The series were presented one at a time, with sound and / or Cued Speech (that is with the visual input of the language spoken completed). We have tried to know which condition is the most favorable to memorize a verbal or a visuo-spatial information and which type of information (verbal or visuo-spatial) is the best memorized.

We have observed for the 2 groups a difference of performances with the verbal or the visuo-spatial modality, the second one being better / giving better results. What is surprising is that the results also show that Cued Speech for this type of memorizing task, and more especially with the verbal modality, doesn't give any help to improve the deaf children performances. For the hearing children, we notice that the more information they have the better their scores are with the verbal modality. The best successful condition for the deaf children with the 2 modalities I the one with only images or only points in a grid without any use of audition and / or Cued Speech. These results can be discussed considering the limits of the study (Number of children, age of the pose of the cochlear implant, school level).

S13-10

Academic achievement of experienced CI children

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Introduction: Rehabilitation results of hearing-impaired children with cochlear implants are the success of medicine and technology. The medical model of disability and rehabilitation treatment allows an achievement of biological standards and the use of prosthetic hearing in the form of a cochlear implant facilitates patients to acquire the function of hearing. There is a lack of research in Poland regarding the effects of hearing rehabilitation in children with cochlear implants on the level of performance of their academic skills. The main objective of study is to evaluate the effectiveness of rehabilitation of hearing loss in children using cochlear implants in terms of educational attainment.

Material and method: Test results of school results at the end of primary school (test carried out in accordance with the Regulation of the Minister of National Education of 30 April 2007) were gathered from children with cochlear implant. Location of the students from study group in the Polish education system was confirmed with the use of survey distributed among parents.

Results and conclusions: The impact of disability is influenced by the biological, social, and institutional aspects which are treated as merging and influencing one other. Persons with disabilities must be ensured the participation in society, with a special focus on education. Obtained results of the study will be presented.

S13-11

Low empathy in hearing-impaired (pre)adolescents compared to normally hearing controls

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Objective: The purpose of this study was to examine the level of empathy and prosocial behavior in hearing-impaired (pre)adolescents compared to normally hearing controls and to define the influence of language and various hearing loss characteristics on the development of empathy.

Methods: The two groups were compared using self-reports, a parent-report and observation tasks to rate the children's level of empathy, their attendance to others' emotions, emotion recognition, and prosocial behavior. The study group (mean age 11.9 years) consisted of 52 children with cochlear implants, 70 children with conventional hearing aids, and 129 normally hearing children.

Results: Hearing-impaired children reported lower levels of empathy than their normally hearing peers, regardless of their type of hearing device (F 15.45, $p < 0.001$). The level of emotion recognition scored by parents was equal in both groups. During the observations, hearing-impaired children showed less prosocial behavior compared to the children without hearing loss. Story comprehension was strongly (positively) related to the duration of use of cochlear implants, empathy, prosocial behavior and the ability to attend to others' emotions in hearing-impaired children; this relation was absent in the control group.

Conclusions: Hearing-impaired children show lower levels of empathy than normally hearing children, which can have numerous consequences for initiating and maintaining relationships. Language development has a major impact on this development.

S13-12

Are our school systems ready to take on cochlear implanted children - The Indian perspective?

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Introduction: In our country children with severe to profound hearing loss were usually placed in special schools for the deaf or in some instances not given any formal schooling opportunities. This was due to the fact that verbal communication skills are an absolute necessity for mainstream education here. In recent years with the advent of cochlear implantation, achieving verbal communication skills is now possible for these children. Families want their implanted children to attend school with normal hearing peers and work towards the objective of mainstreaming. Inclusive education in India came into effect in 2010 and the Right of children to free and compulsory education on April1, 2010. Since then there have been various government sponsored programs set us to achieve these goals. All these programs have a desirable intent but most of them have failed to generate the comprehensive meaning of inclusive education. Their focus seems to be more targeted towards quantity and capacity building than participation. At our center there is a strong focus on placing all our young implantees into mainstream education.

Objectives:

1. To determine the educational placements of all the hearing impaired children implanted at our center since 2006.
2. To assess the level of support provided by the schools in dealing with the concerns of mainstreaming.

Methodology: All the parents of hearing impaired children who underwent cochlear implantation at our center from 2006 till date were interviewed with respect to the educational setting their child attended.

A preliminary survey was done in the mainstream schools in Pune, which were attended by our cochlear implant recipients. The survey consisted mainly of Yes/No type of questions and few subjective ones to be answered by the educational staff. Questionnaire was primarily based on following points:

1. Knowledge about the child's area of disability.
2. Knowledge about the intervention provided to the child.
3. Academic readiness of the child.
4. Environment acoustically appropriate/ modified.
5. Support staff assigned.
6. Responsibility of in-service staff regarding the equipment.
7. Information transfer between the educational staff and family.
8. Readiness of in-service training regarding the technology.

The data obtained was statistically analyzed.

Discussion: Educational placement in mainstream schools cannot be considered as an end in itself in children fitted with cochlear implants. Investigating educational outcomes, psychosocial perspective of the child as well as readiness and knowledge of the schools in dealing with these children should provide better insight into helping these children towards successful integration. Just placing a challenged child into a regular school does not mean successful integration. It requires sensitisaton and commitment from all the stakeholders to achieve the goal of complete cognitive development of the child.

S13-13

Exploring the impact of cochlear implants (CIs) upon educational progress and inclusive education of deaf pupils and what are factors that affect the benefits of CIs at primary school in Saudi Arabia from parents, teachers and clinicians perceptions and experiences

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The cochlear implant could be a significant early intervention program for children with deafness (Hyde, Punch & Grimbeek, 2011). The aim of the research is to explore the impact of cochlear implants (CIs) upon educational progress and inclusive education of deaf pupils and what are factors that could either reduce or promote the benefits of CIs at primary school in Saudi Arabia from parents, teachers and clinicians perceptions and experiences. Percentage of hearing disability in the Kingdom of Saudi is three times the global average (Sraj Zagzog cited in RCHD,2012). Yearly around 1000 cochlear implants operations are performed in Saudi Arabia (RCHD,2012). A questionnaire, a combination of open and closed questions, and semi structured interviews are chosen to collect data. All participants who potentially deal with CIs have been involved, so that each aspect of this study could be covered: parents of deaf pupils with cochlear implants (n=60), parents of deaf pupils without cochlear implants (n=100), teachers of pupils with cochlear implants (n=50), and clinicians, speech therapists and audiologists (n=10). All the participants live in Riyadh, Saudi Arabia. First research question aims to explore the impact of cochlear implants upon educational progress. To answer this main research question, two different approaches were used (questionnaire and interviews). Also, the Saudi national student evaluation system standardized for use in primary schools, was used in order to identify differences between pupils with/without CIs in terms of educational progress in all subjects. The impact of CIs in promoting inclusive education is the second main question. The factors ,that could affect the benefits of CIs, are involved to be examined are age of implantation; early intervention; rehabilitation programs; family awareness; team work ;presence of more than one hearing-impaired individual in a family; laws and regulations; using a hearing aid and approaches to dealing with students. Twenty six of participants were involved in pilot study. Results of pilot study shows that deaf pupils with CIs made good educational progress after the CI compared to their results before. Deaf pupils with CIs show higher performance in school subjects' results than deaf without CIs. Analysis takes account of time of implantation, bilateral implants, number of deaf family members, early intervention, educational settings and communication approaches as independent variables. Findings by parents and teachers of deaf with CIs regarding functions and behaviors of relationships, independence, participation and competition, student voice, and academic ability that could be enhanced by CIs resulting in promoting inclusive education for deaf with CIs were positive. The data found regarding the factors that affect the outcomes of CIs indicate that factors of age of implantation, early intervention and using hearing aids had highest mean of all the participants' responses.

S13-14

Cochlear Implant Paediatric Prognostic Index (CIPPI) - A review of factors that affect paediatric cochlear implantation outcomes

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Objective: Compilation of the most useful and common variables / factors in paediatric cochlear implantation (PCI) (auditory status; otological features; neurological factors; general medical aspects; psychological status; family / social situation) into a prototype prognostic index (CIPPI) that is evidence-based, analytical and exhaustive. The index is intended as a reference tool during PCI prognostication.

Method: The CIPPI lists those factors that represent a potential threat to the PCI outcome during case assessment. During evaluation of the individual case, the threat posed by each tangible factor is considered by the likely severity and probability of the threat. The factors within each of six domains (auditory cortex, otological, general medical, psychological, family / social) are then assessed for their cumulative effect within that domain. The six domains are then evaluated together for the final prognostic threat assessment prior to case summation.

Clinical Useage: The role of the CIPPI is to assess the child's status during the pre-operative phases and provides a structure for evaluation of any adverse feature perceived in the case. This will enable practicing PCI clinicians to have a full understanding of the prognosis, that is based on both diagnostic and assessment information, to facilitate appropriate family counseling and achieve an optimal outcome for the individual child.

Results: The CIPPI has proven a valuable tool for a thorough and accurate assessment of case PCI prognosis, as it combines a comprehensive “checklist” plus a logical threat evaluation. It is now routinely used in the major Brisbane PCI programs.

Conclusions: In PCI potential adverse factors are numerous and disparate in nature, frequency and severity. To assist in the interpretation of these factors a prototype specialized tool has been developed as a predictive model to assist in the pre-operative prognostication process

S13-15

Screening children from families at social risk with the LittlEARS® (MED-EL) auditory questionnaire - is the development of early listening skills affected?

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Objective: Socioeconomic status (SES) has often been discussed to influence health outcome in people. The objective of this study was to assess early listening skills in children from families with a low SES by using the LittlEARS® auditory questionnaire (LEAQ) as a hearing screening tool. The aim was to analyze the results of the LEAQ in this special group by comparing them with the average population.

Methods: Participants with low SES were recruited from the youth welfare service of the city of Cologne, Germany. 67 families with children aged 4-32 months took part in the study. To gain information about the hearing status of the children, the LittlEARS® auditory questionnaire (LEAQ) was applied. If a child failed in the initial screening with LEAQ, parents were encouraged to visit their paediatrician or paediatric audiologist for further testing. The results of LEAQ of the children from families with low SES were compared with the results of a German field study from 2008-2010, where 5320 randomly chosen participants not leaning towards any specific SES were screened with LEAQ at a regular paediatrician check-up visit.

Results: Within the group of 67 participants nine children failed in the initial screening with LEAQ which is about four times more than expected, compared with the results of the average population. Although further testing resulted in none of the children being actually affected by a permanent hearing loss, an increased medical attention to such children might still prove useful. In the main study it was found that children with a conspicuous LEAQ-screening report not only had an enhanced risk to be affected by a permanent hearing loss, but also had higher likelihood of developing other speech or developmental dysfunctions later. LEAQ seems to be not only sensitive to hearing disorders but also to other developmental delays that are associated with early hearing and communication deficits.

Furthermore from the nine children of the 67 participants with low SES who failed the screening, two children had medical indispositions that referred to an enhanced risk to develop a hearing loss (meningitis, down-syndrome). These two children were currently affected by chronic otitis media. As some children had emergent risk factors, parents were given more information about early hearing and communication development and were asked to pay close attention to the further development of their children.

Conclusions: It could be shown that children from families with low SES have a considerably higher probability to fail the LEAQ-screening and therefore might be more affected to develop a temporary or permanent hearing loss or other dysfunctions in their further development. Listening and early communication skills should be monitored closely in that group to prevent late diagnosis.

S14 Sound processing

S14-1

Spatial speech understanding in the presence of a single interferer: Informational and energetic considerations with bilateral cochlear implants

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Speech understanding is often impaired in noisy settings due to a combination of energetic masking (EM) that results from spectral overlap between concurrent signals at the auditory periphery, and informational masking (IM) that is caused by confusion at a higher central level due to similarity between competing signals and uncertainty in how to group signal components (streaming). Release from masking can generally result when competing signals are spatially separated (spatial release from masking, SRM). Normal hearing listeners can achieve SRM by monaurally attending the ear shadowed from the masker, and by binaurally processing information from both ears at a central level. While bilateral cochlear implant (BiCI) users have been shown to also benefit from monaural attendance of the shadowed ear, little evidence exists to suggest additional benefit from binaural listening. Past BiCI masking studies have employed free running speech and noise stimuli, without considering the implications of target-masker temporal overlap on masking and SRM. The present study assessed SRM in BiCI users, and the likely contributions from EM and IM, when competing signals are either temporally synchronized or interleaved. Speech understanding of six BiCI users was tested in the presence of a single masker. Target sentences were spoken by a female talker, and presented form a loudspeaker directly in front of the listener. Maskers comprised either sentences spoken by a different female (F), or speech modulated noise (N) with an average spectrum matched to F. Target and masker tokens were either synchronized (Sync) or interleaved (Inter), and were either spatially collocated or separated by 90° azimuth. It was assumed that token interleaving eliminated EM and reduced IM, and that varying the content of the interferer from F to N reduced IM without significantly altering EM. SRM was determined from the difference in spatially separated and collocated performance. Performance while listening unilaterally with the shadowed ear was also measured to assess the proportion of SRM likely attributable to binaural listening. Significant masking effects were observed at all conditions except N Inter. Speech recognition scores improved significantly when F maskers were replaced by N maskers, with either token synchrony state, due to diminished IM. Performance also improved when competing tokens were interleaved rather than synchronized, for either masker type, due to elimination of EM and possibly reductions in IM. SRM was observed in all conditions. Monaural listening completely accounted for performance in the spatially separated Sync conditions, regardless of masker type, and it was only during the Inter conditions where binaural processing provided benefit. These findings suggest that both EM and IM impair speech understanding in BiCI listeners, and that binaural processing can only yield unmasking benefits when target and masker do not temporally coincide.

S14-2

Speech recognition skills in quiet and in noise background and satisfaction in users of Neurelec Digisonic SP Binaural cochlear implant

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Background: The cochlear implant is a breakthrough in the treatment of deafness. Such devices allows auditory rehabilitation on one ear only, however there are great evidences that bilateral implantation (leading to bilateral hearing) offers better benefits. This article aims to describe the post-operative performance of five cases implanted with a Neurelec Digisonic SP Binaural cochlear implant, a specific cochlear implant that allows simultaneous and synchronous electrical stimulation in both cochlea with the same device.

Methods: Pure-tone thresholds and speech perception in quiet and in noise background situation were collected pre- and post-operatively after 10 months of device use. The Brazilian Portuguese version of Hearing in Noise Test (HINT) was applied in a free field to evaluate the recognition skills in quiet at 0° azimuth and in noise background situation at 0°, 90°and 270° azimuth, to three different listening conditions: left side activated only, right side activated only and both right and left side activated. Satisfaction survey was also performed for all subjects pre and post-operatively with the Satisfaction with the Brazilian Portuguese version of the Satisfaction with Amplification in Daily Life (SADL) questionnaire.

Results: Speech recognition performance in quiet and in noise background in all conditions of test and pure-tone thresholds were significantly better after 10 months of device use to all subjects evaluated. Patients showed better results when both ears were stimulated together than with each ear alone, with a significant difference to the best ear separately. All subjects were satisfied or very satisfied with the device and the overall score average of SADL was 5,4, showing a high level of satisfaction of them.

Conclusion: Binaural cochlear implant was effective in providing improvement in hearing thresholds, speech perception in quiet and noise background and personal satisfaction to all users.

S14-3

Predicting cochlear implant recipient benefits from noise reduction

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Introduction and aim: Noise reduction technologies have been very successful in providing speech understanding benefits for cochlear implant recipients. Group outcomes in a number of research and clinical studies have reported between 1 and 2 dB improvement from noise reduction technologies. These improvements are very significant and provide significant real-world benefit over processors with no noise reduction. Even more impressive is the listening quality ratings, where users report very large improvement in listening quality with noise reduction. Although almost all individuals gain benefit with noise reduction and acceptance is very high, there is a wide range of individual outcomes. In particular, individual speech understanding results from our research group range from 0 dB to over 6 dB improvement. This study investigates possible patient factors which could contribute to outcomes, and describes a method to predict benefits from noise reduction technologies. These results help understand noise reduction technologies for cochlear implants and provide important additional information to clinicians, particularly when counseling potential upgrade recipients.

Material and methods: This study completes a retrospective analysis of 60 cochlear implant recipients. Speech testing results analyzed compared a baseline condition without noise reduction to a test condition with noise reduction enabled. Individual improvement results were collected and used in a multi-regression analysis to investigate the contribution of, thresholds, comfort levels, age, length of implantation, gender and baseline performance level.

Results: Results show that noise reduction provides significant speech understanding improvements across all studies included in this analysis. A very significant correlation between baseline performance and improvement with noise reduction was found ($p< 0.01$). The correlation showed that poorer performers received larger benefits compared to good performers. Other correlation results did not provide any correlation outcomes.

Conclusion: Speech understanding benefits from noise reduction are correlated to individual baseline performers. Understanding individual performance will aid clinicians predict benefits from noise reduction, and understand the expected range of outcomes from this technology.

S14-4

Cochlear implant performance using multi-microphone noise reduction in adverse conditions involving reverberation and microphone mismatch

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Many cochlear implant (CI) sound processors aim to reduce noise in order to improve speech perception. While single microphone methods deliver some improvement in steady background noise, microphone array directional beamformers generally deliver superior noise reduction when sounds are spatially separated. Nevertheless, effectiveness is known to decline in reverberation, and as microphone sensitivities change over time.

In this study, a two-microphone noise reduction algorithm that aims to improve directional beamformer performance is presented and evaluated in adverse conditions involving reverberation and microphone mismatch. The beamformer post-filter estimates a spatially-based signal-to-noise ratio (SNR), attenuating time-frequency elements that have poor SNR. The attenuation function is specifically tuned for application to CIs.

The post-filter was compared against three directional settings available in the Cochlear Nucleus 6 CP900 sound processor. Speech intelligibility of CI users was measured with an adaptive speech reception threshold (SRT) test using spatially separated 4-talker babble noise (configured with one competing talker in each quadrant surrounding the listener). Reverberant conditions used both real and modelled rooms (RT60 from 100 to 900 ms). Microphone mismatch was introduced via broad band attenuation of the rear microphone (from 0 to 6 dB).

In reverberation, all directionality settings improved intelligibility, while the post-filter provided greatest benefit compared to the other directionality settings. As expected, CI performance was degraded as reverberation increased. Remarkably the benefit provided by all three directionality settings increased at the highest level of reverberation. In particular, the post-filter provided 11 dB SRT benefit over the omni microphone compared to 5 dB in low reverberation. This suggests that directional algorithms are effective at reducing noise in reverberant conditions. SRTs with microphone mismatch showed the post-filter provided superior intelligibility at mismatches of 0 and 2 dB. By 4 dB, there was no discernable difference between any of the directional algorithms. This helps inform clinical decisions regarding tolerable levels of microphone mismatch in CI systems. The beamformer post-filter provided superior noise reduction performance in adverse conditions involving reverberation and microphone mismatch. Reverberation did not pose a problem as predicted, and benefit actually increased at the highest level of reverberation. Microphone mismatch was an important factor, degrading performance such that all directional benefit was obliterated by 4 dB mismatch. This research was financially supported in part by the HEARing CRC established and supported under the Australian Government's Cooperative Research Centre's program. The Bionics Institute acknowledges the support it receives from the Victorian Government through its Operational Infrastructure Support Program.

S14-5

Evaluation of ClearVoice with digital adaptive remote microphone technology

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It is well known that many cochlear implant recipients experience difficulty understanding speech in noise. Numerous technologies have been developed to improve speech recognition in noise including noise reduction signal processing, directional microphones, and remote microphone systems. For instance, ClearVoice is an Advanced Bionics pre-processing algorithm designed to reduce gain in channels with an unfavorable signal-to-noise ratio (SNR) with the goal of improving listening comfort and speech recognition in noise. Additionally, wireless, digital, adaptive remote microphone systems (i.e., the Phonak Roger system) capture the signal of interest in close proximity to the mouth of a talker and wirelessly deliver via digital radio requency transmission this signal to a miniature receiver attached to the listener´s cochlear implant sound processor. As the competing noise level increases, the gain of the signal delivered by the remote microphone system also increases in an attempt to improve speech recognition in noise.

This study evaluated speech recognition in quiet and in noise for 15 Advanced Bionics cochlear implant users. Speech recognition was assessed in each of four conditions:

1. ClearVoice disabled and no digital adaptive remote microphone technology (i.e., Phonak Roger),
2. ClearVoice enabled without digital adaptive remote microphone technology,
3. ClearVoice disabled with the use of digital adaptive remote microphone technology, and
4. ClearVoice enabled with the use of digital adaptive remote microphone technology. In each of these conditions, sentence recognition (AzBio sentences) was evaluated in quiet and in classroom noise at 50, 55, 60, 65, 70, 75, and 80 dBA.

The results of this study will be presented along with implications for clinical use.

S14-7

Speech performance and sound localization in a complex noisy environment: Comparison between patients sequentially and simultaneously implanted

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Introduction: Most studies report a benefit of simultaneous bilateral implantation, specifically in term of sound localization and speech recognition in noise. Nevertheless, the improvement of speech intelligibility in a noisy environment after a sequential implantation seems weaker. The objective of this study was on the one hand, to evaluate speech performance in quiet and noise, localization ability and quality of life in a group of 32 adult patients sequentially implanted, and on the other hand, to compare the results to a group of 27 patients simultaneously implanted, and previously evaluated with the same protocol [Mosnier et al., Audiol Neurotol 2009, 14: 106-114].

Methods: Thirty-two patients were sequentially implanted. The mean subject age was 55 years (first implant), ranging from 19 to 74. Patients received their 2nd CI from 0.5 to 14 years after the first CI (mean: 5 years). Subjects were assessed before, 6 and 12 months after the second CI. Speech perception tests and sound localization measurements were performed in quiet and noise (SNR +15 dB to 0 dB) using disyllabic words, with a cocktail-party background noise coming from 5 loudspeakers. Quality of life was assessed using Nijmegen questionnaire.

Results: A bilateral advantage was observed at 12 months in quiet and noise in bilateral condition compared to the results obtained by the better ear in patients simultaneously implanted patients, and compared to the first and the second CI in sequentially implanted patients. Speech scores were asymmetrical in ~50% of the patients in both studies. No factor predicting the best performing ear in case of simultaneous as in case of sequential implantation was found. In 59% of cases, the first implanted ear obtained the better scores in patients sequentially implanted. The sound localization ability and the scores of the Nijmegen questionnaire were improved compared to monaural conditions as soon as 6 months after the second implantation.

Conclusion: A significant improvement of speech recognition in quiet and noise and of sound localization was observed compared to each ear alone in case of simultaneous as in case of sequential implantation. Bilateral sequential implantation provides improvement of quality of life as soon as 6 months after the second CI.

S14-8

Enhancement of envelopes to improve localization performance of cochlear implant users

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Intro: Cochlear implant (CI) users show difficulties in localizing sounds, which has been attributed, in part, to reduced availability of binaural cues, i.e., interaural time differences (ITD). Even though temporal information is encoded in the envelope and - in some CIs - in the fine structure (TFS), it becomes degraded due to quantization of the pulse timings, current spread and the small number of stimulation channels used. Localization performance relies on binaural temporal information especially in reverberant spaces. Kerber and Seeber (2013) have shown that localization performance of CI users is significantly more impaired in reverberant space than for normal-hearing listeners and is correlated with the ability to make use of envelope ITDs (envITD). Based on this consideration, Monaghan and Seeber (2012) postulate that a selective enhancement of envITDs could improve localization performance in CI users in reverberant spaces.

Method: To test this hypothesis, they used a method to enhance envITDs by setting the envelope to zero immediately prior to specific peaks. Those peaks need to exceed a minimum direct-to-reverberant ratio (DRR). In this study, we further analyzed the time point for setting the envelope to zero to maximize the information of the onset by analyzing the DRR peak relative to the peak in the envelope from a signal processing point of view. Based on the results of this analysis, the effect of envelope enhancement at variable time points prior to the peak of the DRR (*DRR offset*) were investigated in a lateralization task and compared to the results from the method used by Monaghan and Seeber (2012) [*DRR peak*]. In this experiment, different source-receiver distances (SRD) and varying envITDs with *(a)* direct sound only [*anechoic*] or *(b)* direct sound in reverberation [*reverberant*] were presented. Subsequently, speech comprehension was examined by using OLSA test sentences to ensure that the onset enhancement does not compromise speech intelligibility.

Results: Our results show that *(i. Signal processing analysis)* maximal DRRs depend on the SRD, and DRR peaks tend to occur prior to envelope peaks for larger SRDs. *(ii. Lateralization experiment)* Onset enhancement improves lateralization performance across all tested SRDs when compared to the condition without enhancement. In general, the *DRR peak* method yielded better results than the *DRR offset* conditions. However, *DRR offset* revealed a slight tendency to improve at larger SRDs. *(iii. Speech comprehension)* Speech comprehension is not compromised by onset enhancement.

Conclusion: Selectively enhancing peaks in the envelope increases the perceptual saliency of envITD cues, which improves localization abilities in reverberant environments. The use of variable time points of enhancement did not result in improved lateralization for the SRDs tested, and point to the fact that the time before enhancing a peak does not influence extraction of envITD information to a large extent.

S14-9

Speech perception in noise with F0mod, a cochlear implant pitch coding strategy

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Background: The fundamental frequency modulation (F0mod) sound processing strategy was developed to improve pitch perception with cochlear implants. For voiced segments of the input signal it modulates the amplitude of the electrical stimulus based on a fundamental-frequency estimator. In previous work using an off-line Matlab implementation of F0mod, it has been shown to improve performance in a number of pitch-related tasks such as pitch ranking, familiar melody identification and Mandarin Chinese Tone identification. In the current study, speech recognition in quiet and noise was compared between F0mod and the standard clinical strategy.

Methods: F0mod was implemented on a real-time system. Speech recognition in quiet and noise was measured for 7 cochlear-implant listeners, comparing F0mod with the standard advanced combination encoder (ACE) strategy. Dutch-language speech materials were used: (1) consonant-vowel-consonant words in quiet and stationary noise at fixed signal-to-noise ratio, (2) closed-set sentences (the Matrix test) at signal-to-noise ratios of 5 dB and 10 dB, and (3) open set sentences in an adaptive test to determine the speech recognition threshold.

Results: Immediately after switch on of the F0mod strategy, speech recognition in quiet and noise were similar in all conditions, for 4 out of 7 listeners. The remaining 3 listeners were subjected to a short training protocol with F0mod, after which their performance was reassessed. After training, performance of all 7 listeners was similar for the two strategies.

Conclusions: As F0mod improves pitch perception and does not interfere with speech recognition in quiet and noise, it is promising for implementation in a clinical sound processor.

S14-11

Application of a test measuring frequency modulation difference limen as a tool to assess processing of temporal fine structure information in cochlear implant patients

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Among limitations of present-date systems one of the most important is a deficit in representation of fine structure information. Studies on signal decomposition and the importance of its components (envelope and fine structure) indicate temporal fine structure (TFS) to be significant for music and speech reception in difficult listening conditions.

Therefore, representing fine structure information by cochlear implant systems in a way that it can be perceived and utilized by patients may allow further improvement of outcomes. Temporal fine structure can be represented by especially designed processing strategies, which have been an active area of research in recent years. In patients after PDT temporal fine structure information is contained in preserved low-frequency hearing. However so far there is only a limited number of studies on how and to what extent cochlear implant users can take advantage of this information. Thus, the extent to which TFS information is available to implanted patients is in present unknown. Evaluation of access to fine time structure information by an individual patient can provide optimal choice of a stimulation method (EAS with or without the frequency overlap, EC or ES), as well as detailed parameters of electrical stimulation (including in particular the speech processing strategy).

A method that has been chosen for this purpose is a frequency modulation difference limen (FMDL) measurement, as there is a body of evidence for a temporally based mechanism in frequency modulation detection for low-frequency carriers (deteriorating with increasing frequency and breaking down at about 4-5 kHz), particularly at low-modulation rates (< 20 Hz). FMDL test was created using forced choice adaptive procedure with adjustable parameters and graphical interface.

Measurements using the test were conducted with basic signal frequency parameters: carrier frequency 250 and 1000 Hz, modulation rate 2 Hz, signal level selected individually by the patient as most comfortable. A three-alternative forced choice 2-down 1-up adaptive procedure was used with feedback given to the patient. Results of normal hearing were obtained as reference values. Preliminary measurements in cochlear implant patients (with EAS, EC and ES) were conducted showing FMDL test can be a useful tool to evaluate access to TFS information. Further research using the test may give important notes on possibilities of utilizing fine structure information by cochlear implant patients.

S14-13

Effect of place of stimulation on rate pitch perception

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Background: This study investigated the effect of place of stimulation on cochlear implant rate pitch perception. The first hypothesis was that performance on rate pitch tasks would improve as more electrodes were stimulated, because the temporal information would be carried on a larger number of nerve fibres. The second hypothesis was that performance for low pulse rates would be better on the apical electrode than the mid electrode, because of a better place-rate match.

Methods: Each stimulus was a pulse train delivered on either a single electrode, or multiple electrodes sequentially. Four stimulation patterns were used: single apical electrode (E22), single mid electrode (E12), dual electrodes (E22 and E12), and eleven electrodes (E22 to E12). Within one block of trials, all stimuli had the same stimulation pattern, but pulse rate differed over a 9 semitone range from a base rate of 131 pps (C3). Three experimental procedures were used: pitch ranking, Modified Melodies test with Backward modification, and Modified Melodies test with Warp modification.

Results: Contrary to both hypotheses, there were no significant differences in the group mean scores among the four stimulation patterns, for any of the procedures.

Conclusion: Recipients were unable to combine temporal information from different places in the cochlea to give a stronger pitch cue. Performance on rate pitch tasks was independent of place of stimulation.

S15 Hearing and structure preservation

S15-2

Key factors to preserve residual hearing in round window approach for cochlear implantations

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Introduction: The preservation of residual hearing in cochlear implantations (CIs) has become a goal of soft surgeries to improve speech perception. A lot of factors including surgical skills, electrode design and postoperative inflammation may affect residual hearing preservation (HP) after CIs, even though round window approach (RWA). We investigated which factors influence on residual HP.

Methods: One hundred seventeen patients who received CIs at Ajou University hospital between 2009 and 2013 were retrospectively reviewed. The sample was limited to 27 patients who had residual hearing levels less than 90dB HL at 250, 500, or 1000Hz. HP group has been defined that worsening of preoperative pure-tone average in low-frequency was less than 30dB. No HP (NHP) was defined as a change in low-tone PTA greater than 30dB between preoperative and postoperative audiograms. We compared the rate of HP according to type of electrode, intra- and post-operative use of steroid, insertion time of electrode, percentage of RW exposure, age at CI, and presence of anomaly. We compared speech performance between HP and NHP group.

Results: HP were detected in 17 (63%) among 27 patients. The rates of HP in patients with the lateral and perimodiolar type electrodes were 67% and 56%, respectively ($P>0.05$). The patients with use of steroid showed significantly higher success rate of HP than the patients without use of steroid ($p< 0.05$, 70% vs 40%). NHP group showed higher values in insertion time of electrodes and age at CIs than HP group ($p>0.05$). In the percentage of RW exposure, HP and NHP group showed no significant difference (31.2±27.7% vs 21.4±12.5%). The open set sentence scores of HP and NHP group were 83.3±18.2% and 81.4±9.2% ($p>0.05$).

Conclusions: Intra- and post-operative use of steroid may be a major factor affect HP. Therefore, the strategy to maintain residual hearing after surgery may be to use steroid routinely in CI.

S15-4

Hybrid vs traditional cochlear implant voices, melody and instrument recognition in noise

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Hybrid cochlear implants allows very interesting performances mainly in noisy conditions. Few previous studies reported very interesting results of Hybrid Cochlear Implants patients in noise for identification and bisyllabic words recognition. In our study we extended the comparison to voices, melodies and musical instrument recognition, in quiet and noise conditions, among the most difficult tasks for cochlear implant patients. To our knowledge, there are not similar reported studies including these kind of timbric aspects for hybrid patients. We studied 3 adult patients with traditional (TCI) cochlear implants (Cochlear CI24 RE-CA implant and CP-810 processors) and 3 adult patients with Hybrid (HYB) implants (1 L24 and 2 CI422 implants, with freedom hybrid processors). We made the following tests: 1- Bisyllabic words recognition; 2- Different voices recognition; 3- Common melodies recognition; 4-Common melodies identification; 5-Musical instrument recognition; 6-Musical instrument identification. All tests were conducted in both quiet and noise modes. Mean results in quiet: test 1: 35% HYB, 47%TCI; test 2: 92% HYB, 42% TCI; test 3: 37,5% HYB, 50% TCI; test 4: 88% HYB, 100% TCI; test 5: 30% HYB, 20% TCI; test 6: 50% HYB, 20% TCI. As for tests in noise: test 1 28% HYB, 46% TCI; test 2: 75% HYB, 25% TCI; test 3: 56% HYB, 50% TCI; test4: 81% HYB, 87,5% TCI; test 5: 50% HYB, 20% TCI; test 6: 60% HYB, 30% TCI. The better results obtained for Hybrid patients mainly in noisy timbric tasks should be explained by the better quality of low frequency stimulation with electroacustic modality. An encouragement for further studies and a larger future diffusion of this kind of implants.

S16 Hearing implants in the military

S16-1

Single-sided deafness: An initial examination of cochlear implants in the military

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Intro: Deaf individuals are generally ineligible to enter the United States military and, with very few exceptions, service members who become bilaterally deaf are medically discharged. However, current regulations generally allow service members who acquire single-sided deafness (SSD) to remain in active-duty status, and in some cases, to be deployed with their units to forward operating locations. Because of the nature of their jobs, service members are likely to be more dependent than the general population on binaural cues for situational awareness. Individuals with SSD may be at a severe disadvantage in complex military listening environments due to a reduced ability to detect, identify, localize and perceptually separate concurrent sounds. Recent results in non-military populations have shown CIs to be an effective treatment option for SSD, improving speech perception in noise and sound localization. A question of great interest in military medicine is the extent to which service members with SSD might obtain significant operational benefits from the use of a CI in the deaf ear. Previous studies of CIs for SSD have examined simple listening conditions involving speech perception in the presence of a single noise masker or single-source localization. However, some of the most important benefits of having two ears arise in complex multisource situations, where interaural difference cues can facilitate the perceptual segregation of spatially-separated sources. This study examined the effect that a CI had on the spatial hearing abilities of seven military beneficiaries (active-duty, retired and dependents) with SSD implanted at Walter Reed National Military Medical Center.

Methods: Experiment 1: Listeners were required to segregate a target talker from one or two masking talkers, with both the masker and target signals presented to the normal-hearing ear. The CI was presented with silence or with a mixture containing only the maskers, thereby testing whether listeners could binaurally integrate the masker signals to better perceive the monaurally-presented target.

Experiment 2: Listeners identified and localized the positions of environmental sounds presented from a spherical array of loudspeakers. The target sound was presented alone, or concurrently with one or three additional sources. A head-mounted tracker monitored head movements during the task.

Results: In Experiment 1, presenting the maskers to the CI improved performance in the most difficult source-separation condition, where the target talker was masked by interferers of the same gender as the target. In Experiment 2, the CI substantially improved localization accuracy and reduced the amount of head-turning required to perform the task.

Conclusion: CIs for SSD facilitate multisource sound separation and localization.

Learning outcome: CIs may provide a viable way to allow service members with SSD to improve the auditory spatial awareness required in dynamic military environments.

S16-2

Hearing with Cochlea implant in military flight personal (Case report)

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Rehabilitation of hearing is important to maintain fitness for duty, esp in military personal. The new technology of cochlea implant enables to use the device in special situation, including aircraft personal. The ability to communicate in loud surrounding is difficult for normal hearing persons already. As flight personal relies on radio transmitted communication, the use of technical assisted hearing is common use. A crew member who suffered single sided deafness due to a scull base fracture was treated with cochlea implant. The noise surrounding of CR53 Helicopter was measured and analyzed. The CI Device was fitted to address the noise specific conditions, which increased the speech understanding in this condition by 25%, compared to classical fitted CI-program. Additional the direct input was used in real flight condition for the radio-transmitted communication. The speech understanding was in this condition far superior to the normal hearing colleagues, as no background noise disturbed the radio transmitted signal. Hearing can be restored by cochlea implants. It is possible to achieve a hearing ability superior to normal hearing in specific conditions. This example shows the need for newly defining fittness for duty criteria. This definition must take the new technological features of hearing implants into account, accepting better hearing quality through the device in some job specific situations.

S16-4

Electromagnetic compatibility of cochlear implant with C-97 aircraft

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Introduction: There have been no studies to date on the effectiveness of radio communication with CI users, especially taking into account the background noise inherent in the cockpit. For CI be considered an option for the rehabilitation of deaf pilots, it is important to rule out the possibility of interference between the implant and the aircraft´s equipment, given that transmission of the CI's sound stimulus involves radio frequencies and that the external component is attached using a magnetic device.

Objectives: The primary objective of this study was therefore to evaluate the electromagnetic compatibility of bilateral CI use with cockpit and flight instruments in a Brasilia (C-97 FAB 2014) aircraft. The secondary objective was to evaluate the interference of the electromagnetic emissions of the aircraft cockpit instruments with the functioning of the CI.

Methods: Testing was conducted to ascertain the degree of interference that a bilateral CI user sitting in the copilot´s seat in the cockpit of a Brasilia aircraft (C-97 FAB 2014) could have on the aircraft systems that are necessary for safe navigation. The tests were performed with the aircraft on the ground and with the engines running. Constant communication with the implantee was maintained using a Very High Frequency(VHF) radio so that the CI could remain activated during the entire test. The test was coordinated by the Aeronautics and Space Institute (IAE) of the Department of Aerospace Science and Technology (DCTA) in São José dos Campos - Brazil.

Results: The presence of the CI user had no effect on any of the navigation equipment during the test flight. The volunteer reported no discomfort, diminished hearing, headache or neurological symptoms during the test flight or after it.

Conclusion: We concluded that there were no changes in the examined equipment that would compromise flight safety during electromagnetic compatibility testing between the C-97 FAB 2014 aircraft and CI in the cockpit environment. There was also no interference in the functioning of the CI caused by the aircraft´s cockpit instruments.

S16-5

Functional magnetic resonance imaging evidence of middle-ear kinesthesia involvement in tinnitus: Implication for implantable device

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According to Job's fMRI study [Job A et al. (2012) *Brain Behav* 2(2):187-99], a small region in parietal operculum OP3 was found hyperactivated as a function of tinnitus periodicity in subjects with acoustic trauma tinnitus sequelae. This region was localized in the vicinity of neural correlates of middle-ear tympano-ossicular chain movements due to pressure variations [Job A, Paucod J-C, O'Beirne GA, Delon-Martin C (2011) *Hum brain mapp* 32(5):744-9]. We hypothetized that this specific hyperactivation in OP3 area could correspond to middle-ear representation and that middle-ear proprioceptors could be involved in tinnitus. We designed a study that stimulated proprioceptors by repetitive vibrations and demonstrated that few minutes exposure to comfortable click trains at a repetitive frequency rate of 30 Hz in healthy subjects could distinctly trigger transient tinnitus-like aftereffects whose fMRI neural correlates were unequivocally localized in the same parietal region as in acoustic trauma tinnitus sufferers (Peak T value = 5.29, Height threshold p= 0.0001, p value < 0.001 corrected for cluster level). Our results strongly suggested that middle-ear kinaesthetic/proprioceptive disturbance might be at the origin of phantom illusory percept. Possibly, middle-ear micro-implantable device, stimulating stapedius and tensor tympani tendons at specific frequency rates might be beneficial to cases of intractable chronic tinnitus.

S16-6

Vocational rehabilitation of soldiers: What we can learn for civilian life

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Activities with increased hearing competence are often in the military field. It must be ensured in all kinds of acoustic and climatic environmental conditions. The German military can´t dismiss highly qualified employees due to hearing loss. The costs of early retirement and increased educational programs exceed the costs of hearing rehabilitation. In 2012, about 6,900 soldiers were seen in our ENT department for hearing assessment. 171 had to be supplied with hearing aids. 13 soldiers were treated with a CI, most of them due to a single-sided deafness. All soldiers could continue with their job. The use of additional devices such as FM systems is essential is some job specific conditions. Successful hearing rehabilitation in soldiers is possible, including Cochlea implant patients. The experience can be transferred to many other, nonmilitary jobs.

S17 Hearing and structure preservation

S17-1

Younger age is a positive prognostic factor for residual hearing preservation in conventional cochlear implantation

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Introduction: The modern cochlear implantation is characterized by the attempt to preserve residual hearing, particularly in the context of electric-acoustic stimulation. Despite scientific and technical development in this field, little is known about the factors that predict the preservation or loss of hearing after cochlear implantation. This study investigates the prognostic significance of various factors in hearing preservation after traditional cochlear implantation.

Methods: A retrospective chart review of 422 cochlear implantations between January 2006 and December 2011 at an academic tertiary care center was performed. Residual hearing at the frequencies 250, 500 and 1000 Hz on the unaided preoperative pure tone audiometry (PTA, air conduction) was the main inclusion criterion. All patients received a cochlear implant with a conventional full length electrode, whereby patients with special pathologies like Gusher phenomenon and auditory synaptopathy / neuropathy were excluded. Unaided preimplant and postimplant pure tone thresholds were compared. The change on the residual hearing after implantation - loss or preservation and in which extent - were analyzed regarding various factors, such as age, gender, site of implantation, shape of the preoperative PTA curve, type of the electrode carrier and approach of electrode insertion in the cochlea. Preservation of residual hearing was defined as a measurable PTA threshold at the frequencies 250, 500 and 1000 Hz.

Results: From 422 implantations performed in the examined period, a total of 153 fulfilled the study criteria. Preservation of residual hearing was observed in almost half of the cases (72; 47%). In more than a half of these patients (39; 54%) a complete hearing preservation (0-10 dB) was achieved. About a third of these implantations (21; 29%) showed a moderate preservation of residual hearing (11-20 dB) after surgery. In the other 12 patients (17%) the preservation of hearing was marginal (>21 dB). Interestingly, hearing preservation and its extent was significantly better in children. On the contrary it was not related to gender, site of implantation and shape of preoperative PTA curve, type of the electrode carrier and approach of electrode insertion in the cochlea.

Discussion: The preservation of residual hearing after conventional cochlear implantation is possible. The majority of the examined factors didn't show any correlation with hearing preservation. Only younger age of the patients seems to have a positive influence on hearing preservation.

Conclusion: This study points out the prognostic significance of younger age of the patient in residual hearing preservation after traditional cochlear implantation. This finding may be of importance and may have implications for future developments.

Learning outcome: Hearing preservation after conventional cochlear implantation significantly correlates with younger age of the patient.

S17-2

Residual hearing preservation with full length electrode insertion in 129 consecutive adult cochlear implant recipients

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Intro: Residual hearing preservation(HP) in cochlear implantation is a barometer of structural preservation. Its impact on auditory performance remains unclear but its practice is accepted as a means to optimize performance. Audiometric outcomes are presented to establish relevance in a group of subjects who underwent a full electrode insertion.

Methods: 129 hearing preservation(HP) cochlear implant(CI) candidates were treated between 2008 and 2013. The MedEl Flexsoft(n= 99) and Flex28(n=30) implants were used in those with measurable thresholds in the low frequencies to within 90 dB. Mean age was 63 years; minimal post-activation use was 6 months. Standardized pre- and post-operative pure tone thresholds were obtained between 250-2000 Hz; various presentations were employed to best illustrate the levels of HP. Speech recognition scores were obtained using the Hearing in Noise Test(HINT), AZBio Sentence Test(AZBio), and Consonant Nucleus Consonant Test(CNC). Insertion depth was calculated using post-operative skull X-rays.

Results: HP was achieved in 89 % of subjects at 250 and 500 Hz (10% to within 10 dB), while 21% lost hearing. Subjects with HP trended toward better performance but only statistically significant with AZBio-in noise($p < 0.05$). Deeper insertions trended toward better performance without statistical significance. When HP was stratified by insertion depths, >540 degrees of insertion and concomitant HP led to better performance with HINT-in noise ($p < 0.05$). Total hearing loss was encountered in 24% of subjects who had a shallower insertion, as compared with 21% of those who had a deeper Insertion. There were 56 subjects who had more than 2 years of use following surgery; 86% showed sustained HP.

Discussion: It is unclear if HP truly confers an advantage in speech outcome over those who lost hearing; the data is not robust enough to differentiate those with inner ear structural damage and those without when HP is not achieved. Data that gave support to HP may have pointed to a subset of patients who manifested structural integrity with full cochlear coverage. Given HP is fast becoming a standard of practice, it is important to clearly define levels of residual HP to help understand what is worthwhile preserving. Establishing common reporting criteria and frequency-specific benefit plots are the first steps toward standardization. Correlating clinical outcomes with Insertion depths is insufficient to address the question of inner ear trauma, unless better imaging and electrophysiological techniques are also incorporated to reveal structural injury.

Conclusion: Residual HP needs to be clearly defined to have relevance; it is feasible with fully implanted electrodes. There is a trend toward better speech performance if HP is achieved, this conferred statistical significance in a limited fashion.

Learning Objectives: Understand the feasibility of HP in fully inserted electrodes and correlate with speech outcomes.

S17-3

Hearing preservation after partial deafness cochlear implantation with cochlear Nucleus CI 422 electrode in children and adults with substantial residual hearing

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Objectives: Low frequencies are crucial for fine time structure information delivery, which is especially important for appropriate language development in children, but also for music perception and intonation. Cochlear implantation aiming preservation of low frequency residual hearing requires special atraumatic approach. 6 steps surgical procedure for partial deafness treatment was designed and applied for this purpose being applicable in adults as well as in children.

Methods: 22 children and 31 adults with audiometric criteria for low frequency hearing threshold (EC- 500Hz < 30dB) underwent cochlear implantation with Nucleus CI422 cochlear implant. Minimal invasive surgical procedure with round window approach for partial deafness treatment was applied in every case. In all implanted patients steroids were administered peri-operatively and up to 14th day after implantation

Results: By understanding preservation of hearing as the elevation of hearing threshold in tonal audiometry no greater than 10dB - in 91% of implanted cases substantial preoperative hearing was preserved in low and middle frequencies postoperatively. Over 36 months of follow up thresholds were estimated as stable within given conditions in 87% of cases. Speech audiometry tests showed significant improvement of performance both in AAST and SA.

Conclusions: 24 contacts electrode, like Nucleus CI 422 is proved to be a good solution for cochlear implantation aiming preservation of hearing in low frequencies. Partial deafness cochlear implantation surgery in children gives possibility for successful preservation of low frequency hearing, and combined electric - acoustic stimulation.

S17-4

Deep insertion- round window approach for hearing preservation surgery by using soft electrodes: Flex EAS, Flex soft, flex M

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Objectives: Preservation of substantial or residual preoperative hearing is becoming a challenge and a necessity in perspective of treatment of sensory-neural hearing losses, especially facing development of new devices. Keeping in mind, that future technologies will bring procedures which might have the potential to restore function of organ of Corti it is essential to preserve inner structure of cochlea. Technical parameters of new types of electrodes - soft ones - make it possible to minimize potential intracochlear insertion trauma.

Methods: Atraumaticity of insertion of Flex soft, Flex EAS, Flex M electrodes in a groups of, respectively: 91, 47 and 62 was assessed. In all analyzed insertions round window approach cochlear implantation surgical technique was used for treatment of partial deafness. In all implanted patients steroids were administered peri-operatively and up to 14th day after implantation. Atraumaticity was evaluated by means of assessment of pre- and postoperative hearing measurement in tonal audiometry and position of electrode inside cochlea by means of CT computed tomography.

Results: Preoperative hearing was preserved in 95,7% implanted subjects, taking preservation of preoperative hearing as an elevation of hearing threshold no greater than 10dB. In radiological evaluation there was no dislocation of electrode from scala tympani into any other compartment of labyrinth. Angular depth of insertion was assessed, what has been correlated with level of hearing preservation.

Conclusions: It was stated, that these soft electrodes used in surgical procedure of round window approach entirely fulfill requirements of hearing and structure preservation and give chances for complete hearing preservation even when performing deep insertions covering distribution of all frequencies.

S17-5

Preservation of residual hearing with a full insertion of regular length electrode array (Digisonic SP-Neurelec)

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Objective: Cochlear implantation has extended to patients with residual hearing, in particular in the lower frequencies. Attempts of hearing preservation is nowadays recommended by most teams. Shorter electrode-arrays (EAs) likely offer the best chance to preserve residual low frequencies. However in case of failure, a shorter EA could compromise the functional outcome. Here we report a preliminary series where hearing preservation was attempted in patients implanted with a regular length EA (24-25 mm) despite a full insertion.

Patients and methods: From May 2008 to May 2013, all charts of patients implanted with the same type of cochlear implant, Digisonic SP (Neurelec), with a 25-mm EA or 24-mm EA for the recent Digisonic SP EVO were analyzed. Out of this series we extracted patients with attempts of hearing preservation. Depth of insertion and hearing preservation were the main outcome measures.

Results: 75 patients were included (89 consecutive cochlear implantations. There were 21 children (2,9 yo; ext :1-9 yo) and 54 adults (56+/-15 yo). Mean follow up was 29+/-15 months. All patients were implanted through a transmastoid route with posterior tympanotomy. In 8 cases a combined transmeatal - trans mastoid approach was necessary. Full insertion was obtained in 80 cases (90%). Seven cases out of 9 attempts of hearing preservation were successful in the early postoperative period. One of these patients presented a sudden and complete deafness in the implanted ear 4 months afterwards. The overall rate of hearing preservation was thus 66%.

Conclusion: Preservation of residual hearing can be possible in about 2 third of cases with a Digisonic SP cochlear implant. This series confirms the rate of 90% of full insertion with this type of EA.

S17-6

Residual hearing preservation following adult cochlear implantation

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Introduction: Hearing preservation has become an important priority during cochlear implant surgery for various reasons. It is vital for those with good low frequency hearing, as preservation thereof facilitates using a combined electro-acoustic device or their natural residual hearing. It is furthermore imperative to ensure the neural structures in the cochlear are left undamaged to enable benefit from possible future therapies and technologies. Recent finding also suggest better postoperative speech perception performance, especially in complex listening environments, where preservation has been achieved.

Aims: To determine whether hearing preservation was achieved at a tertiary hospital setting (The Emmeline Centre Hearing Implants) and investigate which factors contribute to hearing preservation. A further aim was to determine whether speech perception scores are higher for recipients with more hearing preservation

Methods: Data was retrospectively collected for adult patients implanted in the Emmeline Centre over the last three years (2011-2013). A total of 120 adults with measurable preoperative hearing thresholds and recorded postoperative hearing thresholds were included. Preservation was determined at each frequency (125-8000 Hz), to determine whether the preservation was complete (loss of ≤10dB), moderate (loss of 11-20 dB), marginal (loss of 21-40 dB) or no (loss of >40 dB). Speech perception scores using the Auditory Speech Sounds Evaluation Test and Bamford-Kowal-Bench Tests were used to determine whether recipients with more hearing preservation had better functional results.

Results: On average hearing preservation was achieved and was either complete or moderate. Preservation was better in the lower frequency range. There were a few cases indicating an improvement of hearing thresholds post-operatively. The influence of age, gender, side of implant, electrode array implanted, and surgeon and surgical technique are explored. The speech perception results were generally high amongst recipients with preserved residual hearing.

Conclusion: Findings have indicted the benefit of measuring post-operative hearing thresholds as well as functional outcomes and have impacted present service provision. They have provided evidence based information to guide counseling for future recipients at the Emmeline Centre. Further evaluations will be required to determine preservation rate in the long-term.

S17-7

Sunnybrook experience with hearing preservation: comparing electrode lengths and depths of insertion

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Intro: With a wide selection of electrode lengths, surgeons now have the option of pre-operatively selecting a specific electrode based upon anatomical and audiometric considerations. The Cochlear Implant Program at Sunnybrook Health Sciences Centre has been implanting the Flex Soft 31, 28 and 24 mm electrodes in our patients with residual hearing. We will present our experience and compare and contrast the hearing preservation rates.

Methods: All patients undergoing cochlear implant surgery with residual hearing using the MED-EL Flex Soft electrodes were enrolled and data prospectively collected.

Results: 130 patients were implanted with MED-EL Flex Soft electrodes. Soft surgery techniques were adhered to during surgery and no pre-operative steroids were given. Four patients had a 24 mm electrode, 29 patients had a 28 mm electrode and 97 patients had a 31 mm electrode. Our overall hearing preservation rate was 76%. The hearing preservation rates between the 31 and 28 mm electrode were similar and was not statistically significant. The degree of insertion of the 31 mm electrode was 500 degrees versus 475 degrees with the 28 mm electrode, which was not statistically significant. Deeper rates of insertion were not correlated to lower rates of hearing preservation. In patients with standard insertion, hearing preservation did not correlate with statistically significant hearing performance results. However, in patients were very deeply inserted electrodes (630 degrees), patients with hearing preservation did have statistically significant hearing performance results and overall were our best performers.

Discussion: Hearing preservation is possible with all electrode lengths as long as soft surgery techniques are closely followed. In our experience, it does not appear that deeper insertions are associated with higher rates of complete loss of residual hearing. Hearing preservation appears to be especially important in deep insertions as the hearing performance rates are significantly improved. The importance of structural preservation is demonstrated by improved hearing performance improvement in some of our patients.

Conclusion: Hearing preservation is an attainable goal for cochlear implant centers. Very deep insertions with hearing preservation yield the best results of our hearing preservation cohort.

Learning outcome: Discuss the methods to achieve hearing preservation and benefits for patient hearing performance.

S17-8

Hearing preservation and clinical outcome of EAS surgeries

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Background: Minimally invasive concepts of cochlear implantation surgery are currently expanding the criteria for electric acoustic stimulation. This study was conducted to evaluate hearing preservation results and speech discrimination outcome of hearing preservation surgeries using medium/long electrodes.

Methods: Thirty-two consecutive minimally invasive hearing preservation cochlear implantations (using a round window approach with deep insertion of a flexible soft electrode) were performed in 30 Japanese patients (two were bilateral cases), including 6 patients with less residual hearing. Hearing preservation rates as well as speech discrimination/perception scores were investigated.

Results and conclusion: Post-operative evaluation after full insertion of the electrodes (24mm, 31.5mm) showed residual hearing was well preserved in all 32 ears. In all patients, speech discrimination and perception scores were improved post-operatively. Our results indicated that electric acoustic stimulation is beneficial for Japanese-speaking patients, including those with less residual hearing at lower frequencies. Successful hearing preservation results together with the progressive nature of residual hearing in the lower frequency portion in these patients, means minimally invasive full insertion of medium/long electrodes in cochlear implantation surgery are a desirable solution.

S17-9

Immediate and delayed hearing loss secondary to cochlear implantation in an animal model

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Objectives: To assess the hearing thresholds shifts during and following cochlear implantation (CI) in normal hearing animals.

Methods: Fifteen adult fat sand rats (29 ears) were studied. In 12 animals, one ear of each animal was implanted while the other served as a control for cochlear histology. Auditory brainstem (ABR) thresholds were obtained for air (AC) and bone conduction (BC) clicks and 1 kHz tone bursts and for AC, 6 kHz stimuli before and during each stage following one week after cochlear implantation. In addition, three animals (five ears) underwent similar surgical intervention without cochlear implant insertion (control insertion CI).

Results: The degree of hearing loss was found to significantly escalate throughout the stages of the cochlear implantation surgery, as well as one week later ($p < 0.0001$). Incision of the round window (RW) was found to be the most deteriorating surgical stage. Most of the hearing loss was of a conductive type, mostly of a 6 KHz frequency followed by clicks and finally 1 kHz ($p < 0.0001$). Overall, for clicks the AC threshold shift reached 58 dBSPL and for BC the threshold deteriorated by 16 dBSPL. Similar losses were found for 1 and 6 KHz frequencies. In the control insertion CI group, the hearing loss pattern was similar. No significant differences were found in cochlear histology between the operated and non-operated ears.

Conclusion: Hearing loss was progressive and mainly of a conductive and not cochlear origin. The hearing loss was not associated with significant changes in inner ear histology. Changes in mechanism of the inner ear are most likely responsible for major threshold shifts during and after cochlear implantation.

S17-10

Endolymphatic hydrops is prevalent early after cochlear implantation

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Background: Why hearing may fluctuate or deteriorate in the months following cochlear implantation (CI) is poorly understood. Auditory thresholds may improve, but can also deteriorate, or begin to fluctuate in the months following hearing-preservation cochlear implantation. These patterns of hearing have all been associated with endolymphatic hydrops, and we have recently seen this in approximately a third of cochleae three months following experimental cochlear implantation (Lee et al, Audiol Neurotol, 2013). Similarly hydrops has been observed in over 50% of cases in a human cadaveric study of CI recipients (Handzel et al, Otol Neurotol, 2006). In light of these observations, we have undertaken an experimental study to assess the prevalence of hydrops early after CI.

Methods: CI was undertaken in the guinea pig. At surgery electrocochleography (ECochG) was performed. Cohorts of animals survived at time intervals up to three months after CI. Each cohort underwent a final ECochG, prior to preparation of the cochleae for micro-CT. Outcomes were the presence of hydrops as assessed by morphological criteria (micro-CT) and functional measurement (ECochG).

Results: On micro-CT, endolymphatic hydrops was seen in most cochleae at a week after CI, with the prevalence decreasing with time following surgery. Similarly, the “signature” of hydrops on ECochG, namely the ratio of the summating potential to the action potential (SP/AP ratio), was elevated at a week after CI and decreased again over time. The SP/AP ratio and morphological extent of hydrops were highly correlated.

Conclusions: Endolymphatic hydrops is prevalent after CI in this experimental model and as mentioned above, has been observed in the human cochlea following implantation. However, in these experiments there had been no surgical trauma to the cochlear duct, suggesting that this is not a prerequisite for hydrops to develop. These findings suggest that hydrops may be implicated in the changes in hearing observed in the weeks to months following CI surgery.

S17-11

Determinants of delayed hearing loss after cochlear implant

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Background: Hearing loss that occurs months to years after otherwise successful hearing preservation cochlear implantation (delayed hearing loss) occurs in approximately a third of patients and can compromise the functional utility of the residual hearing. The cause(s) of delay hearing loss are not known. Here we examine in detail audiometric data followed for at least 12 months after CI surgery from Melbourne, and from published series to determine the factor(s) influencing delayed hearing loss.

Experimental Methods: The literature was searched for reports of post-operative hearing following hearing-preservation surgery where both post-operative (1-3 months) and long-term (12-24 month) audiograms were transcribed into a database, and the relationships between thresholds, frequency and time were explored.

Results: Across the studies, pre-operative hearing and the early post-operative (short-term) hearing loss were seldom correlated. Similarly, there were no significant correlations between pre-operative hearing and long-term hearing loss. Early short-term and long-term hearing loss was positively correlated (r2 0.7-0.9). Hearing short-term hearing loss was correlated across frequency (r2 0.55-0.86).

Conclusions: Hearing loss soon after CI is not related to pre-operative hearing and occurs at similar levels across frequency. The main determinant of the rate of progression in hearing loss over the first year is the extent of the early hearing loss. These results help to refine an understanding of the pathophysiology of delayed hearing loss. The mechanism(s) would appear to be independent of the extent of cochlear degeneration prior to implantation. Rather, they would appear to be related to the extent of initial injury during implantation.

S17-12

Hearing preservation and electroacoustic stimulation: Melbourne experience with the CI422 Electrode

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With progressively improving outcomes achieved with Cochlear Implantation there is increasing need to preserve residual acoustic hearing and consider combined electroacoustic stimulation. Whilst such patients can be expected to use a hearing aid with benefit in the contralateral ear - Bimodal Mode - there has been demonstrated benefit in using the acoustic hearing in the implanted ear - Combined Mode. This does provide improved speech discrimination in noise, improved localization and subjective music appreciation, compared with Bimodal implant use. There remains uncertainty and controversy as to the optimal electrode length and insertion depth that will provide the best outcomes. With careful surgical technique, useful acoustic hearing may be preserved in a significant number of cases using a variety of electrode types. Recently we have used the CI422 slim straight electrode for such cases. This paper reports the hearing preservation achieved and the use of preserved acoustic hearing in both adults and children. There is a significant incidence of delayed sensorineural hearing loss. When this does occur better hearing outcomes in CI alone and Bimodal mode are achieved with standard length electrode insertion depth.

S17-13

Electric-acoustic stimulation of the auditory system - single-center results of the North American clinical trial

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Objective: Electric acoustic stimulation (EAS) of the auditory system has been shown to improve cochlear implant performance, especially with background noise. The aim of this presentation is to report single center results of the MED-EL North American EAS clinical trial.

Design: Prospective data collection, single center, FDA approved clinical trial with investigational device exemption (IDE)

Methods: Thirty-one patients were enrolled and implanted at the study institution. All subjects were followed for at least 12 months following EAS fitting and data are reported for this interval. A standardized test battery was utilized including speech testing in quiet and noise. Data collected preoperatively and at the various postoperative intervals were analyzed and statistically evaluated. A multivariate analysis was conducted.

Results: Thirty of the 31 patients successfully completed all test intervals. One subject was lost to follow-up. Two patients (2 of 30, 6.7%) lost hearing during the immediate postoperative period. Hearing was completely preserved in 11 of 30 subjects (36.7%). The remaining subjects demonstrated partial preservation of pure-tones and speech discrimination. Aided speech perception scores using various conditions in both quiet and noise were consistent with previous reports and the EAS benefit was present in all subjects and accounted for an improvement of about 20% in word recognition scores in quiet. A multivariate analysis did not demonstrate any predictive factors.

Conclusions: Subjects implanted demonstrated typical EAS results. The EAS benefit was most predominate in noise but also present in quiet. Hearing preservation outcomes were consistent with previously reported results with about 90 percent of subjects demonstrating some level of preserved hearing. More data are needed to elucidate the predictive effect of certain variables.

S17-14

Hearing preservation in cochlear implantation using FLEX-electrodes

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Introduction: The aim of the study is to present our concept to preserve residual hearing in cochlear implantation. We focus on the techniques of hearing preservation surgery as well as on the outcome.

Materials and methods: Therefore we analyzed the data of 51 patients, age 1-83 years, with sensorineural hearing loss. To preserve residual hearing these patients were implanted with FLEX-electrodes, using the round window approach. Steroids were applied both systemically and locally. Hearing and vestibular function were tested pre- and postoperatively and a questionnaire was used to evaluate symptoms of vertigo.

Results: In this study patients showed similar postoperative hearing thresholds compared to preoperative thresholds. Using FLEX-electrodes three patients complained about postoperative vertigo and only one patient had reduced function of the lateral semicircular canal on the operated side. In the control group of 72 patients who underwent cochlear implantation following the standard procedure 20,4% of the patients complained about vertigo and 9,3% showed pathologic test results postoperatively.

Conclusion: Following the surgical principles for hearing preservation and using FLEX-electrodes seems not only to preserve residual hearing but although may help to reduce postoperative vertigo in cochlear implant recipients.

S17-15

Is there an optimal range of electrode array insertion angles for electric-alone stimulation?

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Introduction: Widespread adoption of electro-acoustic stimulation (EAS) and an increased awareness of the importance of hearing preservation have driven development of a wide range of CI electrode arrays in recent years, where the length of the array is one of the most important variables. There is general acceptance that shorter arrays are more appropriate for cases where there is relatively good pre-operative residual hearing as it is clear that hearing preservation is less successful when very long arrays are used. The optimal electrode insertion angle for cases where there is no usable residual hearing is more uncertain, however, and the selection of electrode for EAS cases needs to consider likely electric-alone performance if residual hearing is lost during or following surgery.

Methods: The aim of this presentation is to examine the published literature for evidence of an optimum range of electrode insertion angle for electric-alone stimulation. Papers providing data on influences of electrode length on performance outcomes and hearing preservation were identified from PubMed and Medline searches and relevant data extracted.

Results: The rationale for a relatively long electrode is to maximize the spectral information delivered, but there is evidence from psychoacoustic, modeling and speech recognition studies that spectral information provided by electrical stimulation towards the apex of the cochlea may be unreliable, probably because the spiral ganglion extends only to some 1.5 to 2 cochlear turns. Several studies reporting on outcomes with relatively short arrays (often those designed for EAS) have demonstrated reduced electric-alone performance when electrode insertion angle is much below 360^{o}, though interpretation of some of these studies is complicated by confounding factors such as electrode number. On the other hand, there appears to be little evidence for any correlation between performance outcomes and insertion angles between around 1 and 1.5 cochlear turns. There may be some differences in this respect between perimodiolar and straight electrodes, however, the latter being currently generally favored for hearing preservation.

Conclusions: It appears that there is a reasonably wide range of insertion angles over which optimal electric-alone performance is obtained, and in cases where hearing preservation is an issue it seems logical to limit insertion depth to the lower end of this range. Cochlear dimensions vary significantly among individuals, but an array of appropriate length would be expected to result in a satisfactory insertion angle in the large majority of cases, such that pre-operative estimation of cochlear size may be of little practical importance.

S17-16

The effects of extended preoperative systemic steroids in hearing preservation cochlear implantation

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Intro: Steroids have been shown to reduce the hearing threshold shifts associated with cochlear implantation. However at present, studies have only examined the administration of steroids just prior to surgery. It is well known that steroid effects are dependent upon the duration of exposure. The aim of this study is to examine the role of extended preoperative systemic steroids in hearing preservation cochlear implantation.

Methods: An animal model of cochlear implantation was used. 24 Hartley strain guinea pigs with a mean weight of 768 g and normal hearing were randomised into a control group, a group receiving systemic dexamethasone one day prior to surgery and a group receiving steroids 5 days prior to surgery. A specially designed cochlear implant electrode by MED-EL (Innsbruck) was inserted through a dorsolateral approach to an insertion depth of 5mm and left in-situ. Auditory brain stem responses at 8kHz, 16kHz and 24 kHz were measure preoperatively, and 1 week, 1 month and 2 months postoperatively. Cochlear histopathology was examined at the conclusion of the study.

Results: At 1-week post op, the group receiving dexamethasone 1 day prior to implantation had lower threshold shifts across all frequencies and which was significant at 32kHz ($p< 0.05$). The group receiving steroids 5 days prior to surgery had significantly lower shifts at both 32kHz and 16 kHz ($p< 0.05$). At 1 month, both steroid groups had lower threshold shifts compared to control and from 1 month to 2 months, both steroid groups maintained their thresholds compared to control ($p< 0.05$). The 1 day prior steroid group had less fibrosis compared to control at 2 months post-surgery ($0.29mm^2$ vs.$0.42mm^2$), $p=0.08$. The high frequency selectivity of systemic steroids suggests maximal effects around the basal turn of the cochlea. Further histopathology results will be presented.

Discussion: This is the first study to demonstrate the benefits of extended preoperative steroids on hearing outcomes in cochlear implantation surgery and its predilection for effects in the basal turn of the cochlea in the animal model. This may mean that when high frequency hearing has been lost, the effect of systemic preoperative steroids may not be seen.

Conclusion: The high frequency selectivity of preoperative systemic has implications for considering the concept of "complete steroid coverage" where steroids are used before, during and after implantation. Steroids not only reduce the threshold shift but maintain it post cochlear implantation.

Learning objectives: To discuss the role of preoperative systemic steroids on hearing outcomes in the animal model

S17-17

Using the cochlear implant electrode for intraoperative hearing monitoring during cochlear implantation - early experiences

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Introduction: Preservation of residual cochlear function during cochlear implantation is paramount to optimizing hearing rehabilitation post-operatively. Refinements in electrode design and surgical technique are believed to contribute to successful preservation of residual cochlear function. Intra-operative monitoring of cochlear function is contributing to a more complete understanding of the relative importance of these and may provide feedback to the operating surgeon. Currently electrocochleography (ECochG) is the most widely employed technique for intraoperative monitoring of neurophysiological function, however drawbacks with the conventional approach in using promontory or round window electrodes include the potential instability of the measuring electrode and the relatively small responses achieved that can be difficult to interpret. An intracochlear electrode avoids these drawbacks and may represent a more efficient and effective approach for measuring the intracochlear response to electrode insertion. We present our early experience in the use of the cochlear implant electrode to monitor the cochlear response to electrode insertion in real time.

Methods: A cohort of adult and paediatric patients undergoing cochlear implantation in two tertiary referral cochlear implant centers was studied prospectively. A round window approach was used, with full insertion achieved in all cases. Baseline recordings were taken after posterior tympanotomy and at each stage of the electrode insertion using a prototype modified ART algorithm. Pre- and postoperative audiometry is used to measure the efficacy of hearing preservation in each case.

Results: Intracochlear responses could be measured in all cases. In some cases of low frequency hearing preservation the responses grew stronger as the electrode was inserted. In patients with profound hearing loss an intracochlear response could still be measured. Intracochlear responses were maintained postoperatively, indicating preservation of cochlear function.

Conclusion: Our preliminary experience indicates that the use of the cochlear implant electrode array to monitor the intracochlear response to electrode insertion shows promise and may provide accurate and real time feedback to the surgeon, thus facilitating and improving the efficiency of hearing preservation surgery. Intracochlear responses could be elicited in patients with profound hearing loss, indicating the presence of residual cochlear function that should be preserved. Further work is required to refine the software algorithms and to more fully understand the applicability of this technique.

Learning outcome: This represents a novel technique for measuring intracochlear function. Patients with profound hearing loss may have residual hearing, preservation of which may contribute to an improved audiological outcome. Consequently the hearing preservation technique should be applied to all patients undergoing cochlear implantation.

S17-18

Intracochlear pressure changes due to round window opening - observations in a model

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Introduction: The indication criteria for cochlear implantation have been changed over the last years. Due to new techniques the indication for cochlea implantation has evolved to patients with residual hearing. To preserve residual hearing the electrode design has changed and the atraumatic insertion of the cochlea electrode has moved into the interest of cochlea implant research. The aim of our study was to observe intracochlear pressure changes due to different openings of the round window in a cochlear model.

Material and methods: Round window openings were performed in an artificial cochlear model. Intra cochlear pressure changes were estimated by a micro-optical pressure sensor which was placed in the helicotrema area. Openings of the round window membrane were performed by a needle, a canula, a diode laser and a CO2 laser. Additionally temperature changes were evaluated by a fiber optical sensor.

Results: Statistically significant differences were seen between the different ways of the opening of the round window membrane in regard of the intracochlear pressure changes. Lowest pressure changes were seen by opening the round window membrane with the diode laser. Similar pressure gain were seen due to opening of the round window membrane by the needle and the canula. The opening with the CO2 laser showed a high negative intracochlear pressure and loss of intracochlear fluid. Temperature changes were insignificant.

Discussion: The atraumatic approach to the cochlea is assumed to be essential for the preservation of residual hearing. In our model experiments we could compare objectively different ways of opening the round window membrane by the estimation of intracochlear pressure. The influence on intracochlear trauma remains unclear since several more factors, e.g. electrode design, insertion depth, insertion speed, have to be considered as well.

S17-19

Comparison of round window membrane sealants following cochlear implantation associated with a low frequency delayed threshold shift in a guinea pig model of cochlear implantation

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Introduction: Delayed loss of residual hearing is being increasingly recognized following cochlear implantation as patients with more residual hearing are being offered cochlear implantation. Yet causes behind this type of post implantation hearing loss remain unclear. The RWM remains the route of choice for hearing preservation cochlear implantation due to the reduced amount of drilling required to insert the electrode. A previous study has suggested that muscle plug on the RWM of a guinea pig results in a delayed loss of low frequency threshold over time. We postulate that different sealants will affect RWM compliance over time and affect threshold differently. Here we compare different RWM sealants following short electrode insertion in a guinea pig, using muscle, fascia and a commercially available fibrin glue Tisseel™.

Methods: 21 normal hearing guinea pigs were placed into 3 groups; muscle plug, fascial plug and fibrin glue (Tisseel™). These were used following implantation with a shortened electrode through the RWM. The electrode used was a shortened electrode that penetrated approximately 2-4 mm into the scala tympani. Following insertion, the RWM was then plugged with different sealants. Thresholds were tested by auditory brainstem response (ABR), pre operatively and again at 1 week, 1 month and 3 months post operatively. Histology was collected at termination and analyzed for tissue reaction and histological cell counts.

Results: The muscle and fascia groups both displayed a delayed loss of threshold in the lower frequencies. A within group comparison showed the muscle group to have a delayed loss of threshold in frequencies 2 and 8 kHz from 1 week to 12 weeks post operatively which, is consistent with findings from a previous study. The fascia group also demonstrated a delayed loss but at 2 kHz only and in a slower fashion to the muscle group. In contrast, the Tisseel™ group showed a large loss of threshold initially and then demonstrated a recovery of threshold shift from 1 week to 12 weeks in frequencies 2, 8 and 16 kHz. A between group comparison of threshold at 12 weeks in these lower frequencies showed no significant difference. Histological analysis of tissue reaction volume and hair cell counts showed no significant differences between groups and therefore did not account for the difference seen in the threshold shift over time.

Conclusion: Here we also describe a similar loss of low frequency threshold associated with muscle and fascial plug following RWM intervention. In contrast, fibrin glue showed a recovery of the threshold over time. These findings suggest that the sealant used in RWM surgery is important in affecting low frequency hearing possibly by affecting compliance of the RWM over time. Given that autologous grafts are commonly used in clinical practice this may be of interest to the field. In the setting of cochlear implantation in patients with residual hearing Tisseel™ may provide a viable clinical alternative.

S17-20

Delayed low frequency hearing loss following round window intervention in an animal model of cochlear implantation

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Introduction: Delayed loss of residual hearing is being increasingly recognized following cochlear implantation as patients with more residual hearing are being offered cochlear implantation yet causes behind this hearing loss remain unclear. Here we describe an animal model of delayed low frequency hearing loss as a result of round window membrane (RWM) intervention (electrode insertion and control) with a muscle plug.

Methods: 35 normal hearing guinea pigs were placed into 5 groups; 2 RWM groups (electrode insertion and control) and 3 cochleostomy groups (medially placed electrode, laterally placed electrode and cochleostomy control. Specially designed guinea pig electrode was inserted into the guinea pig cochlea using a piece of muscle plug. Thresholds were tested by auditory brainstem response (ABR), pre operatively and again at 1 week, 1 month and 3 months post operatively. Histology was collected at termination and analyzed for electrode trajectory, tissue reaction and histological cell counts.

Results: All groups lost hearing across all frequencies at 8 kHz and above immediately post operatively and this threshold shift remained relatively stable over the study period. Only the RWM intervention groups (RWM insertion and RWM control) demonstrated a delayed loss of threshold at 2 kHz over 3 months that was not observed in the cochleostomy groups. An analysis of the tissue reaction volumes were much greater in the electrode insertion groups when compared to controls. Yet there was not a significant association between volume of tissue reaction and development of delayed hearing loss. Separate analysis of the tissue reaction and changes in hearing were performed. Correlations showed there was no association between the fibrotic tissue reaction and hearing loss at any frequency. The osteogenic tissue volume however did correlate significantly to hearing shift at 16 and 24 kHz which, is the region of the cochlea where the cochleostomy was created and electrode inserted.

Conclusion: Here we show an animal model of delayed low frequency threshold shift associated with muscle plug on the RWM. We postulated that altering the electrode position within the cochlea and the route of insertion (round window/cochleostomy) may affect the amount, type and position of the tissue reaction and therefore affect the pattern of threshold shift. Although the volume of tissue reaction was greater in the electrode insertion groups than control groups, threshold shifts across frequencies were comparable and not made worse with electrode insertion. Subsequently, no correlation could be found between the tissue reaction which, was greater in the electrode insertion groups and the threshold shifts observed across frequencies or the delayed threshold shift observed at 2 kHz in the RWM intervention groups. Delayed loss of threshold observed in this study was secondary to the muscle plug on the RWM and not the amount of tissue reaction within the cochlea.

S17-22

Thinking in future reimplantations: Experimental study on hearing preservation after cochlear implantation in normal-hearing experimental animals

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Introduction: Some clinical experiences show it is possible to invade intracochlear spaces when inserting a cochlear implant electrode array while preserving, to a greater or lesser extent, existing residual hearing. The objective of this work is to establish the degree of hearing preservation in normal-hearing experimental animals after the insertion of an electrode array and, in case hearing deteriorates, establish the cause.

Materials and method: A 10-mm long (Hybrid S Nucleus) and a 13-mm Nucleus Experimental Animal Electrode Array (HL14) electrode arrays were placed in a group of 15 Macaca fascicularis specimens, in total 20 ears, following the same surgical steps as those performed in cochlear implant surgery in humans. Audiometric tests (BAEP and dpOA) were performed before and after implantation (during 8 months). Once the survival period had elapsed, the animals were put to sleep and the temporal bones were processed for its histopathological study.

Results: The average difference in hearing thresholds pre- and post-implantation, as determined by the BAEPs, was 20 dB SPL (Range: 0 to 60 dB SPL). Hearing preservation levels were higher in the last specimens that were operated on, which suggests there is a learning curve in the development of greater atraumacity during surgeries. There was a correlation between audiometric and histological results, so the group of animals that preserved their hearing did not present intracochlear lesions, while it showed minimal reactions to foreign bodies around the electrode array.

Conclusions: The cochlea may be approached by means of atraumatic surgical techniques while preserving hearing to a great extent.

Conflict of interest: This study has been supported by cochlear AG

S17-24

Cochlear implantation in the mouse: Functional and histological outcomes

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Introduction: Extending the use of cochlear implants to patients with residual hearing entails an increased understanding of their effects at a cellular and molecular level. Animal models are the only means of assessing such consequences. Mice are an excellent model for auditory research and this is in part due to the range of naturally occurring and genetically-modified strains which mimic human deafness. To date, very few studies of cochlear implantation (CI) in mice exist. Our aim was to create a mouse model of CI and subsequently assess the effects of implantation on cochlear ultrastructure and function.

Methods: CI via the round window was performed in C57Bl/6 mice aged 3 and 6 months using either a dummy implant (n=20) or a specialized electrode array (n=12). The contralateral cochlea acted as a control. Auditory brainstem response (ABR) audiometry prior to and at time-points following CI was undertaken. Following sacrifice, cochleae were harvested and prepared for histological examination.

Results: ABR analysis showed greater threshold shifts in the implanted ear compared to the control ear post-implantation, but substantial preservation of hearing. There were no cases in which implantation caused a profound hearing loss across all frequencies. Cone beam computerised tomography and light microscopy confirmed correct placement of the electrode array within the scala tympani. Histological analysis showed encapsulation of the implant in tissue with features suggesting the presence of fibrosis. Immunolabelling using CD45 (leucocyte marker) revealed significantly greater numbers of positively labelled cells within the basal turn of implanted cochleae compared to controls (Mann-Whitney U Test, $p< 0.05$). This was particularly seen within the region of the spiral ligament, scala tympani and basilar membrane.

Discussion: Although the mouse cochlea is small and the surgery challenging, our results demonstrate that mouse CI via the round window is feasible and provides a means for exploring the interface between the biological and technological aspects of CI.

Conclusion: Mouse CI via the round window offers a model for exploring tissue responses to implantation.

Learning outcome: Further investigation into the presence of inflammation and fibrosis using this mouse model will help identify measures to potentially reduce these effects. The model will also allow for future research using eluting electrode arrays as a means for drug delivery to cochleae, ultimately enhancing patient outcomes.

S18 Accompanying modalities: awareness, self-helping rehabilitation, self-helping groups to support performance, support & aftercare in assistive listening devices, growing populations

S18-2

Parents and professionals working together in establishing qualitative rehabilitation for hearing impaired children

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Purpose: Studies from Denmark have questioned the content in the rehabilitation offered to families with hearing impaired children. The parent organization, Decibel, and professionals joined forces and obtained enough funding to carry out a three-year project seeking to implement Auditory Verbal Therapy, AVT. The primary aim is to describe best practice for the content in rehabilitation offered to children with hearing loss. The study seeks to answer questions of how AVT, where families play a primary role in the rehabilitation, can be implemented in a country with double working families. The study also aims at documenting hearing impaired children's speech and language outcome when enrolled in an AVT-program over a three-year period.

Material and method: AVT is an intervention targeting families with children in need of all kinds of hearing technology, hence 60 families with children with CI/BAHA/HA were invited to participate. The parent organization carried out the recruiting. In order to investigate whether AVT works for children with additional needs and their families, 20% of the families chosen for the project had children diagnosed with an additional handicap. Children were all preschoolers and they had to have an age at project start that would allow three years of AVT prior to school start. Families from Sweden, Norway and the Faroe Islands were accepted for the study. The project does not cover transport expenses or economically compensates for the parents taking time off from work. Four therapists carry out the AVT, they either must have finished or have started the three year training provided from mentors, who are cert. AVTs. The families attend sessions every other week, monthly or 2-3 monthly. The child is assessed yearly using the following standardized tests/assessments: Little Ears, PPVT-4, Reynell impressive, Active Vocabulary, Phonological test and MLU. At five years of age and at the end of project the CELF-4 is used. Parental interviews are carried out on a yearly basis covering aspects such as; the understanding of the goals and activities, the carry-over of AVT to everyday life, possible stress factor of attending AVT. Information about parental educational level and socio economic status is collected in order to document whether such parameters affect the child's speech and language outcome and whether they affect the parents' attendance to and experience with AVT.

Results and conclusion: Preliminary results will be presented. At this initial stage of the project it is interesting to observe the overwhelming interest from families with hearing impaired children to join a three year project regardless of double working parents, long distance of transport and no economic compensation. There is a waiting list for families wanting to join the project and a tentative conclusion is that parents in Nordic countries seem interested in AVT as intervention for their hearing impaired child.

S18-3

Role of parents in their child's auditory habilitation process

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Introduction: Shortly after birth, the baby has the ability to acquire and develop the linguistic system of the culture in which he is inserted and it is imperial to be aware of all behaviors, since communication is not restricted to speech, involving a complex set of behaviors ranging from screams, laughs, vocalizations, facial expressions, words, and gestures, until a speech full of verbal and nonverbal behaviors that make child a competent communicator. When we have a baby with severe to profound bilateral sensorineural hearing loss who has a limited access to the world of sound and to the linguistic world, it becomes even more important to make a close observation of all communicative behaviors, in order to understand his real communication abilities. For these children, the cochlear implant is crucial to allow the access to sounds, and after cochlear implantation it is of utmost importance to understand how auditory, language and communication skills develop. The auditory habilitation after cochlear implantation has a decisive role in the evolution of the child's communicative abilities.

Objectives: To analyze the effect of a more effective inclusion of parents in the initial process of auditory habilitation and speech processor programming, in order to optimize this step and reduce the anxiety and frustration for both.

Material and methods: Since late 2011, our center started to offer parents a family-centered intervention, in which parents are committed to actively collaborate in the process of speech processor programming, the child´s auditory habilitation and auditory and language stimulation in different contexts. Since then, their role was not confined to the family context, but also in direct collaboration with the audiologist and the speech language pathologist. Since then, 35 families of children who use cochlear implants collaborated in this family-centered intervention.

Results: The family-centered approach proved to be important for a greater involvement of the family and allowed to convey to parents greater confidence in their abilities to help their child in the habilitation process. Parents of children who use cochlear implants proved decisive in helping their child learn to listen. They are extremely important in helping understand and enjoy environmental and speech sounds. When parent's doubts are clarified and their integration in the rehabilitation team is established, the auditory habilitation process is optimized, with significant acquisitions being achieved in this period not only for the child but also for the family.

Conclusion: The integration of parents in the habilitation team after cochlear implantation enables this process to happen more quickly, with a significant increase in the understanding of the sounds' meanings, and a decrease in frustration, both for the child and the family.

Keywords: Hearing loss, Auditory Habilitation, Family-Centered Approach; Cochlear Implants.

S18-4

Bilateral cochlear implantation for hearing-impaired children: Criterion of candidacy derived from an observational study

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Introduction: Policy-makers struggle to define the hearing thresholds at which children should be offered cochlear implants (CIs), rather than hearing aids (HAs). This study compared outcomes for children with bilateral CIs and children with bilateral HAs, to determine candidacy criteria for paediatric CIs.

Method: Eligibility included diagnosis of hearing impairment before 31 months and pure-tone average (PTA) thresholds ≥ 50 dBHL at 2 and 4 kHz bilaterally. Seventy-one children participated; aged 46 to 86 months (mean 64 months). Twenty-eight children used bilateral CIs; 43 used bilateral digital HAs. Speech perception was measured using closed-set word tests in 3 conditions: quiet, pink noise, and 2-talker babble.

Results: Odds of 4:1 of a better outcome with CIs were associated with a 4-frequency PTA of 79, 86, and 76 dBHL or a 2-frequency PTA of 83, 92, and 80 dBHL for word tests in quiet, noise, and babble, respectively.

Conclusion: Children with an unaided 4-frequency PTA of 80 dBHL or poorer bilaterally should be considered candidates for bilateral CIs, (provided odds of 4:1 are acceptable). If 4-frequency PTA not measurable, then criteria should be: 2-frequency PTA of 85dBHL or poorer bilaterally. If adopted by policy-makers, these recommendations would expand provision of CIs to children in England and Wales.

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S18-5

Referring for a cochlear implant assessment in the UK, do the referrers know the criteria?

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Introduction: The effect of a severe or profound hearing loss on a patient's life is significant. National guidance recommends 'appropriate and timely referral' of profoundly deaf adult patients to assess suitability for cochlear implantation (CI). National Institute for Clinical Excellence (NICE) guidelines suggest recommend referral for hearing losses of 90dB or worse at 2 and 4 kHz in the better hearing ear. This study lookedaimed to assess the extent of knowledge of the NICE referral criteria of both audiologists and ENT specialists in the UK, and whether further education could be beneficial in this area.

Methods: A questionnaire compiled of clinical scenarios around referral for CI assessment was compiled. Four pure tone audiology (PTA) results were used along with text questions. The questionnaire was distributed to 52 audiologists. Following the questionnaire, audiologists were given a training session on CI, including information on referral criteria. The questionnaire was then repeated. The same questionnaire was answered by 136 otolaryngologists via the national ENT-UK mailing list, using an online survey website.

Results: In one1 of the four PTA scenarios where the patient was suitable for CI assessment only 29% of otolaryngologists and 24% of audiologists would have referred the patient. This improved in the audiologist group following training. Results from the clinical scenarios also demonstrated a lack of awareness regarding appropriateness of referral in specific situations. For example only half of ENT-UK members and a third of audiologists would have referred a deafened adult with other significant health problems. Similarly around half of respondents did not refer deafened adults with learning difficulties when it was appropriate to do so. A third of ENT-UK members and more than half of audiologists would not have referred deafened adults over 75 even though age is not a restricting factor. All answers improved in the audiology group following training.

Discussion: Epidemiological data suggests that there are profoundly deaf people living in the UK without cochlear implants because they have never been referred for assessment. This study suggests that there is a lack of knowledge amongst audiologists and otolaryngologists in the UK regarding which patients are appropriate for referral for assessment. Any professional dealing with patients with hearing loss should be aware of the guidelines.

Learning outcome: This study suggests that local training may be one way of raising awareness through liaison between cochlear implant services and local otolaryngology and audiology departments and this study shows the potential benefit of such an approach.

S18-7

Music therapy as specific and complementary training in the early rehabilitation of adult CI users

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Since January 2014, an integrated outpatient rehabilitation program for adult CI users has been established at the ENT- clinic of the university hospital Heidelberg in cooperation with the German Centre of Music Therapy Research (DZM) e.V. In addition to medical and technical care, speech therapy and psychological support at the ENT- clinic, music therapy offered by the DZM is an integral part of the program. Music therapy was developed for postlingually deafened CI users in early rehabilitation after CI-surgery and initial activation of the CI speech processor. The rationale of the standardized music therapeutic approach is based on the analogy of linguistic features and musical components such as pitch, rhythm and timbre. As the features of speech and music are processed in overlapping neuronal networks, the training of musical dimensions can facilitate speech processing and understanding. After initial activation of the speech processor, CI users have to learn to decode the unfamiliar perceptions transmitted via the CI. Specific musical interventions are therefore aimed at simulating the gradual acquisition of language in infants, from the early prelingual dialogue with their parents to accomplished verbal communication. Music therapy offered in the context of the rehabilitation program consists of seven individual 50-minutes-sessions. The musical interventions are composed of five modules incorporating a variety of exercises. The exercises can be selected and adjusted individually to meet the varying needs and differing hearing abilities of the CI users. The first part of the training aims at improving speech comprehension and production, focusing especially on emotional speech prosody. The second part of the training addresses music perception itself in order to gain satisfaction from music perception via the CI. Specific diagnostic tools consisting of psychological and musical tests have been developed in order to evaluate the effectiveness of the music therapeutic approach. Preliminary results indicate that CI users may benefit from the training with regard to hearing performance of both musical and linguistic dimensions as well as in situations of daily life.

S18-10

Cochlear™ wireless accessories for cochlear implant recipients with residual hearing using Nucleus® 6 sound processors

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Intro: The Nucleus® CP900 series sound processor has 2.4GHz wireless audio-connection capacity potentially relieving recipients of the use of cables for certain communications. Cochlear™ wireless accessories are also compatible with certain GN ReSound® hearing aids providing a Bimodal wireless audio solution. Currently cochlear implant recipients' access to assistive technology involves connecting an audio cable or using an intermediary device such as an FM system. In this study we evaluate the use and acceptance of the Cochlear wireless accessories in experienced cochlear implant users. In addition we compare the performance with the Cochlear wireless Mini Microphone to that with an industry-standard FM system.

Methods: Fifteen experienced adult Nucleus CI recipients were recruited. In contralateral ears, where appropriate, subjects were refitted with GN Resound hearing aids. Each participant used their selected Cochlear wireless accessory and Nucleus 6 sound processor for a 2 week take-home period. A baseline questionnaire was completed by each participant at the fitting visit. A usability and preference diary/questionnaire was completed by the participant during the take home trial period. Speech testing using an adaptive speech-to-noise ratio procedure was conducted in a simulated classroom environment: Speech was presented the front (0°); speech level was 65 dB SPL at the ear with the transmitting device placed at 15 cm from the speaker. Noise was presented from left front/right front (±60°) and left/right back (±120°) at a distance of one meter from the subject.

Results: Preliminary results show that experienced Cochlear implant recipients are satisfied with the Nucleus 6 Wireless accessory range. The final outcomes of the study will be presented.

Conclusion: The Nucleus 6 Wireless accessory range is well accepted by experienced cochlear implant users.

Learning outcome: Integrated wireless audio capability may facilitate the daily use of accessories to improve the communication performance of cochlear implanted subjects.

S18-11

FM/Wireless technology use by young people (11-19 years) with a hearing loss

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Objective: Research has highlighted the benefits of improved signal to noise ratio (SNR) on classroom learning for young people with hearing loss. However, there is a paucity of research which explores the practical benefits/challenges of FM device use for young people in and out of school. This study consisted of two phases. The first phase focused on the views of young people on remote microphone usage. Phase 2 looked to explore the use of remote microphone technology during outdoor activities.

Methods:

Phase 1: Data were collected via semi-structured interviews from 20 young people (11-19 years of age) using FM devices with their hearing aids (n=7) or cochlear implants (n=13). Interviews were transcribed and thematic content analysis was used to interrogate the data.

Phase 2: Videos were collected from young people and users of transmitters during outdoor activities. The views of different users of the transmitters and young people using the receivers were sought.

Results:

Phase 1: Four main themes and 19 sub themes were identified in the participants' accounts which describe their experiences and views on FM technology use.

Phase 2: The videos identified the perspectives of teachers of the deaf, teaching assistants, activity leads and young people.

Conclusions: Participants in phase 1 of the study identified the benefits provided by FM technology in educational settings but many reported challenges associated with FM device use. The use of FM outside of educational settings was not common and very few were able to discuss the potential for this. Phase 2 highlighted the different views of those using transmitters and the young people using the receivers. Feedback highlighted an initial reluctance by some to trial the transmitters in situations that may be considered difficult to manage. However, after using the device both the users of the transmitters and the young people identified the benefits in communication and ease of listening the remote microphones provided. Overall a need to improve awareness and knowledge on the optimal use of FM technologies was identified.

Learning Objectives:

- Recognize the benefits and challenges to remote microphone usage for young people in particular.
- Appreciate the increased importance of an improved signal to noise (SNR) for young people with a hearing loss in different environmental settings.
- Identify situations where remote microphone use may provide increase benefit to young people with a hearing loss.

S18-13

Redefining the borders: Stretching the criteria for paediatric benefit from cochlear implantation for 2014

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Intro: Over the past 10 years there has been a significant shift in the audiological and functional listening criteria that would suggest a child will have improved access to sound over and above what can be provided by acoustic amplification. In an integrated cochlear implant program that is embedded in a comprehensive listening-based early intervention service the opportunity exists to closely monitor the progress of children with different levels of hearing over up to five years and the ever improving outcomes for children with cochlear implants has also driven shifts in candidacy criteria. This retrospective study reviews the changing criteria in a paediatric cochlear implant program over the past 3 years, and the changes in speech, language and listening outcomes. Additionally, medical, audiological and psychosocial outcomes are also reviewed and compared to those of children using traditional amplification.

Methods: A retrospective file review was conducted to review the candidacy criteria, medical and surgical outcomes and long terms outcomes with respect to listening, speech, language and the family. The candidacy characteristics and subsequent outcomes for 148 implant procedures over 3 years was reviewed in order to clarify the current criteria for paediatric cochlear implant evaluation in 2014.

Results: Audiological criteria has been gradually shifting over the past 3 years. Children with more residual hearing are now being considered appropriate candidates for implantation and are showing improved outcomes compared to pre-operative listening and compared to children using traditional amplification. Surgical and medical aspects of cochlear implantation have not shown any significant change in the impact on the individual or their post-operative residual hearing. Other characteristics are emerging as likely outcomes such as reduced effort in listening and improved confidence.

Conclusion: Over the past three years, the audiological criteria for implantation has changes significantly and has become just one component of the information driving a family to consider cochlear implantation rather than the sole piece of evidence for consideration. The value of the description 'borderline' needs to be reconsidered as it is defined differently by different clinicians and at different points in history, and this has proved only to add confusion for families and professionals. The criteria for benefit from cochlear implants has shifted significantly and will continue to shift and professionals need to keep abreast of these shifts in order to ensure candidates are obtaining the best access to sound that technology can provide.

Learning outcomes: Participants will have the opportunity to review current cochlear implant candidacy criteria, current clinical practices in an integrated paediatric implant program and how the longer term outcomes for children compare to those of children with similar hearing levels using traditional amplification.

S18-14

Exploring views on current and future cochlear implant service delivery: The voices of users, parents and professionals at cochlear implant centers and in the community

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A survey was conducted to explore the views on the current and future challenges faced by cochlear implant services and their service delivery as perceived by users, parents and professionals. The survey was conducted across Europe. We received 1052 responses in total, out of which 742 were from the UK. This report provides the findings from this research of the responses in the UK:

- Responses were from a wide range of respondents including those in cochlear implant centers and local community services. They included surgeons, ENT consultants, audiologists, teachers of the deaf, speech and language therapists, psychologists, social workers, parents, carers and cochlear implant users.
- In-spite of the wide range of respondents, there was a broad consensus of opinion, regardless of how the data was filtered across groups.
- The majority of participants (70% and 65%) see implantation in adults and children increasing.
- The majority of participants were quite satisfied with the service they currently receive. They reported their current experience of implant services to be mainly driven by decisions made by the implant team. For the future they preferred the service to be mainly driven by decisions made jointly by cochlear implant centre staff and the user and/or parent/career.
- The majority of participants wanted the cochlear implant services to be integrated into local audiology and other services, such as education, when it comes to the provision of appointments, accessories, treatment and long term management.
- The current challenge perceived by the majority of participants from implant centers was 'restrictions on number of candidates funded´. The long term challenges perceived by those at implant centers included both ´political decisions/issues´ followed closely by ´restrictions on number of candidates´ and ´restrictions on funding per candidate´.
- Qualitative analysis of the open ended responses indicated that, while there was a large degree of satisfaction, the majority of participants wanted some change in the current services:
    - integration of services with local provision
    - additional resources with an awareness of the challenge of cost savings
    - the provision of long term rehabilitation and management
    - a more proactive role for families/users than is currently available.

Recommendations for service delivery based on the findings of the survey are included at the end of the report.

S18-15

Exploring experiences of adults not selected for cochlear implantation

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Objective: The objective of this study was to explore, by interview, the experiences of adults who have undergone assessment for cochlear implantation and were considered unsuitable.

Methods: 10 adult participants were interviewed. Interviews were transcribed and thematic content analysis was carried out to analyze them. 6 main themes and 16 subthemes were identified.

Results: The findings from the study demonstrate that adults who underwent the assessment for cochlear implantation were significantly impacted socially and emotionally as well as at work as a result of their hearing loss. Most participants found the speech testing in the assessment process to be a poor representation of hearing challenges in everyday life. A range of expectations from implantation were noted; the most common one being improvement in speech and communication. The management of these expectations needed attention. A number of other suggestions regarding the actual assessment process and aspects around it were highlighted.

Conclusions: A need to revise audiological criteria and modify speech testing methods to resemble hearing challenges in everyday life is highlighted. The impact of hearing loss on social, emotional and work aspects need to be addressed thoroughly. An awareness of available technology and other coping strategies should be part of the assessment protocol. Uniformity across different centers in terms of providing information pre-assessment needs to be achieved. Consideration of the individual and his hearing and communication needs in addition to formal hearing assessments before deciding/refusing implantation needs to be developed.

S18-16

The relationship between UNHS and the diagnosis age, intervention age of deaf children with cochlear implant

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Objective：To analyze the relationship between UNHS implementation and the diagnosis, intervention age of cochlear implant children with profound hearing loss.

Methods: Their detailed medical information were collected and analyzed for a total of 217 children with profound hearing loss from 2009 to 2010, including their UNHS results, diagnosis age and intervention age.

Results: Of the 217 profound hearing loss children ranging from 1 to 9 years old, 35% (76 / 217) were identified through UNHS with mean diagnosis age of 5±0.3 months and intervention age of 8±0.7 months; 65% (141 / 217) were identified by parents and diagnosed in our hospital with mean diagnosis age of 27±0.8 months, and intervention age of 37±0.5 months. The diagnosis and intervention age in these two groups showed significant differences ($p>0.05$). More than 90% of children in UNHS program were born after 2005, mainly from shanghai or Zhejiang province. Children without UNHS were mostly from Anhui or Jiangsu provinces.

Conclusion: UNHS is effective way for early identification and intervention of hearing loss, but its implementation should be universalized and public awareness should be strengthened.

Key words: Hearing loss; Diagnosis; Age; UNHS; Cochlear implantation;

S18-17

The project HD5090 - reference data for hearing devices -

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Main target of the HD5090 project is to prepare and apply a test profile for the validation of the listening performance of hearing impaired persons using either hearing aids (HA) or cochlear implants (CI). The age range of the target group is between 50-90 years and the hearing loss range is from 50 to 90 dB HL.

Reference data for both acoustical hearing aids and cochlear implants will be collected in a multinational and multilingual context. If needed, also dialects will be involved. Comparing and linking the data of hearing aids and cochlear implants should result in age-dependent values for Equivalent Hearing Loss (EHL). These EHL-values can be included as an evidence-based element in counseling patients in this age group re HA or CI. The HD5090 test profile will be easy to handle and take little time and effort for the patient as well as for the professional. The test profile will be „adaptive“ and allow the use of the test language as preferred or needed by the patient. The test profile will contain PTA measurement (using duotone, Coninx) at 4 frequencies, speech recognition thresholds in quiet and in stationary as well as fluctuating noise (using AAST, Coninx), speech recognition threshold with focus on high-frequency consonants (using AAST-HF, Coninx), an identification test for non-sense words at MCL and an AAST-compatible version of the Text Recognition Test (TRT, Kramer and Zekveld) to assess cognitive-linguistic central processing skills.

S21 Speech coding

S21-1

Optmizing channel selection in sequential stimulation; Early results of a novel *n-of-M* type coding strategy

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Recently it has become clear that in *n-of-m* type cochlear implant strategies such as ACE™ innovative channel selection algorithms can further enhance speech understanding in noise [1,2,3]. Optimal channel selection is particularly challenging for example when the signal is energetically masked by noise, or when the source transfer function biases specific frequencies (for instance when listening to a telephone or poor audio equipment). New ways to dynamically select channels by combining with noise reduction [2] or modeling masking phenomena [3] have been shown to give benefits in specific conditions or to save stimulation power from which we conclude that optimizing the way channels are selected is an important and promising path forward in further improving *n-of-m* type sound coding strategies. In the current study we propose a novel way to select channels taking using a mathematical iterative optimization procedure to take into account spread of excitation and refraction behavior of the nerve. It is demonstrated in simulation that this new strategy shows less channel selection errors when the frequency shape of the source transfer function is not flat. Early clinical results will be presented that demonstrate that these benefits do translate into improved speech understanding in noise after training, and in addition show less sensitivity to the transfer function. A pilot group of 10 CI users participated in this study and the speech reception threshold in both party and steady-state noise was significantly lowered for the new strategy in a lab test. We also show that the benefits did not appear until after the users got used to the new strategy for a short time.

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S21-2

Comparing the coding strategies of Crystalis and Crystalis XDP (Neurelec)

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The aim of the study is to determine whether implant users with a Cochlear Implant by Neurelec benefit from the coding strategies of Crystalis XDP. In addition to a new signal processing strategy, Crystalis XDP offers further setting parameters, for example output compression function and noise cancelling. Ten implant patients were included in this study. The validation is based on the following tests: aided threshold measurement in free field, speech tests: HSM-Sentence test and Freiburg speech test with monosyllable and multisyllable words. The test signals were always sent from a loudspeaker at 0° azimuth and in a distance of one meter. The settings of the HSM-Test and of the Freiburg speech test with numbers of two or more syllables were set at free field at 65 dB speech recognition without and with background noise with SNR at 10, 5 and 0 dB. An APHAB questionnaire provided the basis for the subjective evaluation of the ability of hearing; those results were compared with answers of WDRC hearing aid wearers. The aided threshold measurements resulted in an almost identical threshold with the exception of a few outliers. The Freiburg speech test resulted in a significant spread of values with a similar median. The answers given in the APHAB questionnaire show that the awareness of the relevant issues by all tested implant patients exceeds the threshold of 50 % of the WDRC hearing aid wearers. Therefore, there are some tendencies. Some implant patients benefit from Crystalis XDP and their perception of speech is more accurate and clear, and this perception was confirmed by the tests.

S21-3

Assessment of musical sound quality in MED-EL cochlear implant users: A comparison between fine structure processing and HDCIS strategies

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Background: Few studies have examined musical sound quality differences between MED-EL's newest generation processing strategy, Fine Structure-Processing (FSP) and the older default strategy, High Definition Interleaved Continuous Sampling (HDCIS). Existing studies have been limited to subjective quality rating scales and questionnaires as a measure of musical sound quality perception. The aim of this study was to use a documented and well-established method, the Cochlear Implant-Multiple Stimulus with Hidden Reference and Anchor (CI-MUSHRA), to measure musical sound quality discrimination between FSP and HDCIS using a within subject experimental design.

Methods: 8 CI users, who were utilizing a FSP strategy for at least 9 months, were enrolled in this study. In the first session, participants completed the CI-MUSHRA evaluation with their FSP strategy. Patients were then programmed with the HDCIS strategy and allowed to practice for two months. In the second session, participants were retested with HDCIS and then switched back to their FSP strategy and tested acutely. 16 normal hearing (NH) controls completed a CI-MUSHRA evaluation for comparison. For the CI-MUSHRA evaluation, participants were presented with a high-quality, real-world musical stimulus (termed, reference) and versions of the reference in which various amount of bass information was removed. Participants were required to rate the degree of sound quality deterioration of each version as compared to the reference. The ability to detect differences among versions served as indicator of musical sound quality perception.

Results: Repeated measures ANOVA analysis revealed that performance in CI-MUSHRA differed between the processing strategies tested at the specified intervals ($F(2, 14) = 14.4$, $P < 0.001$). Pairwise comparisons with Bonferroni correction revealed that performance decreased after 2 months of practices with HDCIS ($p < 0.05$) and performance increased after acutely switching back to FSP ($p < 0.05$). Importantly, FSP baseline performance was greater than performance with acute FSP testing that followed 2 months of practice with HDCIS, suggesting that participants were no longer fully acclimatized to FSP ($p < 0.05$).

Conclusion: Overall, musical sound quality discrimination more closely resembled NH performance when CI participants utilized FSP, as compared to HDCIS. These results suggest that FSP provides improved musical sound quality discrimination over HDCIS, as measured by CI-MUSHRA. Collectively, these findings suggest that delivering fine structure to apical channels via the FSP strategy may allow CI patients to enjoy and appreciate more aspects of music.

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S21-4

FS4 high rate - speech perception and listening experience with the new high rate setting of the FS4 speech coding strategy

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Objective: With a recent update of the fitting software the fine structure coding strategy FS4 is now available with a higher stimulation rate of the basal 8 channels. Until then only a stimulation rate of 750 pps/channel was available. Patients often reported a dull sound when switching from FSP to FS4. The aim of this study was to evaluate whether a higher stimulation rate of the basal 8 channels in FS4 would result in increased speech perception.

Methods: 26 patients were fitted with 4 „flat maps“, meaning that stimulations levels were the same for each channel. FS4 with high rate, FS4 with low rate, and CIS with high and low rate were used. Only the volume was adapted to a similar level. Monosyllables tests in quiet were taken and subjective listening qualities were assessed by a visual analogue scale (VAS). All tests were performed acutely in a randomized sequence.

Results: A statistically significant improvement of monosyllable scores was noted with the FS4 high rate strategy compared to all other strategies. Subjective VAS scores showed a similar trend albeit without statistically significant differences due to the high variation of VAS scores.

Conclusion: FS4 high rate offers improved speech perception with cochlear implants.

S21-5

Perception of unresolved harmonics processed by fine structure coding strategies in CI users

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Formant frequencies play a major role in vowel identification and are characterized by the resonant frequencies of the vocal tract. Changes in formant frequency lead to amplitude variations of the harmonics of the signal. Unresolved harmonics are generated in cochlear implants when multiple harmonics fall within the frequency range of one filter band. Modifications in the amplitude of these unresolved harmonics, for example due to formant frequencies changes, can cause a temporal shift of zero crossings in the bandpass filter output. This will result in deviations of a constant pulse rate when fine structure coding strategies such as FS4 (MED-EL) are used, because they trigger stimulation pulses according to the zero crossings. Furthermore the modulation depth of the signal envelope and the overall amplitude varies with the changes in amplitude of the harmonics. This study investigated if CI user were able to use temporal variations of the stimulus pattern for better formant frequency differentiation or whether the perception is dominated by the amplitude modulations.

The temporal shifts and the amplitude modulations were simulated in a simple model considering two harmonics within a frequency band. In experiment 1 the discrimination of temporal variations and amplitude modulations was measured in isolation and in combination in 10 subjects by direct stimulation of the implant. Additionally the discrimination threshold was measured for a CIS simulation. Experiment 2 considered the prepossessing of the OPUS 2 processor and included 19 subjects. The discrimination thresholds were measured with the FS4 and HDCIS strategy, in a one-channel-condition (electrode 2 activated) and with a completely activated electrode array. The results of experiment 1 demonstrated that CI users were able to discriminate the temporal variations of the stimulation pattern. However, amplitude modulations were also important for discrimination. However, the perception was dominated by amplitude modulations, so that no differences existed between constant and alternating pulse rates in combination with amplitude modulations. In experiment 2 two thirds of the subjects showed nearly equal results for all conditions and confirmed the results of experiment 1. The remaining subjects however showed better results for FS4 over CIS, as well as better results for the one-channel-condition over the full-map-condition. Possible explanations and consequences for signal coding strategies are discussed in the presentation.

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S21-6

Cochlear implants with single and multi-channel automatic gain control

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The limited dynamic range of electric hearing is a problem that in most of today's cochlear implant (CI) systems is addressed by a single broad-band AGC system at the front-end of the sound processor. In contrast, acoustic hearing aids typically use multiple independent AGC channels. We examined whether two-channel AGC would bring benefit to CI recipients. A low-frequency noise was added to the 20 tokens in a vCv test, using an adverse signal-to-noise ratio. Four Advanced Bionics recipients listened to the stimuli, following processing by one- or two-channel AGC systems. Five normal hearing (NH) adults were also tested, using six-channel vocoded stimuli.

All participants scored better with the two- than with the one-channel AGC. Group mean scores for two- and one-channel compression, respectively, were: 61% and 29% ($t=2.13$, $p=0.002$) for the NH group and 54% and 26% ($t=3.18$, $p=0.001$), for the CI group. Similar results were obtained with several real-world noises.

The results indicate that two-channel front-end AGC can give better results than one-channel AGC and that controlling the AGC with a classifier could lead to a greater improvement for real life situations.

S21-7

A numerical investigation of the effect of pulse width coding vs pulse amplitude coding in different stimulation modes

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Most cochlear implants encode the sound energy present in each frequency band by modulating the amplitude of the pulse of stimulation. However, it is also possible to encode intensity by modulating the pulse width. McKay and McDermott (1999) have shown that to maintain equal loudness when doubling the pulse duration, patients did not halve current amplitude but tended to decrease it by a smaller amount. The exact mechanism behind this phenomenon is hypothetically linked to the auditory nerve membrane leakiness. It has often been inferred from these single pulse results that pulse amplitude coding is more efficient than pulse width. This general claim is overstated if one considers the increasing evidence for finer effects in electrical stimulation. For instance, the simple fact of changing pulse shape is known to drastically change patient's stimulation thresholds, spread of excitation and pulse rate discrimination ability. We investigate here thoroughly the differences between pulse width and pulse amplitude modulation coding. We use a 3D model of the implanted cochlea to simulate the intra-cochlear electric field produced at the nodes of Ranvier. The actions potentials of auditory nerve fibers model are recorded and used to compare the impact of both types of coding strategies. We study how the spread of excitation varies when nerve fibers of the modiulus are stimulated by a single pulse of varying duration or amplitude. The total number of spikes produced in each strategy is used to model the changes in perceived loudness. Similarly the spread of excitation produced by trains of pulses is investigated. Finally, we demonstrate that the stimulation mode also interacts with the type of pulse modulation used when coding sound intensity.

S21-8

The effect of stimulation field spread on cochlear implant users' pitch ranking performance: A model-based investigation

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Intro: Although many cochlear implant (CI) recipients perceive speech very well in favorable conditions, they still have difficulty with music, speech in noisy environments, and tonal languages. Studies show that CI users' performances in these tasks are correlated with their ability to perceive pitch. The spread of stimulation field from the electrodes to the auditory nerve (AN) is one of the factors affecting performance. This study proposes a model of auditory perception to predict the performance of CI users in pitch ranking tasks using existing sound processing schemes. The model is then used as a platform to investigate the effect of stimulation field spread on performance.

Methods: The data used are 192 synthetic vowel-like sounds with four fundamental frequencies spaced at ½ octaves (viz. G2, C#3, G3, C#4). The model comprises a two-layer feed-forward neural network acting as a pitch classifier followed by a decision layer that determines which of the two sequentially presented sounds has a higher pitch. The network is trained using the back-propagation algorithm. The input to the network is the simulated activity of 200 AN fibres generated by either a model of acoustical (representing normal hearing, NH) or electrical stimulation (CI) of the AN. For the latter, the input stimuli are processed by a CI simulator using the ACE or CIS strategies with standard configurations. NH listeners achieve near-perfect scores on this task, while CI users score about 70% correct on average. The attenuation of the stimulation field along the cochlear duct is described by a field spread function. The scaling factor (SF) indicates the width of the function and can be used to match the electric model output and a CI patient's individual ECAP recordings.

Results: The model performance is 100% on NH data. CI results for different SFs are shown in Fig. 1.

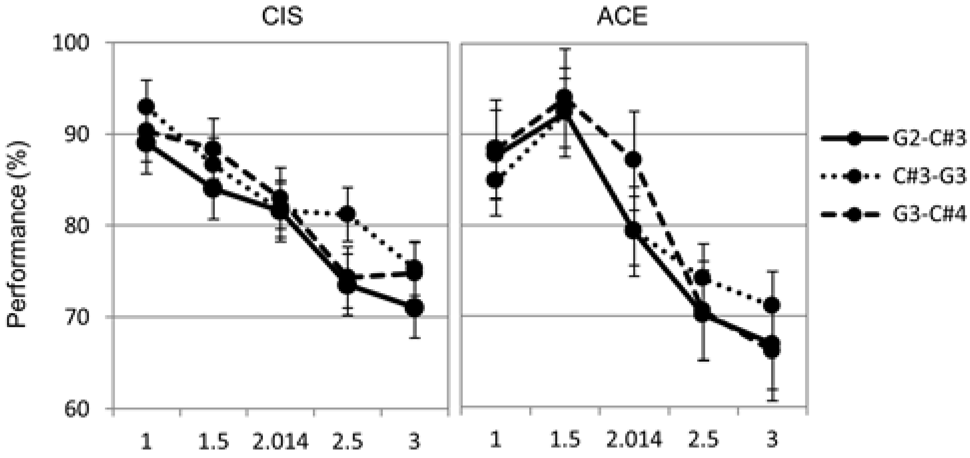

Fig. 1: Pitch ranking scores vs. SF for the CIS and ACE strategies. Pitch pairs are separated by ½ octaves and shown with different line styles. The patients' average estimated SF is 2.014. Smaller (larger) SFs indicate less (more) degree of stimulation field spread in the AN. Vertical lines show standard error within simulation trials.

[figure]

Discussion: Both processing schemes benefit from focused stimulation fields. Pitch ranking scores drop when wider fields are applied. ACE proves to be more sensitive to the amount of field spread compared to CIS.

Conclusion: Strategies like ACE, where multiple adjacent electrodes are activated simultaneously benefit more from focused stimulation currents in performing demanding tasks such as pitch ranking.

Learning outcome: Computational models of the auditory system can help explain human auditory performance and be applied to investigate the factors affecting the performance of CI users.

S21-9

Evaluation of temporal masking in a cochlear implant speech processing strategy: TPACE

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The recently developed PACE (Psychoacoustic Advanced Combination Encoder) strategy modifies the n-of-m maxima selection algorithm with a psychoacoustic model that employs simultaneous masking to select the perceptually relevant channels for stimulation. The results with this new strategy, which was clinically released under the name MP3000, were encouraging. It was possible to reduce the number of stimulated electrodes and preserve the same level of speech intelligibility as with a conventional n-of-m strategy (i.e. ACE). This successfully reduced the energy consumption of the device. However, the performance of the patients was not further improved. A novel CI coding strategy TPACE, which is based on the PACE, proceed in the direction of removing unnecessary information to save bandwidth for the very limited electrode-nerve interface. The psychophysical model for maxima selection was enhanced by a temporal masking algorithm. The strength of temporal masking in TPACE is described by Temporal Masking Half-life $T_{½}$. This time constant gives the time after which the strength of temporal masking has decreased to the half amount of simultaneous masking. The TPACE algorithm was implemented using Nucleus Implant Communicator software interface. Acute streaming experiments where performed with twelve cochlear implant subjects using two time constants $T_{½}$ of 0.5 and 1.1 ms. The speech intelligibility in speech shaped nose was tested with HSM sentences. The performance of TPACE with $T_{½}$= 0.5 ms improved significantly compared to PACE. Results were 35 % for PACE, 45 % for TPACE with $T_{½}$ = 0.5 ms and 39 % with TPACE with $T_{½}$ = 1.1 ms. These results indicate that the consideration of short-acting temporal masking can improve speech understanding in noise in cochlear implant subjects. The goals of the following investigations will be the determination of an optimal time constant and the evaluation of this new strategy in a chronical study.

S21-10

Relevance of high frequencies for speech recognition in noise

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Introduction: Currently, the maximum frequency at which cochlear implants can produce stimulation is around 8 kHz. In quiet conditions, the majority of patients have very good results in speech recognition tests. However, this is not the case when noise is added. Experience in telephone communications using digital devices with a single microphone, which can register a maximum frequency of 4 kHz, demonstrates that even normal hearing users have difficulties in understanding a conversation as the noise volume increases. This led to the hypothesis that the key to better speech recognition in noise could be partially related to the high frequency components of speech. To this end, an experiment that studies the effect of the suppression of the frequency components of words above 8 kHz using normal hearing subjects was conducted.

Methods:

Subjects: 29 subjects were selected, aged 19-55 years. All were native speakers of Spanish language. The subjects had pure tone thresholds better than 20dB when subjected to a preliminary audiometry. All subjects came voluntarily and gave informed consent.

Speech material and background noise: Frequency modifications were applied to the bisyllabic "Test de Navarra" and noise files were generated using MatLab R2012b. Six lists were used. Two groups were made of three lists each. In the first group, frequency components were unaltered and sampled at 44,1 kHz. In the second group, a Butterworth filter of order 4 with a bandpass from 70 Hz to 8 kHz was used. The sound pressure level (SPL) of the lists was calibrated to be 65dB. Two white noise files were also generated. The first was sampled at 44,1 kHz and the second was created from the first, but the above mentioned Butterworth filter was applied. Three sets of SPLs were used for the two noise files: 60dB, 65dB and 70dB, establishing three sets of signal to noise (SNR) conditions: SNR +5dB, 0dB and -5dB respectively.

Results: The study indicates a tendency towards better performance in the cases where the high frequency components of words are not suppressed for SNR +5dB and -5dB. In both situations, 17% more of the words were correctly identified for the lists were frequency components were not filtered. However, for the intermediate case (0 SNR), an unexpected situation arises: Both conditions yield statistically similar performance.

Discussion: This study suggests that high frequency components do play a significant role in word identification in noisy environments. Nevertheless, there seems to be a difference in the way these are identified when both signals and noise have equal sound levels.

Learning outcome: Mid to high frequencies might constitute a natural filter that helps humans to recognize words in noisy conditions.

S21-13

Speech perception in noise with fine structure coding strategies

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Introduction: development in speech coding strategies in cochlear implants (CI's) has recently focused on the enhancement of temporal fine structure cues. This temporal coding is believed to improve speech perception in noise, sound quality and music perception and may also contribute to better sound localization in patients with contralateral acoustic hearing or with bilateral CI's. The goal of this study was to investigate the effect of FSP on speech perception in noise in various CI user groups.

Methods: Speech perception in noise was measured with CIS and FSP strategy in three CI groups: (bilateral deaf CI users, EAS users and SSD CI users. Subjects were followed up for minimum 12 months.

Results: FSP significantly improves speech perception in noise for the bilaterally deaf group and SSD group. For combined EAS no significant improvement in speech perception in noise was measured.

Conclusion: FS coding strategies can significantly improve speech perception in noise. However in cases of combined EAS FS does not significantly effect on speech perception in noise. In EAS acoustic amplification is applied in low frequencies and FS is applied to channels assigned to higher frequencies than in regular cases. FS may be less efficient in these cases.

S21-14

Evaluation of sound localization performance of normal hearing and cochlear implant listeners

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For sound source localization in the horizontal plane the brain relies on binaural cues, namely interaural time- and level differences (ITDs and ILDs). With these cues sound sources at different locations in space can be separated even in complex acoustic environments, such as concurrent speakers and background noise. The ability to separate sound sources increases the speech reception threshold.

In the intact hearing system (normal hearing: NH), these binaural cues are coded in the firing patterns of both auditory nerves. This study evaluates auditory nerve responses in the case where both ears are fitted with cochlear implants (CIs). Where it is already known that CI users can utilize ILDs, the focus of this work is on the evaluation of ITD cues. The performance and localization limits were tested with a model approach [3,4]. Here the Lindemann model [1], a derivate of the coincidence (Jeffress-) model [2], was modified to work with spike trains of electrically (CI) or acoustically (NH) excited auditory nerves. Test signals were engineered with artificial ITDs and ILDs. The modified Lindemann model [1] provided quantitative data to evaluate the precision of these cues for sound localization. The robustness and limits of ITD cues were tested with added background noise at different signal to noise ratios.

Our analysis revealed that the CIS strategy did not provide useful ITD cues. However, todays latest fine-structure coding strategies, as FS4 by MED-EL, are already able to convey viable cues for sound source localization. At the level of the auditory nerve, the localization model was able to discriminate up to 7 localizations in the horizontal plane by ITD cues alone. Measurements with bilateral CI users are ongoing to test, if CI users are also able to take advantage of these ITD cues.

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S21-17

The use of partial bipolar stimulation in cochlear implants to create spectral channels apical to the stimulated electrode pair

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Objective: Cochlear implant electrode arrays have a more shallow insertion depth than the physiological place-to-frequency distribution, as a deep insertion could lead to intra-cochlear trauma. An alternative for a deeper insertion can be the so-called phantom channel, which is partial bipolar stimulation, with non-equal amplitudes on the two stimulating contacts. Through the use of psychophysical experiments and computational modeling this study investigates the neural excitation, place of stimulation and the perceived loudness of a phantom channel.

Method: Ten postlingually adult deafened users of the HiRes90K cochlear implant with a HiFocus1J electrode array were selected to participate in this study. The stimulation level required to maintain equal loudness with monopolar stimulation was determined with a psychophysical loudness balancing experiment. The largest achievable pitch shift by varying the bipolar coefficient was determined in two steps, using a pitch-ranking procedure followed by a pitch matching experiment. Through use of a computational model of the cochlea, the mechanism underlying phantom stimulation was studied, predictions concerning the current correction required to reach similar excitation widths and the largest pitch shift for three different cochlear morphologies with the electrode array in both medial and lateral position.

Results:

1. More current is needed on the primary electrode when increasing the current on the compensating electrode to maintain equal loudness.
2. All subjects exhibited an apical pitch shift with an average of 1 electrode contact.
3. The psychophysical results are in line with the predictions of the computational model.
4. The computational model predicts that the electrode array in lateral position exhibits a larger pitch shift to apical than the medial position.

Conclusion: Both the computational model of the cochlea and the psychophysical data show that it is possible to stimulate in a more apical region with phantom stimulation and that more current is needed to maintain equal loudness. The model predicts, however, that stimulating at lower levels decreases the pitch shift and the electrode array in a lateral position would generate a larger pitch shift than in medial position.

S21-19

Reducing electrical interaction during parallel stimulation using various compensation techniques

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Background/ Purpose: To improve spatial selectivity, various multipolar stimulation paradigms were tested in recent years. In general more charge is required to reach sufficient loudness, in turn requiring broader pulses and reduced rates to stay within voltage compliance limits. The use of parallel stimulation is a possible solution for this problem. However, this was associated with performance degradation in the past, most likely as a consequence of electrical interaction.

Methods: This study uses psychophysics and computational modeling to evaluate three methods to reduce electrical interaction for parallel stimulation.

The compensation methods used targeted to get the same neural excitation elicited by sequential monopolar stimulation and were compared with standard simultaneous stimulation. The following compensation methods were evaluated: the Channel Interaction Compensation (CIC) algorithm (Zierhofer, 2008), partial tripolar stimulation (pTP) and a phased array compensation (PAC) method. In this last method the target was not to achieve a zero potential along the array but to get a field equal to the superposition of two monopolar current sources.

Result: In both model and patients (n=8) the loudness growth was evaluated for all four situations, where ideally the same growth of the sequential monopoles would be found. Additionally, the interaction between simultaneously stimulated maskers (with 3 or 5 contacts in between) was measured in the patients using forward masking experiments, with a monopolar probe contact exactly in between the two maskers. The model allowed for detailed analysis of the neural excitation patterns created by the different stimuli on a range of levels. Preliminary results indicate that with just 3 contacts between the maskers, none of the compensation methods is successful in reducing the threshold shifts caused by interaction between them. For the wider separation detection thresholds are all slightly lower, but only the PAC and the pTP are in the same range as the sequential stimulus. The loudness experiments show that CIC and the PAC restore the loudness growth towards that of the sequential paradigm while pTP needs much more current.

Conclusion: The preliminary conclusion is that it is possible to compensate for the negative effects of electrical interaction during parallel stimulation at least at the level of excitation patterns. Future research has to demonstrate whether this will also lead to better speech perception.

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S21-20

Enhanced sound coding for the perception of prosody by cochlear implant users

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Intro: Novel sound coding variants with enhanced spectral and temporal processing (STEP) were developed with the aim to explore and improve the perception by CI subjects of prosodic information carried by voice pitch. A dual filter-bank approach was employed with a bank of narrow, high Q filters (SP) and a bank of parallel wide filters (TE). SP filters reduced redundancy between channels and TE filters enhanced modulation depth and synchronization using “beating” between harmonics.

Methods: Five Nucleus CI recipients have been evaluated in acute experiments on several F0-based tasks using three coding variants: ACE and STEP were compared using the standard Nucleus frequency-to-electrode allocation function (FAT) along with STEP combined with an “efficient” F1-centric FAT (Ming & Holt, 2009, JASA 126; 1312-1320): STEP-F1 allowed the resolution of harmonics for F0 >150 Hz by allocating more electrodes to low frequencies. In these initial trials subjects used their standard stimulation rates; 720 to 1200 pps/ch. Voice prosody perception was evaluated with a female speaker (F0 180-500 Hz) using the 24-item French Question/Statement discrimination task developed by Patel et al. (2008, Music Perception 25; 357-368). Further, pitch ranking was evaluated for the F0 ranges 126 to 165 Hz and 165 to 212 Hz, using band-pass filtered vowel stimuli similar to those employed by Milczynski et al. (2009, JASA 125; 2260-2271).

Results: Two of five subjects performed well (d' > 2; sig. > chance) on the Question/Statement discrimination task for all three coding variants. The other three subjects performed at or near chance for both ACE and STEP using the standard FAT; however using STEP-F1 all three subjects had high scores (d' >2). Pitch ranking functions (PRF) were mostly monotonic across all subjects for the lower F0 range. Overall STEP increased maximum scores or improved DLs compared to ACE. However for the higher F0 range PRFs were low and flat or irregular for two subjects even at 900 pps/ch. In these two cases STEP eliminated pitch rank reversals but did not restore the monotonic psychometric function. Increasing spectral resolution with STEP-F1 improved overall performance and partially restored the monotonic pitch ranking function in one case.

Conclusion: The current results are mostly in agreement with other studies of F0 enhancement in CI: Temporal envelope enhancement only was not sufficient to provide large functional benefits on F0 related tasks for individuals, or small benefits across subjects. However when spectral cues to F0 were additionally enhanced using STEP-F1, significant improvements in speech prosody perception were seen for subjects with generally poorer F0 perception.

Learning outcome: Temporal enhancement of F0 cues alone does not produce functional benefits. However the additional enhancement of spectral cues to F0 may improve performance for speech prosody and tonal language perception. The effect of experience is currently unknown.

S21-21

An application of Pitch-Envelope Analysis for speech encoding and transposition

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The algorithm named Pitch-Envelope Analysis (PEA) was initially developed by our team for the analysis of transient evoked otoacoustic emission fine structure and was evaluated both as a first stage of speech encoding strategy and as a method for speech transposition.

The idea of this algorithm was inspired by the unpublished presentation by Chris James (Cochlear Europe, Symposium “Sound processing and beyond”, Amsterdam, Sept. 2012). In our algorithm we made significant improvements: we use 3 sets of FFT transforms combined by fuzzy logic, a very effective iterative frequency refining in narrow bands, least squares method for amplitude estimation, the component reduction loop and final reordering of results for simplification of further data processing. The algorithm is suitable for the analysis of a signal where the signal supposed to consist of transient tonal components and a noise, the amplitude of components changes much faster than their frequencies and only few number of components (3—20) are significant simultaneously. In contrast with some other algorithms the PEA tries to describe each component by a fast amplitude changing instead of a bunch of frequencies or a broadened spectrum. In silent environment the algorithm has very high time as well as frequency resolution. The algorithm represents a signal as a set of dominant tones in a fixed number of channels. Supposedly these data can be directly recalculated to stimulation current of a cochlear implant (CI). A frequency transposed speech could also be recovered. For the representation of consonants a special channel must be used together with PEA. In this presentation the perception of sound processed by this algorithm and recovered back by normal hearing subjects is investigated. Parameters of the algorithm were optimized by two criteria: the score of world recognition in speech tests and a pleasantness of sound in a radio show. The possibility of a frequency transposition was also inquired. The results obtained can be used as a starting point for development of speech encoding strategy for CI.

S22 Difficult and atypical patients, challenging situations, borderline cases, CI for children in deaf families

S22-2

Ludwig van Beethoven A CI candidate; wrong timing. A biography of his deafness

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This music-enhanced oral presentation discusses briefly a concise biography of the deafness of the great musician Ludwig van Beethoven. Conclusions have been drawn from the available historic data and documents as to attempt to figure out the type and etiology of his hearing loss. From the history, symptoms and progress of his auditory handicap, a faith has been developed relating his deafness to a sensorineural pathology. A likely differential diagnosis was drawn and discussed. Beethoven was probably an ideal candidate for cochlear implantation, but he just came in the wrong timing; a couple of centuries earlier.

S22-3

Somatosensorial perception with Cochlear Implant stimulation in adults with prelingual deafness

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Introduction: With improvements in Cochlear Implants (CI) technology it became evident, that speech perception and quality of life can improve after implantation in at least some adults with prelingual hearing loss (Peasgood et al, 2003; Waltzman & Cohen, 1999; Zwolan et al, 1996).

Objective: The purpose of this study was to investigate auditory outcomes in prelingually deaf adults CI patients, comparing the overall pre-CI and the post-CI speech perception scores, with focus in somatosensory stimulation.

Material and methods: Prelingually adult deaf patients implanted at the Cochlear Implant Center “Prof. Diamante”, Buenos Aires, Argentina, were subjects in this study. They are 35 subjects, 13 females (43%) and 16 males (51%); the mean age at CI was 26 years (18- 42 years) Patients were evaluated with the Latin American Protocol (Cochlear Corp) using vowels, consonants, disyllabic words and sentences. Results were compared in relation with the presence or absence of somatosensory stimulation with the CI activation.•

Results: All patients showed gradually improving performance in speech perception. The results showed a high variability in outcomes. 40% of these patients experienced somatosensory phenomena with activation of CI. These 14 prelingually deaf subjects ,(mean 0% in the pre CI to 16 % in recognition of disyllabic words and 12% in sentences 12 months post CI) although these differences are not statistically significant they reported subjective benefits with their CI Comparing the mean results of this group with the group that do not have somatosensory stimulation (38% in recognition of disyllabic words and 40% in sentences, 12 months post CI), we see significant statistical differences comparing pre vs post CI. The somantosensory phenomena was located ipsilateral to the implanted ear (e.g., head, neck, chest, abdomen) with CI stimulation. These sensations resolved gradually for all patients, up to 4 months after tune up.

Conclusions: We consider with Mc Feely et al., (1998) that the presence of somatosensorial phenomenon in CI patients could be due to central disorganization or colonization of the auditory cortex by other sensory modalities. As Sharma (2009) established, when auditory stimulation is not delivered in a timely fashion, then areas of the auditory cortex will re-organize to process stimuli from other sensory modalities: and may occur Compensatory or Maladaptive plasticity: Cross Modal Re-organization. It is necessary setting appropriate expectations (including possible somatosensorial perception) during pre-CI evaluation and counseling of adults candidates with preilingual deafness.

Key words: somatosensorial perception, prelingually deaf adults, central disorganization, cross modal re-organization.

S22-4

Benefits of cochlear implantation in prelingual adult patients with long-term deafness (twenty years or more)

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Intro: Until recently, the benefits that cochlear implantation could provide to adult patients with long time deafness were still uncertain. However, lately, this concept has begun to change. The aim of this study is to present the results of late cochlear implantation in prelingual deaf adult patients.

Methods: This research is a retrospective study on ten prelingual profound deaf adult patients, with limited benefit in the previous use of hearing aids. Seventeen patients were unilaterally implanted, three patients bilaterally. All of them were implanted after twenty years or more, the deafness had been diagnosed. They received cochlear implants at ages ranging from 20 to 64 years. Currently, these patients are users of CIS, HDCIS or FS4 strategy and used their devices for at least one year. The participants were evaluated with the Speech, Spatial, and of Hearing Scale. The perception of music with the cochlear implant was evaluated through the Munich Music Questionnaire. Speech recognition was evaluated through lists of 25 disyllabic phonetically balanced words using their actual hearing device.

Results: Results indicate that all patients were benefited by the use of cochlear implants, especially regarding the quality of sound and music perception.

Conclusion: Later cochlear implantation can be considered for prelingual adults patients with long time deafness as a therapeutic alternative. Regardless of the limited number of subjects included in this study, it can be affirmed that all of them reported important improvements in their auditory skills after implantation.

Learning outcome: gives information about auditory and musical skills in prelingual adult patients with long-term deafness.

S22-5

Cochlear implantation outcomes in older children with prelingual deafness: should we be saying no?

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Introduction: Paediatric candidacy for CI has been expanding in recent times with guidelines for benefit according to hearing thresholds being relaxed. Despite this, guidance for implantation in children with congenital profound hearing loss (HL) has become more robust with the ideal age for CI thought to be around 10-12 months. Referral protocols advise against the referral of children aged 4 and over for CI unless sufficient benefit from hearing aids can be demonstrated. However, the idea of 'sufficient benefit' is often difficult to define.

Methods: A retrospective case review from 2006 to 2013 was undertaken. Children with congenital or suspected congenital profound prelingual HL referred for assessment, aged 6 years and over, were identified. Postoperative outcomes including Categories of Auditory Perception scale (CAP2), Speech Intelligibility Rating (SIR) and Categories of Expressive Performance (CEP) scores were collected prior to and following implantation. A Brief Assessment of Parental Perception (BAPP) following CI was also administered.

Results: We identified, 13 patients with prelingual HL over the age of 6 years who proceeded to CI following assessment. The mean age at implantation was 8.7 years (range 6 - 14 years). Analysis revealed that the majority of children who were implanted attended either mainstream or resource-based placements. Those who underwent CI also used spoken language or a combination of sign and speech as their main form of communication. Attendance to a deaf school and/or use of British sign language as a primary communication mode was not a considered a contraindication for CI during assessment.. Improvements in all 3 outcome scales were noted postoperatively following CI with the mean CAP2 scores improving significantly on statistical testing (t-test: p=0.003). The BAPP questionnaire revealed that all parents reported improvements in quality of life (QOL) following CI and would recommend CI to others.

Discussion: This study demonstrates the positive impact CI can have in older children who would otherwise not be considered candidates according to current criteria. The benefits are not only in terms of listening, speech intelligibility and expressive language but also in terms of QOL.

Conclusion: Identification of older prelingually deaf children through thorough diagnostic assessment who may benefit from CI is an important area where candidacy can be expanded with positive outcomes.

Learning outcome: Age alone should not be a factor at rejecting older prelingually deaf children from CI.

S22-6

Late cochlear implant

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Late cochlear implant opens doors for children older than 6 years of age and adults to the auditory world giving them the opportunity to develop listening skills, improve oral and written language , focusing on providing a better quality of life.

Prelingual children over 6 years of age may have different communicative situations:

1. Children with sign language.
2. Auralized children who manage augmentative systems such as lip reading or cued speech.
3. Auralized children whose only support is lip reading.

Miyamoto y col(1986):" "The possibility of making the most of global learning and brain adaptation capacities during early childhood is what advices on an early implant in children who are eligible on candidates selection". Children with sign language. Auralized children who manage augmentative systems such as lip reading or cued speech:

1. Listening and oral procedures are constructed from the potential and framework the child brings in order to construct the word heard from the sign and writing of it.
2. Sign and written word already have a concept but an acoustic and oral image is added.
3. Lip reading will be favored by hearing.
4. Phonological awareness improves with hearing supported by literacy.

Auralized children with solely lip reading back up:

1. Basic period of language development was assimilated by lip reading.
2. There was cognitive work, formed by words which need better acoustic information.
3. Phonological awareness in suprasegmental aspects will be worked on to improve the rhythm and intonation of the word.

Conclusions:

- Improvement of the word in a noisy environment.
- Better development in language, oral and written competence.
- Need support of lip reading and writing.
- Children implanted during adolescence fail to speak by phone.
- Achieve semi -closed form.
- Better speech production at suprasegmental level.
- Segmental aspect is not achieved by all children. Some children reach category 4 (according to Moon and Gears).

S22-7

Case study of a congenitally deafened cochlear implant recipient

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Introduction: This case-study presents Jacob, a congenitally deafened 25yr old with no measurable hearing in either ear. He has not worn hearing aids since the age of 16. Jacob uses sign language (Auslan) as his main form of communication, though he tries to vocalize as well, which results in a very high pitched squeal. Jacob identifies as a deaf person and with the deaf community, and leads a busy and fulfilling life. He currently works in IT and is studying software engineering at university. Jacob was originally assessed for CI at the age of 12 but was told at the time that a CI would be of little benefit and his candidacy process was discontinued. Jacob decided to seek further information about CIs because a number of congenitally deafened friends had obtained a cochlear implant and appeared to be finding them beneficial, especially with regard to voice monitoring and to some degree speech production. Jacob had very realistic goals - and among these was the hope to be better able to monitor his voice, with regard to both pitch and volume.

Method: A comprehensive assessment was completed to evaluate Jacob's suitability for cochlear implantation including:

- Audiological and medical (including electrophysiological) assessment;
- Speech production tests;
- COSI goals &
- Counseling with regard to realistic goals and outcomes.

After much consideration Jacob decided to go ahead with cochlear implantation in his “better” ear and was implanted in June 2013.

Results: Pre and post-operative audiological and speech production assessments are being done at defined intervals and will be presented as a part of this paper, as well as outcomes with regards to his goals.

Discussion and conclusion: Jacob's initial reaction to the CI was one of emotion, however since that time he has gathered both momentum and enthusiasm. He gains good benefit from his implant, having gained good environmental awareness and is building an ever growing understanding of different sounds around him. Aided assessment has suggested that Jacob has the potential to access all speech frequencies. He is finding he can gradually both more easily lip-read and understand things people are saying to him. His vocalizations have increased and more importantly, he is better able to monitor his own voice- such that he no longer has the high pitched squeal he had prior to implantation.

Learning outcome: It is hoped that this case study may influence candidacy evaluation of other motivated young adults with congenital deafness considering cochlear implantation, when discussed with realistic expectations.

S22-9

Screening for Usher Syndrome in children with sensorineural hearing loss: the importance of vestibular and balance assessment

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Objectives: Quantify the prevalence of vestibular and balance deficits in children with Type I Usher Syndrome and examine the use of balance function assessment as a screening tool for further evaluation.

Methods: Nineteen children with cochleovestibular deficits were sent for full ophthalmologic evaluation, including electroretinography, as part of an assessment for Usher Syndrome. Static and dynamic balance was evaluated using the Bruininks-Oseretsky test of motor proficiency (BOT-2). Horizontal canal function was assessed with caloric testing, rotational chair and/or video head impulse testing and saccular function was assessed using vestibular evoked myogenic potentials.

Results: Balance as measured by BOT-2 scores were significantly worse in children with known cochlovestibular deficits compared to a larger cohort of children with sensorineural hearing loss ($p< 0.0001$). Of the 19 children with cochleovestibular deficits, a high proprotion (8/19, 42%) were diagnosed with Usher Syndrome. In the majority of cases (7/8, 88%) children who went on to a diagnosis of Usher's demonstrated complete bilateral vestibular end-organ dysfunction (horizontal canal/saccule) and this was significantly more frequent than in the other 11 children (2/11, 18%) ($p=0.007$) who did not receive a diagnosis of Usher Syndrome. Balance scores were not significantly different between groups ($p=0.18$).

Conclusion: In this study, all children with Usher Syndrome had complete vestibular loss and poor balance. We used this phenotype to initiate specialized opthalmalogic evaluation, which lead to Usher Syndrome diagnosis in nearly half of children investigated. Given the high yield, we continue to use vestibular and balance dysfunction as a trigger for evaluation of Usher Syndrome prospectively. The use of phenotype as a trigger for ophthalmologic evaluation reduces unnecessary and anxiety provoking evaluations and streamlines the interpretation of genetics results in the setting of Usher Syndrome

S22-10

Clinical findings before and after cochlear implantation in a patient with Susac Syndrome

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A 20 year old female presented with a sudden sensorineural hearing loss for evaluation. She was diagnosed with Susac's Syndrome with the clinical triad first described by Dr. John Susac in 1975 which includes: (1) encephalopathy, (2) branch retinal artery occlusions and (3) hearing loss. In her case the hearing loss was profound and hearing aids were not helpful. Her audiogram showed a flat sensorineural loss averaging 90 dB in the left ear and no residual hearing in the right ear. Her speech recognition was 0%. The decision was made to implant both ears during the same surgery. She received 2 Cochlear CI24RE devices in 2007 without any complications. Intra-operative NRT showed some interesting findings, which will be described, including sweep functions, recovery functions and spread of excitation. Post operatively, her speech recognition scores were very good and her right ear had better scores on CNC words, AzBio Sentences and the BKB Speech in Noise Test. Retrospective comparisons of her intra-operative NRT and her post-operative speech perception results were consistently better in the right ear. Her audiogram had shown some residual hearing but only in her left ear. In this case, the preoperative audiogram did not predict the better performance of her right ear. We suggest that the NRT findings were better for the right ear possibly due to better nerve survival.

S22-11

Profound sudden sensorineural hearing loss in patients diagnosed with Superficial Siderosis of the Central Nervous System (SSCN)

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Superficial siderosis (SSCN) can be a destructive disorder affecting the auditory-vestibular system. SSCN is not a common diagnosis, but it may be more prevalent than clinicians realize. The sites of lesion may be anywhere within the auditory-vestibular system from the inner ear to the cortex. The cochleovestibular nerve and cerebellum are particularly vulnerable. The progressive retrocochlear nature of this disorder can make the differential diagnosis difficult and the development of effective treatment options challenging. It is essential that audiologists and otologists recognize this uncommon cause of sensorineural hearing loss and balance disorders. We will summarize our review of 49 patients diagnosed with SSCN as well as 30+ published case reports. We will also report on 2 specific cases of SSCN who received a cochlear implant.

S22-12

Outcomes of cochlear implantation in auditory neuropathy spectrum disorder

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The aim of this study was to describe the results of cochlear implantation (CI) in patients with auditory neuropathy spectrum disorders (ANSD) and identify any influencing factors.

Retrospective case series in a tertiary, referral centre. Hearing performance in patients with ANSD treated with CI was assessed with Categories of Auditory Performance (CAP) and the Manchester Spoken Language Development Scale (MSLDS). The pre- and post-CI hearing outcomes were compared. Multivariate linear regression analysis was performed to identify any affecting factors among age at referral, age at implantation, follow-up time and pre-implantation scores. Twenty-seven children with ANSD were implanted with average age at implantation 35.4 months (range 19-68 months) and follow-up 63.1 months (range 6-140 months). Nine children were implanted bilaterally, while 13 were bimodal. The pre-CI CAP and MSLDS scores were 2.5 (range 0-5) and 2.5 (range 0-6), while the post-CI scores 5.8 (range 2-9) and 7.7 (range 3-10), respectively. The difference between the pre- and post-CI scores was statistically significant for both scales ($p < 0.001$). Cognitive disorders and co-morbidities and the follow-up time (duration of use) were identified as influencing factors ($p < 0.05$), while the age at implantation was not. CI is a justified hearing rehabilitation option for children with ANSD with limited benefits from hearing aids. Cognitive disorders predict worse but still beneficial results. In children with ANSD treated with hearing aids, older age at implantation does not seem to affect significantly the CI outcome. CI is beneficial in children with auditory neuropathy spectrum disorders.

S22-13

Hypoplastic and aplastic cochlear nerves: is cochlear implantation a viable option?

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Introduction: Hypoplasia or aplasia of the cochlear nerve is a recognized cause of severe to profound sensorineural hearing loss in around 18% of cases. The management of these patients presents a challenge in terms of decision-making regarding whether to proceed with cochlear implantation (CI) and remains a controversial topic. Despite abnormalities of the nerve, previous studies have demonstrated that CI can be of benefit in this group, with patients having significant gains in terms of speech recognition and improved quality of life. We describe our experience of CI in patients with hypoplastic or aplastic nerves.

Methods: A retrospective case review of patients implanted between 2003 and 2013 was undertaken. Patients noted to have hypoplastic or aplastic cochlear nerves following detailed imaging in the form of magnetic resonance imaging (MRI) in conjunction with computed tomography (CT) underwent thorough preoperative assessment. Correlation of scan findings with audiological results was done as part of the assessment and this was the main factor that influenced the decision to offer a CI. Outcomes in terms of audiological measures and performance ratings including categories of auditory performance (CAP2), speech intelligibility rating (SIR) and categories of expressive performance (CEP) were assessed post-implantation.

Results: Six children were identified from the database fulfilling the inclusion criteria. Three patients underwent simultaneous bilateral CI and three patients had sequential bilateral implants. Detailed pre-operative assessment, MRI and CT imaging together with counseling was performed in all cases. MRI demonstrated hypoplastic nerves in three patients and absent nerves in two patients. Mean age at implantation was 2 years (range 1-6 years). Currently, five of the six children remain users of their implants and three are in mainstream schools. The mean CAP2, SIR and CEP scores were 4, 2 and 2 respectively at the last follow-up.

Discussion: Cochlear implantation in children with hypoplastic or aplastic nerves remains controversial and can often be expected to have limited value in terms of sound and speech recognition in comparison to children with normal cochlear nerves. However, the relative potential benefits should be weighed against the alternatives and patients should not be declined CI without proper assessment.

Conclusion: Our experience shows that some patients with deficient or aplastic nerves do benefit from CI and should not be excluded without thorough assessment.

Learning outcomes: Management of these patients is complex and preoperative evaluation is multifaceted. There are difficulties in assessing these patients pre-implantation in terms of audiometric testing and radiological findings. Careful pre-implant counseling is required to ensure that the family have appropriate expectations.

S22-14

Contributions of transtympanic promontory EABR (TEABR) in patients with congenital temporal bone and cochlear nerve anomalies

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As the indications of cochlear implant candidacy have broadened in terms of ranges of hearing loss, there has also been an increase in patients with congenital anomalies considered for implantation. These cases include temporal bone and cochlear nerve anomalies, at times accompanied by additional congenital central nervous system anomalies such as Dandy-Walker syndrome. In some cases, some cochlear implant teams would consider a brain stem implant as either the primary options, or a secondary option if the cochlear implant does not provide satisfactory benefit. The question then arises, how we can evaluate these patients preoperatively to attempt to determine the optimal device, or an alternative treatment to promote communication. We have been using transtympanic EABR for over two decades in a variety of patients, and our experience consists of over 600 cases. In the past the norm was unilateral implants.

We needed a tool that would help us select the most favorable of the two ears, especially in cases of congenital temporal bone malformations and cases with anomalous courses of the cochlear nerve. Initially we based our decision simply upon presence-absence of response and its threshold. In a cohort of patients with congenital temporal bone anomalies we found a statistically significant reduction in wave V amplitude in children with narrowed IAC in comparison to the other two groups ($p< 0.05$), and that lower EABR threshold (< 600µA) and higher wave V amplitude (0.5uV<) demonstrated higher Speech Perception Category post-op ($p< 0.05$).However, we also observed that the mere presence of a response at a reasonable threshold did not always coincide with somewhat effective CI use: some CI patients did poorly with their CI, in spite of reasonable T-EABR thresholds: having only detection or pattern recognition, and lagging behind their CI peers in receptive and expressive language development. Often, these were patients with ANSD and / or narrow IAC/ hypoplastic cochlear nerve. We subsequently discovered that these patients presented with "abnormal adaptation" as indicated by TEABR amplitude reduction, or complete disappearance when consecutive responses were elicited at the same stimulus level. This raises the question whether we can make the assumption that everyone with suitable hearing loss can benefit from some type of neuro-electrical implant, placed somewhere in the auditory pathway ? Further, as auditory brainstem implants become more acceptable, we also need to attempt to make a determination as to how to predict when a patient functioning poorly with a cochlear implant may gain more benefit with an ABI. The presentation will include examples of cases with conditions such as ventriculomegaly, Dandy-Walker syndrome who were either not considered for a CI or did poorly with a CI. We will attempt to answer the question if such cases may benefit further from an ABI, and what if any role a TEABR could play.

S22-15

Cochlear implantation in patient with dual diagnosis of hearing loss and autism

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Intro: Few studies have evaluated the benefits of cochlear implantation (CI) in children with autism. These studies demonstrate varying degrees of benefit. The current study will add to this body of literature by assessing receptive and expressive language skills in children with autism post-implantation and look at quality of life of these kids and their parents post- implantation.

Methods: Retrospective review of patients with autism who had CI in our center. The implant programming, perception and expression scores, development of speech and changes in behavior were analyzed. Quality of life of these patients and their family were examined.

Results: Hearing impaired Children with autism demonstrate significant progress through usage of cochlear implant. Their communication skills are significantly improved with improved perception and expression scores. Their behavior and quality of life after CI are also improved. They are more aware of their environment, they have a significant improvement in name recognition, response to verbal requests, and enjoyment of music. The programming require specific measures adapted to the needs of this population.

Discussion: Kids with autism benefit from cochlear implantation, however measuring the benefit requires to adjust our evaluation methods to be able to score adequatly their receptive and expressive language. Rehabilitation post implantation require more time but also specific adjustment to the needs of these kids (i.e. using behavior therapy or using visual communications methods). Parents of these kids are overwhelmed by amount of different type of therapy required for their child, they will benefit from specific support to help the CI rehabilitation.

Conclusion: Hearing impaired Kids with Autism made significant progress through CI. Significant speech perception and overall behavior improvement are noted. Counseling parents in appropriate expectations and facilitating development through collaboration with behavioral therapist is recommended.

Learning outcome: Appropriate counseling of parent of kids with autism in regard of benefits of cochlear implantation. Adjusting the rehabilitation post implantation to the needs of these kids will help to have better outcome.

S22-16

Stimulation rate reduction and auditory development in poorly performing cochlear implant users with auditory neuropathy

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Objective: Patients with auditory neuropathy spectrum disorder (ANSD) exhibit altered neural synchrony in response to auditory stimuli. It has been hypothesized that a slower rate of electrical stimulation in programming strategies for cochlear implant (CI) users with ANSD may enhance development of neural synchrony and speech perception abilities.

Study Design: Retrospective case series.

Setting: Tertiary otologic practice.

Patients: Twenty-two patients with ANSD underwent CI. Patients with complete postoperative audiometric data and at least 2 years of follow-up were included in further analysis.

Intervention: Thirteen patients patients met inclusion criteria. Five "poorly performing" CI recipients with ANSD who had not developed closed-set speech perception abilities despite at least 2 years of implant use underwent implant programming to lower the neural stimulation rate.

Main outcome measures: Speech perception abilities over time using parent questionnaire, closed-set testing, and open-set measures.

Results: A high incidence of comorbid conditions was present in the poor performers, including cognitive delay (n = 2), motor delay (n = 3), and autism spectrum disorder (n = 1). The median time to rate slowing in 5 poor performers was 36 months after implant activation. Five of 5 patients achieved closed-set speech perception scores higher than 60% after 6 to 16 months of implant use at the slower rates. At last follow-up (median, 42 mo), 2 poor performer had achieved open-set speech perception abilities. Of all CI recipients with ANSD included in analysis, open-set speech perception abilities developed in 61.5% (8/13).

Conclusion: In CI recipients with ANSD who demonstrate limited auditory skills development despite prolonged implant use, lowering the stimulation rate may facilitate acquisition of closed-set speech perception abilities. Further efforts on the study of programming parameters in ANSD patients with CIs are necessary to maximize auditory development in this patient population.

S22-17

Pushing the boundaries: Is it ever too late for an implant?

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Introduction: An audit of 22 prelingually deafened adult cochlear implant users was performed. These adults had profound non-progressive hearing loss before the age of three years. Prelingually deafened adult candidates often present with poor speech intelligibility and may be bilingual, using sign and/or oral language.

Increasing numbers are now presenting as implant candidates. Benefit for this group is not easily quantified, as these recipients do not score on standard sentence level speech discrimination tasks. A review was conducted of their outcomes to establish benefit, to inform our pre-operative counseling, and to implement appropriate rehabilitation techniques.

Method: For this group of patients, implanted for more than year, we sought their views on benefit and experiences by extended questionnaire. We also reviewed the following aspects:

1. Phoneme discrimination measures (pre and post implant);
2. Rates of use and non-use of CI; and
3. Vocal changes

We also rated patients for their functional (practical) communication outcomes.

Results: Responses on the questionnaire indicated the implant offered increased awareness of environmental sounds, better sense of personal safety, and enjoyment of music. Implants were reported as more comfortable to wear than hearing aids and giving better sound perception. Implant use did not interfere with their use of signing.

Phoneme discrimination for this group of patients improved over time with their cochlear implant but not to the same degree as a postlingually deafened group. Several subjects showed changes in vocal quality, improved rhythm of speech and control of their own voice intensity. For some there was also an increase in the number of vocalizations, so that voice was used more widely with lip pattern than preimplant. Rating on our functional outcomes scale proved an informative way of charting post-implant changes.

Discussion and conclusions: The results indicate positive outcomes with this group. Although standard speech discrimination scores may show little (or no) change post implant, clinical rating of outcomes describing their functional benefit does show change. Patients report better access to environmental sounds and enjoyment of music.

S23 Bone conducting hearing devices

S23-2

Preclinical evaluation of a new bone-conduction hearing aid using giant magnetostrictive material

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Objectives: To circumvent some of the disadvantages of conventional hearing aids such as sound distortion, feedback, and cosmetic factors, various implantable hearing devices have been developed. However, these hearing devices still have problems such as insufficient output at high frequencies, inflammation, and so on. In this study, a new semi-implantable bone-conduction hearing aid (SBHA) was proposed. For the first stage in the development of the SBHA, a prototype was made and its fundamental properties were compared with those of the Bonebridge (BB, MED-EL, Innsbruck, Austria).

Principles, structures, and functions of SBHA

The SBHA consists of two parts, i.e., an external unit and an internal unit. The external unit is composed of a microphone, a speech processor, a battery and a transmitting coil that generates a magnetic field corresponding to sound stimuli received by the microphone. The internal unit is composed of a receiving coil, a driving coil, permanent bias magnets, and a vibrator made of giant magnetostrictive material (GMM).

Methods: The GMM vibrator and the BB were fixed on the mastoid part of cadavers by screws. The vibrations caused by the GMM vibrator and the BB on the surface of the temporal bones were measured with a PolyVinylidene DiFluoride (PVDF) film which was put on the surface of the temporal bones. Sinusoidal waves (0.125 - 8 kHz) were applied to the GMM vibrator and the BB directly through an amplifier (HSA4011, NF) and an ammeter (WT210, TOKOGAWA) from a function generator (WF1945B, NF). The signals generated by the PVDF film were amplified by a charge amplifier (R&D-amplifier, TOKYO SENSOR). Simultaneously, the vibration on the same surface was measured by a scanning Laser Doppler velocimeter (LDV). Current of 100 mArms was applied to the GMM vibrator, and voltage of 1 Vrms was applied to the BB.

Results: Frequency responses of the vibration generated on the cadaver temporal bone by the GMM vibrator and the BB. The vertical axis shows the output voltage from the charge amplifier normalized by apparent power applied to each device, and the lateral axis shows the input frequency. Two peaks were observed at 1 and 4 kHz in the response curve of the BB, which were believed to be resonances of the BB. By contrast, the response curve of the GMM vibrator was relatively flat and gradually increased with increasing frequency.

Conclusion: The GMM vibrator of the new bone-conduction hearing aid has a flat frequency response and is able to generate the same level of excitation force as the bonebridge.

S23-3

BC811 - a new bone conduction instrument that requires no surgery

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Introduction: Patients with conductive hearing loss or mixed hearing loss may benefit from bone conduction hearing aids. These are usually either mounted on eyeglasses or implanted surgically. The new „Concha Anchored Instrument"(CAI) BC811 is a bone conductive hearing aid that requires no surgery or eyeglasses. It is mounted on an otoplastic inside the concha of the ear, transmiting the sound via the jaw bone to the skull and into the inner ear. In our study we have tested the performance of the BC811 and compared it with conventional bone-anchored instruments.

Method: Four subjects participated in the study. Initial audiometric procedure before the testing period comprises tone and speech audiometry with headphones. Afterwards, the fitting of the own device was optimized and audiological outcome was measured. Then the patients were fitted with the new BC811 which they tested for a period of two weeks in every-day situations. The evaluation of both devices was done in unaided condition containing speech perception in quiet (Freiburg Monosyllable test) / noise, (OlSa) as well as aided / unaided thresholds. Subjective benefit was measured using the APHAB questionnaire.

Results: In sound field the patients got an average aided hearing threshold of ~29 dB HL (PTA, 0.5 - 4 kHz) with the BC811. With their own bone anchored device they got an average threshold around 32 dB HL (PTA, 0.5 - 4 kHz). The speech perception at 65 dB SPL with the BC811 was 91% WRS with the BC811 and with their own device 90% WRS. With a speech in noise test (OLSA), the patients achieved a mean SNR value of -1.9 dB with the BC811 and a mean SNR of -3.3 dB with their own device.

Conclusion: The BC 811 can be seen as an alternative to bone anchored hearing aids since it does not require any surgical intervention.

S23-4

A new Bone Conduction Implant - BCI

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Background: A Bone Conduction Implant (BCI) device has been developed by the Gothenburg group and implanted for long-term use in six patients with conductive or mixed hearing loss. The BCI uses an intact skin solution and consists of an external sound processor and an implanted unit called the Bridging Bone Conductor. The latter contains the retention magnet, a signal demodulator unit and the transducer. The BCI transducer is attached close to the bony ear canal opening and has a flat surface contact to temporal bone. The external sound processor uses advanced signal processing and the signals are transmitted to the implanted unit via an inductive link.

Objectives: One objective is that the surgical procedure should be safe and simple. Another objective is that the BCI device should have similar or better rehabilitation effect as a BAHA on a headband with intact skin drive, and perform significantly better than the unaided condition. A third objective is to follow the implant performance over time.

Methods: Six patients have been implanted so far and followed for 3-6 months using an extensive study protocol including tone and speech audiometry, cone beam CT and nasal sound pressure. For the audiometric measures the BCI performance has been compared to the Ponto pro power on a head band.

Results: It was found that the surgical procedure installing the implanted unit is easy and safe for the patient. No adverse reactions have been observed. For the audiometric measures, the BCI offers a significant improvement over the unaided condition, and in the majority of the audiometric measures the results are also superior to the reference device on a head band. Moreover, transmission and attachment properties of the implanted unit were found to be stable over the present follow up period.

Conclusion: The BCI offers a competitive rehabilitation for patients with conductive or mixed hearing losses. Regulatory work is currently undertaken to obtain a CE mark for commercial introduction on large scale.

S23-6

A new transcutaneous bone-conducting auditory implant: a multicenter preliminary experience

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Background and Objectives: Regardless of good results on hearing performance, a significant number of patients refused percutaneous bone conduction devices due to psychological and aesthetic issues. The new version of BAHA with a transcutaneous magnetic system should overcome these reticences as well as avoid skin problems. Indeed, major complications of the postoperative period are the lack of osseointegration as well as skin reactions. The transcutaneous BAHA has been released to overcome such drawbacks and reduce the complication rate. In this study, we analyzed the principle and complication of the transcutaneous system and assess whether it should be powerful enough to provide a satisfying hearing level restoration as the percutaneous system.

Methods: The study was done according to a multicentric and prospective design. In 4 tertiary referral centers, 18 patients (age 38-71 yr) with unilateral (UCHL), bilateral (BCHL) conductive or mixed (MHL) hearing loss or single side deafness (SSD) were enrolled in the study as follows: 6 patients with UCHL, 5 with BCHL and 7 with SSD. Both surgical and audiologic results were analyzed. Preoperative auditory testing was performed on softband with processor and repeated after 1 month and 2 months. Time of surgery, skin thickness and intraoperative complications were recorded. Postoperative wound healing was evaluated at 7 days and processor fitting at 1 month. Quality of life questionnaires were administered pre and postoperatively.

Results: Sex ratio was 10 women for 8 men. The mean thickness of the skin over the magnet was 5.4 mm [2.5-8]. The mean surgical duration was 43.6 min [31-53]. Three patients were operated on local anesthesia. Skin was free of edema or hematoma and no subcutaneous collection appeared during the 7 days after surgery. Two patients reported scalp sensibility during 10 days after surgery. The mean preoperative pure-tone average bone conduction threshold was 25.7 dB [10-35]. The mean pure-tone average air conduction threshold was 70 dB [50-85] preoperatively and 30.2 dB [15-27] postoperatively. The speech recognition threshold (SRT) was 66.4 dB [50-80] preoperatively and 32 dB [25-40] postoperatively. Results from questionnaire showed a high level of satisfaction with the implant.

Conclusion: BAHA Attract is a new transcutaneous bone-conducting hearing implant efficient to restore hearing level. The users receive clear audiologic as aesthetic benefits from this new system. BAHA Attract permit hearing improvement equal or slightly better compare to softband.

S23-8

The Transcutaneous Bonebridge bone conduction implant : Two years' experience in France

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Bone conduction (BC) hearing systems are an attractive solution to restore hearing in patients with conductive (CHL) or mixed hearing loss (MHL), or with single-sided deafness (SSD). The Bonebridge (MED-EL GmbH, Innsbruck, Austria), a semi-implantable active Bone Conduction Implant (BCI) which is a transcutaneous system, in which the Bone Conduction Floating Mass Transducer (BC-FMT) is positioned completely under the skin. It has been designed for adult patients with conductive or mixed hearing loss and good speech discrimination who do not achieve adequate benefit from conventional hearing aids and are not good candidates for reconstructive middle ear surgery.

Objective: To investigate the safety and efficacy of a new transcutaneous bone conduction hearing implant, over an 24-months follow-up period.

Study Design: Prospective, single-subject repeated-measurement design in which each subject serves as his/her own control.

Setting: Multicentric study in tertiary referral centers in France and Belgium.

Patients: Subjects were 30 French-speaking adults who suffered from CHL in chronic middle ear disease (n =11) CHL in earcanal atresia (n = 5), MHL (n = 1), or SSD (n = 13). The upper bone conduction threshold limit was set to 40 dB HL at frequencies between 500 Hz and 4 kHz.

Methods: The BC-FMT was placed into the mastoid bone in the sinodural angle (i.e. presigmoid area) in 27 cases, in the retrosigmoid area in 2 cases, and in the middle fossa area in 1 case. Performance was measured by pure-tone and speech audiometry tests in quiet and in noise (air conduction, bone conduction, and sound field at frequencies 500 Hz to 8 kHz). Subjects were monitored for adverse events and given a questionnaire (APHAB) to assess their satisfaction levels.

Results: The average age at implantation was 48 (19-63) years in 18 female and 12 ale adults. After first fitting at day 21 postoperatively, all patients became regular Bonebridge users. Pure-tone tests showed that thresholds measured with the Bonebridge were close to BC thresholds in CHL and MHL subjects. In SSD subjects, thresholds measured with the Bonebridge were 5-10 dB lower that contralateral BC thresholds. In all cases, aided thresholds improved postoperatively at all tested frequencies and continued to improve during the follow-up, in quiet and in noise. Air conduction and bone conduction thresholds showed no significant changes, confirming that subjects' residual unaided hearing was not deteriorated by the surgery.

Conclusion: The Bonebridge demonstrated to be safe and effective in adults up to 24 months of device use. The functional benefits of the Bonebridge are equivalent to existing technologies, in agreement to our expectations, with the potential of less cutaneous complications and a generally high level of patient satisfaction.

S23-9

Audiological results of a transcutaneous bone conduction hearing instrument for conductional and mixed hearing loss

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Introduction: In conductional, mixed hearing losses and single-sided-deafness bone anchored hearing aids are well established treatments. Patients with this type of hearing loss have little or no benefit in most cases of conventional hearing aids. The transcutaneous transmission across the intact skin avoids the percutaneous abutment of a bone anchored device with the usual risk of infections and requires less care.

In this clinical study the audiological results of the Bonebridge transcutaneous bone conduction instrument from MED-EL are compared to a generally used percutaneous device.

Objective: Nine patients from the ENT department at the Medical University Hannover, implanted between Aug. 2011 and Dec. 2012 with a transcutaneous hearing instrument, were audiologically analyzed and compared with the results of nine patients, implanted with a percutaneous device, between Oct. 2002 and Nov. 2011. All patients fulfilled the audiological criteria for both devices (BC ≤ 45 dB HL at 0.5, 1.0, 2.0, 4.0 kHz) and had at least 8 weeks of experience with the respective device. Patients with single-sided-deafness were excluded from the study. Tests included AC and BC thresholds with headphones and unaided and aided thresholds in sound field. The speech intelligibility was determined with speech from the front (S_0) using the Freiburg monosyllable test and hearing in noise with the Oldenburg sentence test (OLSA) in sound field. All sound field measurements were performed with the contra-lateral ear plugged and muffled. The subjective benefit was assessed with the APHAB.

Results: In comparison to unaided condition there was a significant improvement of aided threshold, word recognition score and speech reception threshold in noise, measured in free field, for both devices. The comparison of the two devices revealed a minor but not significant difference in aided threshold (Bonebridge PTA=36.7 dB; BAHA PTA=39.4 dB). In terms of speech intelligibility no significances between the devices could be found. The assessment of the subjectively perceived benefit with the APHAB showed a significant improvement in the aided situation with both devices. Otherwise results were similar between both devices without significances or pronounced trends.

Conclusion: Our data shows that the transcutaneous bone conduction hearing instrument is an attractive alternative to bone anchored devices in conductional hearing loss with a minor sensorineural hearing loss component.

S23-10

Challenges and specific considerations for surgery in the use of the MedEl Bonebridge in patients with chronic ear disease

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Introduction: Hearing rehabilitation in patients that are unable to wear conventional hearing aids (due to the occlusion effect or intolerance of the hearing aid mould material) can be challenging. A bone conduction hearing device may be necessary in such cases. The use of percutaneous bone conduction devices can be complicated by skin problems around the abutment. Passive devices are limited by reduced power as compared with active devices. The MED-EL Bonebridge, a transcutaneous active bone conduction device, has a comparatively large floating mass transducer (FMT). Its positioning within the mastoid bone must satisfy the requirements of the depth of the recess, the thickness of adjacent bone for fixation and avoidance of critical anatomical structures. In patients with chronic ear disease, who commonly have a comparatively small mastoid bone and may have undergone previous surgery, adequate positioning of the Bonebridge FMT may be challenging and it may be necessary to sacrifice one or more of these ideals. We present our experience in the use of the MedEl Bonebridge in such cases, using case examples to highlight specific challenges encountered and describe techniques adopted to overcome these, thereby ensuring secure and suitable positioning of the FMT in such cases.

Methods: Retrospective case note analysis of patients with chronic ear disease who have undergone MED-EL Bonebridge implantation for hearing rehabilitation in a tertiary referral hearing implant centre. The use of imaging in facilitating effective pre-operative surgical planning, that will raise suspicion of challenges and in turn allow adequate preparations to be made to address these intra-operatively.

Results: All patients with chronic ear disease who have undergone implantation with the MedEl Bonebridge required decompression of their middle fossa dura and/or sigmoid sinus in order to adequately accommodate that Bonebridge FMT within the mastoid bone. In one case a longer screw and spacer were required to ensure secure placement and optimal positioning for bone conduction. Such maneuvers did not aversely affect audiological outcome.

Conclusion: Positioning the MedEl Bonebridge FMT in patients with chronic ear disease can be challenging. Appropriate pre-operative planning is critical to predicting this and surgeons should expect to have to decompress critical structures to suitably accommodate the FMT within the mastoid bone. Such techniques do not compromise audiological outcome and the MedEl Bonebridge remains a suitable alternative for the hearing rehabilitation of such patients provided they satisfy the published audiological threshold criteria.

Learning outcome: The role of pre-operative surgical planning including appropriate imaging is mandatory to ensure adequate preparation and the availability of the necessary instruments and equipment to address specific challenges to the placement of the MedEl Bonebridge FMT in patients with chronic ear disease.

S23-11

BoneBridge: Auditory and quality of life outcomes in conductive, mixed hearing loss and single sided deafness

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Introduction: The transcutaneous bone conduction auditory implant *Bonebridge* is a new semi-implantable device indicated for conductive and/or mixed hearing loss (C/MHL), or single sided deafness (SSD).

Objective: To evaluate the surgical outcomes, auditory benefits, quality of life and patient satisfaction scores in conductive, mixed hearing loss and single sided deafness, in patients implanted with the *Bonebridge* system.

Methods: Prospective study on patients with C/MHL, or SSD. The auditory outcomes, quality of life outcomes, and satisfaction scores with the device will be assessed.

Results: 24 patients have been implanted, including 12 males and 12 females. Fifteen of those cases were placed in the sinodural angle and 9 in the retrosigmoid region. Twelve patients received the device for C/MHL and 12 for SSD. C/MHL patients showed a statistical significant ($p< 0.04$) mean gains of 25.8 and 26 dB in PTA at 1 and 3 months after surgery, respectively. SSD patients also showed a significant ($p< 0.03$) mean gains of 60.2 and 77.1 dB at 1 and 3 months after surgery, respectively. Positive indicators were obtained in general satisfaction with the device, as well as significant improvement ($p< 0.05$) in the speech perception, sound localization and quality of sound, compared to their pre-op status. Benefits in their general health and quality of life were reported too.

Conclusions: The active transcutaneous active bone conduction auditory implant *g*ives significant auditory gain to patients with C/MHL and SSD. Patients report high satisfaction with the implant with improvements in their auditory gains, general health and quality of life.

S23-13

The value of a preoperative planning for Vibrant Bonebridge implantation

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Introduction: The vibrant bonebridge is the first bone conductive system with an subcutanous actuator. Since the actuator (B-FMT) related to its specific size can cause a conflict with temporal structures (sinus sigmoideus, dura , brain) a preoperative planning of the positioning of the B- FMT can make sense. The aim of the present study was to compare the amount of conflict with temporal structures in cases of non- software supported positioned B-FMT´s and cases with software supported positioned B- FMT`s in the temporal bone.

Material and methods: In 4 patients the postoperative CT scan implanted with a B- FMT was evaluated and the amount of conflict was estimated and compared with a virtual software supported positioning of the B- FMT . The amount of conflict was calculated and compared.

Results: In all 4 cases a significant reduction or complete prevention of conflicting situations with the sinus sigmoideus or the dura of the middle fossa could be achieved.

Discussion: Preoperative planning of B-FMT positioning allows a reduction or prevention of conflicting situations.

S23-14

Bone anchored hearing device surgery: Linear incision without soft tissue reduction. A prospective study

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Background: Numerous techniques have been described to manage the skin and subcutaneous soft tissue during bone anchored hearing device surgery. Now, more and more surgeons are using a less invasive approach than the one originally described.

Objective: We wanted to investigate bone anchored hearing implant placement using a single, linear incision with no underlying soft tissue reduction.

Patients and methods: 30 patients (28 adults and 2 children) were **prospectively** enrolled to undergo a single stage bone anchored hearing implant surgery with this technique. After measuring the thickness between the bone and the skin with a needle, a small (less than 2.5 cm) linear incision was used and carried down to the periosteum, no soft tissue was removed and standard technique was then followed with placement of the abutment (at least 3 mm longer than the measured thickness). Patients were reviewed regularly (1 week, 2/4 weeks, 6/8 weeks and 12 moths) to asses wound healing (including Holger´s scale).

Results: Only 16% of patients had a minor skin reaction during their first visit and all were solved with topical steroids and antibiotics since they were Holgers 2 or less . 8% of patients remained with some minor complication in the next visit and all patients had normal healing in the third visit. None required revision surgery, there were no implant failures and only 2 cases needed a longer abutment and this procedure was performed as an office based procedure.

Conclusion: These results suggest that this technique is a simple and effective insertion technique with favorable healing process and cosmesis that leads to a greater patient satisfaction.

S23-15

Soft tissue stability around hydroxyapatite-coated abutments for bone conduction implants placed using soft tissue preservation surgery

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Introduction: Meticulous removal of subepidermal tissues is the recommended surgical procedure to ensure soft tissue stability around skin-penetrating titanium abutments for bone conduction implants. Previous research has shown that soft tissue does not adhere to a machined titanium surface, leaving deep epidermal pockets around skin-penetrating titanium devices. However, research has demonstrated that with calcium phosphates, such as hydroxyapatite, it is possible to establish close contact with the surrounding soft tissue, thus limiting epidermal down growth and subsequent pocket formation. The aim of the present investigation was to demonstrate that hydroxyapatite-coated abutments improve soft tissue stability, thus providing favorable conditions for obtaining good outcomes when performing bone conduction implant surgery without soft tissue reduction.

Methods: Forty-eight bone conduction implants with hydroxyapatite-coated abutments (n=24) or standard titanium abutments (n=24) were inserted in the skull of eight adult sheep. A minimally invasive surgical technique was used, leaving the soft tissue thickness intact. After a 4-week healing period, implants and abutments with surrounding tissue were retrieved for qualitative and quantitative histology. Statistical analyses were performed by an independent biostatistician; a mixed model analysis was used for statistical comparisons.

Results: Qualitative histological assessment showed healthy soft tissues around the abutments with limited or no signs of inflammation. Tight adherence between hydroxyapatite-coated abutments and surrounding dermis was consistently observed, while less firm adherence was generally noted on titanium abutments. Morphometric measurements showed significantly smaller pocket depth ($p=0.0013$) and less epidermal down growth ($p=0.0003$) around hydroxyapatite-coated abutments compared to titanium abutments.

Discussion: The results suggest that the use of hydroxyapatite coatings may make it possible to obtain good clinical outcomes with bone conduction implants without having to remove subepidermal tissues around the skin-penetrating abutment. Leaving the soft tissue thickness intact has significant advantages in terms of healing and aesthetic outcomes for the patient.

Conclusion: The results confirm that hydroxyapatite-coated abutments improve soft tissue adherence and reduce epidermal down growth and pocket formation compared to standard titanium abutments.

S23-16

Comparison of audiological results and patient satisfaction of bone-anchored hearing aids: Baha® BP110 versus Ponto Pro Power

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Introduction: Despite a variety of implantable hearing systems (e.g., transcutaneous bone conduction devices and middle ear implants) for patients with mixed or conductive hearing loss, bone-anchored hearing aids are still an important alternative in rehabilitation. This study aims to investigate the audiological outcome and patient satisfaction for two new high power bone-anchored devices: The Ponto Pro Power (Oticon Medical) and the Baha BP110 (Cochlear).

Methods & Material: Patients (N = 11) experienced with bone-anchored devices and with a bone conduction PTA (0.5 - 4.0 kHz) threshold equal or better than 55 dB HL on the implanted side were included in the study. Patients tested the devices in a balanced cross-over design to avoid bias. All patients received a fitting of each device according to the manufacture's guidelines followed by a 3-week period of everyday usage. At the end of each test period, subjects were audiologically and subjectively evaluated. Audiological outcome was determined by aided threshold, intelligibility of monosyllables (Freiburger) and speech reception thresholds in noise (OLSA, S_0N_{90} or S_0N_{270}) for the respective devices and settings (omni- and full-directional mode). The subjective benefit was evaluated by the APHAB, SSQ-C questionnaire and a handling questionnaire which addresses the operation of the device, occurrence of feedback and annoyance to wind noise.

Results: Audiological results indicate similar performance for the two devices in terms of functional gain (29 dB for both devices). The intelligibility of monosyllables ($L_{50\%}$ 58 dB HL (Ponto) vs. 55 dB HL (BP110), $p > 0.05$) and speech intelligibility in noise (SNR_{omni} 0.3 dB (Ponto) vs. -0.3 dB (BP110), $p > 0.05$; SNR_{full} -1.0 dB (Ponto) vs. -2.4 dB (BP110), $p > 0.05$) were found slightly better for the BP110. However, subjective evaluation of the two devices imply a better performance of the Ponto Pro Power due to a better rated speech understanding, sound quality in different every-day hearing situations and less feedback and wind annoyance. Some of the accessed categories attained significance, explaining greater patient satisfaction compared to the BP110.

Conclusion: Objective audiological outcomes and subjective rating of the Ponto and Baha are minor, but point into opposite direction. The absence of clear disadvantages of either device shows the necessity for testing both options to give room for a patient's individual decision and preference.

S23-18

Early hearing outcomes and experience with the MedEl Bonebridge in single-sided sensorineural hearing loss

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Introduction: The optimum technique for hearing rehabilitation in patients presenting with single-sided sensorineural hearing loss (SSSNHL) is evolving. Contralateral routing of sound (CROS) by air conduction hearing aids is the most commonly employed technique. CROS by bone conduction is an alternative option for those patients who are unable to wear conventional hearing aids (due to the occlusion effect or adverse reaction to the mould). Such techniques can only deliver monaural stimulation (with an awareness of sound on the implanted side) and are thus limited by poor sound localisation and impaired perception of speech in noise. Binaural hearing could be reinstated in some cases by use of a cochlear implant, however use of a cochlear implant in this context is limited as compared with CROS options. The use of percutaneous bone conduction devices is complicated by skin problems associated with the percutaneous abutment and passive devices are limited in power. As a transcutaneous active bone conduction device, the MedEl Bonebridge avoids these complications and may offer a suitable alternative for hearing rehabilitation in patients with SSSNHL with published recommended hearing thresholds for its use in this context. Positioning of the floating mass transducer (FMT) within the mastoid bone must satisfy the requirements of adequate depth of recess, adequate thickness of adjacent bone for fixation and avoidance of critical anatomical structure. We present the outcomes from our early experience in the use of the MedEl Bonebridge in SSSNHL.

Methods: A retrospective case note analysis was carried out of all patients who have undergone MedEl Bonebridge implantation by a tertiary referral implant team for SSSNHL. The pre-operative and post-operative subjective (Abbreviated Profile of Hearing Aid Benefit - APHAB; Speech, Spatial and Qualities of Hearing - SSQ) and objective (speech in quiet, speech in noise) outcomes of hearing performance are presented and compared.

Results: There were no peri-operative or post-operative complications associated with the implant. Improvement in hearing was demonstrated by both objective and subjective measurements in all cases. In patients with chronic ear disease or a modification of the surgical technique may require to ensure safe and effective positioning of the FMT.

Conclusion: Our early experience supports the use of the MedEl Bonebridge in patients with SSSNHL.

Learning outcome: The MedEl Bonebridge represents a safe and effective CROS alternative in the hearing rehabilitation of patients presenting with SSSNHL. Surgeons must be vigilant to the requirements for appropriate positioning of the FMT. Thorough preoperative planning aids in anticipating the need for modifications to the standard surgical technique.

S23-20

Comparison of the binaural performance of Baha attract, bone bridge and cochlear implantation for single sided deafness: Early experiences

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Introduction: This paper explores current implantable treatment options for unilateral deafness and compares patient outcomes and quality of life measures. The devices compared are active and passive bone conduction implantable devices and cochlear implantation which provides direct electrical stimulation to the deaf ear.

Study design: Prospective design.

Patients: 36 patients with unilateral deafness were enrolled in this study. 28 patients had chosen cochlear implantation as an intervention for their unilateral deafness. Of the other 8 patients, some had no viable auditory nerve for cochlear implantation or had had self-selected a bone conduction device as their preferred rehabilitation option.

Methods: The adaptive Bamford Kowal Bench speech in noise test was employed to compare each patient's pre-operative versus post-operative performance in the following listening conditions;

1. speech and noise from the front (S0/N0),
2. speech from the front and noise from the implanted ear (S0/Nci),
3. speech from front and noise from the normal hearing ear (S0/Nhe), and
4. speech from the implanted ear and noise from the normal hearing ear (Sci/Nhe). Tinnitus distress was assessed using the Tinnitus Reaction Questionnaire (TRQ). Subjective improvement of hearing was assessed using the standardized Speech, Spatial, and Qualities of Hearing (SSQ). All patients were asked to complete the SSQ pre and 3 months post implantation.

Localisation ability was assessed using a 13 speaker, 180 degree array at head level.

Results: Our results show that cochlear implantation provides improved listening performance in noise and in the ability to localize sounds as well as providing some tinnitus relief for those experiencing significant tinnitus pre-operatively. The bone conduction devices do not provide direct stimulation which is reflected in limited speech in noise and localisation benefits. However for some patients, a bone conduction device which offers less invasive surgery and virtually no rehabilitation requirements, is a more appealing option than a cochlear implant.

Conclusion: Our initial results indicate that cochlear implantation gives the best performance in terms of improved speech in noise and localisation abilities. However, for some patients, the degree of commitment to the rehabilitation process means they would prefer a Bone Conduction device.

S24 Speech testing (in adverse listening conditions, testing across languages)

S24-2

Speech recognition with the Nucleus 6 sound processor in various noise conditions

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The recently launched Nucleus 6 sound processor (CP900 series, Cochlear) contains two omnidirectional microphones which can be adaptively configured as a directional beamformer microphone combination. The directivity of this system is continuously adjusted to maximally reduce interfering noise signals. This study compares the standard processing option without microphone directivity with the adaptive beamformer setting for various sound field conditions using a speech in noise sentence test (Oldenburg sentences, OLSA). Adult German speaking subjects who either were fitted previously with another sound processor and subsequently were upgraded to the Nucleus 6 sound processor or recently implanted patients with at least 6 months of processor experience participated in this experiment. The SRT50 (speech reception threshold for 50% speech intelligibility in noise) was determined using sentences presented via loudspeaker at 65 dB SPL in front of the listener and noise presented either via the same loudspeaker in front (S0N0) or at 90 degrees at the implant ear side (S0NCI+) or the opposite unaided side (S0NCI-). The fourth, diffuse noise condition (S0ND3) consisted of three uncorrelated noise sources placed at 90, 180 and 270 degrees. A fifth condition consisted of car noise reproduced through a circular array (diameter of 3 meters) of 12 loudspeakers and speech presented at 90 degrees at the implant ear side. This condition should be representative of a communication situation whereby a car driver keeps his head position constantly toward zero degrees and listens to a person speaking from the side. The noise levels in all conditions were adjusted through an adaptive procedure to yield a signal to noise ratio where half of the words in the sentences were correctly understood. Two repetitions of each SRT measurement were done for each of the ten conditions (reference condition with omnidirectional microphone setting versus beam processing options in five noise source configurations). Results will be presented at the conference.

S24-3

An Australian clinical evaluation of the Nucleus 6® cochlear implant system

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Introduction and aim: SmartSound iQ in the Nucleus 6 system includes a range of new technologies to improve hearing and ease of device use. An automatic scene classifier (SCAN) is able to automatically and seamlessly change programs depending on the listening environment. A background noise reduction technology (SNR-NR) and a wind noise reduction technology (WNR) are able to improve speech understanding in noisy environments. This study aims to evaluate the clinical performance of the Nucleus 5 compared to a range of Nucleus 6 programs in adult recipients in both quiet and noise.

Material and methods: A total of 21 Australian adults participated in the study. Word understanding at 50 dB was evaluated using CVC words in quiet. Sentence understanding at 65 dB was evaluated using an adaptive speech reception threshold (SRT) noise tests. Nucleus 5 Every day and four Nucleus 6 programs were tested in quiet. Recipients preferred Nucleus 5 program and five Nucleus 6 programs were tested in noise after a one week acclimatization period. The four noise conditions included speech weighted noise and 4-talker babble, presented in both speech at 0° noise at 0° (S0N0) and speech at 0° noise at 90°, 180°, 270° (S0N3) speaker configurations.

Results: In the SWN S0N0 condition, the Nucleus 6 SCAN program provided a significant improvement compared to all other programs. Improvements compared to Nucleus 5 preferred and Nucleus 6 none, were 1.7 dB and 2.3 dB respectively. In the SWN S0N3 condition the Nucleus SCAN program provided a significant improvement compared Nucleus 5 Preferred (1.3 dB), Nucleus 6 none (4.8 dB) and Nucleus 6 ADRO+ASC (3.9 dB). No difference was found between programs in the 4-talker babble S0N0 condition. In the 4-talker babble S0N3 condition Nucleus SCAN provided a significant improvement compared to Nucleus 5 Preferred (0.5 dB), Nucleus 6 none (3.9 dB) and Nucleus 6 ADRO+ASC (3.5 dB). In quiet, no difference was found between the Nucleus 5 Everyday, Nucleus 6 ADRO+ASC and Nucleus 6 SCAN programs. A significant improvement was found for the Nucleus 6 Whisper program compared to all other programs in quiet.

Conclusion: The newly released Nucleus 6 system's SmartSound iQ default program, SCAN, provides benefit or equivalent speech understanding when compared to a range of other Nucleus 5 and Nucleus 6 programs. SCAN was found to automatically select technologies that gave improved speech understanding compared to the user preferred Nucleus 5 noise program. All subjects successfully upgraded to the Nucleus 6 system, and accepted the new automated default SmartSound iQ settings.

S24-4

Fine structure information benefit for sound quality and speech-in-noise intelligibility in bimodal cochlear implant users at six and twelve months post implantation

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Intro: This study investigated the effect of the fine structure information provided by the MED-EL FSP strategy (FS4) versus the alternative CIS strategy (HDCIS) on sound quality and hearing in noise in 14 adult bimodal CI users, with bilateral severe to profound hearing loss, tested at 6 and 12 months post CI implantation. The 12-month time data and larger sample size extend the results reported at CIAP 2013.

Methods: All participants used MED-EL OPUS 2 processors programmed with both FS4 and HDCIS strategies. All tests were performed in bimodal and CI-only configurations and with both strategies. All participants chose to use FS4 in daily life and wore a contralateral hearing aid (HA). For sound quality, the participants used a visual analog scale to rate 6 short recordings of speech and music as the listening configuration and CI strategy were varied. Stimuli were presented in a sound booth using specially designed headphones and a computer controlled implant remote control that allowed trial-to-trial blind CI program selection. For spatial unmasking of speech (SUS), 20-sentence HINT thresholds were compared between co-located (speech and noise in front) and separated (speech in front and noise on the HA side) conditions.

Results: For sound quality, 6- and 12-month outcomes showed a significant overall preference for FS4 and for the bimodal configurations. Between 6 and 12 months, ratings for some recordings improved significantly only in FS4/CI-only and FS4/bimodal configurations. For spatial unmasking, at 6 months, SUS was significantly higher for FS4 alone and for both bimodal FS4 and HDCIS than for HDCIS alone. SUS for FS4 alone was higher than for FS4/bimodal. At 12 months,FS4/CI-alone, FS4/bimodal and HDCIS/CI-only SUS scores were the largest, almost equal, and improved from 6 months. Although not significant, SUS in FS4/bimodal increased and in HDCIS/bimodal decreased between 6 and 12 months.

Discussion: Sound quality was improved via the delivery of fine structure information via either the HA or CI at both time points. Spatial unmasking was initially highest for the configurations that provided a single source of low-frequency fine structure (FS4/CI-only and bimodal HDCIS), but HA benefit increased for FS4 and decreased for HDCIS at 12 months.

Conclusion: Sound quality and SUS results indicate a benefit of the FS4 strategy for bimodal listeners. The SUS results suggest a trend for gradual acclimatization to bimodally delivered fine-structure (FS4/bimodal) and decline in effective integration of hearing-aid fine-structure with the non-preferred HDCIS strategy (HDCIS/bimodal).

Learning outcome: FS4 provided sufficient fine structure information to improve the perceived quality of speech in quiet and the spatial unmasking of speech in noise at 6 and 12 months post CI implantation.

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S24-5

Impact of reverberation on speech perception in cochlear implant users

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Speech perception of cochlear implant (CI) users decreases in reverberant environments compared to free-field conditions. Previous studies showed exponential decrement in word recognition with increasing reverberation time (RT). Another detrimental factor is the logarithmic direct-to-reverberant ratio (DRR), which decreases with increasing distance to the sound source. This study evaluates the influence of the DRR on speech perception in CI users as well as the impact of beamforming on speech perception. Speech test material consisted of the Oldenburg Sentence Test (OLSA), which was recorded with DRRs between -18 and 21 dB. Recordings were carried out with a dual microphone hearing aid held by a dummy head. The diffuse reverb tail of the impulse responses (IR) of a classroom without acoustic treatment (RT 0.75 s) and a church (RT 4.1 s) were extracted from a library of monaural IRs. The final stimulus presentation consisted of a direct speech sound source in frontal position (0°) and the reverberated signal, which was generated by 20 equally-distributed surrounding plane waves created by wave field synthesis (WFS, 128 loudspeakers). The speech reception threshold (SRT) depending on DRR was assessed in quiet and in noise (10 dB SNR). Tests were carried out in 8 normal-hearing (NH) subjects with monaural headphones presentation. Therefore, speech test material was processed by a 6-channel sine-vocoder to simulate CI listening. Furthermore, 8 users of Advanced Bionics CIs were tested monaurally in two conditions: (1) direct input to a Harmony speech processor, and (2) preprocessed by means of an advanced beamforming algorithm. DRR calculated in dB or speech score percentage difference measured at 50% DRR level was assessed respectively. The mean SRTs in classroom reverberation condition were about -18 dB DRR for both groups. With additional noise, the CI subject group showed a slight mean decrement of 2 dB. Mean SRTs in church reverberation condition in the NH group were -13.7 dB DRR (quiet) and -12.5 dB DRR (noise). The CI group thresholds were -13.1 dB DRR (quiet) and -10.7 dB DRR (noise). On average, speech scores improved about 28.3% in the advanced beamformer condition compared to standard processing. The SRTs in quiet showed no statistically significant difference between subject groups. However, a detrimental effect of noise in addition to reverberation in the church reverberation condition was present in the CI subject group. The ability of NH subjects to listen to CI-simulating speech in adverse conditions consisting of reverberated speech and additional noise is superior compared to the performance of CI users. While often reporting difficulties in reverberated conditions, the performance of CI users in terms of DRR was better than expected. Hence, the DRR seems not to be the main parameter to signify degraded speech intelligibility. Beamforming algorithms can significantly improve speech perception in diffuse reverberant environments.

S24-7

Evaluation of the performance in noise with two processing algorithms of MED-EL cochlear implants

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Objectives: To compare the performance of cochlear implant users with HDCIS and FS4 strategies in different conditions.FS4 strategy emphasizes lower frequencies with a specific algorithm for the first four apical electrodes. This study wanted to evaluate if FS4 supports a better comprehension in conditions where lower frequencies prevail, such as listening in noise, consonant recognition test and discrimination between female and male voices.

Design: Six patients using MED-EL Opus2 cochlear implant for at least twelve months. They have been implanted between 2008 and 2012. All patients underwent testing with pure tone and speech audiometry with and without cochlear implant, using male voice, in quiet and noise conditions. Moreover, all patients undertook consonant recognition test, using five lists of sixteen phonemes each. This test was performed in noise and quiet, with male and female voices, at 30dB of intensity over threshold. Patients have been evaluated with their map and after map change at 1 and 2 months follow-up.

Results: Pure tone and speech audiometry, did not show a significant difference between HDCIS and FS4.The overall results showed a better performance of FS4 over HDCIS, especially in noise with female voice in consonant identification with a better identification of consonants containing lower frequencies in their spectrum. Subjects preference of map, was independent of performance.

S24-8

The benefit of noise reduction technology for CI users in various listening conditions

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Directional microphone systems and noise suppression algorithms can provide improved speech intelligibility for hearing impaired people especially in noisy environments. For CI users access to this technology is as important as for hearing aid users.

With the Naida CI sound processor both, an adaptive directional microphone (UltraZoom) and a noise suppression algorithm (ClearVoice) are available to aid speech understanding in noise. The current study investigated the benefits of such technology in comparison to an omni-directional microphone for three different noise conditions. Ten CI users participated in this study. All participants were postlingually deafened and had at least six months experience with the CI and at least 3 months experience with ClearVoice. Speech intelligibility was measured unilaterally in a loudspeaker setup where speech was always presented from the front (0° azimuth). Stationary speech shaped noise was presented either: i) from eight loudspeakers distributed evenly in 45° increments around the listener, including the front direction, ii) from five loudspeakers at ±70°, ±135° and 180° azimuth or iii) or from five loudspeakers at ±70°, ±135° and 180° azimuth together with a single-talker interferer that was moving between those loudspeakers. Speech reception thresholds (SRT's) were determined for the omni-directional microphone, the adaptive directional microphone and the adaptive directional microphone plus ClearVoice using the Oldenburg sentence test in the three loudspeaker configurations.

The adaptive directional microphone resulted in 4.4, 6.0 and 6.8 dB better SRT's than the omni-directional microphone, for configuration i), ii) and iii) respectively. When adding the noise suppression algorithm to the adaptive directional microphone SRT's improved significantly by another 0.9 dB for the fixed noise conditions whereas no improvement was seen for the moving noise condition. This might be due to the fact that the noise suppression algorithm is designed to suppress stationary noise and thus is not effective in situations with a single-talker interferer. For CI users the combination of an adaptive directional microphone with a noise suppression algorithm offers large speech intelligibility improvements in a range of different listening conditions.

S24-9

Performance in noise with the beamforming technology of the Naída CI Q70, the new sound processor from Advanced Bionics

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Intro: The Naída CI Q70 sound processor from Advanced Bionics incorporates a Phonak adaptive beamformer option, called UltraZoom, that can be activated when the user needs to hear a talker face-to-face in noisy situations. UltraZoom's dual-microphone technology emphasizes sounds in front of the listener while reducing noise at the side and back. A pilot study conducted in ten experienced cochlear implant users showed a remarkable improvement when using UltraZoom in such environment. This study will determine the benefits of UltraZoom in a larger panel of users of the Naída CI Q70 processor.

Methods: This study is conducted in multiple centers around North America, Europe and Asia. The objective of this multicenter clinical study is to demonstrate the benefits of UltraZoom in comparing speech understanding in noise when the speaker is directly in front of the listener with two programs: one with UltraZoom switched-on and one program without. The speaker setup depends upon the facilities available at the individual study site: either two loudspeakers - one in front of the subject and one directly behind the subject - or a surround-speaker array. Performance is evaluated with a sentence test, either using a fixed-SNR method or an adaptive method depending on the centre.

Results: The pilot study showed an average of 6 dB of improvement in the SRT when using the UltraZoom feature compared to the standard omnidirectional microphone, in a test set-up with five loudspeakers delivering stationary speech-shaped noise. Centers and subjects inclusions are still ongoing and the preliminary results from this multicenter study will be presented.

Conclusion: Previous studies have already shown that the Naída CI provides significant improvement in speech understanding in noise. This multicenter study will enable to gather a large amount of data from various countries and centers to confirm these results.

S24-10

A dynamic listening environment best captures the benefits of binaural hearing in bilateral and EAS cochlear implant listeners

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Traditional testing using a single loud speaker in front of the patient may show summation effects but cannot capture other benefits of binaural hearing, e.g. squelch and head shadow. Our traditional testing in quiet and with speech and noise coincident in space showed on average less than a 7% advantage for listeners using bilateral cochlear implants (CI) compared to the better CI ear alone. An even smaller benefit was demonstrated for EAS (electric plus acoustic stimulation in the same ear) listeners in the combined condition (bilateral acoustic hearing plus a single CI) compared to the bimodal condition. The benefits of binaural hearing, either bilateral electric or bilateral acoustic hearing, require a more dynamic testing environment. We designed a dynamic test, the 'Roving Cocktail', to capture more accurately 1) the benefit of bilateral CI compared to the better CI ear and 2) the benefit of a second acoustic ear, e.g. the benefit of preserving hearing compared to the bimodal condition for EAS listeners. A roving target was used to more closely mimic daily life encounters that CI users engage in particularly when they are in a group setting. Ten bilateral listeners using the MED-EL CI device and 10 EAS listeners using the MED-EL EAS or the Cochlear Nucleus Hybrid device were tested in RSpace™, a test environment that creates a virtual restaurant setting with the listener surrounded by an eight loudspeaker array. Target sentences were comprised of the BabyBio sentences, and were presented randomly from five loud speakers in the frontal horizontal plane amid a background of restaurant noise emanating from all eight loudspeakers. A signal to noise ratio (SNR) was calculated using the better CI ear for the bilateral listeners and the EAS condition for the EAS listeners to achieve 40-60% understanding to reduce ceiling effects. Results for the Roving Cocktail test demonstrated a mean of 28 percentage points for bilateral CIs compared to the better CI ear alone. Bilateral CI listeners had the benefit of an improved SNR despite from which side the target was presented. The EAS listeners gained a mean of 13 percentage points in the combined condition when compared to the bimodal condition indicating the benefit of preserving hearing in the implanted ear. The EAS listeners may have been penalized due to the deficiency of high frequency information when the target was presented on the unimplanted side, but they had the benefit of squelch from bilateral acoustic hearing. A roving target shows increased benefit of having a second ear, whether electric or acoustic, and captures the binaural effects of head shadow, squelch, and summation. The 'Roving Cocktail' test is a sensitive measure that can be used to provide surgeons, clinicians, and potential CI candidates with expected outcomes for bilateral implantation and underscores the benefit of preserving hearing for EAS candidates.

S24-11

Evaluating speech perception ability using new audio-visual test material

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The goal of this study was to create two sets of audio-visual sentence lists to evaluate the speech perception abilities of hearing-impaired and cochlear implant (CI) users. For set 1, our intention was to generate audio-visual lists with an equivalent level of difficulty in both the auditory and visual domain to evaluate performance across conditions. For set 2, our intention was to generate sentence material that contained lists of the same difficulty when presented auditory-only, but with varying difficulty when presented audio-visually.

To meet the goal of set 1, we developed a corpus of 150 audio-visual sentences. These sentences were previously normed for audio-visual difficulty (MacLeod & Summerfield, 1990). Sentences were rerecorded at Arizona State University (ASU) with both video and audio by a single female talker. The average intelligibility was measured by processing each sentence through a 15-channel CI simulation in noise and calculating the mean percent correct for 30 subjects. Sentences were ranked from high intelligibility to low intelligibility for both visual and auditory cues. Sentences were assigned to 10 lists, each containing 15 sentences that were balanced for both visual and auditory difficulty. At conclusion, we developed sentences that produce an average percent correct of 52.3% (SD=.5%) when presented audio-only and 92.9% (SD=1.6%) when presented audio-visually. These sentences will allow us to measure how vision modifies speech perception across different hearing conditions. To meet the goal of set 2, we developed the Easy-Difficult sentences. The Easy-Difficult sentences include a corpus of 90 sentences borrowed from a group of three hundred sentences previously graded in lipreading difficulty (Kopra, Kopra, Abrahamson, & Dunlop, 1986). Sentences were rerecorded at ASU with both video and audio by a single female talker. The average intelligibility measured by processing each sentence through a 15-channel CI simulation in noise and calculating the mean percent correct for 8 subjects. Sentences were ranked from high intelligibility to low intelligibility for both visual and auditory cues. Sentences were assigned to 6 lists, each containing 15 sentences. Half of the lists were sorted to produce a low audio-visual score and half to produce a high audio-visual score. All 6 were sorted to produce the same auditory-only score. At conclusion, the average percent correct for all 6 sentences when presented audio-only was 24.3% (standard deviation= 1.1%).The average percent correct when presented audio-visually was 58.0% (SD=2.5%) for lists 1-3 and 96.2% (SD=1.2%) for lists 4-6. These sentences will allow us to measure cues that contribute to high visual benefit and low benefit in both normal hearing and CI populations.

Outcomes: Attendees will understand the benefit of adding visual to auditory cues. Attendees will be able to identify the difference between easy and difficult to lipread sentences.

S24-12

Is the effect of a noise reduction algorithm on noise tolerance and speech intelligibility in noise related to spectral resolution?

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Intro: Recently, noise reduction algorithms were applied in clinically available cochlear implants. This study was intended to test the hypothesis that CI recipients with low spectral resolution might have more advantage from noise reduction algorithms than CI users with high spectral resolution on noise tolerance and on speech intelligibility in noise at different performance levels.

Methods: In a double blind cross-over design we measured the effect of the noise reduction algorithm ClearVoice on noise tolerance with the Acceptable Noise Level test(ANL) and on speech in noise for three performance levels: Speech Reception Thresholds(SRT) at 50%, 70% and at a speech-noise-ratio of SRT50%+11dB. Furthermore, we tested speech intelligibility in silence. We measured effective spectral resolution with a spectral-ripple discrimination test. Twenty users of an Advanced Bionics Harmony processor with HiRes120-processing participated in this study.

Results: We found that the ANL significantly decreased with a mean improvement of 3.6 dB due to the noise reduction algorithm. The noise reduction algorithm had no significant effect for any of the three speech in noise performance levels. Spectral-ripple discrimination thresholds were not correlated with the effect of noise reduction on the ANL or the speech intelligibility in noise. The spectral-ripple discrimination thresholds correlated significantly with maximum speech intelligibility in quiet (R^2=0,5, p< 0,001), but not with speech reception thresholds in noise.

Conclusions: The investigated noise reduction algorithm ClearVoice improves noise tolerance, but this improvement in noise tolerance is not related to spectral-ripple discrimination thresholds. This suggests that CI recipients with low spectral resolution do not have more advantage from noise reduction than CI users with high spectral resolution.

Learning outcome: Both good and poor CI performers may benefit from the use of noise reduction

S24-13

The influence of linguistic skills on speech recognition in noise in listeners with normal hearing and cochlear implant users

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Intro: In counseling hearing-impaired people, judgment of cochlear-implant or hearing-aid candidacy, and evaluation of rehabilitation progress there is need for a more detailed understanding of factors that influence speech recognition in noise. Here we present studies on the influence of linguistic skills on speech recognition, in listeners with normal hearing and CI users.

Methods: In a first study Speech Reception Thresholds (SRTs) were measured for sentences in steady-state and fluctuating noise and digit-triplets in steady-state noise (DIN). Lexical-access ability was measured with a lexical-decision test and a word-naming test. Also vocabulary size was measured. To introduce variation in linguistic skills, three groups of 24 young listeners with normal hearing were included: high-educated native, lower-educated native, and high-educated non-native listeners. In a second study we measured digit-triplets and sentences in steady-state noise in 30 CI users. Next to lexical access and vocabulary size the non-auditory test battery also included a reading span test and a Text Reception Threshold (TRT) test.

Results: In listeners with normal hearing, lexical-access ability was most accurately measured with combined results of lexical decision and word naming. Lexical access explained about 60% of the variance in SRT outcome. The DIN test was hardly influenced by linguistic abilities. CI-users score in the same range as non-natives on Lexical access. Their values for vocabulary size, TRT and reading span are in the normal range. The relation between speech recognition and linguistic abilities is, as expected influenced by reduced auditory processing. This relation will be presented in more detail.

Conclusion: Lexical access ability is, more than vocabulary size, an important predictor of SRTs in normal hearing listeners.

S24-15

Clinical validation data of VoiceTrack, a noise-reduction algorithm for cochlear implants

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Aim: The goal of the present study is to present clinical validation data of noise-reduction algorithm named VoiceTrack available for Neurelec Cochlear implants.

Material and methods: 20 cochlear implant recipients were included. Speech perception was assessed through speech in quiet and in noise tests with two noise types: steady-state speech-shaped noise (5dB SNR) and multitalker babble (0, 5 and 10dB SNR). Pure-tone thresholds were also assessed. A questionnaire was used to evaluate sound quality and everyday life listening situations. Subjects were tested immediately, then after one month of use.

Results: VoiceTrack did modify neither pure tone thresholds, nor speech intelligibility in quiet. Significant improvement in steady noise has been observed. Moreover, significant speech perception improvement was found in babble noise. Listening quality testing for noise annoyance and overall preference also found significant improvements.

Conclusions: VoiceTrack has shown significant speech perception and quality improvements, it is an adapted solution for patients experiencing difficulties in noisy situations.

S24-16

First clinical results Crystalis XDP coding strategy including multiband output compression function

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Aim: The goal of the present study is to present the first results from clinical validation data of Crystalis XDP coding strategy, available for latest Neurelec Saphyr Neo collection speech processors.

Material and methods: 20 cochlear implant recipients were included (10 Digisonic SP users, 10 Digisonic SP Binaural users). Speech perception was assessed through speech in quiet and in noise tests using multitalker babble. Pure-tone thresholds were also assessed. A questionnaire was used to evaluate sound quality and everyday life listening situations. Subjects were tested immediately, then after one month of use.

Results: Crystalis XDP did not show any modification of pure tone thresholds, however important improvement was observed for speech in babble noise after one month of use. Speech in quiet also showed significant improvement at lowest and highest intensities for different XDP configurations. Improvements were more salient for binaural users. Listening quality testing for noise annoyance and overall preference also found significant improvements.

Conclusions: Crystalis XDP has shown significant speech perception and quality improvements, it is an adapted solution for patients experiencing difficulties in noisy situations. More investigation will be needed to fine tune the fitting procedure with use of both functionalities simultaneously activated, optimal results are expected in that case.

S24-17

Putting the "Diagnostics" back into aural rehabilitation with *Adult EARS*

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The *Adult EARS Test Battery* is a new test that measures an adult's speech perceptual abilities with a cochlear implant. The full test battery consists of open set (e.g. *High Frequency and Low Frequency Word Identification*) and closed set (e.g. *Consonant Identification, Vowel Identification*) test materials. The *High Frequency Word Lists* consists of one syllable words with CVC format where the consonants are all voiceless blends, stops or fricatives and the vowels all have second formants above 1500 Hz. *The Low Frequency Word Lists* consists of one syllable words with CVC format where the consonants are all voiced blends, glides, nasals or stops and the vowels all have second formants below 1500 Hz. The High Frequency and Low Frequency Word Lists each have two sub lists of 50 words, and these sub lists have been found to be reliable in a test-retest study completed at *Sunnybrook Health Sciences Centre.* A cochlear implant user's responses to the *High Frequency and Low Frequency Word Lists* can be analyzed to find error patterns that reflect the person's spectral resolution. This information allows the clinician to better target auditory training as well as mapping to improve the listener's spectral resolution in the problem frequency range. Case studies and examples will be presented, demonstrating how the *Adult EARS High Frequency and Low Frequency Word Lists* can be used to diagnose problems with spectral resolution.

S24-19

International matrix tests as comparable tools for speech audiometry in different languages

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In audiological diagnostics or when providing, fitting and assessing hearing devices such as cochlear implants, it is necessary to determine how well a patient understands speech. This can lead to language barriers, for example if the patient speaks a different language than the audiometrist or audiologist. Usually the speech material is presented to the patient and the patient has to verbally repeat what he or she understood. Such speech tests can only be conducted if the patient and the audiometrist speak the same language. It can be seen even for normal hearing individuals that speech reception in noise is worse for non-native speakers than for native speakers. Measuring speech reception in noise is relevant for users of any kind of hearing device because it allows not only for assessing the amplification of a device but also for evaluating the effectiveness of noise reduction algorithms or beamformers in realistic test situations.

The EU projects HearCom (Hearing in the communication society) and Hurdig (Network for multilingual hearing and speech intelligibility diagnostics) worked on development, optimization and evaluation of internationally comparable speech tests in various languages. So called Matrix Tests like the German Oldenburg Sentence Test (OLSA) are meanwhile available in ten languages. Further language versions are being developed. Using an adaptive procedure, Matrix Tests determine the patient's SRT in noise or in quiet. The speech material consists of syntactically fixed but semantically unpredictable sentences (e.g., “Steven prefers three large windows”). Sentences are generated from a limited corpus of fifty words in a seemingly random fashion. After a training session of two measurements, the Matrix Test can be used repeatedly with the same patient since the sentences are difficult to memorize. One measurement (i.e., one list of twenty sentences) typically takes two to four minutes. In addition to the standard open format, the test can be performed in a closed format, making it suitable for use with patients of a different native language than the audiometrist or audiologist, but also for automation. This contribution provides a cross-language comparison of the available matrix tests and discusses their application in studies as well as in everyday audiology.

S25 Radiology

S25-2

The accuracy of the cone beam CT in evaluating the size of the facial recess

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Introduction: The facial recess approach is the standard approach in the cochlear implantation surgery. The size of the facial recess depends on the course of the chorda tympani. The chorda tympani branches from the mastoid portion of the facial nerve, and the position of the bifurcation varies from case to case. In some cases, the chorda tympani branches from the facial nerve at very superior portion. In that case, the posterior tympanotomy can be challenging. The chorda tympani runs through a bony canal (posterior canaliculus), and the posterior canaliculus can be detected using an X-ray microtomography (McManus et al., 2012), but the machine is not for clinical use. In clinically available conventional computed tomography (CT), however, the posterior canaliculus is not always detectable (Parlier-Cuau et al., 1998). Recently, cone beam CT has been used in a clinical setting. The cone beam CT has higher resolution than the conventional high resolution CT, and multi planar reconstruction can be obtained with ease. In this study, we explored the detectability and accuracy of cone beam CT in the evaluation of the course of the chorda tympani.

Material and methods: A total of 12 human temporal bones are included in this study. All the temporal bone received cone beam CT (Accuitomo, Morita, Japan). The acquired image was 3D reconstructed. First, the mastoid portion of the facial nerve was detected, and the three dimensionally reconstructed image was rotated around the mastoid portion of the facial nerve. With this technique, even the smallest branches are easily detected. The branch was diagnosed as the posterior canaliculus when it can be followed to the pyramidal process. The distance between the bifurcation and the tip of the short crus of the incus was measured. The temporal bone was dissected afterwards, and the actual distance between the bifurcation and the tip of the short crus of the incus was measured.

Results: In all the 12 temporal bones, the posterior canaliculus was detected with the above described technique. In all specimens, the chorda tympani branched from the facial nerve within the temporal bone. In the CT-based evaluation, the average distance from the bifurcation and the incus short crus was 12.7 mm (8.3 - 15.8 mm). The actual distance after dissection was 12.6 mm (8.2 - 16.4 mm). The largest difference between the distances evaluated with the two procedures was 1.1 mm.

Conclusion: The cone beam CT is very useful in detecting the course of the chorda tympani within the temporal bone. The measured distance is accurate enough to be used in the clinical setting.

S25-3

The effect of cochlear duct length and cochlear size on hearing outcomes in hearing preservation cochlear implantation

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Intro: Hearing preservation cochlear implantation relies upon the assumption of atraumatic insertion of the electrode. Whilst it is common to utilize a single length electrode for the majority of implanted ears, it is well known that there is variability in cochlear duct lengths within the population and even within the same individual. This variability may result in cochleae that are more or less suited to a particular length of electrode. Insertion depth may be related to the degree of electrode trauma and therefore hearing outcomes. The aim of this study is to determine if cochlear duct length is a relevant factor in determining outcomes after hearing preservation surgery.

Methods: 56 adult patients undergoing hearing preservation cochlear implantation were reviewed. 35 patients received the Flex 31 electrode (31mm) and 21 patients received the Flex 28 electrode (28mm). Full insertion was documented through a round window approach in all patients. Preoperative high-resolution temporal bone CT scans reformatted in axial and oblique coronal planes were used to measure the basal turn of the cochlea (A value) and to measure the outer and mid-scalar lengths of the cochlear duct to 720 degrees. Postoperative plain XRs were done to determine degrees of insertion and number of electrodes within the cochlea. Pure tone average thresholds and speech discrimination at 6 months were compared between the two groups

Results: The cochlear outer wall and mid-scalar lengths are significantly correlated with the A value measured in the oblique coronal plane ($R=0.7$ and 0.6 respectively, $p< 0.05$). Both measures of cochlear duct lengths were highly correlated ($R=0.85$) and normally distributed, consistent with temporal bone studies. The Flex 28 electrode had a greater mean insertion depth of 525 degrees and 11.3 electrodes within the cochlea compared to the Flex 31 electrode with 488.29 degrees and 10.9 electrodes. The shorter Flex 28 electrode also had a greater depth of insertion in larger cochleae. In addition, for the Flex 28 electrode, CNC word scores at 6 months were higher in larger cochleae ($R=0.7$, $p< 0.05$) but not for the Flex 31 electrode. Effects on hearing preservation rates will be presented.

Discussion: This study demonstrates that standard radiological software can be used to measure the cochlear duct length and that the basal cochlear diameter is a predictor of cochlear duct length. The shorter electrode paradoxically had an overall greater depth of insertion and in larger cochleae, achieved a greater insertion angle and greater speech discrimination. This may suggest postoperative migration of the longer electrode despite full insertion.

Conclusion: Cochlear duct lengths vary between individuals and longer electrode lengths may not necessarily result in deeper insertions or better outcomes, indicating the need for individualized electrode choice.

Learning outcome: To discuss the role of cochlear size on electrode insertion and outcomes

S25-4

Cochlear duct length: the variability and significance

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Functioning of cochlear implant is based on Greenwood equations, which in turn depends mainly on length of cochlear duct and depth of insertion of electrode array. Though a lot of studies have been done on insertion depth and its impact on cochlear implant results, but only a few studies have been done to study cochlear duct length and this factor is not given much importance in preoperative evaluation.

We calculated cochlear duct length of 143 patients (286 ears) using special cuts in HRCT temporal bones and mathematical equations. Mean cochlear duct length was 29.9 mm with a range from 28 mm to 34.7 mm.

These findings clearly show that cochlear duct length is very variable and in this highly developed organ, even 1-2 mm makes a lot of difference, so probably we need to rethink about the traditional fixed electrode length implants which we are using. Secondly, this study, being one of the very few studies which have been done in this geographical area, shows that cochlear duct length is smaller than rest of the world, indicating that we might be stimulating lower frequencies much more than we know.

S25-5

Radiological and surgical planning with a new computer tomography software

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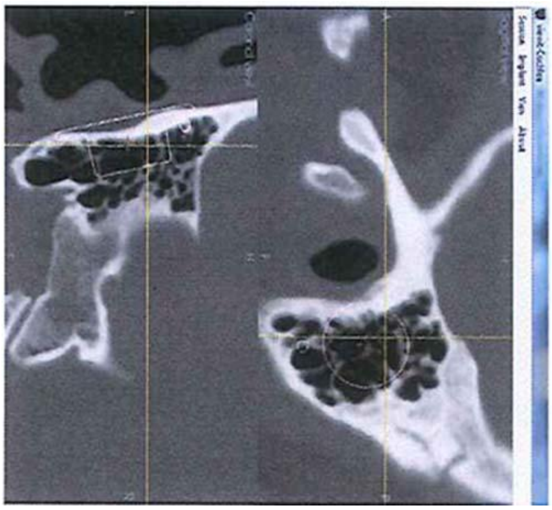
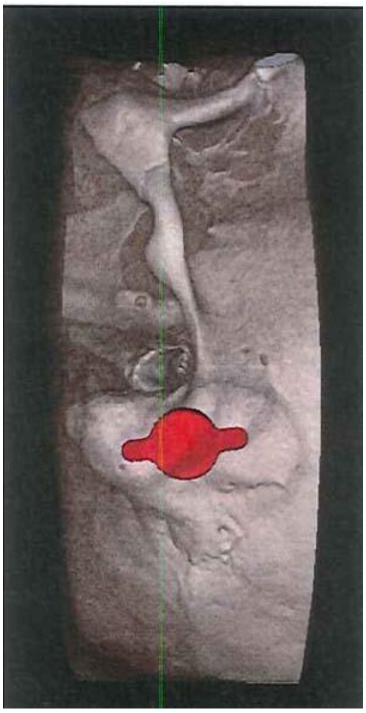
Introduction: Viewit-Chochlea is newly developed research software which enables surgeons to easily and accurately assess the proper placement options of bone-conduction devices, such as the Bonebridge, on the temporal bone of the patient. The implantation of bone-conduction devices, and in particular the Bonebridge BC-FMT, requires a recess to be drilled into the cranial bone. This software allows the surgeon to analyze the dimensions of the bone and to verify whether an optimal placement of the device is possible without compressing critical structures like the dura or sigmoid sinus.

Material and methods: The placement process starts with importing a Computer Tomography scan stored in the common DICOM format and the digital template of the bone-conduction device. The bone-conduction template of the BC-FMT can be placed on one of the views, the coronal, the axial or the sagittal view by just one click on the mastoid. It can now be easily rotated in the three dimensions with the mouse. Each of the views can be scrolled through verifying if critical structures are preserved. The implant is fixed on the skull with two cortical screws which placement can also be identified. The last step of the procedure is the surgical planning which consists of the three dimensional reconstruction of the skull showing the proper placement of the device. The reference points like the temporal line, the mastoid tip as well as the spine of Henle guide the surgeon to find the same position on the head of the patient.

Conclusions: The software is an easy to handle tool to carry out an accurate radiological and surgical planning in a very short time frame.



[Radiological 1]



[Radiological 2]

S25-6

Interdependence of the dimensions of the cochlea and scalar position of the electrode array

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Introduction: The anatomy of the cochlea is quite constant in some respects, more variable in others like length of the cochlear duct and size. Therefore, the electrode positions of the electrode array can vary significantly regardless of the insertion technique and may have an effect regarding the auditory outcome. Traumatization of the cochlea - indicated by scalar dislocation for example - may be detrimental in regard to future technology like hair cell regeneration or light based stimulation of the cochlear nerve as it may promote degeneration of ganglion cells. As type of electrode array and the implantation process are under control of the surgeon implanting, it is important to understand the interdependency of array and anatomy of the cochlea to optimize the position of the electrode array.

Methods: 440 adult patients (518 ears) without cochlear anomalies have been implanted with a perimodiolar electrode array (contour advanced, Cochlear) in the years 2003 to 2010 at the Department of Oto-Rhino-Laryngology, Medical Center - University of Freiburg. Cone beam tomography is used for postoperative evaluation regularly and has been analyzed in regard to electrode position (scala, insertion angle) and cochlear size (diameters and height). Speech discrimination scores have been collected during the postoperative rehabilitation phase using the Freiburg monosyllables and Oldenburg sentence test.

Results: Speech perception is influenced by the scalar position of the electrode, albeit a small effect size. Scalar dislocation is most likely to occur after the first half turn, no reliable correlation between the cochlear dimensions and probability of dislocation could be found.

Conclusion: Due to the small effect sizes expected, a higher number of samples may be necessary to show the effects of the size relation between cochlea and electrode array. Nevertheless, postoperative quality control in the form of imaging techniques and the prevention of cochlear damage is important to optimize the surgical technique. Cochlear trauma may not only be detrimental to future techniques of hearing rehabilitation but influences speech discrimination outcomes.

Learning outcome: The listener will learn about the variations in cochlear anatomy and factors in scalar dislocation.

S25-7

Electrode migration in patients with perimodiolar electrode arrays

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Introduction: Cochlear implantation is a safe procedure with a low risk for major complications. Migration of the electrode is associated with vertigo, tinnitus, low speech perception and nonauditory stimulation, but is a rather uncommonly complication. So far it was only observed in lateral wall electrodes. The aim of our study was to detect electrode migration by comparing postoperative insertion depth angle with the insertion depth angle after surgery of the second side in patients with perimodiolar electrode arrays.

Material and methods: Between 1999 and 2013 59 patients underwent bilateral cochlear implantation in our institution. Most of the patients received perimodiolar electrode arrays (Nucleus Contour, Contour advance, Helix). The electrode array position was observed radiologically by the surgeon and 2 radiologists using a Flat Panel Tomograph (Philips Allura) or a high resolution CT scan. The insertion depth angle was estimated on the postoperative scans and compared with the postoperative scans performed after the second side surgery.

Results: In 40 patients radiologic images were evaluable and the insertion depth angle was estimated. The mean timeframe between surgeries was 24 month. 6 patients were detected with an electrode array migration of more than 20°.

Discussion: In our population migration of the electrode array was seen in 15% of the patients. Fixation of the electrode array is required to avoid electrode migration even in perimodiolar electrodes. Electrode migration in perimodiolar electrodes seems to be less frequent and to a lower extent than in lateral wall electrodes.

S25-8

Visualization of human inner ear anatomy with high resolution 7 Tesla magnetic resonance imaging

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Cochlear implantation requires detailed information of the microscopic anatomy for surgical planning, morphological calculations and to predict functional success. In many centers MRI of the inner ear and auditory pathway - performed on 1,5 or 3 Tesla systems- is part of the preoperative work-up of CI-candidates. A higher magnetic field strength results in a higher signal-to-noise ratio that can be used for more detailed imaging than previously possible. The visualization of delicate and small-sized inner ear structures might benefit from such higher resolution imaging. However, due to technical complexity, protocols need to be specifically developed for higher field scanners. The aim of this study was to investigate the feasibility of representing inner ear anatomy on images performed with 7 Tesla MRI.

A high resolution T2-weighted protocol of the inner ear was developed in healthy volunteers on a 7 Tesla MRI system (Philips Healthcare, The Netherlands), with an isotropic resolution of 0.3 mm, resulting in a scan duration of 10 minutes. Two high permittivity pads, which consisted of a deuterated suspension of barium titanate ($\varepsilon_r \approx$ 290), were designed using numerical simulations and positioned next to the ears to enhance the signal at the location of the inner ear. The optimized protocol has been applied to 17 CI candidates and was independently compared to the standard pre-operative 3 Tesla MRI work-up by two experienced radiologists. The use of dielectric pads was essential in obtaining a high image quality. Without these pads, the magnetic field inhomogeneities result in signal loss in the area of interest. In CI candidates, the images obtained at 7 Tesla showed improved contrast and spatial resolution in comparison to the regular 3 Tesla protocol.

Fine intra cochlear anatomical structures, such as modiolus, interscalar septum and spiral osseous lamina were identified in high detail. This resulted in a clear delineation of scala vestibuli and scala tympani within the 2.5 cochlear turns. The isotropic resolution is allowed for oblique multiplanar reconstruction, without the loss of image quality and resulted in excellent visualization of the different branches of the cochleovestibular nerve. The high resolution achievable with 7 Tesla MRI enables and even substantially improves the representation of the inner ear anatomy and can contribute to improve preoperative planning of cochlear implantation.

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S25-9

Assessment of scalar position and potential post-surgery movement of the Advanced Bionics HiFocus Mid Scala electrode based on fusion of cone beam CT and MRI

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Introduction: One of important aspects related to the performance with a cochlear implant (CI) is the achievement of consistent electrical coverage with the electrode. Ideally, we would be able to accurately assess the position of the CI electrode in relation to the inner cochlear structures. In our experience, the best segmentation of the scalae is achieved using MRI, which is not possible after CI surgery. Cone Beam CT (CBCT) does provide accurate information about the position of the electrode but the delineation of the scalae is limited by electrode scattering. Here we present an approach that combines CBCT imaging together with MRI. By superimposition of registered volumes with sub voxel accuracy (< 0.2 millimetres), one can benefit from the advantages of both modalities. Repeating the CBCT over time also allows the clinician to diagnose problems such as migration when they arise. This toolset is applied to investigate the new Advanced Bionics High Focus Mid-Scala Electrode.

Methods: Pre-operatively, a high resolution MRI was made of the cochlea. One day after surgery, the first CBCT scan was made and registered to the MRI. After 3 months the second CBCT scan was made and an in-house developed image-processing algorithm calculated the migration in millimetres.

Results: Superimposition of CBCT with MRI allows for the assessment of the CI electrodes in 3 dimensions. The preliminary data of the performance of the Advanced Bionics Mid-Scala Electrode will be presented.

Conclusion: In our experience, fusion of CBCT and MRI, is a useful tool for clinicians interested in cochlear implant electrode position after surgery.

S25-10

Scalar localization of the electrode array using the cone beam computed tomography: A comparative study between straight and periomodiolar precurved electrode array

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Objectives: To compare the fidelity of conebeam x-ray CT (CBCT) in vivo imaging in characterizing cochlear implant insertion between a straight electrode array and a precurved perimodiolar electrode array.

Materials: Fifty one adults patients and 60 implants were included in the investigation (nine patients had a bilateral implantation), 27 women and 26 men. The mean age was 49.9 years old (18 - 89). All subjects had binaural deafness or severe sensorineural hearing loss in non-malformed cochleas.

Thirty patients were implanted with a Cochlear N24RE(CA) implant (Cochlear Corp., Sydney, Australia) fitted with the Advance Off-Stylet (AOS) electrode insertion technique.

Thirty patients were implanted with a MED-EL (GmbH, Innsbruck, Austria) Flexsoft standard (9 implants), Flexsoft 28 (18 implants) and Flexsoft 24 (3 implants).

In all subjects, round window insertion technique had been applied by the same surgeon using a pure round window full insertion, i.e. through a vertical micro incision in the anterior quadrant of the RW membrane. Complete insertion within the round window had been performed in all cases. For this study, approval by the ethics committee of the university hospital was obtained.

Radiological procedure: Post-operative CBCT imaging was performed with a NewTom 5G (NewTom, Verona, Italy). The system used a 200 x 25 mm flat panel detector at 650 mm from the radiation source. The 360° rotation of the X-ray tube took 18s. Tube voltage was 110kV, with a 19 mA charge at the terminals. Total filtrations were 2 mm and pitch 125 µm, with field of view corresponding to a 12 x 7.5 cm diameter cylinder. Images were reconstructed in 125 µm isometric voxels and obtained in axial, coronal and sagittal planes, using the software provided by NewTom.

Image Analysis: CBCT imaging of the temporal bones was reviewed by three independent neuroradiologists who were blinded to the details of the electrode insertion, electrode orientation and insertion depth. Evaluation of the 3D imaging included an assessment of the scala implanted and Basilar membrane disruption.

Results: The results were collelated within the 3 neuroradiologists in 56 out of 60 implants. A rereading was performed for 4 mismatches by the three neuroradiologists. In the perimodiolar electrode array group (Cochlear) (n= 30) a disruption of the basilar membrane was observed in 2 cases and an elevation of basilar membrane in 7 other cases. In the straight electrode array group (MED-EL) (n = 30), no disruption of the basilar membrane was observed and an elevation of the basilar membrane was observed in 3 cases with standard Mendel electrodes.

Conclusion: CBCT is a fast and accurate examination in the postoperative imaging of cochlear implants that enables to control the scala position of the electrode array. A straight flexible electrode array has a higher chance of a strict scala tympani positioning than a perimodiolar precurved electrode array.

S25-11

Complete Cochlear Coverage: Importance and method to achieve it

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Background: Complete Cochlear Coverage (CCC) with atraumatic deep electrode insertion is beneficial for better place pitch frequency mapping. The audio-processors from the various CI manufacturers are designed to stimulate with an approximate frequency range from 40 to 10000 Hz distributed between the most apical and basal contacts. In order to get the optimum place pitch match, it is desirable to place the electrode in the right location inside the Scala tympani (ST). Histological studies have shown that the cochlear duct length (CDL) of a normal anatomy cochleae measured at the Organ of Corti (OC) ranges from 25 to 35 mm, a 40% variation. The MED-EL electrode arrays are designed in a way that the most basal contact is located approximately 4mm away from the marker stopper. This ensures better place pitch match, when the right electrode array matching the CDL is chosen and fully inserted.

Aim: Estimating the CDL prior to surgery helps to select the right electrode array. The method to estimate the CDL, validating the method and presenting the results in a simple way (computer APP) to use by surgeons and audiologists is the focus of this study.

Method: Different methods are available to estimate the CDL using simple measures from the pre-op clinical imaging. One such method is the use of mathematical equations that were formulated using data acquired from prior published studies to estimate the CDL for various insertion depths. The mathematical equations take the longest basal turn diameter “A” from the pre-op clinical imaging as the input and estimate the CDL. A temporal bone study (n=15) with electrode insertion was done to validate these mathematical equations.

Results: Validation study shows that the mathematical equations predict CDL with a correlation of 0.96. The Greenwood function provides the mathematical basis for estimating the frequency location of lateral wall electrode contacts with a known CDL. By combining the CDL estimate with the Greenwood function, the frequency distribution for each cochlear length can be derived. With discrete electrode array lengths of 20, 24, 28 and 31.5 mm cochlear coverage up to close to the apical region can be surgically planned.

Conclusion: Pre-op radiographs are routinely taken for evaluating the condition of the cochlea and with that it should be possible to

1. Estimate the CDL and select the right electrode array length for maximum CCC and to prevent structural damage caused by over insertion.
2. Program the implant with a better place pitch-match if so desired. This may also result in enhanced fine structure processing.
3. A combination of CDL and frequency map would be very essential for selecting the right electrode array for EAS cases with no progressive hearing loss where electrode placement in the functional residual hearing region is detrimental to delicate structures.

S25-12

Retrospective analysis of straight electrode array dislocation to the scala vestibuli and the audiologic effects

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The frequency of cochlea implantation is increasing because of the better outcome of hearing performance and speech recognition. The main factor is of course the permanent development of the electrodes and processors of the cochlea implant, but the auditory performance shows individual variability. The cause of the different outcome was researched in many studies. Van Wermeskerken et al. showed 2009 that the quality of the interface between the electrode and the auditory nerve endings play a major role. According to Aschendorff et al. the localization of the electrode has a significant impact on the speech recognition. Patients where the electrode array was inserted in the scala tympani had a better outcome than patients where the electrode array was inserted in the scala vestibuli or dislocated from scala tympani to scala vestibuli. To control the localization of the electrode array the cone beam computed tomography is a reliable method.

The aim of this study was to analyze the relationship between electrode position in the cochlea and auditory outcome after implantation in patients at the Department of Otorhinolaryngology, Head and neck surgery Medical University Innsbruck. 75 cochlea implantations with various straight electrodes (MED-EL, Innsbruck, Austria) were included in this study. The main aim was to analyze the dislocation frequency and if dislocation has any influence on the hearing outcome. Therefore the pure tone audiograms of week 6, 12, 24 and 48 after implantation have been compared. In only 5 patients the cone beam CT scan showed a dislocation from scala tympani to scala vestibuli. No audiologic differences in patients with dislocated electrode array and patients with regular positioned electrode array could be noted. In contrast to current studies, these results show no significant differences between the auditory outcome of patients with or without dislocation.

S25-13

MRI scanning in patients implanted with an alternatively coupled floating mass transducer of the Vibrant Soundbridge

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Introduction: MRI Scans play an important role in the clinical routine process. Due to an actuator magnet placed in the middle ear, the Vibrant Soundbridge (VSB) System differs fundamentally from other implantable Hearing Systems. The aim was to further investigate the consequences of an MRI scan of the patient group, which were provided with an alternatively coupled FMT of the Vibrant Soundbridge System.

Method: In a retrospective study 65 patients were included. Out of them 41 questionnaires were evaluated concerning their statements about their medical, otological and general condition before, during and after an MRI scan, which was carried out despite the previous implantation of an alternatively coupled Vibrant Soundbridge System.

Results: In 3 patients (7.3 %) four MRI examinations were performed. These were carried out due to different indications (knee and shoulder joint diagnostics. During the scanning, noise and subjectively perceived distortion of the implant was described . The respective body region examined (e.g. shoulder, knee) played a role in the occurrence of these effects. An affection of the hearing threshold or the hearing with the VSB system was not observed.

Conclusion: MRI examinations in patients with an alternatively coupled VSB can lead to unpleasant side effects. A negative effect on the residual natural hearing or hearing performance with the implant was not observed.

S25-14

Observation of cortical activity during speech stimulation in prelingually-deaf adolescent and adult patients with cochlear implantation by PET-CT

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Objective: To evaluate the cortical activity of prelingually-deafened cochlear implant (CI) adolescent and adult patients who have been trained by auditory-verbal/oral communication since childhood.

Methods: Brain activities examined by positron emission tomography (PET) using 18-fuluoro-deoxy-glucose (FDG) of 6 prelingually-deafened CI users were compared with those of 10 normal individuals. Changes in regional cerebral blood flow were measured during auditory language stimuli while listening to a story. The mean age at CI of the 6 patients was 19.7 years old (ranging from 12 to 34 years old; 3 male and 3 female). The mean postoperative observation time was 26.7 months (ranging from 4 to 70 months). Ten normal volunteers were observed as age-matched controls (mean age = 27.1 ranging from 22 to 34 years old; 6 male and 4 female).

Results: In the successful prelingually-deafened adult users, the auditory-related regions, when compared to same regions in the controls, showed hypermetabolism in left dorsolateral prefrontal cortex and left precentral gyrus, which is similar to successful CI user of prelingually-deafened children and postlingually-deafened adults. In the unsuccessful prelingually-deafened adolescent users, the hypermetabolism was seen in the primary auditory cortex and Broca's area. These findings may indicate the relationship between the postoperative performance and the cortical activity in older prelingually-deaf CI patients from the viewpoint of cerebral functioning. As for visual-related regions, hypometabolism was observed in visual-related regions of BA18 and BA19, and this is thought to be due to the intensive auditory-verbal education without visual sensation since childhood. In other words, this might show the relationships between auditory and visual center system.

Conclusion: Despite the limits imposed by the small sample size and the spatial resolution of PET, this study yielded insights on the nature of the brain plasticity in prelingually-deafened adolescent and adult CI users.

S25-15

Tonotopic organization of the primary auditory cortex

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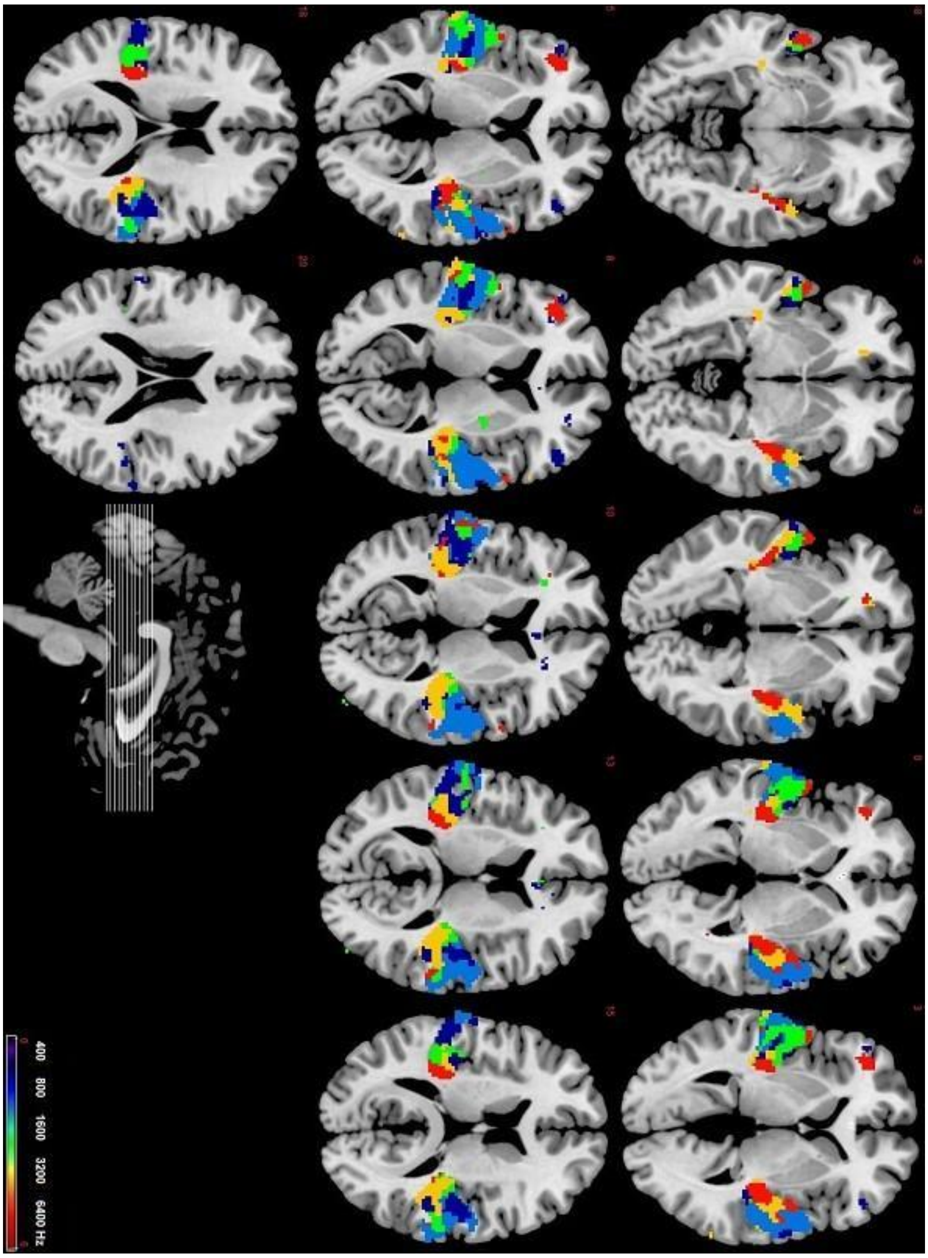
Introduction: Tonotopic organization found in the human inner ear is preserved in all structures of the auditory system, including the primary auditory cortex (PAC).Functional magnetic resonance, despite its limitations, has proven a valuable tool to assess the phenomenon (Saez et al. 2013).A modified study scenario by Humphries et al. 2010 was tested, with the emphasis on crucial aspects of auditory fMRI data collection.

Material and methods: Twelve healthy adults (mean age 32 years ±11 mths, 6M, 6F) participated in an fMRI study.The study was performed on a Siemens 3T MRI MAGNETOM Trio scanner. Multi-tone sequences were presented with the following central frequencies: 400, 800, 1600, 3200, and 6400 Hz.All were normalized to 80dB SPL (C).Two-tone and three-tone stimuli were presented pseudo-randomly and there were 8 presentations of each sequence type and silence in one run. The study was done using a *sparse* paradigm, with sounds presented in silent gaps between data acquisitions (2s-periods).The imaging parameters were: TR = 1000ms, TE = 30ms, 28 slices, voxel size 2x2x2mm.All subjects participated in three fMRI runs, each 8:33 minutes in duration. Brain responses were explored with SPM12b, followed by detailed analyses in Brain Voyager QX.Two approaches were used, one showing SPM t-maps of the primary auditory cortex engagement directly and the other revealing scaled PAC maps ($t \geq 4$, $p < 0.05$ FWE).

Results: The tested fMRI paradigm provided robust group activations in the primary auditory cortex, showing frequency-specific maps in bilateral superior temporal gyri.Despite some inter-individual differences, tonotopic maps showed consistent patterns (see Figure 1.).A V-shape high-low-high frequency gradient was found across the Heschl gyri.



[Fig1.Normalised group SPM t-maps.]

Conclusions: The study revealed tonotopic organization of the primary auditory cortex, as shown with functional magnetic resonance. Factors, such as the stimulation intensity and subject attention have to be considered. More participants need to be involved in the project to confirm the brain response patterns in wider healthy population.

References: Humphries, C. et al.(2010).Tonotopic organization of the human auditory cortex, Neuroimage,50(3),1202-1211.

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S25-16

Partial deafness - mapping tonotopy in the primary auditory cortex

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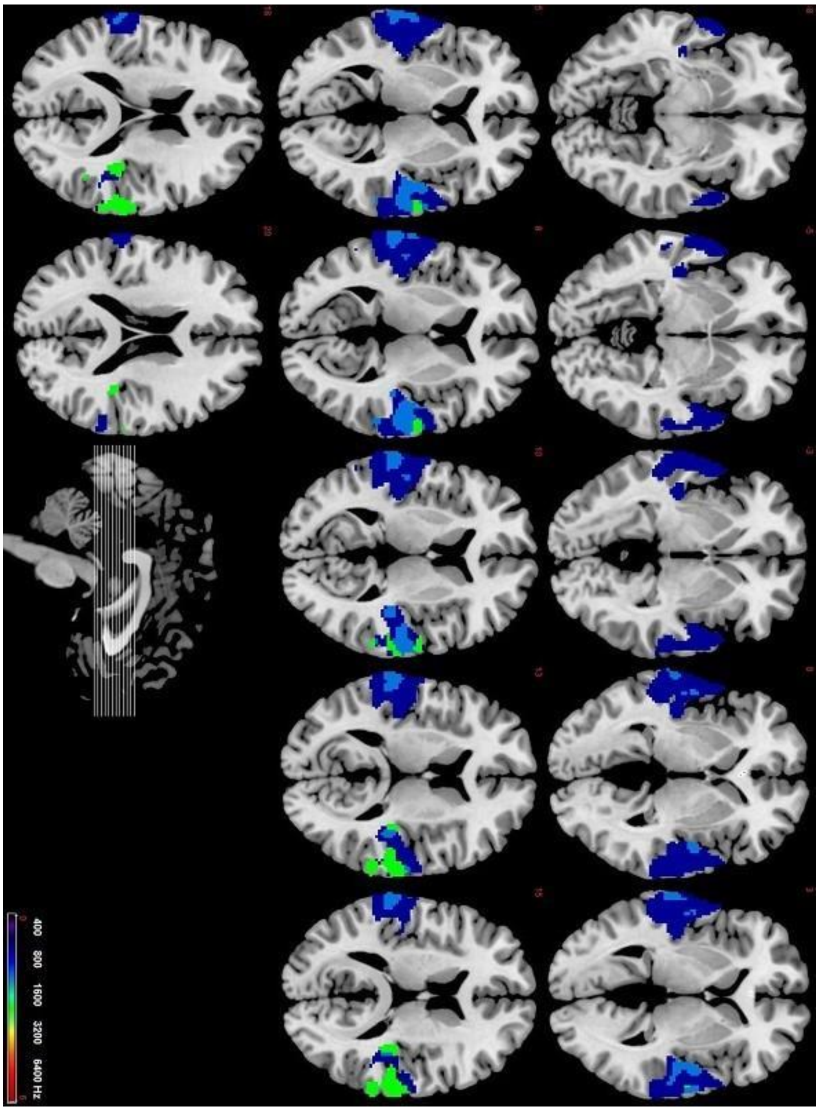
Introduction: Partial deafness (PD), with characteristic profoundly impaired processing of high frequency sounds is a common type of hearing loss. One treatment option is cochlear implantation. The solution provides good but variable auditory outcomes in PD patients. Pre-operative fMRI brain activation studies can serve to assess the specific tonotopic organization of the primary auditory cortex (PAC) in patients.

Materials and methods: Fourteen patients with bilateral symmetrical partial deafness (7F,7M, mean age 35 years ± 9 mths) participated in an auditory fMRI study. Average hearing loss in the following frequency bands: 125, 250, 500, 1000, 2000, 4000, 8000Hz was approximately 25, 30, 40, 60, 80, 90, 100dB HL, respectively. The study was performed at a Siemens 3T MRI MAGNETOM Trio scanner. The paradigm was described in Ciesla et al. *Tonotopic organization of the primary auditory cortex*. SPM12b and Brain Voyager QX were used for data analysis. Two methodologies showed both SPM t-maps representing the primary auditory cortex engagement directly, as well as scaled PAC maps ($t \geq 4$, $p < 0.05$ FWE). In addition, patients performed tests assessing their psychological performance and life quality. Behavioural tests were also administered to a matched healthy group.

Results: Patients showed unique tonotopic maps in the primary cortex. They were divided into sub-groups reflecting their audiological profiles and brain response patterns (see Figure 1. showing one sub-group brain responses to 400,800, and 1600Hz, normalised t-values). The effects of deprivation-related auditory plastic reorganization were visible. Among others, behavioral assessments revealed slightly elevated depressive and anxiety symptoms in patients and less active coping strategies.



[Fig1.Normalised group SPM t-maps.]

Conclusions: The study shows specific brain response patterns in partial deafness. If certain limitations of the fMRI technique are taken into account, it proves a valuable tool to investigate auditory plasticity. Further neuroimaging studies, combined with behavioral data analyses, are essential to explore this unique population and potentially improve future rehabilitation measures.

S25-17

Tractography of the language network in prelingually deaf patients

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Introduction: Prelingually deaf adults who receive a cochlear implant (CI) usually develop only a limited ability to understand spoken language. In these patients, missing stimulation via the auditory pathway in early childhood leads to a cortical reorganization in such a way that the processing of other sensory modalities, e.g. visual information, takes over regions that are normally occupied by the auditory system. In order to investigate to what extent this reorganization is reflected in the white matter, we visualized fiber tracts of the language network by means of diffusion tensor imaging (DTI). In the past, DTI studies dealing with deaf patients focused on subcortical structures relevant for auditory processing. Since understanding speech, however, requires not only an intact auditory pathway, but also a well-developed language network, we applied tractography to study the relationship between prelingual deafness and white matter anatomy of language-associated tracts.

Methods: Five prelingually deaf adults with bilateral hearing loss (mean age 29; 3 women) and five normal-hearing controls (mean age 27; 3 women) took part in the study. Each subject underwent one MR scanning session, in which a T1- and a diffusion-weighted data set was acquired. Subsequent tractography was carried out using ROI-analyses (region of interest).

Results: None of the participants displayed neuroanatomical pathologies. Tractography revealed a shorter left arcuate fasciculus in patients compared to controls. In addition, the left uncinate fasciculus was less pronounced in the deaf.

Discussion: Representing one of the major pathways in language processing, the left arcuate fasciculus connects Broca and Wernicke area and is involved in both language production and perception. The uncinate fasciculus plays a role in auditory-verbal memory and semantic tasks, which is also essential for successful language comprehension. Our results confirm the importance of these tracts for the processing of spoken language and underline the significance of a sensitive period for the acquisition of spoken language and the development of the language network in early childhood. By means of DTI we could show that missing auditory stimulation during this critical time window leads to a reorganization of neuronal connections, which impedes the possibilities of speech rehabilitation in prelingually deaf CI users despite the ameliorated hearing conditions provided by the implant.

Conclusion: The arcuate and the uncinate fasciculus in prelingually deaf adults are insufficiently developed, which impairs successful comprehension of spoken language despite the benefits of a CI on hearing. In order to investigate this and employ it for diagnostic purposes, DTI serves as a good instrument. It is easy to integrate into routine examinations and reveals additional information about the neuroanatomical prerequisites for the hearing and speech rehabilitation of CI patients.

S25-20

Three-dimensional surgical anatomy for cochlear implantation

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We examined the three-dimensional (3-D) surgical anatomy relating to cochlear implantation (CI) by using computer-aided 3-D reconstruction from human temporal bone specimens. As for the round window (RW) niche, the shape was found like an inverted pouch having unexpectedly small variation in shape with its longest distance inside of about 3 mm on average, and its mean volume of approximately 4.7 mm^3. The shortest distance between the aperture of RW niche to the lateral margin of RW, indicating how much we can drill away the bony overhang of the RW niche for visualization of the RW membrane, was 0.7 mm on average. The RW membrane was shaped like a saddle having a considerable variety in shape with the mean area of 2.7 mm^2. RW was located exactly at the floor of the end of the hook portion, which curved medially for about 45 degree to reach the vestibule. At its posteromedial margin, the RW membrane was directly attached to the osseous spiral lamina (OSL), and crista semilunaris was located exactly at the anterior end of the site where the RW membrane met the OSL. Basilar membrane (BM) was also quite close to the RW membrane at the hook portion with the shortest distance of approximately 0.6 mm at the superior margin of the RW. When we consider the facial recess approach during CI surgery, the angle between the trajectory of the electrode advancement to the RW and the plane of the anterior part of the RW was quite small being about 30 degrees.

S25-21

Artifacts induced by bone conduction implant with MRI-scan. A method to reduce their impact on radiologic assessment

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Background: The Bone Bridge implant is being said to be MRI-scan safe and its applicability to the treatment of single sided deafness and conductive or mixed hearing losses has been demonstrated. However, the limitation due to the MRI-induced artifacts is still unknown and may impact the follow-up of otologic or cerebral diseases.

Objectives: To evaluate artifacts induced by the Bone Bridge implant exposed to a 1.5 Tesla magnetic resonance field. We aimed to analyze first the impact of these artifacts on the visualization of the temporal bone and intra-cranial structures, and second to test whether different positioning of the implant may reduce the location and size of the artifacts.

Methods: Ten healthy volunteers underwent a cranial MRI-scan. MRI-scan was done without implant and repeated with the Bone Bridge implant just applied onto the skin in the mastoid area, maintained by a standard bandage Artifacts' areas were measured relative to surface of the whole slices for two different slices: one reference axial *section* crossing the column of the fornix and one reference axial section crossing vestibular labyrinths. 3 different positioning of the implant relative to the orbitomeatal plane were tested: 0°, 45° and 90°. MRI-scan acquisitions were repeated identically. We performed a quantitative and qualitative analysis of artifacts' areas using the Osirix software. The relative percentage of artifact area was calculated for each patient and each implant position. The mean percentage artifact area for each MRI sequence and each implant position was calculated and compared intra- and inter-individually. Using a qualitative assessment grid, two radiologists evaluated the visibility and deformation of specific intra-cranial structures for each subject with regards to implant positioning. Wilcoxon signed-rank test (non-parametric statistical hypothesis test) was used to compare artifact area in regard of sequence, slice thickness or implant position.

Results: Whatever the type of MRI-scan acquisition, implant positioning at 90° impacted significantly less both the surface of artifacts ($p = 0.002$) and the visualization and deformation of structures. Artifact area is greater for 2.5 mm slices comparing to 5 mm slices ($p = 0,002$ for T2 weighted sequences, $p = 0,006$ for T1-weighted sequences). T2-weighted sequences create fewer artifacts than T1-weighted sequences with a 90° implant positioning ($p = 0.002$). Radiologist evaluation found better scores for 90° implant positioning ($p = 0.03$).

Conclusion: tifacts are reduced by the positioning the Bone Bridge implant perpendicular to the orbitomeatal line, by using thicker slices and T2-weighted sequences. This experimental study provides trails for further clinical studies with patient requiring bone vibrator implants. This study helps to adapt the position of implant according to a specific cerebral or temporal bone pathology needing radiologic follow-up.

S26 Active middle ear implants II

S26-1

Alternative inner ear stimulation with the Cochlear™ Codacs™ Direct Acoustic Cochlear Implant Actuator

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Background: The working principle of the Cochlear™ Codacs™ Direct Acoustic Cochlear Implant System is the stimulation of the inner ear via a standard K-Piston through the stapes footplate (SFP) after a stapedotomy. Alternatively the stapes head (SH) or SFP can be used as possible stimulation sides. Here the Codacs actuator efficiency in these alternative applications was investigated.

Methods: All experiments were performed with the Codacs actuator in cadaveric human temporal bones in analogy to ASTM standard F2504-05. Prior to the standard K-Piston application (N = 9), the SH was stimulated with a “Bell prosthesis” (N = 9) and the SFP with an “Omega connector” (N = 8). The axial coupling force in the alternative coupling conditions was adjusted to ~ 5 mN, whereas the K-Piston application uses ~ 0 mN static loading force. The displacement of the round window (RW) membrane served as reference for output determination and was measured with a Laser Doppler Velocimeter for the three conditions.

Results: In all conditions, the average outputs had a plateau range below ~ 2 kHz (≤ actuator resonance frequency) and a drop-off at higher frequencies (Figure 1). The outputs of both alternative stimulation modes using the SH and the SFP as input site were similar and both significantly more efficient than the K-Piston application. Calculated as equivalent sound pressure output levels [eq. dB SPL] using the RW displacement as reference, the mean (0.5, 1, 2, 3, 4 kHz) outputs at 1 V_{RMS} input voltage were 133 dB SPL (Bell), 134 dB SPL (Omega) and 115 dB SPL (K-Piston).

Conclusions: Both investigated alternative coupling conditions provided significantly higher output than the K-Piston standard application, when the stimulation was performed at controlled axial force. Based on the results, the Codacs actuator generates sufficient output at alternative stimulation sites, provided that experimental conditions are adapted to the “real” situation, including geometric adaptations and providing a constant axial coupling force.

Funding: This project was funded by Cochlear Ltd.

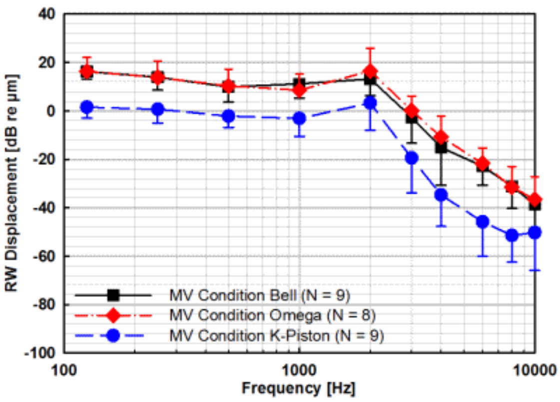

Figure 1: Mean values and standard deviations (error bars) of the RW displacement responses to Codacs actuator stimulation @ 1V_{RMS} in the three investigated conditions.

[Figure_1]

S26-2

Long-term results of direct acoustic cochlear stimulation with Codacs ID

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Intro: Objective of this study was to evaluate the stability of audiometric, functional and subjective results for patients implanted with the Codacs™ ID Direct Acoustic Cochlear Implant (Cochlear Ltd., Sydney) for mixed hearing loss due to otosclerosis.

Methods and patients: Prospective study in a pre- and post-intervention design with multiple post intervention hearing aid measurements and patient questionnaires. Setting: Tertiary academic centre. Five patients with severe to profound mixed hearing loss due to otosclerosis, who were implanted with the Codacs ID in the European phase 1 trial. The patients were implanted with a Codacs Direct Acoustic Cochlear Implant investigational device (ID) combined with a stapedotomy with a conventional stapes prosthesis. The main outcome measures were changes in hearing disability and handicap as evaluated using the Abbreviated Profile of Hearing Aid Benefit (APHAB) and a questionnaire on daily usage. Furthermore aided and unaided pure tone thresholds, and speech recognition scores in quiet and in noise were obtained. All were compared to the short term results after 3 months.

Results: The mean follow up period was 19 months. The aided and unaided thresholds showed stable values compared with the short term results. The aided speech reception and speech in noise recognition values did not show any significant difference. APHAB score were equally improved from the pre-operative situation. All five patients used their implant on a daily basis and were content with the device. No device failure or complications occurred.

Conclusions: The Codacs ID provides stable results during the first years after implantation. No changes in residual hearing were found and technical or medical complications did not occur.

Learning outcome: long-term direct acoustic cochlear stimulation is safe and gives stable results in terms of performance and subjective outcome.

S26-3

Indications, technique and functional results of a fully implantable acoustic device

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Objective: the objective is to report our experience with the Carina fully implantable hearing devices in sensorineural and mixed hearing loss.

Methods: 25 patients implanted with this device from September 2005 to 2011 were followed up prospectively. Evaluation of results were done through a questionnaire (APHAB) and objective pure tone and vocal measurements in free field. Gains were assessed according to comparison in free-field.

Results: 13 patients had a sensorineural hearing loss and the tip of the transducer was connected to the body of incus. 12 patients had mixed hearing loss with the transducer connected to the stapes head or the footplate. Subjective evaluation indicated a good level of satisfaction in mixed loss patients comparing to more balanced results in sensorineural patients. In average, patients benefited from a mean gain of 26 dB (± 6 dB) in PTA, and 44% (± 26) in speech scores at a presentation level of 65 dB.

Conclusion: the Carina fully-implantable middle ear hearing device is a versatile and valuable option to treat patients presenting with moderate sensorineural hearing loss, and especially mixed loss cases, with a good level of satisfaction and tolerance.

S26-6

Active middle ear implant vibrant soundbrigde in sensorineural hearing loss

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Introduction: Middle ear implantation is a relatively new approved treatment for patients with sensorineural hearing loss (SNHL) who do not benefit from conventional hearing aid fitting. Previous studies reported improvements in overall sound quality and better speech recognition scores with the active middle ear implants (AMEI) as compared with conventional hearing aids. The aim is to evaluate threshold level and speech discrimination results in our patients with mild-to-severe down-sloping SNHL who received AMEI Vibrant Soundbridge (VSB).

Methods: 16 patients with stable SNHL fitting all the audiologic criteria were submitted to VSB implantation. In 3 patients VSB was sequentially implanted in both ears. All patients had previous unsatisfying benefit from conventional hearing aids. Pre- and postoperative assessments of hearing thresholds and speech recognition thresholds (SRT) were compared, in the unaided and the VSB-aided solution (uni and bilaterally).

Results: 19 VSB were implanted in 16 patients with an average age of 53.3 years. Preoperative air conduction threshold was, on average, 39 dB at 0.5KHz, 46 dB at 1KHz, 63 dB at 2KHz, 66 dB at 3KHz, 73 dB at 4KHz and 80 dB at 8 KHz and SRT was 54dB. One month postoperative unaided air conduction threshold was, on average, 45 dB at 0.5KHz, 53 dB at 1KHz, 65 dB at 2KHz, 72 dB at 3KHz, 80 dB at 4KHz and 83 dB at 8 KHz and SRT was 58dB (p>0,05 for all frequencies and SRT). Postoperative VSB-aided air conduction threshold was, on average, 31 dB at 0.5KHz, 31 dB at 1KHz, 31 dB at 2KHz, 40 dB at 3KHz and 50 dB at 4KHz (p< 0,05 for 2 KHz and 3 KHz frequencies) and SRT was 28dB (p< 0,05). In bilateral patients, gain at threshold level between unilateral VSB-aided and bilateral VSB-aided was 3 dB at 0.5KHz, 13 dB at 1 KHz, 15 dB at 2 KHz and 23 dB at 4 Khz and SRT improved from 35dB to 22dB.

Discussion and conclusion: In contrast to a conventional hearing aid, the AMEI VSB involves surgery and higher financial costs. Despite these features, the AMEI system VSB can be considered as an effective rehabilitation alternative in subjects with mild-to-severe SNHL and unsatisfying benefit from conventional hearing aids. Bilateral results, although in a small number of patients, are encouraging.

S26-7

Comparison of coupling efficiency of vibroplasty modalities in the management of mixed and conductive hearing loss

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Introduction: Vibroplasty has offered various new modalities of hearing rehabilitation in patients with mixed, conductive and sensorineural hearing loss. The positioning or attachment of the floating mass transducer (FMT) in Vibroplasty surgery has a critical effect on coupling efficiency and hearing outputs. In this study we compare several commonly used vibroplasty modalities, their impact on hearing outputs and coupling efficiency.

Method: This is an ongoing prospective study of 16 patients undergoing either round window, incus or stapes vibroplasty. Conventional hearing aid rehabilitation was not possible for these patients. All patients had a standard audiological test battery including routine audiometric testing, soundfield testing in aided and unaided conditions. Direct drive transfer function analysis was performed to assess coupling efficiency. Quality of life measure questionnaires were used to assess quality of life. 9 patients had round window vibroplasty, 6 had stapes and 1 had incus vibroplasty. Patients had chronic suppurative otitis media, failed otosclerosis surgery, external audiotory canal atresia or eczema.

Results: Patients with a soft tissue coupler between the FMT and the RW had significantly reduced coupling efficiency. Patients who had direct RW contact had significantly improved coupling efficiency and stability across frequencies. Patients who had a stapes vibroplasty had the greatest coupling efficiency.

Conclusion: Our data suggest that whenever possible stapes vibroplasty should be performed. This provides better coupling efficiency and also minimizes the risk of migration of the FMT. In the absence of the ossicular chain, direct placement of the FMT onto the RW membrane should be attempted as this provides better and consistent coupling performance across frequencies when compared to the use of a soft tissue coupler.

S26-9

Improved efficiency and repeatability in round window stimulation by controlled pretension

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Objective: Mechanical stimulation of the round window (RW) of the cochlea is successfully done with existing active middle ear implants (AMEIs). Being independent of any middle ear structure this approach is clinically well established and indispensible, but outcomes show a substantial degree of variability. Using the investigational device Direct Acoustic Cochlear Stimulator Partial Implant (DACS PI, Phonak Acoustic Implants SA) and the Vibrant Soundbridge (VSB) we investigated the impact of static force pretension on efficiency and repeatability of sound transmission via the RW.

Methods: In fresh human temporal bones the obtainable range and maximum equivalent sound pressure output of RW stimulation was investigated. Experiments were performed in analogy to the ASTM standard F2504.24930-1. First the stapes footplate displacement in response to sound applied to the external ear canal was determined. ASTM compliant TBs were implanted perpendicular to the RW membrane with the respective device, using prostheses with a spherical tip (DACS PI: ø 0.5mm; VSB: ø 1.5mm). The stapes footplate vibration in response to actuator stimulation was measured and the achieved output in terms of equivalent sound pressure level at the tympanic membrane was calculated. In case of the DACS PI the static contact force was varied in the range 0 to > 50 mN and in experiments with the VSB it was kept at ~2 mN.

Results: In 10 TBs used for experiments with the DACS PI and in 8 TBs temporal bones used with the VSB, the stapes footplate response to sound was found acceptable according to the ASTM standard. Comparison of sound evoked stapes footplate vibration with DACS PI driven vibration at moderate loading force (~ 4 mN) lead to an average sound equivalent sound pressure level of approx. 103-120 eq. dB SPL @ nominally $1V_{rms}$ input for frequencies ≤ 4 kHz with a roll-off at higher frequencies (6 - 10 kHz). In case of the VSB the obtained equivalent sound pressure output at constant pretension was 97 - 107 eq. dB SPL (0.5 - 10.0 kHz, @ nominally $1V_{rms}$ to the actuator).The variation of the contact force with the DACS PI demonstrated that the output efficiency is monotonously growing with applied force. In experiments with the VSB the inter-individual variation in stapes footplate response was reduced to < 11 dB standard deviation (SD) by combining an interposition with constant force. At low frequencies (≤ 500 Hz) the SD was < 3.5 dB indicating a high predictability of expectable output at constant contact force. Also the repeatability of obtained output was significantly increased leading to a SD of < 4.5 dB in the entire frequency range between 0.25 to 10.0 kHz in repeated experiments (N=11).

Conclusion: Our results demonstrate that the static force in round window stimulation is crucial for stimulation efficiency independent of the used actuator. Controlled pretension leads to a decreased variability between different preparations as well as an improved repeatability.

S26-10

Auditory results of the oval window coupler for implantation of an AMEI

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Objective: Implanting active middle ear implants (AMEI) has become a standard procedure to restore hearing for patients with moderate inner ear, conductive, or mixed hearing loss. For patients with ossicular chain malformation or other middle ear anomalies, several titanium couplers have been developed to facilitate surgical placement of the active element in the middle ear. This study was designed to address the question that arises of whether the OW coupler is beneficial or provides for a safe surgical procedure.

Material and methods: 25 German-speaking patients were implanted with an OW coupler attached to an AMEI floating mass transducer (FMT). They were evaluated preoperatively and postoperatively for bone and air conduction thresholds with and without the implant. Auditory gain and speech perception were also compared.

Results: Functional gain in patients implanted with an OW coupler showed a range of improvement from 30 to 50 dB HL. The median unaided preoperative speech perception of 0% at 60 dB HL improved postoperatively to median 85% at 65 dB HL.

Conclusion: Surgical application of the OW coupler was found to be safe and provided good results in this group with mixed hearing loss

S26-11

Clinical trial of the Vibrant Soundbridge as a treatment for conductive and mixed hearing losses, using direct round window cochlear stimulation

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Introduction: The purpose of this study is to assess the safety and efficacy of the Vibrant Soundbridge (VSB) in patients with conductive or mixed hearing loss.

Methods: Fourteen (14) adults with conductive or mixed hearing loss with an unsuccessful hearing aid trial within the past 24 months, pure tone average (PTA) of 41dB or greater, air-bone gap of at least 15 dB at 3 frequencies, and speech discrimination score of 30% or better in the operated ear were enrolled. Surgery was performed under general anesthesia passing the floating mass transducer through the facial recess or a trough in the external ear canal. Post-operative testing was performed at activation (6-8 weeks after surgery) and at 1, 3, 6, and 10 months post-activation. Pre (unaided) and post-operative (VSB-aided) pure-tone audiometry and sound field testing, Hearing in noise test (HINT), and Consonant Nucleus Consonant (CNC) word list scores were measured.

Results: 3 patients withdrew from the study. Unaided sound field pre-operative results were: PTA 49 dB, SRT 57 dB, CNC 64%, HINT quiet 62 dB SPL, HINT noise 5 SNR (noise at 70 dB SPL). VSB-aided sound field post-operative results were: PTA 31 dB, SRT 35 dB, CNC 98%, HINT quiet 47 dB SPL, HINT noise 1 SNR. Further results will be presented.

Discussion: Post-operative pure-tone audiometry and sound field testing were superior to pre-operative results. Average sound field PTA improved by 18 points. Average CNC improved by 34%. Average HINT quiet improved by 15 dB SPL, and HINT noise improved by 4 SNR.

Conclusions: Based on our preliminary results, the VSB showed a positive impact on hearing rehabilitation in patients with conductive or mixed hearing loss unable to use or benefit from a conventional hearing aid. Further investigations are underway for eventual FDA approval.

Learning outcome: The VSB is a viable option for hearing rehabilitation in patients with conductive or mixed hearing loss, and do not derive benefit from a conventional hearing aid.

S26-12

Cone-beam CT in round-window vibroplasty

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Intro: The Vibrant Soundbridge partially implantable active middle ear device has, since e few years, adopted for restoring conductive/mixed hearing loss, via coupling with elements of the ossicular chain or inner ear-membranes (oval and round window). The auditory outcome is considered strictly related to the optimal matching of the FMT with the coupling structure. A cone beam (CB) CT scan has been performed in a series of subjects who received a round-window coupling (RW-VSB) in order to ascertain and/or confirm a consistent relationship between degree of hearing gain and appropriate FMT placement.

Methods: A series of subjects with functional sequels from open tympanoplasty have undergone RW-VSB during the last three years. All of them underwent a CBCT in order to visualize in detail the positioning of the FMT in relation to the round window niche.

Results: All the patients who received an appropriate gain of their hearing loss showed that the FMT was accurately located in the RW niche, disregarding the interposition of fascia or the presence of fibrous tissue over the RW membrane.

Conclusion: Although important, the result from a RW-VSB is not related to the presence of interposing tissue nor to the absolutely precision of RW coupling with FMT.

Learning outcome: Surgery of RW-VSB may show excellent results also in those cases where coupling of the FMT with the RW membrane is not optimal.

S26-13

Surgical concept of Vibrant Soundbridge in infants with atresia of the external auditory canal

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A bone anchored hearing aid is the therapy of choice in children with bone conduction block due to atresie of the external auditory canal. This can be realized with a softband bone conduction hearing aid until the child is suitable for a bone anchored hearing aid (BAHA) implantation. However in some infants a softband bone conduction device does not provide a sufficient hearing improvement. BAHA and Bonebridge are potential alternatives but not feasible in small infants due to inappropriate skull thickness. Furthermore wound healing issues after BAHA implantation are reported. For these reasons we offer a Vibrant Soundbridge implantation in these cases. Since 2011 we implanted 14 children with a Vibrant Soundbridge (VSB). All children except one had tried a softband bone conduction hearing aid unsuccessfully for at least one month. Three children with bilateral atresia were implanted on both sides sequentially. The mean age at implantation was 3.1 years (0.7 to 6.2 years).

In 4 of the 17 ears with minor malformation of the middle ear a classical incus coupling was feasible. In 9 ears we found a fixed conglomerate of hammer and incus which had to be removed. The stapes was malformed to a variable degree but still mobile. The Floating Mass Transducer (FMT) was superposed on top of the stapes head. Due to the limited space in the middle ear we could not crimp the FMT to the stapes but interpose it between the stapes head and the lateral attic wall. In 3 other cases the FMT was coupled to the round window membrane and in one case the endost of the cochlea had to be exposed to attach the FMT. Audiological controls were feasible in a small number of children depending on age and personality. Instead of that the benefit of the implantation was evaluated by means of a questionnaire. The parents rated the children's behavior before and after VSB fitting. The mean duration of daily usage of the hearing device increased from 2.5 ± 1.8 hours (softband bone conduction hearing aid) to 9.9 ± 2.2 hours (VSB). All families were content with the VSB implantation.

The implantation of a Vibrant Soundbridge is a promising therapeutic alternative in children with atresia of the outer ear canal in combination with middle ear malformation of variable degree. Thanks to the versatility of the FMT in every middle ear situation a sufficient coupling was feasible. In our patients the favorable single point fixation could be achieved in 4 cases only. Time will show, whether growth associated anatomical changes will necessitate repositioning of the FMT.

S26-14

Coupling possibilities of Vibrant Soundbridge middle ear implant in patients with congenital aural atresia

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Objective: To present surgical findings, anatomical peculiarities and coupling possibilities of the middle ear implant Vibrant Soudbridge (VBS) in patients with congenital aural osseous atresia.

Methods: 25 patients (aged 6 to 32, mean 11 ± 4.9) with congenital unilateral or bilateral osseous aural atresia (19 children, 6 adults) underwent implantation of the middle ear implant VBS. Follow - up ranged from 12 to 72 months (mean 22,8 ± 19). Four of those patients presented with associated craniofacial syndromes (3 Treacher-Collins and 1 Pierre Robin). The preoperative Jahrsdoerfer radiological score was 3-4 for 5 patients, 6 to 8 for 12 and 9 for 7 patients. Middle ear implantation was performed using different coupling possibilities.

Results: The coupling of floating mass transducer to the stapes (11 patients), rudimentary stapes (4), oval window (2), round window (4 patients, one - subfacial approach) and incus (2) was performed. One patient underwent third window procedure. The mean threshold with the activated implant in the free field tone audiometry was 23.8± 5.5 db HL. The mean functional gain was 40.35 dB. Functional results are comparable to non- syndromic atresia patients. Surgical techniques and strategies of all of the patients are discussed.

Conclusion: VBS enables satisfactory functional outcomes for patients with congenital aural atresia. The radiologic scores did not correlate to or predict outcomes. For patients with high radiologic score VBS surgery is fast, safe and enables excellent performance. For patients with severe middle ear malformations and poor preoperative radiologic score, the performance of middle ear VBS implantation could lead to satisfactory hearing results analogous to other ear atresia cases.

S26-15

Transcutaneous bone-conduction hearing implant in children with bilateral aural atresia

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Introduction: The aim of this work is to present our experience with management of conductive hearing loss using the Sophono alpha 1 system in children with bilateral aural atresia.

Methods: We examined 6 patients with bilateral aural atresia in whom an Alpha 1 system had been implanted surgically in 5 cases and headband in 1.

4 boys and 2 girls, were between 4 months and 14 years of age

We assessed: surgical procedure (technique, duration, and complications); and the mean preoperative air-bone conduction; mean postoperative threshold with alpha 1 system; improvement of perception and speech

Results: The surgical procedure was simple and really fast without complications

The mean preoperative air-bone conduction thresholds were 51.2±12.5 and the mean postoperative threshold with the alpha 1 system was 18.1± 7.5 dB HL.

Discussion: The new generation of transcutaneous devices has been designed to mostly reduce skin complications, and earlier loading of the sound processor.

Conclusion: The Sophono Alpha 1 implant is completely subcutaneous as such it is free of abutment-related problems. Our provisional audiological results are very encouraging.

Learning outcomes: Alternative devices without a skin-penetrating abutment are now available and have shown promising results in the pediatric population.

S26-17

Bonebridge surgery in paediatric cases

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Introduction: The Bonebridge® (BB) is a new transcutaneous bone conduction hearing aid system. The first surgery worldwide was performed on July 2011. In May 2012 we implanted the first patient under 18 years in Austria. In our presentation we want to share our experience, which we did with our previously children cases. The aim of the study is to define guidelines for the earliest possible implantation age in children

Material and methods: We evaluated patients with bonebridge surgery younger than 18 years. Audiological inclusion criteria were a bone conduction not below than 45 dB hearing loss and the contralateral ear had to be normal. Preoperative pure tone audiogram, free field audiogram and Freiburger sentence test were measured. Preoperative in all cases a CT scan was done in order to analyze the anatomical condition of the temporal bone. Postoperative the audiological tests were done 6 weeks, 3, 6 and 9 months postoperative.

Results: Since May 2012 seven cases below the year of 18 were supplied with a bone anchored hearing implant at the university clinic of Innsbruck and St.Pölten. One patient was implanted bilateral. We included 2 female and 4 male patients. The median age of the children was 12.6 years. (Age range between 5 and 17 years) 6 patients suffered from a atretic ear with a malformation of the pinna; they had an air bone gap of at least 45 dB with a more or less normal bone conduction threshold. One patient had a chronic otitis media with a mixed hearing loss. All patients are very satisfied with their hearing aid measured by the GBI. They wear their audio processor daily for at least 8 hours. No peri- or postoperative complications occurred. Audiological results of free field audiogram, Freiburger sentence test and Oldenburger speech test in quiet and in noise will be presented. The mean follow-up time is 8 month (3-15 month distribution).

Discussion: For children the treatment with the Bonebridge® ensures a high quality hearing improvement. The implant surgery is safe and easy to perform. Due to the good functional results and the minimal exposure by the 30-minute surgical procedure, involving the Bonebridge in the therapeutic approaches in children, especially in congenital atresia is strongly recommended.

Conclusion: Based on our findings we conclude, that BB implantation in children is a safe and reliable procedure starting at the age of 5 years, assumed there is enough space in the temporal bone for the Implant.

S27 Fitting

S27-1

"Why are we waiting?" Next day activation for children with cochlear implants

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Intro: Clinics worldwide are reviewing processes and procedures to ensure every aspect of client management is necessary and evidence-based. This is important in paediatric services where early identification and implantation provide the opportunity to make the most of a child´s neural plasticity. This study reviews the clinical experience over 10 years of cochlear implantation in an integrated specialized paediatric setting as duration to initial activation has steadily reduced.

Methods: A retrospective file review was conducted to examine the initial activation and post-operative medical status for 300 cochlear implant procedures. A close examination of 20 children with early switch-on versus later switch-on was conducted. Duration of access to sound, duration of time to a stable MAP and number of appointments required in the first 3 months was reviewed. Families were interviewed about their experiences. Prospectively, 10 families were also interviewed about their perceptions related to possible time prior to initial activation.

Results: Of the 300 cochlear implant procedures reviewed, no significant difference in post-operative medical complications was observed. Early activation provided faster access to functional listening but did not reduce the overall number of appointments on this context. Parents reported less anxiety around earlier activation as long as children had recovered well from surgery.

Conclusion: In the environment of a specialized paediatric cochlear implant program with specialist paediatric medical support, there was no negative impact of shorter duration to initial activation. Early activation in this group provided families with no greater risks, and the opportunity to commence on the long road to language development as soon as possible.

Learning Outcomes: Participants will consider the current state of activation in a specialized paediatric cochlear implant program and review the risks and benefits of early activation shortly after surgery from a family perspective as well as a medical and audiological point of view.

S27-2

Effect of stimulation rates on orientation and mobility in deaf-blind cochlear implant users

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Introduction: Multiple researches have investigated which cochlear implant (CI) processor parameters lead to optimal speech perception. For example, it has repeatedly been shown that high stimulation rates can improve CI speech performance. Yet, almost no research has explored the impact of processor parameters on either orientation or mobility. These two abilities, along with speech perception, are of particular importance in congenitally deaf-blind CI users.

Objective: The aim of this study was to investigate the effect of stimulation rates on auditory abilities in relation with orientation and mobility in a deaf-blind subject.

Methods: Comprehensive auditory processing, orientation, and mobility capabilities were measured in a bilateral CI user with Norrie syndrome. The monitoring involved i) programming sessions, ii) sound detection and speech perception evaluations, iii) a localization task, and iv) orientation and mobility evaluations involving multiples sound sources. An audiologist and an orientation and mobility specialist closely monitored all procedures.

Results: At high stimulation rates, auditory capabilities were excellent, although general orientation and mobility capabilities were greatly limited despite intensive and long-term training sessions. However, the data suggest that orientation and mobility were greatly and rapidly improved by reducing the stimulation rate, and this without altering previous auditory performances.

Discussion: Our results suggest that a change in processor parameters may be a viable option for enhancing orientation and mobility capabilities without significantly interfering with speech processing in deaf-blind individuals using a CI.

S27-4

Use of the triphasic pulses coding strategy in a case of facial nerve stimulation affecting all electrodes

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Intro: We discuss the case of a female recipient presenting a profound sensorineural hearing loss due to a grade 3 bilateral otosclerosis. Facial nerve stimulation occurred, after a MedEl Flex24 implantation, on all electrodes even during peroperative telemetry measurements. Except triphasic pulse coding strategy, none could allow to reach sufficient MCL levels in order to provide speech comprehension without getting facial nerve responses.

Methods: Typically, symmetrical charge-balanced biphasic current pulses are used in cochlear implants to ensure biological safety. When the cochlea is stimulated by the implant, many electrical fields are created simultaneously. When these fields spread in the otosclerotic bone, facial nerve stimulation can occur, preventing from reaching sufficient electrical stimulation levels. Our patient presented facial nerve stimulation on all electrodes even during telemetry measurements (assessed by electromyography). During the cochlear implant surgery anesthesia, facial nerve stimulation thresholds were identified using the facial nerve monitoring system. Classical MedEl coding strattegies as FS4-p, FSP and HD-CIS (Continuous Interleaved Sampling) could not avoid facial nerve stimulation when reaching efficient auditory stimulation levels. Using triphasic pulse strategy permitted to decrease the electrical field spreading in the bone, avoiding facial nerve stimulation and to program sufficient MCL levels. The recipient was asked to answer the "APHAB" life quality questionnaire before and after cochlear implantation.

Results: Without any device there was no speech recognition at all. Speech recognition reached 60% at 50 dB when using cochlear implant and controlateral conventional hearing aid. Overall, the recipient´s life quality significantly increased as assessed by the APHAB questionnaire.

Discussion: Triphasic pulse stimulation allows hearing stimulation without spreading electrical fields all over the temporal bone. Especially interesting in borderline cases it permitted in this case of otosclerosis to get speech perception without facial nerve stimulation.

Conclusion: Cochlear implant systems have traditionally provided electrical stimulation using biphasic electrical pulses, resulting in a very small residual electrical field in the cochlea following each pulse. As these residual fields can contribute to channel interaction and facial nerve stimulation especially in case of advanced otosclerosis, the triphasic pulse strategy reduce spreading electrical fields and allows to reach comfortable hearing level and speech recognition without facial nerve stimulation.

Learning outcome: Alternative coding strategy are useful even if less efficient than others in usual cases.

S27-5

The effect of pulse rate and pulse width on the loudness growth function

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Current cochlear implant (CI) systems offer only little flexibility for mapping of the acoustic input level to the electrical stimulation level. Typically only electrical threshold und upper comfortable loudness level are determined in the clinical routine, but no further supporting points within the dynamic range. This study was initiated to investigate how well the mapping function matches loudness of individual users.

15 CI users with postlingual deafness were recruited so far. The loudness growth functions were measured using an adaptive loudness scaling procedure with a categorical scale from “inaudible” to “too loud”. Stimuli were applied with direct electric stimulation of a pulse train with a duration of 500ms at a single electrode. Care was taken to deliver stimuli only within the compliance range of the current source. Four electrodes in the basal, middle and apical range were investigated. First, a constant pulse width of 33.2us was used for all CI users as a baseline. Second, the individually fitted clinical pulse width was used and pulse width was further increased in case the compliance limit was reached below the upper limit of the electrical dynamic range.

For 2 CI users the upper loudness range could not be measured with a pulse width of 33.2us for all four electrodes, but only for 1 or 3 electrodes, respectively. The preliminary data show that all CI users have a monotonously increasing loudness growth function, which could be interpolated with two linear intersecting functions. Some CI users with small clinical pulse widths (< 21us) needed increased pulse widths for the perception “too loud”, whereas CI users with higher clinical pulse widths (>25.1us) did not need any changes in their pulse width. The loudness growth as a function of charge units showed for both pulse widths an rms-difference smaller than 1 loudness category in 95% of all measured electrodes. The pulse width had, thus, only little influence on the loudness growth function if it was plotted against charge units.

S27-8

Home based models for programming and managing implantable technologies

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Background: Models of home based management of implantable technologies for device monitoring, programming and management and for preoperative and postoperative habilitation and assessment were investigated. Device management is possible through self-mapping and telepractice either used in isolation or combination.

The aim of this paper is to outline ways to profile recipients who could benefit from home based services and to tailor implementation of services accordingly.

Method: A profiling checklist was used to identify the requirements for tailoring the home based management, including training needs and the program and procedures that would be most appropriate for the client.

Telepractice utilized existing technology available in most homes for all stages of management of implantable technology provided by the multidisciplinary team. Published guidelines for mapping and habilitation were followed for implementing telepractice. Clinical tools provided by the manufacturer for home based basic diagnostics and map adjustments were used in some cases. For some recipients these tools were used combination with telepractice. A series of case studies of children and adults using different models of home based management will be presented, highlighting the mapping and performance outcomes as identified through formal testing and questionnaires.

Results: Participants were highly satisfied with their home based model. Most of the participants felt more integrated into their device management and reported a deeper understanding of their technology and the processes involved. Speech perception and functional outcomes measured using home based models were found in the majority of cases to have no significant difference to within clinic based testing. The use of recipient profiles to tailor the home based approaches used was found to be a precursor to the success of these procedures.

Conclusion: Primarily home based models have been used with populations who are unable to access face to face services due to geographical, socioeconomic reasons or physical circumstances. However there were other indications such as support and mentoring of recipients and their families or for clinicians and educators providing services. Benefits of the tailoring the home based models according to recipients profiles and needs will be discussed. Situations that a home based model may not be sufficient or may not be indicated at all, will be identified.

Learning outcome: Participants will develop a working knowledge of ways to profile recipients who could benefit from home based services and to tailor implementation of services accordingly.

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S27-9

Clinical outcomes for patients fitted with their "Hearing Profile"

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Aim: With the introduction of the "tilt and shift" method by Smoorenburg in 2002 and then the ECAP scaling model introduction Botros and Psarros in 2010, the question of whether a cochlear implant (CI) recipient can be adequately fitted using their "hearing profile" remains of considerable interest. The Nucleus Fitting Software (NFS) from Cochlear Ltd. (Macquarie Park, Australia) incorporates this fitting based on a recipient's hearing profile methodology and thus allows for the question to be investigated. The purpose of this study has been to investigate both the clinical aspects and the recipient outcomes for CI maps created using the methodology. Also, given that the methodology is simpler, it is speculated that similar recipient performance outcomes can be achieved in less fitting time or with lesser experienced, or even inexperienced, audiologists.

Material and methods: The study is a prospective, randomised between subject comparison with 76 paediatric test subjects enrolled. Recipients have been fitted using both the NFS and the standard clinical software. Auditory performance has been analyzed by an expert speech therapist and the parents completed a performance questionnaire. Three, six, nine and 12 month data is available. Also an analysis of the fitting time required and the similarity of the maps created was performed.

Results: The recipient performance outcome results will be presented for each of the three, six, nine and 12 month intervals. There was no significant difference in outcomes for recipients fitted with NFS versus those fitted with the standard clinical system, beyond differences seen in every day practice. These results were despite two audiologists with differing levels of experience performing the fitting. The fitting time when using the NFS software was significantly less than using the standard clinical system. An overview of the differences for each session will be presented, though generally was 50 % less with the NFS system.

Conclusions: The results of this study suggest that it is possible to successfully fit CI recipients based on the "hearing profile". Equivalent performance outcomes are achieved using this newer methodology and independent of the level of experience of the fitting audiologist. The fitting time was significantly less when a recipient was fit based on their hearing profile compared to the traditional fitting methodology.

S27-11

Self-testing as prerequisite for remote fitting

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Intro: Optimal CI fitting is outcome driven and computer assisted. For this we have defined outcome (A§E), set targets and developed computer algorithms (FOX) to assist the audiologist. This yields equal or better results than conventional fitting. One limitation is that the required resources may be limited, especially in the context of remote fitting. For this we have undertaken to convert the A§E audiological tests available into self-tests.

Methods: All A§E tests (audiometry, speech audiometry, phoneme detection, spectral and temporal discrimination, phoneme identification, binaural localization) have been analyzed in terms of stimulus, test task and test procedure. Based on this, self-tests have been developed. Validation consisted of comparing results in hearing and hearing impaired subjects with results obtained by means of the conventional test carried out by an expert audiologist.

Results: Both training and testing are implemented in the self-tests. A graphical user interface instructs the test person to perform the test in his own language and on a touch screen. The training is to get acquainted with the stimuli and the test task. Internal controls verify the response consistency and reliability. If needed, the test person is directed back to the training mode. Scoring is done by statistical analysis of the responses. The test result is sent to a webhost to which the expert audiologist has remote access. The test time is typically smaller than conventional test times. The results are equal to those obtained from conventional testing.

Discussion: The audiological testing for CI recipients is essential to perform target-driven CI fitting. This is a time consuming task usually carried out by trained audiologists. Since this needs to be repeated on a regular basis, it poses an important load on the limited resources available. These results show that it is possible to turn most tests into self-tests for a majority of CI recipients, thus reducing the required resources. It allows the CI recipient to perform the tests remotely without the need for an audiologist next to him. The results are uploaded to the cloud where they are accessible to the CI programmer, or to FOX, the intelligent agent which can recommend modifications to the program. Hence, self-tests may become a crucial element in the provision of remote fitting services.

Conclusion: The audiological tests (A§E) can be performed as self-tests with similar results as conventional testing. This allows the A§E tests to be carried out in a remote setting without the need of an audiologist next to the CI recipient. The CI programmer has real-time access to the test procedure and the test results and can interpret them and use them to optimize the CI fitting.

Learning outcome: Audiological self-tests (A§E) are becoming available. These tests may be crucial in the evolution towards remote target-driven computer assisted CI fitting.

S27-12

Expert telefitting mode for cochlear implant recipients

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Purpose: In a telefitting method an experienced audiologist from the cochlear implant clinic provides fitting service for the patient in distant, cooperating policlinic. Teleconference equipment provides audio and video connection while remote desktop application allows to take the control over the distant computer and perform all necessary measurements. This method proved to be a reliable alternative for standard fitting, but it does not save work-time for a clinician and is not a way to cope with the growing number of patients. In expert telefitting mode the idea is to involve less experienced support specialists from cooperating clinics in basic tasks and to leave the decision making in the hands of experts performing their duties via telemedical solutions. The aim of this work is to present the concept and preliminary data showing outcomes of the new telefitting mode.

Material: The study group consisted of randomly selected patients: 6 children (age 7-16 yrs, mean 11,2) and 7 adults (age 17-64 yrs, mean 44,7) with CI experience ranging from 18 months to 16 yrs. The control group consisted of randomly selected patients: 9 children (age 3-14 yrs, mean 8,8) and 5 adults (age 21 - 36 yrs, mean 27,2) with CI experience ranging from 6 months to 8 yrs.

Method: Each patient in the study group underwent expert telefitting procedure: local ENT, structured interview, free field audiometry, local objective and psychophysical measurements. Then a Remote Expert interpreted the results and created a new map. The controls underwent standard telefitting consultation.

Results and conclusions: The expert telefitting mode seems to be comparable to the standard telefitting mode in terms of patients' satisfaction and appreciation of the results. It allows substantial saving of time of experienced specialists, and in this way may lead to the reduction of cost. These advantages complement benefits of the standard telefitting mode: saving of time, money and effort for the patient, better access to specialists, educational value for less advanced staff.

S27-13

Long-term aftercare using remote fitting in cochlear implant recipients

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The number of cochlear implant recipients is significantly increasing due to improved implant and signal processing technology as well as broader indication criteria. In Germany, more than 3000 patients receive an implant per year and more than 30.000 patients have already been implanted. The major ENT-clinics are challenged by the organization of an efficient and satisfying long-term aftercare concept to guarantee the necessary yearly check-up and service.

The German Hearing Center (Medical University Hannover, Hannover) in cooperation with auric hearing systems (Rheine) has developed a remote care network for patients living in far distances to the clinic. The remote fitting soft- and hardware is based on the proven remote fitting technology from auric and has been tailored to the specific needs of cochlear implant subjects featuring real-time HD audio and video transmission.

The data transmission is highly secured using a VPN (virtual private network) point-to-point broad-band internet connection. 14 out of 50 auric hearing centres in Germany are equipped with the programming hardware and the involved hearing aid acousticians are trained to assist the remote fitting procedure.

The reimbursement of the new aftercare procedure could be negotiated with health insurance companies through a so-called “integrated care contract” involving the clinic, auric and local ENT-specialists. Thus, the audiological and medical expertise can be provided at the remote locations.

The clinic keeps track of the patients' development by synchronizing the programming data (MAP) and speech test results with the remote care centers. In 2013, more than 150 remote fitting sessions have been performed with a forecast of 350 sessions in 2014. A remote care network offers close-to-home aftercare while keeping up the high fitting quality of the cochlear implant center. Travel costs and absence at work are being minimized for the patient.

S28 Various aspects of binaural hearing

S28-1

The benefits of bilateral cochlear implantation

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For spatially separated sound sources, bilateral cochlear implant (CI) users display lower speech reception thresholds (SRTs) than unilateral CI users. This effect results partly from better-ear listening, but the majority of studies indicate that this is a fairly modest benefit (~4 dB). Culling et al. (2012) showed that alternative spatial configurations and measures indicated much larger benefits. Speech reception thresholds (SRTs) for speech/noise sources in mirror image configurations of +60º/-60º and -60º/+60º were each measured four times in eight unilateral CI users. SRTs were 18 dB lower when the speech was on the implanted side. Assuming that a bilateral CI user has similar performance from each implant, one would expect no difference in SRT between the +60º/-60º and -60º/+60º spatial configurations. Therefore, a symmetrical bilateral CI user would have SRTs 18 dB lower than a unilateral CI user when the speech was on the unilateral CI user's unimplanted side. When the speech was on the implanted side there would be no difference in SRT. The advantage of bilateral implantation stemming from spatial separation of sound sources may thus be considerably larger than previous literature demonstrated. However, bilateral cochlear CI users often display benefits from adding a second implant, even when the speech and interfering noise are co-located in front (“summation”), or when the additional ear has the poorer signal-to-noise ratio (“squelch”). These effects suggest that bilateral CI users are often not symmetric. There are probably asymmetries in neural survival, leading to the encoding of different information at each ear. This additional information would be reduced, but not eliminated when the second ear has a poorer signal-to-noise ratio. We simulated these effects using virtual acoustics and tone vocoding. For co-located virtual sources, presenting 8 bands alternately to each ear yielded a marked (7.5 dB) improvement in SRT over presenting odd- or even-numbered bands alone (to either or both ears). For spatially separated virtual sources (±60°), speech reception thresholds were still 17 dB lower at the ear with the better signal-to-noise ratio. There was also some squelch benefit from adding the ear with the poorer signal-to-noise ratio. The modelled asymmetry was so beneficial that deliberately asymmetric processing recommends itself as a potential bilateral processing strategy; it effectively increases the number of frequency channels. This strategy would be a radical departure from the present practice of trying to match electrodes across the ears.

References:

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S28-2

Bilateral cochlear implant fitting based on pitch matching

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Background: A second cochlear implant (CI) should have a positive impact on perception, especially in terms of localisation and speech perception in noise. The benefit does not enable perception similar to that of normal binaural hearing, for example there is evidence suggesting that little or no binaural summation occurs for adults with bilateral CI. Variability in performance among the bilaterally implanted is also an issue which could be in part caused by mismatch between the two CIs. This study examined the efficacy of two different CI research programs based on matching pitch and loudness across the two CI devices for six bilaterally-implanted adults.

Methods: Six post-lingually deafened adults with bilateral CI were recruited. In a cross-over study 2 experimental maps (EM) were provided to each participant and used for 1 month each. One research program was based on direct-stimulation (DS) matching with the use of two clinical programming interfaces, and the other research program based on pure-tone (PT) auditory matching. Evaluation measures included spatial release from masking (SRM) with the use of BKB sentences in speech-spectrum shaped noise, with speech presented from the front (at 0°azimuth) and noise presented to the right (at +90°) or to the left (at -90°), a localisation test (for 30° and 15° of separation) and, finally, an across-ears pitch comparison test . Testing conducted with original mapping at baseline and at the end and with each EM.

Results: Statistically significant improvements were found in localisation at 30° of separation with the research program based on DS only ($t = -3.03^*$, $df = 5$, $p < 0.05$) and in localisation at 15° of separation with the use of DS and PT respectively ($t = -2.62^*$, $df = 5$, $p < 0.05$ and $t = -6.95^{**}$, $df = 5$, $p < 0.005$). Statistically significant improvements were also observed for the 'BKB in noise' with the use of the best research program, compared to the best clinical BKB score with speech-spectrum shaped noise presented on the right and on the left, respectively ($t = -3.179^*$, $df = 4$, $p < 0.05$ and $t = -3.22^*$, $df = 4$, $p < 0.05$) after the exclusion of the participant with unilateral, severe cochlear ossification in the weaker side. Although three out of six participants showed statistically significant improvements in 'BKB in noise' with speech presented from the front (at 0°azimuth), no overall statistically significant improvement was observed as a group. A 'pitch comparison test' was applied across-ears (to evaluate how well matched the two bilateral implants are in terms of frequency) and revealed statistically significant improvement with the use of DS ($t = -5.22^{**}$, $df = 5$, $p < 0.005$).

Conclusion/Discussion: Results are encouraging and suggest that matching the two CIs in bilaterally implanted individuals can be beneficial.

S28-3

Speech understanding in realistic noise environments using binaural signal pre-processing strategies in bilateral CI users

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While many patients using modern Cochlear Implants (CI) already reach up to 100% speech intelligibility in quiet, listening in noisy situations remains a challenge. The increasing supply of profoundly deaf patients with two implants, the so-called bilateral supply, already leads to an increase in speech intelligibility in noise compared to monaurally implanted patients. It can however be hypothesized, that by intelligently combining the two independent CIs, further improvements are possible. In this study, the potential of novel binaural signal preprocessing strategies to improve speech intelligibility of bilaterally implanted CI users in noise is assessed. 2 monaural and 6 binaural noise reduction algorithms were evaluated. All algorithms were implemented in the Master Hearing Aid framework and run online in real-time on a tablet PC. The speech intelligibility threshold (SRT_{50}) was determined using a maximum likelihood adaptive measurement procedure. 3 distinct noise scenarios were created in a reverberant environment ($T_{60} \cong 1250$ ms) using virtual acoustics. The OLSA (Oldenburger Satztest) sentence corpus was used, positioned at 102 cm distance in front of the subject again using virtual acoustics in a reverberant environment. Therefore, an evaluation of the algorithms in realistic listening situations is given. In addition to the speech intelligibility threshold measurements, subject preference scores regarding sound quality and ease of listening were recorded. We were able to show substantial improvements in speech reception threshold in all reverberant, spatial testing conditions. Additionally, when asked to choose between the two, subjects preferred signals preprocessed by the majority of algorithms over unprocessed signals.

S28-5

The effect of early auditory experience on sound localisation and spatial release from masking in children with bilateral cochlear implants

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Introduction: The way in which auditory deprivation and cochlear implant technology interact to influence children's spatial listening is not yet fully understood. Greater understanding of these complex factors would help implant manufacturers and service providers to offer the best possible rehabilitation for hearing impaired children. We therefore aim to examine the effect of early auditory experience on the spatial listening skills of children with bilateral cochlear implants, with reference to outcomes for normally hearing children.

Methods: Four groups of children participated: congenitally profoundly deaf, bilateral implants by 42 months of age (n = 28); congenitally profoundly deaf, first implant by 42 months and contralateral implant after 42 months of age (n = 38); normal hearing or mild-to-severe hearing loss up to 42 months of age, later bilaterally implanted (n = 16) and normally hearing (n = 32). Participants were aged 4-16 years. Sound-source localisation was assessed using two tests: three loudspeakers separated by 60° and five loudspeakers separated by 30°. Spatial release from masking was measured using the adaptive McCormick Toy Test with words from 0° and pink noise from 0°, +90°, or -90°.

Results: Children with acquired or progressive hearing loss localized significantly better than both groups of congenitally, profoundly deaf children, on average ($p < 0.05$). There was a non-significant trend for congenitally deaf, early-implanted children to localize better than congenitally deaf, late-implanted children on average. There was no significant difference in average spatial release from masking between the groups of implanted children. Normally hearing children localized better and displayed more average spatial release from masking than all groups of implanted children ($p < 0.05$).

Conclusion: Acoustic hearing during the first 42 months of life is associated with better sound-source localisation with bilateral implants, but may not influence spatial release from masking. Regardless of early auditory experience, these groups of bilaterally implanted children did not have spatial listening skills within the normal range.

Learning outcome: A child´s experience of sound during the early years is associated with their ability to localize sound sources with bilateral cochlear implants.

S28-6

Analysis of spatial hearing in “REAL-LIFE” conditions

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Introduction and aims of the study: A realistic and preferably objective measurement of impairment due to different kinds of hearing loss is needed. Unfortunately, traditional audiological research pays little attention to the ecological complexities of human communication. Performance measures in the laboratory usually test the segmental intelligibility of a single voice, whose spatial position and spectral/temporal characteristics are static and predictable, in a single noise, which is again static and predictable. “Real life” conditions cannot be created in the traditional auditory testing setup.

Purpose: To create a setup for objective measurement of speech discrimination and sound localization with “real life conditions” and the possibility to simulate different hearing environments.

Methods: We have developed a spatial sound laboratory that provides the hard-/ and software environment for fine-grained control of spatial auditory scenes. An arbitrary number of sound sources can be distributed and mixed so that a realistic spatialized sonic scene with clearly recognizable sound localization can be produced in the lab setting. Beyond static scenes, also sounds of moving objects can be created. In result, the system allows to simulate sonic environments as they appear in everyday life of listeners.

Results: The data recorded in this experimental procedure are multi-modal, containing body posture, user-provided data and video recordings of the subject. We have developed visual rendering procedures that depict the measured data so that patterns can be identified.

Conclusions: From these pilot measurements, we are confident that the experimental setting is capable to analyze spatial listening capabilities and their dependence on variables such as change of a hearing aid program, e.g. in BAHA or Cochlear implant.

S28-7

Cochlear implant users can benefit from a modest head orientation away from the speaker when attending to speech in noise

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Spatial release from masking (SRM), the benefit to speech intelligibility of spatially separating speech from noise is traditionally measured with the head fixed (e.g. Culling et al., 2012) and facing the speech direction. Here we investigated spontaneous and directed head orientation strategies when listeners attended in a sound-deadened room to speech with gradually diminishing speech-to-noise ratio. With audio and audio-visual presentation and with a speech-shaped noise separated by 0, 90 or 180 deg, free-head behaviors were first observed, then fixed-head speech receptions thresholds (SRT's) were acquired. SRT's were measured with or without a favorable 30 deg head turn away from the speaker. Our binaural model of SRM (Jelfs et al., 2011) predicted benefits of such head turns that we hypothesized would motivate head rotation.

9 adult (mean age 59) unilateral CI's (UCI's), 8 adult (mean age 67) bilateral CI's (BCI's) and 10 age-matched normally hearing listeners (NH's) participated. As SNR declined, observed head tracks differed greatly between listeners and listener types. Whilst 50% of NH's spontaneously turned their head, they made generally poor spontaneous use of head orientation. Few cochlear implant users (CI's) turned their head spontaneously but most reached optimal head orientations when directed. Audio-visual presentation inhibited spontaneous head turns for all listeners. Lip-reading improved SRTs by 3 and 5 dB for NH's and CI's respectively, independently of head orientation. Audio SRM improved by up to 5 and 7 dB for CI's and NH's respectively with a favorable 30 deg head turn, as predicted for UCI's but only half as predicted for BCI's. It is believed some spectral summation advantage found in BCI's could explain their reduced head-turn benefit.

The two experiments combined confirmed that CI's could greatly benefit and easily be trained to optimize their positioning and head orientation with respect to target and noise source positions in a social setting.

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S28-8

Binaural balanced tonotopy rehabilitation in a bilateral cochlear implanted recipient

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Cochlear implantation allows recipients to recover main auditory capacities, whereas delayed controlateral implantation provides life quality increase through sound localization, speech understanding in noise and music listening development. The particular rehabilitation of the second cochlear implant makes possible to reach these goals. Therefore, binaural hearing functions determined by frequency and intensity have to be trained specifically.

At Angers´s audiology center (CERTA), rehabilitation needs are assessed for each implanted recipient in order to provide a customed rehab program. A sixty year-old man got a personalized training two years after his second surgery (bilateralization) because his second cochlear implant was decreasing the prior auditory results he had obtained with his first cochlear implant. Demands and feelings were identified and a specific audiological training was performed focusing on neurocognitive binaural balance of his tone perception. Indeed, an important frequency difference between both sides had to be corrected, promoting melodic hearing. Pitch is an objective measure developed from variations of the fundamental frequency. The basilar membrane that performs physical coding stimulates the auditory nerve and enables the transmission of information. The electrodes then encode a set of neurons, and the synaptic selectivity provides a correct match . This low-level processing can be induced by consciously cognitive feedback, allowing a reorganization of the neuronal activity. Then, a frequency binaural balance can be created. Brain plasticity permits this tonotopic restructuring. Using first pure frequency modulated and then harmonics sounds, the patient had to learn to get aware of, to compare and integrate these sensorial perceptions.

Ten sessions have restored the tonal mess. Besides these results, all skills required for binaural listening were increased after this rehabilitation as localization, listening to speech in noise and binaural separation. This audiological program offers many opportunities to ensure the objectives of the bi-lateral implant. It highlights the interest of brain plasticity, and puts the recipient at the centre of his audiological rehabilitation.

S28-9

Do envelope modulations disrupt binaural signals in bilateral cochlear implantees?

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Introduction: Without a formal method to map bilateral cochlear-implant (CI) users, it is possible that envelope modulations distort binaural cues. Specifically, level-dependent interaural level differences (ILDs) may be unintentionally added to signals. This form of distortion to binaural cues is also called interaural decorrelation, which is similar to listening in a reverberant room. Specifically, interaural decorrelation limits the ability to localize sounds and understand speech in noise. We tested if interaural decorrelation was introduced at the stage of mapping CI processors.

Methods: Single-electrode pulse trains were presented to postlingually-deafened bilateral CI users at three different electrode pairs (apex, middle, and base). The signals were 100 pulse per second, monopolar pulse trains presented at a comfortable level. The listeners' task was to detect a target in a three-interval, two-alternative forced choice task. The target was a binaurally out-of-phase pulse train (i.e., a pulse train with a 5-ms interaural time difference or ITD) and the non-targets were in-phase pulse trains (i.e., ITD = 0 ms). The pulse trains had different types of envelopes: constant amplitude, modulated and interaurally correlated, and modulated and interaurally uncorrelated. Listeners were presented 100 repetitions per condition.

Results: Listeners had the best, in many cases near perfect, performance for the constant-amplitude envelopes. Uncorrelated envelopes reduced performance as expected because they distort the available binaural cues. For some listeners and places of stimulation, correlated envelopes reduced performance also.

Discussion: The results suggest that envelope modulations sometimes add significant interaural decorrelation to binaural signals in bilateral CI users. We will discuss the results in terms of what adjustments to the mapping procedure of bilateral CI users would be necessary to maximize binaural performance, and how these adjustments may translate to a clinical setting.

Learning outcome: Attendees will learn about the binaural cues (ITDs and ILDs) that are necessary for sound localization and speech understanding in noise, how mapping affects these cues, and what clinical techniques would be necessary to maximize binaural performance in bilateral CI users.

S28-12

Paediatric unilateral implantation in an era of routine simultaneous bilateral implantation

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Introduction: In January 2009, the National Institute for Health and Clinical Excellence (NICE) issued their guidance for cochlear implants for children and adults with severe to profound deafness. This allowed paediatric services to simultaneously bilaterally implant all children who were within criteria.

Method: A retrospective review of our cases from January 2009 to December 2013 shows a 50-50 split between unilaterally and bilaterally implanted patients receiving their first implant(s). The majority of the unilateral cases were clinically-led decisions rather than parental choice.

Results: Group data with individual case studies will be presented, including medically and socially complex needs, developments in hearing preservation and asymmetrical hearing loss.

Discussion and conclusion: We have a surprising number of children who continue to be unilaterally, rather than bilaterally, implanted based on clinical judgment rather than parental choice. We have demonstrated success in developments such as hearing preservation, and have some cases where we secured locally agreed funding for asymmetric losses. In both cases of expanding indications, a cautious approach is indicated. We also have children and families with high levels of complex needs. In these cases, detailed consideration of the risks versus the benefits of bilateral implantation is essential.

Learning outcome: Bilateral cochlear implantation, although preferable, is not appropriate in all circumstances.

S28-13

BAHA and CI in single side deafness

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Introduction: By hearing only from one side, the patient experience serious difficulties understanding speakers talking from his deaf side, in localizing sound and in understanding speech in noise. One option is to provide a device that will be able to capture the sound coming from the deaf side and send them to the good ear. The BAHA device is a good option to avoid head shadow effects in those patients. The objective of this study is to compare the results achieved in this aspect with those obtained in other group of patients treated with a CI

Material and method: The inclusion criteria were adults patients with unilateral P-SNHL and normal hearing in the contralateral ear (maximum loss of 20dB Bone Conduction)

2 groups of patients will be studied:

- Group1: 5 SSD patients treated with BAHA
- Group 2: 5 SSD patients treated with CI

Patients will be test with the Disyllabic test at 1 and 3 months after switch one in S0N0,S0HBaha-CI,S0NN, in each side separately and with the 2 sides together.

Results: In both groups an improvement in SRT threshold was observed with the use of both implanted devices. No statistical differences were shown between BAHA and CI in treatment of the head shadow effect.

S28-14

The acoustical localization of monaurally and binaurally hearing CI users in a virtual reality

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Introduction: In comparison to monaural listening binaural hearing facilitates the localization of sound sources. In the clinical routine this benefit is generally tested in a localization test setup where the direction of a stationary sound source is indicated by the motionless patient. In such a stationary localization test setup the benefit of binaural hearing was shown for bilaterally treated Cochlea Implant (CI) users in previous studies [Verschuur et al. 2005, Buhagiar et al. 2004]. This stationary localization is a good indicator for the localization abilities of the listeners. Nevertheless, the question remains if the stationary localization in quiet represents the localization abilities in daily life where the listener and the sound source may be in relative motion and the sound source might have to be localized in challenging listening conditions like reverberation.

Method: The binaural and monaural localization abilities of bilaterally treated CI users were tested in an acoustically and visually presented virtual reality (VR) which imitated an anechoic chamber. In the binaural listening condition the localization was compared in a virtual room with two additional reverberation times. Speech recognition was additionally tested according to the clinical routine to test for potential correlations between the benefit in localization. In the VR the measure of the stationary localization and a mobile localization were compared. In the stationary localization task the participant´s position inside the VR was fixed at different positions and asked to indicate the direction of a single invisible sound source, also presented from varying positions. In the mobile localization task the participant showed the direction of the sound source by moving themselves from the starting point through the virtual room to the sound source on the shortest possible track. In both tasks the possible positions of the invisible speaker were unknown to the participants and the participants had to rely on the acoustical localization.

Results: Longer track lengths were required and a higher angular error is encountered in the monaural listening condition. In comparison to the localization in challenging reverberation listening conditions the monaural listening condition led to poorer localization scores. The outcomes of the speech tests indicated improved speech recognition score in the binaural listening condition in comparison to the monaural condition. No substantial correlation between speech recognition and localization scores was found.

Conclusion: Both the track length and the angular deviation between the indicated direction and the direction of the sound source support the importance of the bilateral treatment with CIs. The speech test results support the benefit of the bilateral treatment with CIs in speech, as well.

S29 Outcomes

S29-2

Preimplant expectations and postimplantation outcomes. Do they match?

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Introduction: During preimplant evaluation and counseling one of the most important issues to be addressed is understanding the expectations of the family and the implantee and whether cochlear implantation will fulfill these expectations. Most families preimplantation want assurances regarding the prospective benefit to the child especially in a country like ours where cochlear implantation is a self-funded surgery.

Anatomical anomalies of the inner ear, Behavioural issues, Parental involvement and many issues have a direct impact on the outcomes. Based on these factors professionals assure families of the expected outcomes post implantation. The modified CHIP profile was used at our centre to determine preimplant candidacy. Based on this prospective implantees were divided into 3 categories, commensurate, capable and challenged. Commensurate would be those implantees who are expected to perform well and achieve near normal receptive and expressive skills. These children would enter mainstream education and do not need for long term habilitation support. Capable are those who would do well but never catch up with age appropriate goals. These children need habilitation support for a longer time. The challenged child would need long term therapy and the outcomes would be below normal always.

Aim: To correlate the preimplantation evaluation and prediction with functional outcome measures postimplantation

Methodology and Results: The 132 pre-lingual cochlear implantees attending habilitation at our centre were divided into two groups

- Group I- children below 6 yrs of age
- Group II- children above 6 yrs of age

Candidates with post lingual hearing loss were excluded from the study.

In Group I, IT-MAIS/MAIS, LIP(Listening Progress Profile), CAP & SIR administered for functional outcome measures at pre-implantation, 6months, 1yr, 2yrs and 3yrs post-implantation.

Group I was further divided into Commensurate, Capable & Challenged categories depending on the pre implant profile.

Group II

Data until 1 year post implantation could be collected since the follow up for this group was poor due to limited outcomes.

Conclusions: There is a mismatch between preimplant predictions and realistic outcomes post implantation. This is important to stress during preimplant counseling as not all commensurate or capable children do as well as predicted which can lead to disappointment and frustration both on the part of the parent and the cochlear implant team.

S29-4

Comparison of outcomes in self-funded and instiutional funded cochlear implant patients

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Objective: Comparison of outcomes of CI surgery in patients who paid for the surgery and the rehabilitation with the patients in whom the surgery and the rehabilitation were paid by some Institution. The centre and duration for post op rehabilitation for both kind of patients, was same.

Method: All the patients were prelingually deaf. A study was performed comparing the self-funded and the institutional funded patients, operated between 2007 to 2012. Total of 85 patients were operated during this time, out of which 63 were self-funded and 22 were institution funded. These patients were judged on 3 criteria's:

A. 3,6,12 months Post Op CAP, MAIS and SIR scores.

B. Recent CAP, MAIS and SIR score.

Conclusion: After this study it was established, that, even after going to the same centre and having the same duration of Post-Op rehabilitation, the self-funded patients showed better results.

S29-5

Behavioral factors influencing outcomes in adult implant recipients: The role of counseling in post - implant care and management

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Objective: For adult cochlear implant recipients, optimum pre-operative predictive factors are well understood and include *client* factors (e.g. onset, course and duration of hearing loss), *technological* factors (e.g. implant array, and speech processor programming and function), and *neural* factors (e.g. cochleae formation, spiral ganglion survival). Despite favorable pre-operative predictive factors, some adult cochlear implant recipients demonstrate poor post-implant outcomes. The goal of the present study was to examine patient *cognition*, specifically an individual's thought process which motivates decision making, and *behaviors* influencing post-operative progress. The role of the clinician's own values and beliefs and his/her counseling approach were also examined as influencing factors.

Method: Clinical observations and patterns of patient responses have been collected over a 20 year period, initially in the South Australian Cochlear Implant Program, and in the Melbourne Cochlear Implant Clinic which has been involved in the care and management of over 2000 adult patients. Observations were made during routine post-operative mapping sessions from 'start-up' through to experienced implant users attending for review. Sessions were conducted by the author who is an audiologist with a post graduate qualification in counseling. Counseling strategies included active listening and reflection and open questions adopted from patient centered modalities including Motivational Interviewing practice.

Results: Recurrent themes included the patient's own internal decision making skills which were influenced by factors including fear of change and maintaining control. Cases are discussed where issues were identified and addressed with the patient's permission during post-operative sessions. In some cases psychological issues were identified which required referral for mental health professional support (these patients are not included in this study) It was also observed that a patient's self- perception of their success (particularly if outcomes were poor) could be influenced by their clinician(s) counseling style. Improvements were observed in patient self-satisfaction, and in behavioral mapping parameters and open -set word and sentence understanding (e.g. CVC and CUNY speech perception test scores)

Conclusions: This study highlighted the influence of the individual's thought process which motivates their behavior and decision making during post -implant care and management. This study also highlights the importance of the clinician's awareness of his/her responding skills , sensitivity to the patient -professional dynamic and being mindful of subtle aspects of the patient's interaction. Case studies are discussed to highlight key themes of this research.

Learning outcome: Improved understanding of patient behaviors, and facilitating the clinician's awareness/counseling skills may positively impact adult implant patient outcomes.

S29-6

Long-term outcomes of cochlear implanted children: a benefit for all?

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Aim of the study: The aim of this paper is to provide long term performances of congenitally and prelingually deafened children, 10 years after implantation, on their auditory abilities, speech intelligibility, oral language development and scholarship.

Material and methods: This is a retrospective study after 10 years of implant on a population of 76 children.

Their mean age at implantation is of 45 months. Their evolution in terms of speech perception and language development will be presented through standardized tests. Their academic situation will be described in terms of mainstreaming abilities and high education.

Results: After 10 years of hearing experience with their cochlear implant, 82 % of those children have reached a comprehension of oral speech without the need of lipreading (Category of Auditory Performance scores between 5 and 7).

- 79 % have an intelligible speech which corresponds to Speech Intelligibility Rating scores from 4 to 5.
- For 34 % of them, their oral vocabulary and oral syntactic understanding levels are comparable to those of their hearing peers.
- 58 % could follow their academics in mainstreaming.

The best performances are observed in children implanted before the age of 42 months. Because of their excellent progression in oral language, few years later, 38 % are following higher education programs at university or high schools.

Conclusion: 80 % of our population show good auditory performances and have an intelligible voice when implanted before the age of 42 months. Among other factors, good oral syntactic development is a good indicator for academic success and for the ability to pursue higher education.

S29-7

Unexpected performance in adult cochlear implant users

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Introduction: Numerous variables including age at implantation, length of deafness and poor anatomy have been associated with outcomes in adult cochlear implant users. Despite many studies addressing the issue, unexpected variability in postoperative performance still exists. The purpose of this study was to determine if patients with unexpected performance have baseline characteristics that could explain and predict the unanticipated outcomes.

Methods: Baseline patient demographic data related to length of hearing loss, length of deafness, age at implantation, etiology, hearing aid use, past medical history, preoperative aided CNC, operative reports, electrode type, intraoperative x-ray, and speech coding strategy were examined from adult patients implanted at our institution. A preoperative prediction regarding postoperative performance was assigned as good when patients had a short length of deafness and normal cochlear anatomy, and poor for those with a long length of deafness or abnormal cochlear anatomy. Group 1 included patients who were predicted to have good results but had poor results. A second group consisted of patients who were expected to have poor outcomes but ultimately did well. Comparisons were made to a control group who were expected to perform poorly and did have poor postoperative performance.

Results: A univariate analysis comparing Group 1 to the control group identified significant differences in age at implantation, length of profound deafness, age at onset of hearing loss, and preoperative aided CNC scores; however, a multivariate analysis revealed that only a younger age at onset of hearing loss (not length of profound hearing loss) was predictive of poor performance. Similar results were found for the second group. While the univariate analysis comparing Group 2 to control revealed significant differences in age of implantation and age at onset of hearing loss, the multivariate analysis once again revealed that age at onset of hearing loss was the only significant factor predictive of outcome.

Conclusion: A younger age at onset of any amount of hearing loss was found to be predictive of postoperative performance in adults.

Learning outcome: Age at onset of any amount of hearing loss should be part of the medical history and taken into consideration when counseling cochlear implant candidates about possible postoperative performance.

S29-8

Influence of a pre-operative peripheral vestibular disorder on the post-operative outcome in cochlear implantees

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Deafness or severe hearing loss is frequently accompanied by a dysfunction of peripheral vestibular receptors. It is well known that there is a close structural and functional relationship between the vestibular end organs and the organ of corti. A combined cochlear and vestibular dysfunction could be therefore an indicator for a higher grade of structural degeneration. Structural degeneration due to the deafferentation is the strongest predicting factor for the post-operative outcome in cochlear implantees. The present study was therefore aimed at investigating the outcome of cochlear implantees which suffer from a pre-operative loss of peripheral vestibular function. The results were compared with those of cochlear implantees without any history of a vestibular dysfunction.

In total, 28 implantees were included in this study. Fourteen of them suffers from a pre-operative loss of peripheral vestibular function (vertigo-group). The control-group consists of fourteen cochlear implantees without any history of a vestibular dysfunction. The control group was matched to the vertigo-group in relation to implant experience and duration of deafness. The outcome was tested by determining the speech recognition of monosyllabic words (Freiburger-test), sentences in noise (OLSA-test) and the frequency difference limens eighteen months after the first fitting. The results showed a large variability of speech test results, even if the etiology of the patients was similar (progressive hearing loss). The differences between the vertigo- and the control-group were not statistically significant. Interestingly, patients of the vertigo-group showed statistically significant poorer frequency difference limens especially if the medial part of the electrode was tested.

The results suggest that a pre-operative peripheral vestibular disorder significantly affect the post-operative outcome in terms of hearing quality. This should be taken into account for the estimation of the post-operative rehabilitation effort.

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S29-9

Evaluation of speech perception for the HiFocus1J and the new HiFocus MidScalar electrode arrays

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Purpose: To evaluate initial speech perception outcomes with the new HiFocus MidScalar (MS) array, compared to its predecessor, the HiFocus1J electrode array. Additionally the alignment with the Greenwood map of the new HiFocus MidScalar array is evaluated.

Methods: Twenty-five postlingually deaf adults with normal cochlear anatomy were implanted via a round window approach with the new HiFocus MidScalar electrode array (Advanced Bionics, Valencia, CA). Pre- and postoperative multi-section CTs were obtained and multiplanar reconstructions perpendicular to the modiolus were used to determine the angular insertion of all contacts. The reference group consisted of 75 patients implanted with the HiFocus1J electrode array, using the extended round window approach. The mismatch of the assigned filter frequency to the frequency as determined by the Greenwood function was determined and its influence on the speech perception outcome was determined. The initial results show outcomes until 3 months post hookup. The final presentation will include 6 month follow-up data for this group.

Results: The MS group had a median word score on a CVC word test at three months of 63% correct, where this score was 57% in the reference group (although this difference is not significantly different, probably due to the small number of patients included). The average maximum insertion depth (from the round window, in line with the international consensus; Verbist et al., 2010) was 418° (SD 37°) for the HiFocusMS array which was significantly less than with the HiFocus1J electrode (481°, SD 67°). In line with this, the frequency mismatch was larger with the new array. However, in and between group comparisons did not show any correlation between frequency mismatch and speech perception.

Conclusion: Initial speech perception results with the HiFocus MS are promising, despite the larger frequency mismatch with Greenwood's frequency map and that of the cochlear implant. This frequency mismatch shows a large variability in individual patients and between electrode designs, but this mismatch is not a predictor of the speech performance.

S29-10

Usefulness of the "Auditory Skills Profile" in evaluation of the auditory skills progress in patients with partial deafness after cochlear implantation

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Partial deafness is often the result of progressive hearing loss. Consequently, partially deaf patients lose ability to perceive sounds from high-frequency range, while their low-sound reception is maintained. Such patients have been included in the cochlear implant treatment program since 2002. The tools that had been used so far to assess their auditory skills improvement needed to be reevaluated and adjusted. The specific situation of patients with partial deafness, which is the acoustic reinforcement of the low-frequency sounds and the electric stimulation by a CI for the high-frequency sounds, requires a sensitive tools to confirm the benefits of combined electro-acoustic stimulation. The aim of this study is to examine whether the tools that have been applied so far in traditional CI users to monitor the improvement of their auditory skills in the full range of frequencies are also suitable for patients with partial deafness.

The study included 24 adult patients with partial deafness (19 women and 5 men) who had been randomly selected from more than 4 000 CI users. 6 patients had been using CI for less than 6 months, 12 - for over 6 months, 3 - one year since the first connection to the speech processor, 3 - for more than 24 months. The survey was conducted with the use of the "Auditory Skills Profile" which purpose is to observe auditory skills improvement in patients with profound hearing loss after cochlear implantation surgery. The survey includes 25 tests and evaluation activities divided into 3 difficulty levels. 12 tests from the lowest difficulty level were withdrawn from the original version of the Profile as the patients had already performed them properly at the stage of diagnosis. The performed version of the test included 13 evaluation activities from the original Profile and additional 5 tasks containing modified verbal and non-verbal material within medium and high frequencies. Evaluation of the progress made by the patients was performed after 1, 6, 12 and 24 months since the first activation of the speech processor. The survey results were used to create the individual "Auditory Skills Profile" presenting in a graphical form progress done by the partially deaf patients.

Conducted survey was based on the 18 test tasks. In 8 of them, that had been included in the original version of the Profile, a score of 100% correct answers was achieved by 24 patients only after 1 month of using CI. In the next intervals, the positive changes were observed in the remaining 10 test activities.

The results obtained by the patients confirmed that the hitherto prevailing tools used to monitor progress in CI users are not sufficiently sensitive to changes in patients with partial deafness. Evaluation activities used in the "Auditory Skills Profile" including the modified verbal and non-verbal material within high frequencies range, showed in a better way progress done by the patients after cochlear implantation.

S29-11

Cochlear implant candidacy evaluation using unaided non-linguistic measures

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This study was designed to determine if unaided, non-linguistic psychoacoustic measures can be effective in evaluating cochlear implant (CI) candidacy. Fifteen subjects (28 ears) with hearing loss were recruited from patients visiting the University of Washington Medical Center for CI evaluation. Spectral-ripple discrimination using a 13-dB modulation depth and temporal modulation detection using 10- and 100-Hz modulation frequencies were assessed with stimuli presented through insert earphones. Correlations between performance for psychoacoustic tasks and speech perception tasks were assessed. Receiver operating characteristic (ROC) curve analysis was performed to estimate the optimal psychoacoustic score for CI candidacy evaluation in a development subgroup and then tested in an independent sample. Results showed that strong correlations were observed between spectral-ripple thresholds and both aided sentence recognition and unaided word recognition. Weaker relationships were found between temporal modulation detection and speech tests. ROC curve analysis demonstrated that the unaided spectral ripple discrimination shows a good sensitivity (0.87), specificity (0.80), positive predictive value (0.93), and negative predictive value (0.67) compared to the current gold standard, aided sentence recognition. Taken together, the present study demonstrated that the unaided spectral-ripple discrimination test could be a promising tool for evaluating CI candidacy.

S29-12

Presentation of pain and poor sound quality in paediatric and adolescent cochlear implant users

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At the Manchester auditory implant centre we have seen an increase in adolescents and older paediatric cochlear implant patients reporting pain, equipment issues and poor sound quality. These issues often arise spontaneously and in many cases it has not been possible to identify an underlying cause which has led clinicians to query whether these reports have a psychosomatic element.

We examined 17 case studies where pain around the implant site, hearing background noises when wearing their speech processor(s) and reporting broken equipment (which was subsequently been found to be working) have been the main complaint. Common traits and characteristics which link these cases are outlined and the following factors considered: duration of implant use, age at presentation of symptom, factors linked to school / education, family relationships, deaf identity, and mental health.

In the cases we examined many of the patients reporting issues of pain, equipment issues and poor sound quality arose in adolescent girls who have previously been classified as successful implant users, typically in a mainstream school or college placement. Issues often presented during a period of transition of change within their lives. We also discuss management of these cases at the Manchester Auditory Implant Centre and explain what strategies have been successful. In addition, we also explore possible triggers for this type of event and discuss if they may be pre-empted in the future.

S29-13

Assessment of environmental sound perception and cognition in cochlear implant patients

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Perception of environmental sounds is an important benefit of cochlear implantation. As meaningful and acoustically complex nonlinguistic stimuli, environmental sounds inform listeners about objects and events in the immediate environment. When correctly identified, environmental sounds can alter listeners to danger (e.g., honking cars, gun shots, fire alarms) and contribute to one's sense of awareness and well-being (e.g., waves on the beach, singing birds), leading to a greater overall satisfaction with an implant. Although studies of environmental sound perception in cochlear implant patients have lagged behind in comparison with speech and music, in recent years there has been a renewed interest in their diagnostic and clinical use. Despite their ubiquity in everyday life, recent research demonstrates poor-to-mediocre environmental sound identification even among patients with good speech recognition. Environmental sound perception also appears to correlate with perception of speech; while environmental sound training has been shown to result in improved speech accuracy. To extend this work from laboratory to clinical use, we developed a short test of environmental sound perception and cognition that can be used as a diagnostic and as a rehabilitation instrument. Along with individual sound identification, the test contains sequences of semantically related and unrelated sounds. To assess perception, patients are first asked to name the source of each sound. Next, to assess cognition, patients are asked to recall the names and the order of the sounds in each sequence. Performance on the second part, the sequence test, has been shown to be affected by the knowledge of contextual semantic relationships among individual sound sources in each sequence. Those patients who are aware of contextual relationships among sound sources, demonstrate higher accuracy in recalling the sound order in coherent sequences. Initial results demonstrate the clinical utility of this test as a nonlinguistic measure of real world auditory perception and cognition. Given the rapid growth in the number of implant patients worldwide, accompanied by the frequent lack of language-appropriate tests in many developing countries, environmental sounds may be able to fill the need for a language-independent diagnostic and rehabilitation instrument, with implications for improving patient speech recognition, safety and quality of life.

S29-14

Cochlear implants and the definitive management of Meniere's disease

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This is a preliminary study in evaluating the benefits of labyrinthectomy and cochlear implantation in patients with disabling Meniere's disease.

S29-15

Cochlear implantation in neurofibromatosis type 2 patients

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The natural history of the neurofibromatosis type 2 (NF2) or its treatment eventually leads to profound deafness in many cases, optimal preservation of hearing is one of the priorities in management. The traditional approach has been waiting for hearing loss before resection of the vestibular schwannoma (VS), that means often removal of large tumors, and auditory brainstem implantation (ABI) as the only auditory rehabilitation option. ABI usually do not allow open set speech discrimination. Recently vestibular schwannoma removal with preservation of the cochlear nerve and cochlear implantation has emerged as a reasonable therapeutic option.

A retrospective review in a tertiary referral NF2 center was conducted to evaluate 5 NF2 patients with bilateral vestibular schwannomes (VS), who underwent removal of the ipsilateral vestibular schwannoma (VS) with preservation of the cochlear nerve and cochlear implantation. For the assessment of the cochlear nerve functional integrity an intracochlear test electrode was placed via round window before tumor removal.

4 patients were implanted unilaterally while 1 was bilaterally implanted. 6 cochlear implants were included in the study, in 5 cases were implanted simultaneously and in 1 patient the implantation was sequentially performed 2 months after the vestibular schwannoma removal. Follow up ranged from 6 to 132 months with an average of 48 months. The auditory outcomes were assessed with speech discrimination tests using the cochlear implant in open field and quite; and pure tone audiometry in open field to assess the hearing thresholds. Postoperatively the average bisyllable word recognition score was 84% and pure tone average (PTA) was 34dB.

Cochlear implantation after vestibular schwannoma removal in NF2 patients can be successful, achieving better auditory outcomes than the traditional approach with auditory brainstem implantation.

S29-16

Labyrinthectomy and simultaneous cochlear implantation for single sided intractable Meniere's disease

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Introduction: Some sufferers of unilateral Meniere's disease have severe and frequent attacks of vertigo which may necessitate removal of the vestibular function from the affected ear. Tumarkin drop attacks are often not controlled by intratympanic gentamicin and require surgery. Surgical treatment previously was a labyrinthectomy but this lost favor as it not only destroyed the vestibular function but also the cochlear function. Vestibular neurectomy either by a middle fossa approach or by a retrosigmoid approach can conserve cochlear function although deterioration of hearing due to the persistence of the cochlear pathology and perhaps due to loss of the efferent nerve supply usually occurs. Although the surgery prevents vertigo attacks, it does not improve hearing or tinnitus

Method: A transmastoid labyrinthectomy removing all the cristae from the semicircular canals and the neuroepithelium from the otolith organs was be undertaken immediately prior to the insertion of the cochlear implant.

Results: Six subjects are presented. All subjects have benefitted from the cessation of their attacks of vertigo and have been able to overcome the feeling of imbalance. The speech perception results will be presented in detail but, in brief, all have been able to benefit. In all cases, the tinnitus is suppressed while using the cochlear implant.

Conclusion: The acceptance of the cochlear implant for single sided deafness has allowed the development of a new surgical approach. Electrophysiology recordings show that the cochlear function gradually disappears several minutes after removal of the membranous labyrinth. In the past loss of cochlear function was considered a drawback of labyrinthectomy but with the introduction of the cochlear implant, this disadvantage is overcome.

S29-18

Cochlear Implant after resection of Vestibular Schwannoma in a patient affected by profound prelingual sensorineural hearing loss

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Cochlear Implant represents the gold standard for the hearing rehabilitation of severe to profound bilateral sensorineural hearing loss. Cochlear Implant for profound hearing loss after resection of Vestibular Schwannoma with functional and anatomical preservation of the cochlear nerve is relatively recent indication for implantation. Here we report the case of a male patient with prelingual profound bilateral sensorineural hearing loss who was previously using bilateral conventional hearing aids. By adolescence, the hearing loss stabilized and the patient developed good language. In 2010 he was diagnosed to have a left sided vestibular schwannoma which was fast growing. The tumor was excised using a translabyrinthine approach with cul de sac closure of external auditory canal and preservation of the cochlear nerve. A cochlear implant (Digisonic SP) was placed on the same side. The patient is on follow up radiologically for three years now and is free of disease. The functional and electrophysiological results of cochlear implant are presented. We present a unique case of a successful rehabilitation by means of a cochlear implant in a hypofunctional cochlea from birth and resection of a vestibular schwannoma.

S30 Single sided deafness (SSD)

S30-3

Implantation of the Cochlear® Nucleus® system in adults with single-sided deafness

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Introduction: The objective of this study was to determine if implantation restores functional hearing in the deafened ear and allows for improved binaural hearing for hearing in noise and localization.

Methods: Adult SSD subjects were tested preoperatively with a CROS aid and better ear (BE) alone conditions. Speech perception in quiet and noise was tested and localization. Postoperatively, subjects were tested at 3, 6 and 12 months postactivation; BE alone, cochlear implant (CI) alone and bimodally (CI + BE). Test measures were words (CNC) in quiet, speech reception thresholds (SRT) for HINT sentences in noise and localization. Self-assessment metrics were administered pre- and postoperatively to document subjective assessment of hearing in everyday life and quality of life

Results: Nine subjects were evaluated preoperatively; 7 implanted to date, 5 have 3 months CI experience and 4 subjects are at 6 months. Mean word score in the deafened ear was 0% for the 9 subjects tested preoperatively. By 6 months, mean CNC score improved to 51.3% (N=4).Preoperatively, CROS provided no benefit over BE alone, for SRT, where the signal-to-noise ratio (SNR) at each ear was the same or when the SNR was less favorable at the BE. When a less favorable SNR was at the poorer ear, SRT was 3.9 dB poorer than BE alone. Adding the poorer ear receiving a poorer SNR hindered SRT for BE alone. After 3 and 6 months, the addition of the CI resulted in no improvement over BE alone when both ears received the same SNR, as with the CROS aid. When the CI received a better SNR, SRT improved by 1.7 dB at 3 months (N=5) and 6 months (N=4), which did not occur with CROS. When the CI received the poorer SNR, SRT did not appear to be significantly impacted. Localization was poor preoperatively using BE alone; mean RMS error was 55°. By 6 months, mean RMS error for the better ear alone was 65° and 56° when subjects listened bimodally. Self-assessment indicated that subjects reported improvement across a range of listening situations in quiet and in noise as well as improvement in quality of life.

Discussion: CI in individuals with SSD resulted in improved speech perception for the treated ear. Results suggest improved hearing in noise largely because listeners are able to take advantage of situations where the CI is receiving a better SNR than the BE. Localization also improved bimodally over that for the BE alone. Subjective improvements in real-world listening situations were also noted.

Conclusion: A CI, is an option for individuals with SSD who desire binaural hearing. Results obtained suggest that a CI can restore speech understanding in the poorer ear and delivers the possibility of improved binaural hearing capability. Speaker will also discuss relative and absolute SSD candidacy and some additional research.

Learning outcome: Participants will be able to describe speech perception and hearing outcomes related to cochlear implantation in individuals with SSD.

S30-4

Single sided deafness and cochlear implantation: Cross-sectional study of speech understanding and sound localization

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Background: In early cases of cochlear implantation with acquired single sided deafness (SSD) the benefit was limited. Several newer observations and recent literature however hint to much higher outcomes. We investigated the benefit of CI in SSD, by conducting a cross-sectional study with users of MED-EL cochlear implants.

Methods: Fifteen subjects with acquired single sided deafness participated, all are experienced adult CI users and native German speakers. OLSA sentence understanding (SRT) was tested in competing two talker babble noise. Noise was presented in a free field setup from 0°, ±45° and ±90° incidence angles, while speech was presented from the front. All tests were conducted in normal hearing ear alone (NH) and normal hearing ear plus CI (CI+NH) listening conditions. To assess sound localization abilities, a setup with nine loudspeakers in the frontal horizontal plane was used. A 1s CCITT noise served as the localization stimulus.

Results: Benefit of the CI+NH over the NH condition was greatest in the 45° and 90° (NH side) conditions. This benefit varied among subjects, but accounted to an average of a -5dB SRT shift. When presenting noise from the CI side angles, the benefit was smaller, however still could be demonstrated for some of the subjects. In the noise from front condition, we did not see a significant benefit. Localization with the NH ear alone was negligible to poor, while in the CI+NH condition we observed fair to good performance.

Conclusion: Patients with single sided deafness enjoy substantial benefit from cochlear implantation of the deaf ear. Subjects report good fusion of the initially different perception from both sides and are everyday users of their CI. Our results indicate that a CI is a promising option for the large population with acquired single sided deafness.

S30-5

Audiological evaluation of single sided deaf patients with a cochlear implant

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Treating patients with single sided deafness (SSD) with a cochlear implant is a therapeutic option, that gains increasingly clinical importance. In contrary to the care with contralateral routing of Signals systems and bone anchored hearing aids, that both bypass the deaf ear, the cochlear implant can restore hearing in the affected ear.

In the patients with an acquired deafness or residual hearing on one ear, the normal hearing on the contralateral ear is a challenge in the audiological diagnostic as well as in the fitting and evaluation of the cochlear implant speech processor. Recordings to document the improvement by the cochlear implant in localization and speech comprehension in noise can be done in free sound field. The same test set ups can be utilized that are in use for the evaluations of binaural hearing in patients with bilateral hearing aids or cochlear implants. These measurements aim in showing to what extent the acoustical stimulation on the normal hearing ear and the electrical stimulation on the deaf ear are fused and estimate the gain of the cochlear implant in real life hearing situations.

On the other hand we need information from the implanted ear alone without the interference of the normal ear, for example to optimize the fitting of the speech processor to the individual needs of the patients. As in the programming of speech processors in bilateral deaf cochlear implant patients loudness scaling and the recording of speech discrimination in quiet and noise can give valuable information.

There are three approaches to solve the problem of recording from the cochlear implanted ear alone in SSD patients:

- Recording in free field situation with plugging and muffing the contralateral ear
- Recording in free field situation with masking via headphones in the contralateral ear
- Recording via direct electrical input into the speech processor without affecting the contralateral ear.

Pros and cons of these methods are demonstrated and discussed.

S30-6

Effects of rate and place of stimulation on pitch in single-sided deaf implant users

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Eight experienced MED-EL cochlear implant (CI) recipients with single-sided deafness participated in a study (Schatzer et al, 2013) comparing pitch percepts between normal acoustic and electric stimulation modalities. Electric-acoustic pitch matching experiments were conducted to assess the frequency-place map for electrical stimulation and to investigate the relative importance of place and rate cues to pitch at low frequencies.

Compared to Greenwood's map, the mean shifts of the obtained frequency-place functions were -0.33 octaves in the basal (< 240°) region, -0.35 octaves in the middle, and 0.26 octaves in the apical region (> 480°). Place pitch functions gradually tapered off in the apex, with standard deviations increasing from approximately half an octave at electrode insertion angles below 480° to an octave at higher angular locations. The results are in qualitative agreement with electrical place pitch predictions form a computational model (Frijns et al, 2011).

A second experiment investigated the influence of electrode place on the salience of temporal pitch cues. Subjects matched the rates of unmodulated pulse trains presented to individual electrodes in the apical half of the array to fixed low-frequency pure tones between 100 Hz and 450 Hz. Electrical pitch percepts corresponding to pure tones from 100 to 300 Hz could only be elicited by applying a correspondingly low rate code on electrodes beyond 360 degrees insertion depth. On shallower electrodes only 450-Hz tones could be reliably matched. Also, pitch as a function of pulse rate in the implanted ear increased at a similar rate to pitch as a function of tone frequency in the normal ear only if pulse trains were presented on electrodes in the second turn. At shallower electrode positions, pitch increased more rapidly as a function of pulse rate than a as a function of tone frequency, with the difference in rate pitch slopes being statistically significant.

The results suggest that for an appropriate perceptual encoding of low-frequency information in electric hearing, temporal code and tonotopic place have to match. Pulse rate modulations on low-frequency channels in temporal fine structure coding strategies need to be applied on second-turn electrode contacts to reproduce normal rate pitch slopes.

S30-7

Music perception in SSD with cochlear implants

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In the past cochlear implantation in a deaf ear combined with normal hearing on the contralateral side had not been successful. However, new implant technologies have made this combination a feasible therapy option. The outcomes reported so far concern speech understanding and spatial hearing. Music perception after cochlear implantation with a normal hearing contralateral ear has not been investigated.

Music perception in this special population of implant users is a very interesting topic as an normal ear with all the physiological features necessary to perceive music with its complex acoustic properties is combined with an implant that is only to a limited extend able to transmit these features to an deficient auditory pathway.

7 users were included in this study. They had used their implants between 3 months and 4 years. 6 use a MED-EL system, one a Nucelus Freedom device.

The subjects were tested with the following subtests from the MuSIC Test battery: pitch discrimination, instrument detection and identification, emotional rating of music, dissonance rating. Test conditions were ci only, nh ear only, both ears together in a randomized sequence. The stimuli were presented over headphones. In the CI only condition the normal hearing ear was masked with noise. The MUMU questionnaire was used to assess subjective changes over time for the cochlear implant user and in the different test situations. All users keep the implant on for listening to music. In the music test the results for the ci ear and the normal hearing ear were in the range of ci users or normal hearing controls tested in previous studies. There was no deterioration of performance in the combined condition. As the results of the normal hearing ear reached a ceiling effect in the MuSIC test for most participants no furthere increase of performance could be shown. In the MUMU questionnaire subjects described an increase of all musical activities after implantation. In some areas of musical life the level of the time before hearing loss were reached.

It seems that not only hearing in noise and spatial hearing are impaired by profound sesorineural hearing loss but also listening to and enjoyment of music. Cochlear implantation in ssd users enhances musical activities although two acoustically very diverse systems work together. Muscial enjoyment takes some time to improve after implantation.

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S30-8

Cochlear implants in unilateral deafness: luxury or necessity?

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Introduction: Patients with unilateral deafness (UD) experience difficulties with speech understanding in noisy environments and problems with localisation of sounds. This can lead to learning difficulties and decreased school performance. Selected group of patients with UD who also suffer from unbearable ipsilateral tinnitus can get their tinnitus suppressed by electrical stimulation. Application of cochlear implants (CIs) in this group of patients allowed us to observe additional benefit for speech understanding in noise and improved spatial perception of sound. This study was undertaken to evaluate this benefit in a systematic way.

Objective: To evaluate the audiological results of cochlear implantation in patients with UD.

Methods: Ten patients with unilateral deafness have received a CI, including one professional pilot and one congenitally deaf child of 15 months old. In 8 patients the duration of UD was relatively short (less than 3 years).

After at least 6 months of implant use the results of tonal audiometry, phoneme detection and discrimination test at 70 dBHL and speech understanding using the Dutch NVA word lists (CVC words - phonemic score) in quiet have been evaluated and compared to matched CI patients with bilateral deafness. All these test were performed with the contralateral ear masked according to our masking protocol. In order to investigate the binaural effects, we measured the benefit of speech perception in noise, as well as the localization capabilities in two conditions: with CI and without CI. The speech-in-noise tests were performed in S0N0 and S-90N+90 / S-90N+90 conditions at SNR +10, +5, 0 and -5 dB. The localisation tests were performed in the 11 loudspeaker setup with broadband noise stimuli at 70 dBHL.

Results: When the noise source was placed at the good ear and the speech signal at the CI side the improvement of speech discrimination was up to 20% at 0dBS/N and 40% at -5dBS/N. Presence of noise at the CI side did not cause detrimental effects on speech understanding with the good hearing ear. All CI patients reported improvement in the spatial perception of sounds. Statistical analysis of the results of the localization tests will be presented too.

Conclusions:

1. Cochlear implantation in unilateral deafness results in significant improvement of speech understanding in noise.
2. Improved spatial perception of sound with CI suggests re-activation of the binaural processing.

Keywords: cochlear implant, unilateral, deafness, speech understanding, localisation

S30-9

Localisation ability of CI recipients in single-side-deafness (SSD)

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Cochlea Implantation (CI) is an alternative to CROS hearing aids in case of single-side-deafness (SSD). Speech understanding in noise is more easy using the speech coding strategy of the new processor generations.

In a prospective study we analyzed within a collective of 30 CI recipients the ability to localize within a 306° loudspeaker circle with 12 loudspeakers. The sounds were applied randomly. We could find in all the patients an ability to localize with the CI, we could not see any ability without CI.

Missing ability of localisation in SSD patients can be compensated by CI but not by CROS hearing aids. This is essential to avoid accidents via a better localisation and to ease speech understanding in groups. Both factors do have a direct influence on integrating patients with hearing impairment in society and employment as tax payers.

S30-10

Sound localization in Single-Sided Deaf cochlear implant users, after upgrade to one single-unit speech processor

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Introduction: Previous studies reported multiple benefits, such as tinnitus suppression, speech recognition and sound localization in Single-Sided Deafness (SSD) subjects after Cochlear Implantation (CI). In contrast to the well-known Behind-The-Ear speech (BTE) processor, a one single-unit speech processor was launched recently. Although both speech processors are working on the same audio processor platform, there is a potential localization difference attributed to different microphone placing. Therefore, the study aims to investigate subjective and objective localization benefits in SSD CI patients using their BTE speech processor and using a new one single-unit speech processor.

Methodology: 10 adults with unilateral severe intractable tinnitus resulting from ipsilateral sensorineural deafness, with a mean age of 56 (SD 13) years were enrolled in the study. They were cochlear implanted at a mean age of 48 (SD 14) years. 9 loudspeakers were located in a frontal semicircle at a distance of 0.8 m from the listener's head. Stimulus coordinates ranged from -90° to +90° in azimuth at intervals of 22.5°. 3 different localization stimuli were used: broadband noise (BB; 0.5 - 20 kHz), low-pass noise (LP; 0.5 - 1.5 kHz) and high-pass noise (HP; 3 - 20 kHz). Normative localization data of a control group of 30 normal hearing subjects were used for comparison. Administered subjective evaluation consisted of: SSQ5 and the SHQ. At test moment T0, localization tests were conducted in the BTE speech processor condition and in the CI_{OFF} condition. All 10 subjects were upgraded to the one single-unit processor and retested 28 days later at T28 using their new speech processor, provided with the same fitting map.

Results: A median Root Mean Square Error (RMSE) improvement of 36° and a median Mean Absolute Error (MAE) improvement of 23° was found for BB stimuli, 15° and 10° for LP stimuli and 52° and 26° for HP stimuli. For all 3 stimuli, sound localization improved significantly in SSD patients in the CI_{AIDED} condition compared to the CI_{OFF} condition. No significant difference was found between the BTE and the one single-unit processor condition was found.

Conclusion: Using 4 localization parameters RMSE, MAE, ´b´ and ´d_b´ an overall localization performance and localization accuracy was found in SSD subjects in the CI_{AIDED} condition, compared to the CI_{OFF} condition. Furthermore, the study shows that long-term BTE speech processor SSD users are able to upgrade to a new one single-unit speech processor, without compromising their sound localization.

S30-11

Spatial acuity and lateralisation after cochlear implant in unilateral deafness: where does the auditory cortex come in?

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Sound localization in the horizontal plane relies on two binaural cues: interaural level difference (ILDs) and interaural time difference (ITDs). The aforementioned cues help to localize high frequency and low frequency sounds respectively. Inability to localize a sound source is one of the major complaints of people with unilateral profound hearing loss. Improvement on localization abilities can be the driving force for these patients to explore the possibility of cochlear implantation.

This study aimed to observe the localization performance of patients with unilateral deafness who received a cochlear implant (CI) within the last 24 months. Sixteen adults (9 male, 7 female) with postlingual unilateral deafness who opted for a CI after a trial of wireless CROS hearing aids and bone anchored hearing aid (Baha) were included on this study. All subjects received the MED-EL (Innsbruck, Austria) CI system and wear the speech processor on full time basis. The speech processors were programmed with fine structure speech coding strategies (FS4 or FS4-p). Bilateral loudness balancing was performed for each patients' program settings.

Localization testing was performed using the Auditory Speech Sounds Evaluation software (A§E®, PJ Govaerts, Antwerp, Belgium). Each patient performed the localization testing in two listening conditions: monaural hearing (normal acoustic hearing alone) and binaural hearing (acoustic hearing and CI activated). The order of the test was randomised. All patients had at least 6 months experience with their CI. Analysis of the results showed that the group performed significantly better with CI on when compared with CI off. The majority of patients presented an RMS measure that was similar to those with normal hearing.

S30-12

Binaural and monaural speech recognition in single-sided deaf and bilateral cochlear implant recipients

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Intro: Several studies have shown binaural and monaural speech recognition in noise abilities as well as binaural benefit in adult bilateral cochlear implant (CI) recipients, while other studies presented binaural and monaural speech recognition as well as binaural benefit in adult single-sided deaf (SSD) CI recipients partly using different test setups and procedures. The aim of this investigation was to ascertain and compare binaural and monaural speech recognition in noise as well as binaural benefit in both recipient groups as well as normal hearing subjects using exactly the same test setup and procedure to allow for a comparison of speech recognition of these three groups definitively clear of test setup and/or procedure related effects on speech recognition.

Methods: So far 10 adult subjects have been included into each group. Speech recognition in noise thresholds were examined in the five different speech-in-noise presentation conditions S45N-45, S0N-90, S0N0, S0N90 and S-45N45 using the Oldenburg sentence test (olsa). In SSD CI recipients, monaural speech recognition with the CI ear was assessed by sound presentation in free field and masking the normal hearing ear by presentation of olnoise via the headphone HDA200.

Results: In the SSD CI group there was a CI related binaural benefit in two presentation conditions, whereas the bilateral CI group and normal hearing group showed a binaural benefit related to either of both ears in all conditions. In all presentation conditions, normal hearing subjects showed better binaural speech recognition in noise than SSD CI recipients, and SSD CI recipients obtained better binaural speech recognition than bilateral CI users. Monaural speech recognition varied considerably more across presentation conditions than binaural speech recognition.

Conclusions: Our results show that that there is a binaural benefit for speech recognition in noise in single-sided deaf and bilateral cochlear implant recipients in different numbers of presentation conditions.

Learning outcome: Binaural and monaural speech recognition in noise as well as binaural benefit differ widely between subject groups and speech-in-noise presentation conditions.

S30-13

Cochlear implant (CI) surgery in long-term single-sided deafness (SSD) - first results

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Adults with a very long-term or even congenital unilateral deafness have only recently gained access to a binaural hearing. It is only for almost 10 years that patients with single-sided deafness are provided with a CI. The limitations in social life of SSD-patients are well known. Especially problematic are directional hearing and the quick ear fatigue in noise and in "Party-talk" situations. Because of the extremely asymmetric experience in binaural hearing and the intense one-sided embossing of the central auditory pathway success in binaural hearing after cochlear implant surgery can be only poorly predicted. It raised the question whether this group of patients could benefit from a CI.

In the period of 2011-2013 CI surgery was performed in 18 patients with single-sided deafness. Five of them (2 female, 3 male) suffered from a long-term single sided deafness. At the time of CI surgery the patients were 52.4 ± 15.2 years old. The average duration of deafness was 38.6 ± 13.4 years. Because the term "SSD" must be always set in relation to age, a minimum duration of deafness of 25 years was assumed. Before surgery the subjective problems were specifically asked and an exploratory CROS hearing aid supply was also tested. In standardized experimental conditions, the effect and especially the improvement of the special hearing aid system (CROS) were measured. In cases of failure the patients underwent CI surgery after intensive patient interview and on their special request.

As part of the rehabilitation after CI surgery the benefits were reevaluated. For this purpose the questionnaire “Bern Benefit in Single-Sided Deafness” (BBSS) was used. Once more, the ability to directional hearing with cochlear implant was recorded in a standardized examination procedure. Wearing time of the CI - sound processor was 16 ± 6.2 months on average. All patients are wearing their CI daily.

The tendency is a subjectively improvement of sound localization. Objectively no statistical significance could still be shown.

S30-14

Cochlear implantation in single-sided deafness - Effects on binaural perception

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Introduction: Patients with single-sided deafness (SSD) have great difficulties with auditory perceptions, which are based on binaural procession. Based on the positive clinical results and experience of bilateral cochlear implantation, cochlear implantation is offered increasingly as a treatment option for individuals with severe-to-profound hearing loss in one ear and normal hearing in the other ear. The purpose of our study was to examine if cochlear implantation can successfully restore the binaural auditory perception in patients with SSD.

Materials and methods: To measure the difference in speech perception with and without a CI with sound sources from different spatial positions, an adaptive speech recognition test (Oldenburg Sentence Test, OLSA) was used in the first experiment with 10 patients with severe to profound hearing loss in one ear and normal hearing in the other ear, in different loudspeaker configurations ($S_{CI}N_{NH}$, and Multisource Noise Field, MSNF), and with different background noise signals (Oldenburg-Noise, Fastl-Noise). The speech recognition test was performed in all loudspeaker configurations in monaural, and binaural listening conditions. Speech recognition with Fastl-Noise was assessed in a binaural listening condition in the configurations $S_{CI}N_{NH}$, and MSNF. As a main parameter of the test, the speech-reception threshold (SRT) was calculated.

In the second experiment, the lateralization of test-signals was analyzed. Broadband signals were presented at the same time with different signal levels on both channels of ear-enclosing headphones. Based on a visual analog scale (VAS) the value was determined which centralized the hearing impression, as well as how much the lateralization depended on the level difference. In addition, the subjective benefit was assessed using the Bern Benefit in Single-Sided Deafness (BBSS) questionnaire.

Results: Speech perception scores were significantly better in the binaural listening condition (with CI) as compared to the monaural listening condition (without CI) in the loudspeaker configuration $S_{CI}N_{NH.}$ In the loudspeaker configuration MSNF, speech perception was also better with a CI, although no statistical significant difference was noted. Significant benefits were also reflected in the subjective benefit outcomes.

Conclusion: Outcomes reveal an improved speech perception with a CI in difficult listening situations and suggest that cochlear implantation can successfully restore the binaural auditory perception in patients with SSD.

S30-15

Restoration of binaural hearing with a cochlear implant in single sided deaf subjects

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Intro: Recent treatments for single sided deaf subjects (SSD) are very limited. If treated at all, acoustic signals are only picked up from the deaf side and routed to the hearing side either as an electrical signal (CROS) or through bone conduction (BAHA). Both methods use for the transmission of auditory signals only the contralateral hearing cochlea and do not utilize the peripheral auditory pathways on both sides. However, through electrical stimulation via a cochlear implant the deaf side can be activated. The aim of our present study was to demonstrate that in such a case a true binaural hearing is possible.

Methods: 20 SSD subjects have been implanted with a Nucleus CP512/Freedom device and all of them are fitted with a CP810 speech processor. After at least 3 months of use the speech perception of all subjects was tested using an adaptive sentence test in noise. We also investigated the localization ability using a 47 loud speaker setup. Additionally, subjective improvement in daily life was evaluated through an extended questionnaire.

Results: As result, speech perception scores improved by a mean of 4 dB when noise was presented to the normal hearing ear and speech to the implanted ear with implant on. All subjects but one were able to localize sounds; the questionnaires revealed a great benefit in daily life when using the implant on the deaf side.

Conclusions: The results of the study demonstrate that SSD subjects implanted on their deaf side develop a true binaural hearing.

Learning outcome: The human brain is able to fuse electrical and acoustical auditory Input.

S30-16

Tinnitus loudness as a factor in the decision for a bone conduction hearing implant of a single-sided deaf patient

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Intro: One of the hearing solutions offered to single-sided deaf (SSD) patients, is a bone conduction hearing implant (BCI). SSD is however often accompanied by tinnitus in the deaf ear. The current study aims to verify if tinnitus loudness and tinnitus distress vary between SSD patients that choose to continue wearing the BCI (BCI+) and those who decline BCI surgery after a BCI trial (BCI-). Moreover, we want to find out if tinnitus loudness is affected by the BCI.

Methods: 40 single-sided deaf patients with complaints of tinnitus in the deaf ear, were included in the study. All patients performed a BCI trial of at least two weeks. Prior to the trial, mean tinnitus loudness was rated on a visual analogue scale (VAS, min. 0 - max. 10) and tinnitus distress was determined with the Tinnitus Questionnaire (TQ). After the trial, tinnitus loudness was rated on a VAS for the aided condition. The collected data were analyzed to determine if tinnitus is an influencing factor in the decision making process of a patient whether or not to continue wearing a BCI (BCI- vs. BCI+). Moreover, the effect of fitting a BCI on tinnitus loudness has been investigated.

Results: A statistically significant difference has been found regarding the tinnitus loudness score with a median VAS score of 7 (SD 2) in the BCI- group and a median VAS score of 5 (SD 2) in the BCI+ group ($p = 0.015$, Independent Samples Mann-Whitney U-test). Tinnitus distress was similar in both groups. No improvement in tinnitus loudness has been seen in the aided condition.

Conclusion: The current study shows that the presence of loud tinnitus negatively influences the decision of an SSD BCI candidate with a cut-off loudness of 5.75. Generally, the BCI has no effect on tinnitus loudness in SSD BCI candidates.

Learning outcome: The authors recommend extra attention to patients whose primary complaint is loud tinnitus in the deaf ear.

S30-17

Comparison of the different treatment options in single-sided deafness

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Intro: This study aimed to determine which criteria underlie the choice for simple observation, auditory rehabilitation by CROS, bone conduction implantation or cochlear implantation in patients with single-sided deafness. Our second objective was to assess the outcomes for each of the four options, regarding both binaural hearing and tinnitus relief.

Patients and methods: Twenty-five patients with single-sided deafness or asymmetrical hearing loss, eventually associated with an incapacitating tinnitus, were included in this prospective study. Each patient was proposed one CROS and one bone conduction trial before making his/her decision between four options: observation, rehabilitation by CROS, bone conduction device implantation and cochlear implantation. Binaural hearing and tinnitus were evaluated at inclusion, after each trial (CROS or bone conduction) and 3 months after rehabilitation. Binaural hearing was assessed using an adaptive procedure, which allowed determining the speech recognition threshold (SRT) in three distinct spatial configurations (diotic hearing, dichotic hearing where speech signal was presented at the poorer ear and masking noise at the better ear, reverse dichotic hearing where speech signal was presented at the better ear and masking noise at the poorer ear). Tinnitus severity was measured on a Visual Analog Scale. The Glasgow benefit Inventory was collected three months after the rehabilitation method was chosen.

Results: Four patients opted for CROS rehabilitation, two for a bone conduction device and thirteen subjects chose rehabilitation by cochlear implantation (10 implanted so far). Six subjects considered that their handicap did not justify any further treatment (observation). The only factor which was found to determine the patients' choice was the severity of tinnitus (VAS ≥6), preferentially leading to cochlear implantation (Chi², $p < 0.01$). None of the binaural hearing scores before and after rehabilitation trials was related to the final decision. In the ten cochlear implanted patients, preliminary analyses showed that mean SRTs were significantly better after implantation in diotic hearing (-0.9 dB±1.2 versus +1.8 dB±2.1 at inclusion; Wilcoxon, $p = 0.03$) and in dichotic hearing (-0.6dB±2.7 versus +4.3 dB±2.5, Wilcoxon, $p = 0.02$). Tinnitus severity decreased from 9/10 (±1) at inclusion to 1/10 (±1) after implantation.

Discussion: Cochlear implantation was associated with better results on binaural hearing and tinnitus severity. However, half of subjects opted for an alternative and subjectively satisfactory option.

Conclusion and learning outcomes: Cochlear implantation is effective in single-sided deafness and asymmetrical hearing loss, especially when an incapacitating tinnitus coexists. The choice of the treatment might rely on specific quality of life indices but needs to be investigated in larger multicenter studies, which should also determine the cost-utility ratio for each option.

S30-18

Single side deafness after vestibular schwannoma resection: Cochlear implants (CI), bone anchored hearing aids (BAHA) or contralateral routing of signals (CROS) hearing AIDS?

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Introduction: Single side deafness (SSD) patients experience handicaps related to the diminished capability of speech recognition when the sound is coming from their deaf side and inability to localize sounds, among others. In the recent years BAHA and CROS systems have demonstrated to be an effective method for binaural hearing rehabilitation in SSD patients. Most recently, CIs have been introduced with the same aim, with results initially superior. However, these studies included patients with SSD of all aetiologies, with very few or no cases of vestibular schwannoma. Up to date, CIs are the only device capable of restoring true binaural hearing in the profoundly deaf, however, it is doubtful whether VS patients would obtain these benefits, where it is known that CI offer less performance than in standard SSD patients due to, presumably, cochlear nerve distress. The purpose of this study was to assess the benefit on binaural hearing in patients fitted with three types of devices (CI, BAHA and CROS) operated on VS resection.

Methods: This prospective study was comprised of three groups of patients fitted with CI, BAHA or CROS for hearing restoration after VS.

CI group: Ten patients previously operated on VS by translabyrinthine approach (TLA) who received simultaneous cochlear implantation.

BAHA and CROS group: 20 patients previously operated on VS by TLA, were adapted either with BAHA or CROS according to the patient own preferences.

Binaural hearing was tested in three spatial configurations (Vermeire, 2009).

In the CI group, patients with less than 6 months follow-up were excluded for evaluation. In the BAHA group, three patients had not undergone activation of the device at the moment of collecting these data.

Results: In the CI group, there was a mean improvement of 1.57 dB, 1.42 dB and 0.42 in the three spatial configurations tested. In the BAHA group there was a mean improvement of 0 dB, 2.5 dB and 3.25 dB in the same spatial configuration. Finally in the CROS group the mean improvements were 1.4 dB, 0.42 dB and 2.28 dB respectively.

Discussion: Vestibular schwannoma patients represent a challenge both from surgical and audiological point of view. In the case of sporadic VS with normal contralateral hearing, the audiological impact of this disease centres on the loss of binaural hearing. Our results show that with the three devices fitted, binaural hearing is improved in all the spatial configuration tested. These preliminary results should be interpreted with caution, as they may vary with longer follow up, especially in the CI group. When selecting the device, other factors may be also taken into consideration such as patient preferences, need for an additional surgery, and costs.

S30-19

Relationships between speech perception, localization and pitch matching in patients who have normal hearing in one ear and a cochlear implant in the contralateral ear

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Recently, cochlear implantation has been proposed as a means to restorebinaural hearing in patients with asymmetrical hearing loss or single-sided deafness (SSD). However, little is known about the comparison in pitch percepts between and ear that is stimulated electrically versus an ear that is stimulated acoustically and how those might relate to outcomes. The purpose of this study was to evaluate correlations in speech perception and localization performance to pitch matching results in patients with normal hearing in one ear and a cochlear implant in the contralateral ear.

CNC word and AzBio sentences in quiet were administered via DirectConnect. Spatial hearing was evaluated in quiet using an 8-loudspeaker array. An adaptive speech perception in noise test was also administered. Pitch matching was conducted using pure-tones administered via insert earphones in the normal hearing ear and single-electrode pulse trains via the programming software in the implanted ear. Preliminary results indicate unexpected patterns of pitch matching between ears for some patients. Correlations between pitch matching results and outcome measures will be described. Unexpected patterns of pitch-matching might affect outcome measures. This may have implications for post-implantation counseling and rehabilitation and for the development of future programming approaches.

Listeners will have a better understanding of how differences in pitch percepts between ears can affect outcome measures.

S30-20

Cochlear implantation in single sided deafness

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Introduction: Until a few years, cochlear implant indications were limited to bilateral severe to profound sensorineural hearing loss. Recently, those indications have expanded for single sided deafness in patients with intractable tinnitus founding this indication beneficial. In the current study we evaluate the audiologic and quality of life outcomes in patients with isolated single sided deafness (without tinnitus) with normal and mild sensorineural hearing loss in the contralateral side.

Objective: To evaluate auditory benefits in quiet and noise, quality of life and patient satisfaction scores in adult patients receiving a cochlear implant for single sided deafness, as primary indication.

Method: Prospective study in adult patients who received a cochlear implant for unilateral severe to profound sensorineural hearing loss. All patients included had speech discrimination equal or better than 100% at 70 dB in the contralateral ear. The pre and post audiologic outcomes are evaluated, including hearing in quiet and noise, with and without the implant on. Results are evaluated over time at 6-12-18mo postoperatively. SSQ (Speech, Spatial and Qualities of Hearing Scale) was used to evaluate self-reported auditory disability improvement. Quality of life and device satisfaction scores were evaluated using the Glasgow Benefit Inventory (GBI) and the Hearing Device Satisfaction Scale (HDSS), respectively.

Results: Twenty one patients were included in the study. The mean auditory gain was statistically significant (p=0.02) after cochlear implantation (81 dB). When noise is presented in the non-implanted ear there is a significant improvement (p=0.04) of the S/N ratio at 18 months postoperatively compared to preoperative status (-7.0 and -4.7, respectively). Although there is a trend of improvement prior 18 months, this is not significant at 6 or 12 months. When noise is presented at 0 degrees, there is a trend of improvement of approximately 2dB at 18 months. SSQ scale showed an improvement in all domains after cochlear implantation that progress over time. All patients had improvement in their quality of life after cochlear implantation, using the GBI. A significant improvement (p=0.01) is present at 18months postop compared to 6 months postop in their overall health after CI. Patients satisfaction scores although start to improve at 6 months, they are not significantly better (p-=0.02) until 18 months.

Conclusion: Cochlear implantation for single sided deafness is a valuable hearing prosthesis that provides improvement in noisy environments, particularly when noise is presented in the non-implanted ear. Patients should be counseled about lengthy need for rehabilitation and expectations of satisfaction in noisy environment, quality of life, and quality of sound should be centered at about 18 months.

S31 Young children

S31-1

“Frogs and snakes": Early Implanted children with severe/profound hearing loss attending auditory-verbal early intervention can achieve typical patterns of consonant clusters by age 3

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Intro: Children early-identified with severe/profound hearing loss (HL) following universal newborn hearing screening (UNHS) have been reported to achieve improved speech and language outcomes. However, speech outcome reports have typically been based on broad measures of speech intelligibility and/or singleton consonant accuracy with little known about production of consonant clusters (CCs).

Methods: The range and accuracy of CCs produced by a homogenous cohort of 12 children early-identified with severe/profound HL aged 3- and 4-years were examined using a prospective design. All children demonstrated bilateral aided thresholds within a range of 15 - 25 dB HL across all frequencies, were optimally amplified with cochlear implants (11/12) or hearing aids (1/12) and attended auditory-verbal (AV) early intervention. The purpose of this study was to prospectively examine the *accuracy* and *range* of 2- and 3- element initial and final CCs produced by a *homogenous* cohort of 3- and 4-year old UNHS children with severe/profound HL in single-word and conversational speech contexts.

Results: Standardized speech and language assessments were administered. CCs were strategically sampled in single-word and conversational speech contexts. All standard scores for speech, receptive and expressive language were within normal limits. All children produced CCs commensurate with expectations for typically developing hearing peers at 3- and 4- years-of-age. Children's production of phonetically complex morphophonemes (final CCs marking grammatical morphemes), was also in keeping with developmental expectations.

Discussion: CCs are important to study for a number of reasons, including e.g., one-third of English monosyllables commence with a CC (e.g., blue; street) (Locke, 1983); CCs are evident in many world's languages (Greenberg, 1978); CCs dominate word-final position and are particularly important for marking complex morphophonemes—grammatical morphemes realized by CCs (e.g., plurals: boats /ts/; past tense: jumped /mpt/) (Paul & Shriberg, 1982); accurate use of CCs has been associated with improved expressive language and superior literacy development (Haskill & Tyler, 2007; Overby et al.,2012)

Conclusion: A closer inspection of speech outcome research for children with severe/profound HL suggests that findings to date have been complicated by heterogeneous characteristics of children in the research. This study addresses this issue with some promising outcomes reported. Further research needs to identify specific factors that facilitate these outcomes and track long term literacy developments for these children

Learning outcome: Early Implanted children with severe/profound hearing loss attending auditory-verbal early intervention can achieve typical patterns of consonant clusters by age 3.

S31-2

The influence of newborn hearing screening programs on the age at cochlear implantation in children

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Objective: To evaluate the influence of the introduction of newborn hearing screening programs on the age at cochlear implantation in children.

Material and methods: We performed a retrospective chart review, including all pediatric cochlear implant users who received their implants before the age of 5 years between 1995 and 2010 in the Medical University Hannover, Germany and the University Medical Center Utrecht, the Netherlands.

Results: The average age at implantation gradually declined over the years before the introduction of the newborn hearing screening programs. The introduction of the screening resulted in a much larger decline in the age at implantation in the Netherlands; along with that the number of children implanted within their first year of life increased significantly. Comparing 2-year epochs immediately before and after introduction of the screening, the mean age decreased from 2.4 to 1.2 years and the percentage of early implanted children increased from 9 to 37%. In the German population age at implantation declined significantly over the total period, but did not further decline after the introduction of the newborn hearing screening in 2009.

Conclusion: The introduction of the national newborn hearing screening programs has reduced the age at cochlear implantation in young children in the Netherlands but not in Germany. Correspondingly, it resulted in an increase in the number of children implanted early in life. The difference between the Dutch and German population might be contributed to differences in study populations where children in Germany already received a cochlear implant earlier in life prior to the introduction of the hearing screening as compared to the Dutch population. Besides, differences in study size, referral patterns and geographical distances might be of influence.

S31-3

GROBIC - Baby's observation checklist in pre and post cochlear implantation

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Introduction: Immediately after birth, the baby communicates crying. Communication is not limited to speech but involves a complex set of behaviors ranging from screams, cries, laughs, vocalizations, looks, facial expressions, words, phrases and gestures to a speech full of verbal and nonverbal behaviors that make the child an effective communicator among their peers and in the community. When we have a baby with severe to profound bilateral deafness neurosensory limiting their access to sound world and the linguistic world, a close observation of all their communicative behaviors, becomes even more important, thus to understand their actual communication capabilities with those around you. For these children, the cochlear implant is the only feature that will allow them access to the sounds before and after cochlear implantation. It is of utmost importance to realize how perceptual, language and communication skills are developed in these children.

Objectives: With this work we intended to create a guide for observation and evaluation of communicative behaviors of infants (0-36 months) with profound and severe neurosensory deafness, serving as an initial guidance on pre and post cochlear implantation, GROCBIC (Observation Checklist of Baby's with Cochlear Implants Communication).

Material and methods: Based on the knowledge of already existing assessment tools and experienced observation of different infants before and after cochlear implantation, it was built a guiding checklist for babies up to 36 months of chronological age, for observation and assessment of infants with severe to profound bilateral deafness with a cochlear implant.

Results: The GROBIC was applied to all candidates for babies' cochlear implant teams in the functional unit of the Cochlear Implant CHUC and Hospital CUF Porto. Its implementation afforded to achieve information about the communicative behaviors that babies manifest not only in their communication with parents but also with other people with whom they relate.

Conclusion: The GROBIC allows obtaining more precise information on auditory, language and communication skills of children with severe to profound deafness before and after surgery for cochlear implant placement. This way it can be a huge asset in the evaluation of candidates for cochlear implantation process, taking into account the scarcity of assessment instruments for this age group.

Keywords: Deafness, Baby, Evaluation, Cochlear Implant and GROBIC

S31-4

Is it possible that hearing may improve in the first months of life? - Implications for candidates selection for hearing aids and cochlear implants at an early age

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Introduction: Traditionally it is considered that the auditory system has already developed at birth , and that hearing loss findings are definitive. We decided to analyze the results of our newborn hearing screening program to evaluate this hypothesis

Methods: Review and retrospective analysis of our newborn hearing screening program.

Results: Over 20,000 screening examinations were analyzed.

37 patients presented confirmed hearing loss. Nevertheless, from them, 9 patients who were confirmed to suffer from at least moderate hearing loss showed normalization of their hearing results in subsequent monitorings. These 9 patients have three common characteristics: 1 . They were born premature 2. All had moderate hearing loss, and 3. All suffered from a condition that represents an additional risk factor for hearing loss, such as Hiperbilirrubinemia, or Hypoxia during their stay in NICU.

Discussion: We have been able to identify a group of patients in whom hearing experiences recovery after their neonatal period and that could even lead to normal hearing tests. Treatment decisions for infants with hearing loss are complex, and communication of results as well as consideration for hearing rehabilitation should be taken with caution.

Our results indicate, once again, that In young children, repetion of hearing tests leads to precision.

S31-5

Early literacy skills in children with simultaneous bilateral cochlear implantation between 5 and 18 months

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Intro: Phonological awareness is associated with acquisition of basic sound structures in language, and affects language development. Due to sound deprivation phonological awareness may be delayed in children with hearing loss, and there is evidence for variability in phonological awareness in children with cochlear implants (CI). Since reading relies heavily on phonological awareness, it has traditionally been difficult task for deaf children to master thus affecting their possibility for academic success.

Method: The present study is a prospective longitudinal study. The sample included 38 children, 19 CI-users and 19 with normal hearing, matched on age and gender mother education. The children with CI were simultaneously bilaterally implanted between 5 and 18 months and had no additional disabilities. At the 6-year follow-up, children completed tasks assessing a range for language- and early literacy skills such as phonological awareness, expressive grammar, phonological working memory, receptive vocabulary, letter knowledge, and reading of actual- and non-words.

Results: Independent-sample t-tests were conducted. Preliminary analyses show no significant difference between the CI-users and the normal hearing children with regards to letter knowledge (p=.29), reading of one to three syllable words (p=.07), reading of actual- and non-words (p=.58, p=79.) and phonological awareness (p=.96). Significant differences between the groups were found with regard to phonological working memory measured through word- and sentence-repetition (p=.03, p=.03), receptive vocabulary (p = .00) and expressive grammar (p=.03).

Discussion: Previous studies have shown CI to provide profoundly deaf children with better opportunities to acquire phonological representation and reading skills, though many studies have found that normal hearing children outperform the children with CI. The current results, however, indicate that it is possible for children with CI to perform at age appropriate levels concerning early literacy- and phonological-skills.

Conclusion: The results indicate that children who receive simultaneously bilateral implants between ages 5 and 18 months show phonological awareness and early literacy skills similar to children with normal hearing. The results also imply that children with CI are able to use a phonological strategy while reading non-words. However, the children with CI score significantly lower on phonological working memory and measures of vocabulary, the latter of which could put them at risk for later difficulties with reading comprehension.

Learning outcome: Bilateral simultaneously implantation between 5 and 18 months can provide prelingually deaf children with sufficient auditory access to develop age appropriate phonological skills. Difficulties with vocabulary and phonological working memory require further attention in these children in order promote age appropriate skills.

S31-6

Early predictors of narrative skills after 6 years (72 months) of cochlear implant use

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Intro: Narrative competence, or the ability to tell a cohesive story, requires the integration of many different linguistic skills and is an essential aspect of everyday communication. Measuring narrative competence can therefore provide a more ecologically valid measure of language ability than many other standardized measures of expressive and receptive language. Although children with cochlear implants (CI) are capable of achieving narrative ability comparable to normal hearing peers, the language outcomes of children with CI vary substantially, even when these children receive bilateral implants between 5 and 18 months of age and have no additional disabilities. The objective of the present study is to explain some of this variation by attempting to identify early factors that predict later narrative ability in children with CI.

Methods: Nineteen children with CI were matched pairwise with 19 normal hearing children based on gender and chronological age. The two groups were matched according to mother's education. All children with CI received simultaneous bilateral implants between the ages of 5 and 18 months, had no known additional disabilities, and primarily used an auditory oral/verbal approach to communication. A battery of tests was administered to participants after 3, 6, 9, 12, 18, 24, 36, 48, 60, and 72 months of CI use. Tests measured skills such as receptive and expressive language, grammatical knowledge, and intelligence. Information relating to family, education, language therapy, and other environmental issues was gathered through parent report. Narrative ability was measured by a Norwegian translation of the Renfrew Bus Story Test after 72 months of CI use.

Results: Analyses of the narratives will examine global and local levels of language use, such as inclusion of plot elements and number of subordinate clauses. Descriptive statistics and regression analysis will be used to identify predictors of later narrative ability from amongst the psychometric and parent report data gathered earlier in life.

Discussion: The homogeneity of this study's sample affords more control over confounding variables, such as late age at implantation and additional disabilities, than is typically feasible in research on children with CI. By attempting to isolate cognitive skills and environmental factors as predictors of school-aged narrative ability, the present study provides a potentially clearer understanding of the poor language skills experienced by some children with CI after an initially optimistic prognosis.

Conclusion: Identifying predictors of narrative skill, a nuanced and contextualized language measure, can help explain the variable language outcomes of high-potential CI users.

Learning outcome: If early predictors of later narrative abilities can be identified, children at risk for delays in these complex forms of language can begin to receive more focused language therapy before they reach school age.

S31-7

Factors influencing perception, speech and language development of cochlear implanted children: Multivariate retrospective analysis

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Spoken language development in cochlear implanted children shows a large interindividual variability. This study was designed to describe language acquisition in CI children, and to explore parameters which could explain this heterogeneity.

Material and methods: 181 files implanted children from the CI Center of Lyon University Hospital were selected. Inclusion criteria were implantation between 2000 and 2010, before the age of 5. Children with neurological deficit, mental retardation, and post-meningitis deafness were excluded. Analysis focused on perceptive and expressive results (speech, lexical and syntactic level) 3 and 5 years after implantation, and on personal history factors, such as age at cochlear implantation, deafness etiology and progression, associated deficits, social background, and communication mode.

Results: A large majority of children reach an excellent perception and intelligible speech, and can produce complex sentences, whereas a minority of them has a low language level. Statistical analyses reveal that perception and expression 3 years after implantation are influenced by age at implantation, but results after 5 years of CI use are other deficits, especially vestibular troubles, family socio-economical status, and use of cued speech. Better pre-implant thresholds are associated with a more intelligible speech, but neither hearing loss progression nor etiology seem to be prognostic factors. Anyway, only part of language variability was explained by these parameters.

Conclusion: This study suggests that parameters known to influence results of CI children actually have a limited role when perception, speech and language level are considered 5 years after cochlear implantation, and that they explain only a small part of results heterogeneity.

S31-9

Language development with the German Language Development Test Battery (SETK) after Cochlear Implantation (CI)

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Background: Cochlear Implantation with the first two years of life is considered to have a good prognosis for the primary language development. However literature indicates heterogeneous courses of development. This studies´ hypothesis aims to assess prospective factors at the age of two years hearing experience with CI.

Material and methods: Test measurement took place at 24 months hearing age (24±5,5), 36 months hearing age (36,5±6,1) and >48 months hearing age (54±8,4) with the German language development test battery for children (SETK). This test battery measures receptive and expressive language skills and auditory memory function. SETK 2 consists of 2 subtests for receptive language (word, sentence) and 2 subtests for expressive language (word/ sentences). SETK 3-5 includes subtests for receptive language (sentences), expressive language (Sg/ Pl, decoding of semantic structures) and auditory memory (working memory for artificial words/ memory for sentence). Raw scores were converted in T-scores. For analysis nonparametric tests and descriptive statistics with SPSS Version 21 were used. Data of 16 children were analyzed. 50% had a genetic etiology, 43,7 % were unknown and 6,3 % had a syndrome. 87,5% had as their first language German, 12,5% learnt more than one language. 56,3% of the cohort were implanted before their first birthday, 37,5% in the second year of life and 6,3 % in the third year of life. 87,5% were implanted bilaterally, 6,3% unilaterally and 6,3% bimodal.

Results: At a hearing age of 24 months in all subjects an average language development for receptive language was achieved. However scores for expressive language skills are beyond the norms. Depending on subtests T-cores ranged between 25% (word) and 43% (sentences). At an hearing age of 36 months receptive language skills in 87,5% stayed within the norms of hearing children. 68,8% range within the norm for hearing children in subtest decoding semantic structures. 48,6% showed average scores in developing SG/PL structures. Data of auditory memory for artificial words was within hearing age norms in 43,6%. At the age of 48 months hearing age with CI 62,5% of the cohort illustrated average scores in subtests receptive language and memory for sentence repetition. Working memory for artificial words: 68,6% appeared within average norms. Merely the subtest for phonological working memory 31,2% showed an average development.

Discussion: In this cohort we could not discover a hearing age or age appropriate receptive and expressive language development for all subjects. Though receptive language scores at 24 months hearing experience are seen within the normal range of hearing, results vary until 48 months particularly in working memory and grammatical development. Prospective rating at a hearing age of 24 months seems to be too soon in the recent cohort.

S31-10

Age-appropriate speech/language by 3 years-of-age: Key contributing factors

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Intro: Research data from the USA in 2007 indicated that 30% of school graduates with congenital severe/profound hearing loss (HL) were functionally illiterate. Can these outcomes be improved? What are some key factors contributing to optimal speech language outcomes for this population of children?

Methods: Data from two studies will be presented. First a *qualitative* analysis of clinician interviews along with a *quantitative* examination of published research indicators was conducted in order to identify variables that may impact upon the speech/language progress for children with congenital severe/profound HL. Secondly, a variety of standardized speech/language assessments were utilized in order to conduct a prospective analysis of outcomes for 45 children with early-identified HL at ages 3-, 4- and 5-years. Specifically, we investigated whether adherence to *1-3-6* guidelines could facilitate age appropriate speech/language performances by 3 years-of-age. In particular, if a child with congenital severe/profound HL experienced: Universal Newborn Screening (UNHS) by 1 month-of-age, verification of HL/amplification by 3 months and early intervention within an auditory-verbal (AV) program by 6 months, plus cochlear implantation (CI) prior to 18 months, could typical development be achieved by 3 years-of-age?

Results:

a. Three major *facilitator* variables and three major *barriers* to progress were identified.
b. Strategies were instigated in order to address a number of the identified barriers.
c. Subsequent analysis of prospectively collected data indicated that by age 3 years, 93% of all early-identified participants scored within normal limits (WNL) for speech; 90% were WNL for understanding vocabulary; and 95% were WNL for receptive and expressive language. Progress was maintained and improved so that by age 5 years, 96% were WNL for speech, with 100% WNL for language, including children with profound HL.

Discussion: Unexpectedly, children with early-identified severe/profound HL significantly outperformed both those with mild and moderate HL at 3-, 4- and 5-years of age, specifically with respect to speech. These findings are noteworthy and will be discussed.

Conclusions: Most children with all severities of HL and no other concomitant diagnosed condition, who were diagnosed by 1 month; received amplification by 3 months; enrolled into AV intervention by 6 months and received a CI by 18 months if required, were able to achieve speech and language outcomes commensurate with their typically hearing peers by age 3 years. Individuality of children, families and intervention services will always require strategic management which can significantly improve speech/language performances.

Learning outcome: It is possible for most children with early- identified and early cochlear implanted children with no other concomitant diagnosed condition to achieve age appropriate speech and language by 3 years of age.

S31-11

The effect of noise on speech feature perception in children with cochlear implants. A comparison with children with Specific Language Impairment* (*Research funded by the FP7 Marie Curie project PEOPLE-2012-IAPP-324401 "Hearing Minds")

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Introduction: Both children wearing cochlear implants (CIs) and children with Specific Language Impairment (SLI) often show persistent problems with short, unstressed morphemes (e.g. *is, the, …* or *-s, -ed* as in run*s,* walk*ed*). Recently, in masking noise conditions children with SLI have been shown to have poorer-than-normal consonant identification abilities. This perceptual deficit is most prominent for the phonetic feature 'voicing' as compared to 'place' and 'manner of articulation'. When comparing speech perception performance in different noise conditions, children with SLI have better results in fluctuating than in stationary noise (Ziegler et al 2011).

Aim and hypotheses: The main aim of this study is to assess the transmission of these speech features in deaf children with CIs under different listening conditions and to compare the outcomes with those found in hearing children and in children with SLI. For children with CIs the perception of speech features is expected to differ from the other two child populations in the following ways: (i) overall reduced accuracy of phonemic discrimination and identification; (ii) no improvement in speech perception in fluctuating noise as compared to stationary noise (cfr. Baer, Moore and Kluk 2002, Lorenzi et al 2006 for adult listeners); (iii) contrary to children with SLI, degraded transmission of the feature 'place of articulation'As compared to 'voicing' and 'manner of articulation'.

Methods: To test these hypotheses, speech perception data have been analyzed from 6 children with CIs, 29 children with SLI and a control group of 30 typically developing hearing children by means of a special module within the A§E® psycho-acoustic test battery (Govaerts et al. 2006). All children were between 6 and 12 years old at the moment of testing. Speech stimuli consisted of 10 VCV stimuli (e.g. aba, ada,…) used in discrimination and identification tasks under quiet, stationary noise and temporally fluctuating masking noise listening conditions.

Results and conclusions: In line with our expectations, the overall discrimination and identification accuracy of consonants was found to be significantly lower in children with CIs as compared to hearing children. This holds both for quiet and noise conditions, and no improvement was found for fluctuating as compared to stationary noise contexts. Against expectations, however, the identification accuracy of phonemes for the different phonetic features (voicing, place and manner of articulation) was equally affected in hearing children and in children with CIs. Contrary to children with SLI, children with CIs showed a non-deviant, yet suboptimal, perception of the feature 'voicing'.

Learning outcome: As such, the observed perception deficit may interfere with the development of receptive and productive oral language skills, especially for non-salient speech sounds such as grammatical morphemes when presented in adverse listening conditions.

S31-12

Auditory-cognitive training improves language performance in prelingually deafened cochlear implant recipients

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Objectives: Children with cochlear implants (CI) show deficits in performance on measures of auditory and cognitive skills relative to normal hearing children. Those same skills which are impaired in CI recipient children are those which have been shown to support language learning, suggesting that training to improve functioning on those skills would result in improved language functioning.

Methods: Prelingually deafened CI recipient children who were oral communicators were assessed on measures of expressive and receptive vocabulary and language. Half of the children received training on auditory skills such as rhyme and sound discrimination and cognitive skills such as auditory working memory. Training consisted of a series of short, computer-based, interactive exercises. The other half of the children received no training.

Results: Trained children showed significant improvement in their overall language ability and their expressive language ability following training.

Discussion: Our hypothesis that children who received combined phonological awareness and working memory training would show significant improvements on oral expressive language and a spoken language composite score over untrained children was confirmed. It remains to be seen if children who score more poorly on language measures and/or who have more difficulty understanding spoken language will show as much benefit from auditory-only training or if training will need to be modified to accommodate their particular needs.

Conclusion: Training to improve the auditory and cognitive functioning in CI recipient children may lead to improved language functioning.

Learning outcome: attendees will learn about use of computer based training for CI children and its potential to impact phonological awareness and working memory

S31-13

BabyTalk - A new tele-therapy parent coaching program demonstrates an effective and efficient alternative service delivery model for listening and spoken language

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Introduction: Of the fifty United States, California has the largest population, estimated at 38 million. A large proportion of the population lives outside the major metropolitan areas without access to skilled experts in teaching children with hearing loss to listen and talk. Moreover, state funded programs rarely inform parents about listening and spoken language as a communication modality regardless of degree of hearing loss or technology used to mitigate the hearing loss. Consequently, most families are not offered listening and spoken language as a therapeutic approach for their newly diagnosed child and families in rural areas have almost no access to skilled listening and spoken language service professionals.

Methods: With a generous financial gift, we initiated a new tele-therapy program so that children in remote areas would have an opportunity to develop listening and spoken language. The program, *BabyTalk*, serves children ages 0-3 years who live more than 60 minutes' drive from highly trained professionals with expertise in listening and spoken language (L/SL). *BabyTalk* contains three components: (1) individual consultation from an experienced audiologist and/or social worker to support parents and local professionals; (2) individual, in-home weekly parent-coaching tele-therapy sessions provided by highly skilled therapists using the Apple iPad's "FaceTime" application and (3) ongoing social work support. All technology and services are provided free of charge.

Results: We enrolled families from a larger geographic region than expected. Approximately 75% of the 23 participants have unilateral or bilateral cochlear implants. More than 300 hours of tele-therapy has been provided. Family psychosocial and behavioral challenges are addressed through collaboration among social worker, therapist, family and audiologist.

Discussion: This presentation focuses on the development of a new unique program including successes and challenges encountered during our first 18 months. A case presentation will illustrate how tele-therapy can positively impact families in rural areas. Child (C2) was enrolled during our first year. Though C2 has now aged out of *BabyTalk*, recognizing her progress, her school district is continuing tele-therapy services through a separate financial arrangement and C2 will now enter a mainstream school program. C2's mother stated, "*BabyTalk* is the most important thing that has happened to our family."

Conclusion: Distance, weather issues, gas prices, transportation barriers, minor illnesses and vacations become non-issues for tele-therapy due to the iPad's size and portability. Tele-therapy can successfully provide early intervention for very young hearing-impaired children who would not otherwise have access.

Learning outcome: Audience will describe the successes and challenges of a novel tele-therapy program for listening and spoken language highlighted by a case study.

S31-14

Factors influencing the auditory development in early cochlear implanted children

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Background: Despite of constant development of cochlear implant (CI) technology enormous variability in outcomes have been reported in cochlear implanted adults and children. Although some predictors as age at implantation, co-morbidities, previous experience with hearing aids (HA), communication mode were identified still it is not immediately obvious why some children do extremely well with their CIs while others struggle to achieve only small benefit. Much of the research on CIs has been using audiological outcome measures including a variety of hearing or speech tests which do not take into account the existence of interactions between auditory development of implanted child, it's learning environment and interactions with parents and caregivers.

Aim: The aim of the study is to investigate the influence of factors traditionally regarded as a predictors of the success after CI on the degree and rate of the auditory development in early implanted children with the approach based on parental observations of the child in its everyday environment.

Material and methods: 122 children implanted before the age of two were evaluated with the Polish versions of the LittlEARS questionnaire. The correlations of the LittlEARS total scores across 5 subsequent administrations with factors such as the age at implantation, the age at hearing aids fitting before implantation, the level of residual hearing prior to implantation were calculated.

Results: The correlations between LittlEARS total scores and age at implantation are not significant. The correlations between LittlEARS total scores and previous experience with hearing aids and level of preoperative hearing are significant in the first LittlEARS administrations. Regardless of the level of auditory development before CI, children from the group reached the maximum LE total score around 16 months of CI use.

Conclusions: The preoperative level of residual hearing and the experience with HA influences the degree of the auditory development in children only in the first months after CI. The key factor for auditory development in early implanted children is the experience with CI (duration of CI use). Children with delayed auditory development (lack of preoperative benefit from HA) catch up with their implanted peers with residual hearing within several months of CI use.

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S31-15

Improving outcomes for children anxious about the mapping process: how the use of adapted mapping techniques can establish effective maps in these children and enable improved outcomes as measured by speech perception and/or aided thresholds.

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Intro: Some children with cochlear implants demonstrate significant anxiety about the mapping process. Anxious behaviors can prevent effective map creation. Consequently, these children may not reach their optimal hearing outcome with their cochlear implant(s). Over the 29 years the Melbourne cochlear implant clinic team has been working with implanted children and their parents, we have developed effective techniques to lessen children´s anxiety about the mapping process and speech processor wear. This review details the techniques and their positive outcomes.

Methods: 5 case studies of children who demonstrated significant anxious behaviors about the mapping process were reviewed. They were aged between 2-7 years at the time of cochlear implantation. For 3 of the children the anxious behaviors followed a first implant, for the other 2 children the behaviors developed after they received a second implant.

Results: Anxious behaviors that prevented effective mapping were identified. The age range of the children when they first demonstrated anxiety was 3.5 to 12 years and the time post-implantation varied from 6 months to 5 years. A period of adapted mapping intervention occurred for each child. The duration of intervention ranged from 3-9 months. Modified techniques that were effective usually gave the children more perceived control. Examples of techniques used: ensuring the child always had at least one ear able to hear sounds in the programming room, letting the child choose the stimulus-response game, letting an older child use the computer controls to make map modifications, always giving verbal or signed notice of live stimulation mode turning on or off, letting a child connect the processor to the cable with assistance, putting in progressive maps, practicing stimulus-response games at home and/or during therapy. Parents were counseled about our observations and adaptations. For all five children, following the period of adapted mapping, measures of speech perception (CVC phonemes, Ling Sound detection) and/or aided thresholds improved.

Discussion: The adapted techniques that were found to be effective usually enabled the children to have an increased sense of control during mapping. The more accurate measures of T and C levels for these children likely enabled the improved speech perception and/ or aided thresholds measured in all the 5 children.

Conclusion: Creating optimal maps is a challenge when working with children who display anxiety about the mapping process. By identifying anxious behaviors and using adaptive techniques to lessen anxiety, effective mapping and improved outcomes can be achieved. Consequently, anxiety about the mapping process need not prevent these children reaching their optimal hearing outcome.

Learning outcome: Children can display anxious behaviors during implant programming. Anxiety can be lessened by using adapted mapping techniques so improved hearing and speech perception outcomes can be achieved.

S31-16

Maximizing device choice and fitting in infants - the role of the Infant Monitor of Vocal Production IMP

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Maximizing the potential benefits of newborn hearing screening depends on ensuring that interventions such as early amplification and appropriate device fitting are tailored to the needs of the infant. Access to sound underpins the child's capacity to capture their “auditory diet” in daily activity and in early intervention settings.

Authentic assessment practices are widely recommended in early intervention (Keilty et al., 2009). The design of the Infant Monitor of vocal Production (IMP) (Cantle Moore, 2004, 2006, 2008) uses the process of authentic assessment to generate clinical information and guide parent understanding about the nature and pace of their infant's vocal development following neonatal diagnosis of hearing loss. The IMP is a criterion referenced instrument which evaluates early vocalization competence by systematically monitoring the emergence of audition-led characteristics in the pre-linguistic vocal productions of infants, birth to 12 months of hearing age.

This presentation will provide an overview of the theoretical background for development of the IMP and demonstrate how assessment results can serve as a diagnostic aid in early intervention, and in determining with families their hearing device choice for their young child. Three case studies will illustrate the importance of using the IMP in audiological management decisions regarding implantable technologies .

References:

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S31-17

Speech intelligibility, sentence duration and timing errors in pediatric cochlear implant users

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Cochlear implants (CI) allow children with hearing loss (HL) to achieve speech perception and production outcomes that make their speech understandable to normal hearing (NH) listeners. This capability is characterized by a wide variability of scores. In order to understand the factors that contribute to the overall variability, we investigated the effects of sentence duration and timing errors on speech intelligibility of children with CI. Our sample contained 107 children of 16 years of age, implanted between the ages 2 and 4. This sample was from one of the first cohort of children implanted in the US. Participants' speech intelligibility, duration of sentences and duration of pauses within the sentences were tested using 36 McGarr sentences, which varied in length from 3 to 5 to 7 syllables. Key words defined the sentences as low and high context. Recordings were analyzed using acoustic software to designate the beginning and end of each sentence. Three normal hearing listeners heard, independently, one sentence from one child and wrote down the words they understood. For each stimuli, boundaries of the words and pauses were extracted using Penn Phonetic Forced Aligner implemented based on Hidden Markov Model Toolkit (HTK). Length and amount of pauses were calculated using MatLab algorithms. The analysis showed a significant negative correlation between speech intelligibility scores and duration of each sentence. Our data revealed a positive association between duration of pauses and overall duration of sentences, and a negative correlation between number of timing errors (pauses) and speech intelligibility.

S31-18

Developing a theory of mind with young deaf children - a model of parent intervention

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This study aimed to increase parental knowledge and input of language related to ToM through a short period of intervention. Research has shown that children with cochlear implants regardless of communication mode are delayed in Theory of Mind (ToM) development, Peterson (2004) and that parental input of metal state language correlates positively with this development, Adrian et al. (2005). Theory of mind and emotional understanding predict moral development in early childhood, Lane et al. (2010)

One hour AVT sessions were adapted to include activities that directly promoted key concepts related to ToM development. A questionnaire designed to evaluate parents understanding and inclusion of key concepts related to ToM was administered pre and post intervention. The families in the study included deaf children aged 3 to 5 years all of whom used Cochlear Implants and speaking and listening as their main mode of communication.

Confidence, knowledge and inclusion of activities into home routines were shown to increase for all families. Although not directly targeted, children were shown to develop increased mental state vocabulary. This study shows the importance of working with parents to positively impact upon children's opportunities to develop vocabulary and concepts related to ToM. Further research is needed to look at the impact of ToM and emotional understanding in moral development for young children with cochlear implants.

S31-19

Outcome of congenital CMV sensorineural hearing loss implantations: cerebral anomalies

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Introduction: Congenital CMV infection is responsible of 20 to 30% of all hearing losses. Some of these will require cochlear implantation. The aim of this study is to evaluate the outcome of implanted children with or without cerebral lesions after congenital CMV infection

Method: Retrospective study concerning 333 patients who received a cochlear implant between 1998 and 2013. Twenty six patients were identified as being profoundly deaf after congenital CMV infection: aetiologic diagnosis was confirmed in 16 cases by PCR, 7 had suggestive MRI cerebral images, 3 cases had suggestive medical history in favor of congenital CMV infection. Language level was assessed and the APCEI and K index were calculated for each.

Results: The mean age of implantation was 3.7 year (1.3 year to 16). Eight had a history or prematurity and were symptomatic at birth. All but five had cerebral lesions identified on the MRI: periventricular white matter anomalies, ventricular dilations, polymicrogyria, calcifications. Four presented with neural sequelae as hypotonia and 3 developed psychiatric disorders. Three groups could be identified according to outcome: a positive group (12 patients) for which results were close to normal patients at 4 years; an intermediate group (3 patients) of slow progressing patients; and an unfavorable group (3 patients). The follow up for 8 patients was shorter than 2 years, therefore too short to evaluate the outcome: however, at 1 year post-surgery, 3 had a K index at 5, 4 had a K=2. In the unfavorable group, psychiatric disorders led to explantation or abandon of the implant for 2 patients and the last patient had little benefit from the cochlear implant. No patient with normal MRI had a K ≤3, however, 11/15 patients with abnormal MRI had a K≥4 at 4-year follow-up.

Conclusion: For most CMV congenitally infected children with profound hearing loss, cochlear implantation show similar results to children implanted for other aetiologies. MRI anomalies are frequent and do not seem to help anticipate neurological and psychiatric outcomes.

S31-20

The risk of vestibular impairment after cochlear implant varies as a function of the hearing loss etiology

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Subject: Implantation of a cochlear prosthesis on a functional vestibule leads to a complete loss of vestibular function in 10% of pediatric patients. However it remains to determine if this risk depends on the type of pathological process that was responsible for the profound sensory hearing loss.

Goal: To evaluate the risk of the vestibular loss after cochlear implantation as a function of the hearing loss aetiology.

Experimental design: Retrospective study of 201 profoundly deaf children implanted unilaterally with a cochlear prosthesis. Complete vestibular testing included. Canal tests (caloric test, HIT, earth vertical axis rotation) and otolith function test. (c VEMP).

Results: No complete vestibular loss was found after implantation in connexin-26 deficiency related hearing loss while 43.7% had showed change in vestibular function.

In children with hearing loss induced by Mondini dysplasia and DAV there is a greater risk of vestibular complete loss after implantation (35 %) while vestibular function deteriorated in over 75% after the implant. For the other sensory neural hearing loss 9% had a complete loss of vestibular function and 56% a partial loss in their vestibular function on the side of the implant.

Conclusion: The aetiology of the hearing loss is an important factor to evaluate the risk of complete or partial loss of vestibular function after cochlear implantation. This reinforces the need for vestibular function assessment performed before every cochlear implantation particularly in very young children and in case of inner ear dysplasia. This should be taken in account for deciding the first side to implant (that is, the side with weakest vestibular responses) and giving clear and complete information to the child family in order to avoid the risk of inducing bilateral complete vestibular loss, a handicap that can have severe consequences on psychomotor development.

S32 Surgical and non-surgical complications

S32-3

Reimplantation surgery in pediatric cochlear implant patients: 18 year experience

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Intro: To identify the incidence, etiology, time course, audiologic and surgical outcomes of cochlear reimplantation surgery in our institution.

Methods: Retrospective analysis of prospectively maintained patient database in a tertiary referral pediatric cochlear implant center.

Results: From 1995 through 2013, 733 implants were placed in 511 patients at Boston Children's Hospital. Of the 733 implants, 51 (in 49 patients) were re-implantations. 37 of the 51 explanted devices (5.4% of 682 primary implants) were originally inserted at our institution. The remaining 14 explanted devices were removed from patients who transferred care to our institution prior to or at the time of device failure. The mean age of the patients at the time of the 51 initial implant surgeries that were subsequently explanted was 70 months (range 12-259 months). The mean age at explantation was 113 months (range 22-264 months). 44 patients were reimplanted in the same ear and in the same procedure as the explantation, while the remaining 7 had infections and were re-implanted in the same ear a mean of 6 months after explantation (range 3 to 13 months). 26 of 51 implants were removed due to hard failure, 16 due to soft failure, 2 due to suboptimal position, and 7 due to infection that was treated but not resolved prior to explantation. 14 of the 51 explanted devices were classified as recalled. From a surgical standpoint, all but one patient had a complete electrode insertion on reimplantation, and there were no complications related to the reimplantation surgery itself.

Discussion: Audiological speech recognition data were compared prior to explantation and following reimplantation, for those patients who were developmentally ready for comparable formal measures at both times. For gradual soft failures, speech recognition scores also were compared at 3 points: prior to any decline in performance, just before the explantation, and following re-activation. All re-implanted patients were using their devices. Analysis of speech recognition data was complicated by developmental growth pre- vs. post-reimplantation in young children, different tests given at the two time points, and in some cases more advanced processors used following re-implantation. However, data for all re-implanted patients indicated appropriate development, recovery or improvement in speech recognition ability follow re-implantation.

Conclusion: Overall, audiological benefit was either restored or improved compared to initial implantation data. Device types, intraoperative surgical findings and cause for failure did not present challenges except in one case. Device failure was the most common cause for reimplantation. Educational and emotional supports during periods of reduced auditory access should be managed.

Learning outcome: Reimplantation has a high likelihood of success from both an audiologic and surgical standpoint and should be considered in most cases of device failure.

S32-4

Revision cochlear implantation in older adults

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Intro: Candidacy for cochlear implantation is dependent on unaided residual hearing thresholds, speech perception outcomes with appropriately fit amplification, and health to undergo surgery. Rarely is age considered a contraindication to cochlear implantation candidacy. In fact, many implant recipients are implanted after 65 years of age. Although special consideration regarding the patient's health is considered, these patients find continued success with cochlear implantation over their previous listening condition. This analysis investigated whether the same is true for older adults after revision cochlear implantation.

Methods: The pre and post-revision speech perception of adult cochlear implant recipients was reviewed. Speech perception abilities were assessed with CNC words. Post-revision outcomes between older and younger adults were compared at the 3 and 6-month intervals.

Results: All subjects experienced a restoration in speech perception abilities post-revision implantation. There was no difference in the post-revision speech perception performance between groups.

Discussion: There are similar surgical considerations for older adults at the initial cochlear implantation and in revision cases. When revision surgery is warranted, older adults may experience a similar restoration in speech perception abilities as compared to younger adults.

Conclusion: Advanced age in cases of hard or soft failures should not be considered a contraindication to revision surgery.

Learning outcome: The learner will identify that advanced age should not be considered a contraindication to revision cochlear implantation.

S32-6

Uniform registration of complications and failures in over 1000 cochlear implant patients using a custom database system

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Background: There is a growing demand for quality assessment in medicine and surgical complications are one of the most important outcome indicators. Although major complications are rare in cochlear implantation, there is a need for uniform registration and classification of complications in order to compare results of different surgical approaches, device types and medical centers.

Methods: We created a Microsoft Office Access 2007 database that enables fast and accurate data entry and the use of the most frequently used classification systems for surgical complications. Data from all cochlear implantations between 1987 and 2013 was entered into the database. The majority of the data was entered retrospectively based on the patients' charts and the data from new implantations was entered prospectively.

Results: Since 1987, over 1000 patients underwent cochlear implantation in Nijmegen. In just under 20% of the implantations, one or more medical complications were registered, three-quarters of which were classified as 'minor'. The incidence of hard failure was just over 2%. We found a sharp decrease in device failures over the years, while the incidence of medical complications remained fairly constant.

Discussion: In our series, we found a relatively high number of (minor) complications in cochlear implant surgery that has been stable over the years, while the number of device failures has declined. Unfortunately, results are difficult to compare with other studies, because it is seldom stated what is considered as a complication. This stresses the use of a uniform definition and classification system for complications in cochlear implant surgery, not only to fairly compare results, but also for investigating means for reducing these complications.

S32-7

Explant-reimplant cochlear implants- impedance, NRT and auditory perception outcomes in paediatric patients

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Introduction: Cochlear explant- reimplant surgery occurs mainly for device failure and infection. Our study looks at outcomes with the reimplant in terms of impedance, NRT and auditory performance. Repeat surgery can cause increased intracochlear scar tissue. Impedance is a measure of electrical resistance at the electrode. It depends on the design of the electrode and the surrounding tissues and fluid through which the current exits. Impedance can be used as a way of assessing changes in intracochlear inflammation and fibrosis over time.

Method: The Sydney Cochlear Implant Centre (SCIC) data were searched for cochlear implant children aged 16 and less, with explant and reimplant of the cochlear implant. For mean impedance comparisons, data were grouped patients who had the same array types. NRT and auditory perception was also compared for the initial and reimplanted devices.

Results: The explant-reimplant group receiving Cochlear™ contour array had significantly ($p < 0.001$) raised impedance at switch on, 3 months, 12 months and 3 years, compared with their initial implant. The explant-reimplant group receiving Cochlear™ straight array had marginally significant ($p=0.045$) raised impedance at switch on, 3 months, 12 months, 3 and 5 years. Infection was associated with greater increases in impedance in the reimplant Contour group. NRT was increased in the explant- reimplant group, but not significantly ($p=0.06$). Auditory perception returned to pre-explant levels within 6 months in 61% of children.

Conclusion: Impedance is higher following explant-reimplant and remains increased for years after explant-reimplant with Cochlear™ contour and to a lesser degree the straight array device.

S32-8

Re-implantation, its outcomes

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Objective: To review cases of re-implantation from a large cochlear implant clinic in India, to provide insight into reasons for re-implantation, surgical findings, success rate, and post re-implantation progress, as well as to provide clinical guidelines based on these findings.

Study Design: A retrospective analysis of patients from a single cochlear implant clinic in India. Factors analyzed included time with the implant, reasons for re-implantation, surgical challenges, outcomes and complications, post-implantation progress, and audiological outcomes.

Results: Of the 1050 patients implanted around 35(3.2%) required re-implantation. This revision rate is comparable with the available literature, with the main reason for implantation being device failure (56.3%), followed by trauma (28.1%). Surgical outcomes were good with no complications recorded. All devices were successfully explanted with complete insertion of the new device achieved in all but one patient. Surgical approach used was always the same as the first surgery except a few required a little widening, Cochleostomy (93.5%), Round Window (6.5%). The time between the initial device decline and re-implantation was between one to six months (mean: 3.1month). After re-implantation all patients were able to use the same speech processing strategy parameters, and attained their best initial implant CAP scores between 3 to 12 months (mean:4.5months).

Conclusion: The results imply that there is a high potential of success, both surgically and audiologically, for patients who require re-implantation. This paper will provide recommendations around when to watch and wait versus when to proceed for re-implantation, red flags that clinicians should be aware of, as well as surgical considerations for re-implantation itself.

S32-9

Revision cochlear implantation in children

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Introduction: Cochlear implantation is a well-tolerated and effective procedure in the rehabilitation of profoundly and severely hearing impaired children. The aim of this study is to review the indications of CI re-implantations and to assess the outcome of audiologic performances in revision cochlear implant

Methods: Retrospective study of 503 consecutive children cochlear implant Tertiary referral center**.** All children receiving cochlear implants at our institution between 1990 and 2013;Open set speech perception testing pre- and post-reimplantation; subjective report by child, family, therapist.

Results: Forty-five patients (8.9%) have undergone cochlear re-implantation in our pediatric center during the past 23 years. The mean age at the initial implantation was 5.1 years (range 1.1-14.9 y). The mean time to device failure was 8.9 years (range 0.6 y-18.6 y). The causes of failure were reviewed evaluating the individual history, telemetric, intra operative findings and manufacturer's investigation reports. The causes of revision cochlear implant were hard failure, soft failure (chronic underperformance) as respectively as 40% cases, 33% cases and 6% cases of infections, 9% case caused by traumatic impact 4% due to neurologic diseases and 4% unknown. Auditory performances (open-set PBK and dissyllabic words, phrases in quiet and in noise, speech tracking) assessed after the revision cochlear implant were quite similar or higher than the first implant levels in most revision cochlear implant.

Discussion. However some revision cochlear implants couldn't reach the auditory performance achieved after the initial cochlear implant. Cases (22%) where no reimplantation was achieved (incomplete electrode insertion at revision surgery, associated diseases) were analyzed.

Conclusion: Revision (explantation/reimplantation) cochlear implantation is a safe and effective procedure to restore patients to their pre-operative best auditory function levels in most cases. However, in some cases, results after revision surgery could be very slow and long-term follow up is necessary to achieve good results.

S32-12

Delayed flap necrosis in cochlear implant patients: Why and how to manage?

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Cochlear implant has made a revolution in the field of hearing restoration in profound sensory-neural hearing loss patients. One of the major complications of this surgery is flap necrosis which can end in revision surgery and reimplantation. The incidence of this complication can reach up to 5% in some reports. Good flap design can prevent such problem. In this study we present three cases, with delayed flap necrosis due to different causes, in a series of 1100 patients with cochlear implantation. The study was conducted in Ain Shams University Hospital, a tertiary care center in Egypt. The study discusses the causes of the delayed flap failure, how to avoid and the way we managed it.

S32-13

Management of flap failure after cochlear implantation

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Skin flap failure is a distinguished complication of cochlear implantation. Although new flap designs has lead to drastic decrease in failure rate, infection , skin necrosis and biofilm formation still may cause device explantation. This may result medical and psychological insult to the recipient. Early diagnosis and proper intervention can save time and energy. Simple medical and surgical techniques and clips will be presented which have lead to saving the functional cochlear device and making intact integument. These points will answer to:

- When and what antibiotics should be started?
- What’s surgical intervention plan?
- How to make proper musculo-fascial flap?
- What are the best rotation advancement scalp flaps?
- What’s the final result?

Key words: cochlear implant, complication, flap failure

S32-14

Cochlear implant: A spot light on peri-operative complications

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Cochlear implantation is now a well-established procedure for sever to profoundly deaf children who did not get benefit from hearing aids. In the last few years, much attention has focused on Cochlear implantation at Kingdom of Saudi Arabia depending on the acoustical and psychosocial outcome were reported. A retrospective study design was used. Data were collected from 143 implanted patients over a five years period (out of 450 cases that get implanted since our CI program started at 1993) to review the surgical complications either major or minor and comparing the results of our insitatution with other cochlear implantation centers worldwide. The low rate of complications is discussed along with precautions that taken during the peri operative period.

S32-15

Reasons for explantation and surgical results of re-implantation in 713 consecutive cochlear implantations

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Introduction: Cochlear implantation (CI) has been established worldwide as a safe and effective method for rehabilitation of severe sensorineural hearing loss and deafness. However, complications or device failure may necessitate explantation and in some cases re-implantation. The purpose of this study is to identify causes of CI-explantation and report the surgical outcomes of re-implantation.

Methods: All explantations following 713 consecutive cochlear implantations performed between 1982 and 01/07/2011 at East Danish Cochlear Implant Center were identified in the departments CI database. A retrospective medical record review was performed in order to identify the reasons for explantation and surgical outcomes of re-implantation.

Results: Explantation was performed in 42 cases (5.9%) in 36 patients. The most frequent single causes were device failure (28.6%) and chronic infection (16.7%). Re-implantations were performed in 32 cases, of which full electrode insertion was possible in 24. In four cases, electrode insertion was partial (abnormal anatomy of the cochlea in all cases). In four other cases, the electrode was misplaced after the re-implantation (the cause of explantation was electrode misplacement in all cases).

Conclusions: Device failure and chronic infection are the most frequent single causes of explantation after cochlear implantation. Full electrode insertion in the cochlea is usually achieved in case of re-implantation, although this may fail in abnormal anatomy or in case of misplaced electrode at the primary operation.

S32-16

Misinsertion of cochlear implant electrode array into the vestibule and superior semicircular canal

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The electrode array of a cochlear implant is normally inserted into the scala tympani. The malposition of an electrode array is not a common problem, but it can result in serious complications. Hereby, we report a case of the malposition of a cochlear implant electrode array. A 51-year-old man received cochlear implantation using the round window approach technique. He fainted for several seconds when the device switched on 3 weeks after surgery. An imaging study revealed that the electrode array was curled up within the vestibule and superior semicircular canal. During revision surgery, an electrode array was inserted through the cochleostomy site, and an intraoperative X-ray was obtained immediately after inserting the array to confirm the proper placement of the electrode array. Cochlear implant surgeons should be aware of the possibility of the malposition of electrode arrays and confirm that the array is properly positioned in the scala tympani before completing the surgery.

S32-17

Postoperative complications in cochlear implant users: auiological outcomes and assessment of quality of life

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The aim of present study was to determine the complication rate among cochlear implant users and to investigate audiological outcomes and quality of life after the explantation and reimplantation procedures. The retrospective study of 532 patients was carried out in Tomsk Branch of the FSBE “Research Center of Otorhinolaryngology of the FMBA”, Tomsk, Russia. All patients underwent cochlear implantation between 1 January 2006 and 31 December 2013. Twenty-two cases required reimplantations due to several causes. The patients' data was sorted by age, cause for reimplantation, and duration of implant use, surgical findings, audiological outcomes and results of quality of life. All patients underwent audiological evaluation, device integrity testing and high-resolution CTscans of the temporal bones before the revision surgery. Speech perception performance and quality of life assessment were measured by using several closed and open set tests, as well as questionnaires: 36 Item Short Form Health Survey (SF-36), Cochlear Implant Function Index (CIFI) and Infants-Toddlers Meaningful Auditory Integration Scale (IT-MAIS) according to the patient's age and cognitive and linguistic levels. The study was conducted in 2 stages: before the explantation surgery during the initial period of speech rehabilitation and 3 months after the reimplantation. Current study describes surgical and audiological findings of 532 patients after unilateral cochlear implantation. The study includes 51 (9.6%) adult patients and 481 (90.4%) children younger than 18 years old at the time of implantation. There were 245 males and 287 females in the study. Twenty-two patients (4.1%) were performed explantation due to several complications.

Age/Complication	Infants and young children (< 6 years) (n=11)	Children (6-10 years) (n=7)	Adolescents (11-17 years) (n=3)	Adults (>18 years) (n=1)	Overall (n=22)
Device failure	10	3	3	1	17
Extrusion of implant	-	1	-	-	1
Severe infection	1	3	-	-	4

[Causative factors for 22 explantations]

Post-revision audiological benefit was unchanged or improved compared to the initial implantation values in all reimplanted patients. Only 5 of 22 patients (22.7%) were able to assess quality of life themselves because of age and cognitive level. There were decreases in some domains compared to the initial values according to findings from SF-36: role physical, role emotional functioning and social functioning. For example, descents of role physical and emotional functioning were registered in 3 of 5 cases (60%). As for results of social functioning there was decrease in 80% (4 of 5 cases). The questionnaire CIFI showed decreases in some levels of function in comparison with the initial results: assessment hearing function in social groups and in work environments.
Hence, our study showed that the device failure is the most common cause for the revision surgery among cochlear implant users. It greatly affects patients' quality of life that's why it is crucial to improve device technologies.

S32-18

Endoscopic CI? A call for caution

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Endoscopic technique is gaining ground in otology. The main advantage of this technique is to provide wide view transcanal access to the tympanic cavity and beyond. CI has traditionally been a mastoid based technique that spares the ear canal and the bony annulus. There had been previous experiences with transcanal approaches which had been proven problematic. The middle east have experienced a wave of implantations that were promoted as endoscopic and minimally invasive, but were basically a transcanal approach resulting in significant morbidity, explantations, and revisions. The presentation would summarize our experience in revising those patients. Despite the history of the author as an early advocate of the endoscopic ear surgery, we should not allow the natural tendency to innovate to outweigh our responsibility to our patients to practice safe and time tested surgical approaches. In contrast to chronic ear surgery, CI surgery is a very successful surgery with as it stands. Extreme caution should be exercised when trying out new surgical techniques in this area.

S33 Fitting II

S33-1

Better fittings for children and toddlers

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Currently, the most used technique for fitting cochlear implants involves setting the maximum stimulation levels for each cochlear electrode, ignoring the thresholds. Even more, some clinical engineers are recommending setting thresholds levels to null, to be sure an artificial tinnitus is not induced, as a result that free field audiograms are usually not taken. After gathering experience with more than 300 fitted patients, all MED-EL users, results show that this practice may be greatly ameliorated if correct free field audiograms are used for setting the thresholds. Also, performing many fittings over a short period of time, with high maximum values have adverse effects, “blurring” the understandability of speech, in an irreversible manner.

The presentation shows a better method for fitting, valid for everyone, but focused on children and toddlers, because of the minimal feedback from them. The rationale for the method is also explained with concrete examples.

S33-2

The adaptive categorical loudness scaling with direct electric stimulation in cochlear implant users

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The adaptive categorical loudness scaling is a well-established measurement procedure for the diagnostic of hearing disorders, but also for fitting as well as verification of hearing devices. For normal hearing and hearing impaired listeners narrowband noises as acoustic stimuli are used to estimate the loudness growth function in the auditory dynamic range between the perceptions “inaudible” and “too loud” with an adaptive categorical loudness scaling procedure (Brand and Hohmann, 2002).

For this study, the procedure was adapted to direct electric stimulation at individual electrodes in cochlear implant (CI) - users. The aims of this study were (i) to evaluate the accurateness as well as reproducibility of the scaling procedure as a potential tool for fitting; (ii) to get insight to the loudness perception across the electrode array in CI users with clinical relevant stimulation parameters.

The loudness growth function was measured by presenting pulse trains via direct electrical stimulation with defined current amplitudes to individual electrodes using a research platform; the CI user was asked to rate the loudness with a categorical loudness scale between “inaudible” and “too loud”. In the first phase, the lower (“inaudible”) and upper (“too loud”) limit of the dynamic range was estimated, using ascending and descending current amplitudes delivered in an interleaved manner. In the second phase, the loudness growth function was estimated by presenting stimuli in pseudo-random current amplitudes values, which covered the whole estimated electric dynamic range. Reproducibility was checked by measuring the loudness growth function between the estimated lower and upper electric dynamic range limits in a second appointment, which was about 4 weeks later.

The loudness growth functions from both appointments of 15 CI users showed test-retest-reliability within one loudness category. The iso-loudness contours, i.e., the current amplitudes required for the same loudness across the electrode array, correlated with the contour of clinical M-Levels. However, training as well as adaptation effects occurred especially for the measurement of the upper electric dynamic range. These adaptation effects might be explained with the limit of stimulation in the upper electrical dynamic range in the CI system, which is given by the fitted M-Levels at a comfortable loud level and continuous adjustment of the mapping by the automatic gain control to keep stimulation at a comfortable level.

Brand T, Hohmann V (2002) An adaptive procedure for categorical loudness scaling. J. Acoust. Soc. Am. 112(4): 1597-1604.

S33-3

Programming bilateral vs. unilateral cochlear implants in children: Should loudness summation be considered?

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An increasing number of children are currently implanted with bilateral cochlear implants simultaneously. When providing bilateral acoustic amplification, binaural loudness summation is taken into account and implemented in prescriptive fitting rationales such as NAL-NL1/2. In bilateral CI programming, however, there are no specific prescriptive rationales. Programming methods based on objective measures as the electrically evoked compound action potentials (ECAPs) have been developed to assist in programming of infants and young children and are routinely used. These programming methods, however, have been developed in unilateral CI recipients and their utilization in the programming of bilateral CI users is not straightforward. The purpose of the present study was, therefore, to retrospectively evaluate ECAPs thresholds in relation to behavioral programming levels in children with bilateral CI vs. those with unilateral CI. For this purpose we studied two groups of children that were matched for age at implantation (10-36 months) and duration of implant use (at least 6 months). Group 1 included 30 children with bilateral CI implanted simultaneously, and group 2 included 30 children with unilateral CI, with only some using hearing aids in the contralateral ear. Children used MedEl and Cochlear devices. The relations between ECAP thresholds and behavioral Comfortable levels (C) for Cochlear users, and Most comfortable levels (M) for MedEl users, were compared between the groups at basal, medial and apical electrodes. Preliminary results indicate a different tendency between the two groups: In the unilateral group C/M levels were higher than ECAP thresholds, similar to our previous findings in adults CI recipients. In the bilateral group, the C/M levels were at the same level of the ECAP thresholds. These results may reflect loudness summation and thus support the notion of a need for binaural loudness summation correction for children with bilateral CI implanted simultaneously.

S33-4

Reduction of a risk of overstimulation in children after cochlear implantation

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Background/Purpose: The objective of cochlear implant fitting is to optimize the electric stimulation parameters, then to achieve the best speech perception. When stimulation levels are set too high, sound quality can be distorted lowering hearing benefits. The aim of the study was to assess via objective methods and questionnaires if children undergoing routine fitting could be affected by overstimulation.

Method: The study group consisted of 26 children - cochlear implantees - patients of the Institute of Physiology and Pathology of Hearing. All patients were tested after nine months after first fitting during scheduled follow-up visit. All of them had acoustically elicited stapedius muscle reflex threshold measurement performed. Questionnaires on loudness perception were distributed among children's parents to assess subjective program loudness in everyday use .

Results: Results from surveys indicate that there is no direct correlation between acoustically evoked stapedius muscle reflex threshold and questionnaire responses, but almost 70% of children with “very loud” answers in questionnaire showed acoustically evoked stapedius muscle reflex threshold equal or lower than 70dB HL.

Conclusion: By application of the appropriated tests battery it is possible to identify children suspected of overstimulation. Additionally it seems that parents sometimes are too conservative while describing children hearing sensations.

S33-5

Programming young children with the MED-EL system without objective measurements

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Most cochlear implant systems have integrated eCAP capability to assist with programming of young children, or difficult cases where feedback is hard to obtain. However, virtually all of today's stimulation strategies use monopolar electrode coupling, meaning a wide spread of current that smooth profiles across channels. This presentation describes our success in programming the MED-EL system without reliance on objective measures.

Following review of their surgical reports/ post operative CT s (if available) a group of 10 children were fitted with programs having equally set most comfortable (M) levels. The threshold (T) levels were set to 10% as per recommendation from MED-EL. With the microphone active, all M-levels were increased until consistent responses to sound were obtained. Loud sounds were used to ensure there was no loudness discomfort. Over 8 weeks the profile was adjusted on the basis of detection and discrimination of acoustic patterns (Ling detection and aided testing) as well as determining ´blinking´ levels for each ear individually.

Continuous assessment showed that these children progressed in line with children who had their programs based on objective measures. A comparison of levels showed that the study group's M-levels did not differ significantly from levels in objective measures based programs.

This work shows that while objective measures can be useful, they are not essential for programming even very young children. Careful observation by experienced paediatric audiologists can lead to perfectly satisfactory programs supporting typical development of language and listening skills.

S33-6

Protocol for investigation of Nucleus Fitting Software and Remote Assistant Fitting in postoperative care over implanted patients

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Introduction: The most common model for fitting cochlear implant recipient assumes repetitive fitting sessions in implantation clinic done by experienced multidisciplinary team. Development of new set of tools by Cochlear company: Nucleus Fitting Software and Remote Assistant Fitting - allows to test another approach to this topic - streamlined fittings performed by less experienced specialists in policlinics close to patient home, with electrical stimulation parameters modified in some degree by patients themselves with the use of Remote Assistant Fitting. However, to introduce this model into clinical practice, extensive testing of outcomes and their comparison with standard procedure has to be performed

Aim: The aim of this presentation is to show for discussion methodology of mentioned testing and comparison. The protocol is going to be used in a study investigating effectiveness and quality of fittings in the new model.

Method: The protocol assumes a study group of 20 adult cochlear implant patients to be divided in two subgroups. In the first one the patients are going to be fitted by less experienced specialists using Nucleus Fitting Software and by themselves using Remote Assistant Fitting. In the second subgroup the patients are going to be fitted by expert from World Hearing Center and by themselves with the use of the same tools. Control group consist of patient fitted according to “golden standard” developed and introduced in World Hearing Center. Data collected and compared between groups include map parameters, subjective assessment of the fitting process and audiological outcomes.

Results and conclusions: The first experiences with the new tools are very promising. The protocol showed in this presentation and presented for discussion should be able to closely investigate any possible differences in mean hearing benefits obtained by different groups of patients. The data can shows both interesting similarities and differences in obtained parameters, including the effect of patient's manipulation of the parameters.

S33-7

How clinicians use data logging

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Introduction: Data logging is a new functionality available in Nucleus 6 sound processors. It shows to the clinician the duration of processor is used on a daily basis, identifies which programs the user prefers and demonstrates levels of exposure to speech and noise, permitting the programs to be tailored more specifically to user needs.

Methods: The data logging feature in Custom Sound 4.0 was used by clinicians at 20 clinics in Europe for routine clinical fitting of CP900 sound processors. A survey was conducted to evaluate the ease of interpreting the data logging information and the usefulness of each data logging feature. Detailed feedback was obtained on how the data logs were used by the clinicians for clinical management.

Results: Most clinicians reported data logging to be a very useful tool for the clinical management of CI recipients. Details of how each data logging feature was used by clinicians will be presented.

Conclusions: Data logging is a very useful tool for the clinical management of CI recipients.

S33-8

Auditory-linguistic results in cochlear implanted adults with frequency programming

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Purpose: Compare results in speech perception by different tests in silence and noise between the standard programming and the frequency programming method of cochlear implants.

Materials and methods: We present an observational, cross-sectional and descriptive study, in 10 subjects older than 18 years of age, unilaterally and bilaterally implanted. Disyllabic and sentence tests in silence were administered to all subjects. Speech recognition in noise was tested with the “Hearing in Noise Test” (HINT).

Results: We have 6 unilaterally and 4 bilaterally implanted patients.

The disyllabic test shows than patients with standard programming scored, in average, 76,75%, 69,66% and 83,50% of answers correctly (right ear, left ear, and bilateral) and patients with frequency programming scored 85,25%, 82% and 92,5% respectively.

In the sentence test without support, patients with standard programming scored, in average, 78,75%, 73,66% and 85% of answers correctly (right ear, left ear, and bilateral) and patients with frequency programming scored 87,5%, 83,33% and 96% respectively. The average SRT (**Sentences** Reception Threshold) value was 19,28 in patients with conventional programming and 9,8 in patients with frequency programming. There were statistically significant differences in the averages of correct answers in the tests ($p < 0.05$).

Conclusions: Using the Frequency Programming Method (a software developed by the ENT Department of the Insular University Hospital Complex of Las Palmas de Gran Canaria, Spain) makes progress towards developing, validating and implementing a frequency allocation strategy in those cochlear implant channels where the fundamental note frequencies are found, and modifying the channels whose frequencies represent the different harmonics of each fundamental.

S33-9

A post-hoc characterization of cochlear implant fitting practices

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In this work, we perform an initial characterization of cochlear implant fitting practices on a very large sample (thousands of implants from around the world). Using a set of de-identified Custom Sound databases, we look at the popularity of mapping parameters in users of Cochlear Ltd´s Freedom and CI500 series implants. Then, we characterize distributions of C-Levels, T-Levels, dynamic range and TNRT thresholds in a subset of the sample using otherwise default mapping parameters. Lastly, we explore the progression of these parameters over the first 12 months of use of a CI. It is intended that these characterizations act as a reference point for the research community, who are typically restricted to performing studies with much smaller sample sizes. It is important to note that this work does not make any assessment or judgment on what settings should be used. In demonstrating what is being used, we hope to provide a quantitative basis for discussion of the merits of various fitting practices.

S33-10

A bimodal fitting model : Vibrant Soundbridge and cochlear implant

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Asymmetric hearing loss is increasingly focusing on the fitting of various forms of hearing rehabilitation . One possibility is the bimodal fitting. Bimodal fitting is usually comprised of a cochlear implant and a contralateral hearing aid. The benefit of this form of care was been extensively described.

As the number of Vibrant Soundbridge supply , the question of compatibility and the benefit of a bimodal supply with CI and VSB .

The supply by means of a Vibrant Soundbridge system and a contralateral CI has not been described.

Question: The aim of the study performed was to compare the hearing with a cochlear implant and with a bimodal fitting of a VSB and a CI .

Method: In the tests carried out the evaluation of the 6 patients that have been implanted with a CI and contralateral supplied with a VSB.

- Audiological examination performed were BC and AC , functional gain , monosyllabic words , OLSA in quiet.
- OLSA S0/N0 , OLSA S0/N90 unaided as well as in each of the modes , CI, VSB and bimodal
- A subjective evaluation was performed by SSQ questionnaire.

Results: There was a mean advantage of the bimodal fitting against the fitting of CI alone of 20 % in the monosyllable words and 3dB in OLSA in noise. A clear advantage was also found in the SSQ questionnaires.

Summary: The bimodal supply by VSB and CI is a good variant of the fitting of specific forms of asymmetric hearing loss with advantages in both the audiological examination and the subjective evaluation. The data should be present.

S34 Snapshot presentations on health economics and panel discussion

S34-1

Cochlear implantation in South Africa: The triumph and the tragedy

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Cochlear implantation has been performed in South Africa since 1986. These services were expanded to a second academic centre within two years and there are currently eight independent cochlear implant (CI) programs throughout the country. The South African Cochlear Implant Group (SACIG) is the professional oversight body responsible for maintaining standards of training and service among the programs and provides a forum for national academic discourse.

South Africa has a foot in the first world as well as in the third world. While CI programs have the expertise to perform surgery and rehabilitation of the highest standard, the ability of the South African population to access such services is severely impaired by a dire shortage of hearing screening services, diagnostic audiology services and financial resources to fund the cost of cochlear implants. Educational opportunities are also in desperate need for hearing impaired individuals.

This talk aims to summarize our achievements and explore the challenges we face to an international audience.

S34-2

The direct costs of cochlear implantation in South Africa

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Introduction: This study assesses the direct medical costs of cochlear implantation in a person with deafness undergoing a unilateral cochlear implant in South Africa (SA). The prevalence of acquired permanent bilateral deafness is approximately 180 000 infants across sub-Saharan Africa every year. The incidence of deafness, a figure derived from a number of retrospective studies in SA (population about 50 million; birth rate 12-18/1000 per year), is estimated to be about 17 born per day and 6.205 per annual birth cohort in 2012. The direct costs included are pre-operative visits, hospital expenses, post-operative visits, rehabilitation programs, and maintenance over a one-year period.

Methods: Quality control of data was assessed according to The International Classification of Diseases (ICD-10D, H90.3) codes, and the guideline tariffs of medical schemes to calculate health care provider costs. Costs were examined on a representative national level. Data was collected from four patients' quotations, estimated hospital costs for 1.5 days and theatre costs calculated on three hours of surgery, from four private hospitals in Gauteng, Free State, and Western Cape Province. Blood test costs were obtained from two pathology practices and audiology and speech tariffs from the South African Association for Audiologists. Maintenance costs such as insurance were obtained from three insurance companies. The average costs of a standard hearing aid, FM systems, and batteries were obtained from three private audiology practices and cochlear device agents. These data were used to determine the average cost of a person's CI procedure in one year during 2013 in SA.

Discussion: This paper discusses the cost of cochlear implants only in SA, although the social and economic factors are similar in many developing countries, where a low-cost, high performance cochlear implant system is needed. The mean cost was R375 142.69 (US$36 625.56) per person of the first year after implantation.

Conclusion: The average implant-related and one year follow-up costs were R373 106.23 (US$36 625.56) per person. The primary cost is the implant device. This study takes into account the main factors influencing costs, namely rehabilitation, and maintenance. This approach permits a robust economic analysis reflecting the reality of patient management.

Learning outcome: The costs of a cochlear implantation (CIT) and aftercare require a detailed knowledge, not only for patients but also for the reform of the healthcare system in SA. These results can serve as a baseline as well as a framework for further cost-utility studies. Comparisons of the cost of CIT should be compared with other operations to define a “better quality of life” for all SA citizens.

S34-3

Cost-utility analysis of bilateral cochlear implantation in adults: Choosing the most appropriate health utility instrument

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Intro: Unilateral cochlear implantation(CI) is a medical marvel with well-established cost-effectiveness. However, the same cannot be inferred for bilateral CI, as its provision of care reflects a highly uncertain cost-effectiveness.

Method: Cost-utility analysis- 90 patients and 52 health professionals were recruited as proxies to estimate the benefit of bilateral CI using 4 utility instruments: Health Utility Index-3 (HUI3), Time Trade-Off(TTO), Visual Analog Scale(VAS), and the European Quality-of-Life(EQ5D). Subjects were asked to use these instruments to evaluate 3 clinical scenarios of hearing impairment to establish the gain in utility: 1) Deafness without intervention, 2) Unilateral CI, and 3) Sequential bilateral CI. Cost valuation reflected the burden on a publicly funded healthcare system. The base case included 25 years of service provision, processor upgrades, 50% price reduction for second side, and 15% failure rate. Sensitivity analyses were applied.

Result: Costs were $63,632 (unilateral CI), $111,764 (bilateral CI), and $48,132 (incremental cost of second CI). The most conservative utility measures were obtained by HUI3, while most aggressive was the TTO technique. In the former, the utility gained from no intervention to unilateral CI, and to bilateral CI were 0.270 and 0.305; incremental gain by the second implant was 11.5% of total. Using the TTO, the second implant was valued at a 40% of total. Using the HUI3 as the base case, the Incremental cost-utility ratio(ICUR) was $14,658/QALY for bilateral CI compared to no intervention. It was stable regardless of discounting or sensitivity analyses. ICUR was $ 55,020/QALY from unilateral to bilateral CI with higher uncertainties. It improved with differential discounting, further price reduction of the second implant, and reduced frequency of processor upgrades. ICUR worsened with reduced length of use, and higher failure rates.

Discussion: HUI3 is the instrument least likely to overvalue the benefit of bilateral CI; its hearing and speech attributes are relevant to the subject matter while providing a holistic health related quality of life measure. The HUI3 in the base case showed borderline ICUR in its valuation of UCI versus BCI, but this value failed to take into account the sustained benefit, and the external gains that occur with cochlear implantation. Thus, the application of differential discounting of cost relative to utility resulted in a much more favorable ICUR, to well within the willingness-to-pay(WTP) threshold. Cost-effectiveness also improved through base case variations to reflect different perspectives and cost saving measures.

Conclusion: Sequential bilateral CI is cost-effective in adults when compared to no intervention although gains are made mostly by the first implant. Bilateral CI can be cost-effective compared to unilateral CI when differential discounting or variations from the base case were applied.

S34-4

Obamacare in the US: What does it mean for cochlear implant access?

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In early 2010, Congress passed and President Obama signed the US healthcare reform legislation called *The Patient Protection and Affordable Care Act* (ACA for short), which is often referred to as “Obamacare.” The new legislation offers coverage opportunities for Americans who previously may not have had access to health insurance and it also mandates that insurers provide coverage for pre-existing conditions in children (such as deafness) and disallows lifetime expenditure caps on Essential Health Benefits or services that are covered under typical plans.

Implementation of the new law has been challenging. There continues to be considerable public controversy surrounding its adoption because of difficulties in rolling out a fully functioning website for sign-up; differences in public perspectives regarding the role of government in ensuring health care coverage for citizens; cost of the program; and new operating requirements for private insurers, hospitals, and Federal and state governments.

The American Cochlear Implant Alliance, a non-profit organization whose mission is to expand access to cochlear implantation, has not taken a position for or against Obamacare. Rather the organization seeks to proactively address and expand cochlear implant coverage in the new health care plans being offered to US citizens. To that end, ACI Alliance established its State Champion program to support individuals in each state to address cochlear implant coverage by working directly with state officials, clinicians, and consumers. State Champions, who are primarily cochlear implant clinicians, receive ongoing training and support so that they can serve as effective advocates for cochlear implant coverage.

The paper will share findings on the impact of the new law on access to cochlear implant care as well as the effectiveness of utilizing clinician advocates to impact on the implementation of a major new health care initiative.

S34-5

Factors affecting cochlear implant access in the United States

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Cochlear implant utilization in the United States is about 6 percent of adults and children who are candidates for the intervention. Pediatric use in children is considerably higher than that of adults but is still below that in many other European countries including Germany, the United Kingdom, and Belgium.

The study considers the concept of Standard of Care in a medical setting. For example, do diagnosis and typical treatment options for deafness include routine consideration of cochlear implantation? How familiar is the medical community and the general population with the intervention? How prevalent is the intervention among appropriate individuals? The answer to these questions leads one to conclude that cochlear implants are not considered the Standard of Care for deafness in the US.

This study identifies and explores seven factors that contribute to low utilization and which affect the finding that cochlear implants are not a medical Standard of Care. Clinic and hospital financial issues, including reimbursement rates for elements of the cochlear implant procedure, are a key access factor though other elements of the referral environment were also determined to be very important and to impact on access. Although the initial thinking is often that the US "insurance model" explains the low use rate, in fact this factor does not fully explain the access challenges.

Seven factors impacting access were determined to be:

1. Low general awareness among the general population and health care professionals including those who work in hearing loss such as hearing aid audiologists and specialists;
2. Hearing loss referral networks including primary care physicians and those involved in hearing impairment do not routinely screen for possible cochlear implant candidacy;
3. Political issues associated with deafness and continued opposition to cochlear implants from the Deaf community which has contributed to the lack of comprehensive, unbiased information provided to parents of children with severe to profound hearing loss during early intervention;
4. Clinic and hospital financial issues that relate to insurance coverage as well as reimbursement for the surgical procedure and aftercare, particularly by public payers like state Medicaid programs;
5. Need for widely accepted “best clinical practices” in the absence of our having standard clinical practice guidelines typical of those used for other medical conditions, guidelines which could improve the referral process by primary care physicians as well as non-CI clinicians in hearing health, such as hearing aid audiologists;
6. Need for recent studies of the cost effectiveness and societal benefits associated with cochlear implantation are needed to update the extensive work that was done ten or more years ago; and
7. Need for a dedicated organization focused on cochlear implantation to focus on the above six issues in a comprehensive and ongoing manner.

S34-6

Economic evaluation of cochlear implantation in children using Australian costs and consequences

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Objectives: Interest continues in the health technology assessment of bilateral cochlear implantation compared with unilateral cochlear implantation. The cost-effectiveness of bilateral versus unilateral cochlear implants in children and adults has not been explored in the Australian context. The objective is to undertake an economic evaluation of cochlear implantation and apply this evidence using Australian costs and consequences.

Methods: A comprehensive literature search was undertaken in Embase and Cochrane databases, in June 2012 and repeated in August 2013. These were supplemented by manual and bibliographic searches. Epidemiologic, burden of disease, clinical, health related quality of life, systematic reviews, and economic evidence were reviewed. Abstracts were reviewed against set inclusion criteria. Included papers were then retrieved for full text review against the same set of criteria. Tangible Australian costs were identified from services covered by the Australian Medicare Benefits Schedule (MBS). Consequences data were obtained from Cochlear Limited for explants and re-implants.

Perspective: The Australian health care system with discounted costs and utilities of 5%. Potential educational cost-savings were analyzed as part of the sensitivity analyses.

Results: The costs of cochlear implants included on the Australian Commonwealth Department of Health Prostheses List are $13,570 for the implant, $11,500 for the initial sound processor, and $8050 for a replacement (upgrade) sound processor. The cochlear implant process can be divided into four distinct phases; pre-surgical assessment, surgery, acute post-operative healing and switch-on, and hearing habilitation services. A Markov model was used to generate costs per QALY. These will be reported.

Conclusion: Despite the success of cochlear implantation as clinically effective standards of care for the treatment of moderate to profound hearing loss there are few peer reviewed papers that adequately report the incremental analysis of bilateral cochlear implants compared with unilateral cochlear implants from a health care perspective. Indeed, there is a need for more sensitive, disease specific instruments for measuring utility. As a result health technology assessment of cochlear implants is constrained in its ability to adequately inform on the comparative effectiveness of bilateral cochlear implantation.

S34-7

Adults with cochlear implantation demonstrate significant rise in average annual personal income

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Intro: Cochlear implantation is now the standard of care in patients with severe sensorineural hearing loss. The benefits are well known and widely published. However, cochlear implantation is an expensive intervention and in this era of increasing fiscal restraint in our health care system, more research into the personal and societal economic benefits of cochlear implantation is required. Previously published work has estimated the cost of an unilateral cochlear implant to be approximately $68,000 over the implant lifespan of 25 years.

Methods: Retrospective review of prospectively collected adult cochlear implant demographics and outcomes database. Employment data and personal annual income levels were obtained both directly via a self-administered questionnaire and indirectly via average geographical income levels per profession provided by a Revenue Canada database.

Results: 632 patients had adequate employment and personal income data for analysis. 65 patients completed the self-administered questionnaire. 36.7% of patients suffered a negative personal financial impact on onset of their deafness such as early retirement, loss of employment or demotion. 60% of patients at the time of initial cochlear implantation were unemployed. After cochlear implantation, the unemployed rate was reduced to 49%. Furthermore 25% of our patients reported improved employment status after cochlear implantation such as promotion, new job or salary increase. From our indirect data, patients on average had an annual income increase of $12,000 per annum post cochlear implantation. From our direct data, patients on average had an annual income increase of $10,000 per annum post cochlear implantation. This is likely an underestimation of its true economic effects as indirect costs such as disability and unemployment benefits which were no longer required in many cases were not factored in.

Discussion: Cochlear implantation is a costly intervention but our results demonstrate that on average our implanted patients report an annual income increase of between $10,000-$12,000. This substantial increase in personal annual income allows a substantial portion of the direct costs of cochlear implantation to be recoverable via increased future individual tax revenue.

Conclusion: Cochlear implantation in adults is a cost effective intervention with clear personal economic benefits. In some patients cochlear implantation may potentially be cost-positive over the expected lifespan of their implant.

Learning outcome: Discuss the economic costs of cochlear implants and personal economic benefits.

S34-8

Establishment of a government funded cochlear implant program in Kerala - guidelines for efficient functioning

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The main disadvantage of a cochlear implant program in developing countries is the prohibitive cost entailed in the process of getting a cochlear implant. Because the main focus in developing countries is the paediatric cochlear implant program, there is a lot of emotion attached to it as well. The dynamics of the need to bring hearing to the deaf and the cost involved in a large scale, expensive program has to be balanced so that it is considered truly cost effective. The only answer to this solution is to have a robust Government funded program that will not only reach out to the needy but also provide a cost efficient solution to the exchequer.

The state of Kerala in India is a small state with a population of about 33,387,677and has one of the highest literacy rates, the lowest infant mortality rate and the lowest population growth in India. The Government of Kerala has formulated and designed a cochlear implant program with the help of professionals in the industry to be as close to ideal as possible. Funding for the program is generated from the state lottery and donations to the social security mission which is a government organization under a separate ministry. The evaluation process for the centres that are chosen for executing the implant program is based on facilities, professional experience and the willingness to perform to the strict criteria made by the government. The program is also designed to follow up patents, evaluate outcomes and ensure that the ideals are met.

We evaluated 350 cases done in 18 months in Kerala and did an analysis of the patient profile, the economic status, age of diagnosis, age of implantation, cause of deafness and the outcomes and complications in eight centers across the state. We have come to the conclusion that a robust, well founded government cochlear implant program is the need of the hour in a country like India. Only this can convince the economists about the cost effectiveness and the value of the program to people even if the numbers are statistically small.

S34-9

Improving cost-effectiveness of pediatric cochlear implantation before one year

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Objective: This study provides evidence, based on speech perception, language skill and rehabilitation sessions, CI is a cost-effective health care intervention in profoundly hearing-impaired young children.

Study Design: A prospective study based on ninety -five children *implanted in* Iran. The influence of outcomes and other variables on total costs was examined using multivariate regression analysis.

Results: We showed that speech perceptions and language skills improved significantly in children implanted before one year better than children implanted in older age (p=0.00). Also, average rehabilitation sessions after 5 years follow-up in children implanted before one year is significantly less than other group (p=0.000)

Conclusion: Early identification of hearing loss, CI and language intervention by one years of age are cost-effective for language acquisition that can approach the levels of normal-hearing children. CI was a cost-effective intervention for the majority of subjects, including the group given implants when younger than one year of age.

S34-11

10 years of cochlear implantation in India: Trends and outcomes

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Objectives: The growth of cochlear implantation in India has been prodigious, particularly in the last 5 years. In 2010, there were approximately 1000 implant surgeries in the country, with many clinics conducting approximately 100 surgeries per year. This is even more remarkable given that this is a fully private market, with patients paying for all of the costs. Cochlear implantation commenced around 1996**,** and there are currently over 10000 recipients, with 90-95% of these being children. However, despite the large numbers of recipients, there is little published information about the trends and outcomes for these patients over this time.

Study Design: This is a retrospective analysis of the data for all the patients who received rehabilitation at Asha Speech & Hearing Clinic in Delhi, India that commenced implantation in 2001. We currently have over 400 patients.

Results: The presentation will show the trends in implantation over the 10-year period for factors such as the age of implantation, the number of surgeries, the age hearing loss was diagnosed, the number of cases seen each year, and staff numbers including audiologist & speech pathologist, rehabilitationist, etc. . Further, outcomes for the patients over this time frame will be reported, along with any trends. The results show the tremendous growth in the number of surgeries and children seen per year, particularly in the last 5 years, with over 85% of the patients having been implanted since 2006. Of the 400 patients, 15 were post-lingually deafened adults. The results show that the age of implantation has decreased over this time, with a consistent improvement in outcomes. One other important consideration is that staff numbers have not increased substantially over this time (p value < 0.001).

Conclusions: Despite the tremendous growth of implantation in India in the last 5 years, patient outcomes have not been affected, and are as good as those in many developed countries. As this growth is expected to continue, monitoring outcomes and trends is critical, and has large implications for clinics, surgeons, audiologists, therapists, the Government, and health insurance

S34-12

The DoD Hearing Center of Excellence - creating a hearing health improvement network

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In the Military, the ability to hear and communicate is critical to the safety of each warrior and their unit, and is central to effective command and control, and mission accomplishment. In spite of current hearing conservation efforts, hearing loss and auditory injuries in the military continue to rise as the most predominant wounds of war. Although the Services teach the importance of hearing protection, provide the means for hearing protection, and monitor risk through conservation programs, the need for hearing during battle often overrides the expediency of hearing protective devices. Military members equate hearing protection with increased vulnerability, widening the gap between preventive efforts and hearing preservation. The scope and magnitude of the effect of war and Military Service on the auditory system validates congressional legislation that called for the establishment of the Department of Defense Hearing Center of Excellence (HCE) to address the scope of these injuries, and warrants a vigilant, focused effort to combat them. This presentation will present the HCE mission, concept, organizational establishment and outreach as a virtual hearing health improvement network. The HCE will provide leadership, support, and communication towards building transparency and value into an interactive, collaborative system of readiness, care and research.

S34-13

Transferrability of Lean tools and methodologies to CI programs functioning in non-lean medical centers

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Cochlear implant programs worldwide continue to feel pressure to deliver high-quality care to more patients in an environment of limited resources. A model line project was completed in 2008 using principles of lean at the Listen for Life Program in Seattle. The gains were achieved in the setting of a hospital fully invested in Lean as a management structure. The issue of transferability of the advances in improved patient access an in fiscal performance was studied first at the Swedish Neuroscience Institute in Seattle where a new CI program was started in January, 2011. This presentation will outline the challenges to lean implementation and the positive outcomes in this new center and will then present identical data from a pilot study looking at the implementation of Lean principles at two programs (New York Eye and Ear Infirmary and at the University of Cincinnati), both in hospital systems which have not used Lean methodology in the past.

S35 Vestibular function and CI

S35-3

Retrospective longitudinal assessment of balance control in adult cochlear implantation

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Objective: To assess balance control in adult cochlear implant (CI) users before and after surgery.

Methode: A retrospective cohort study of patients implanted with a cochlear implant in a tertiary care center between 2003 and 2013 was performed. Records of 358 deafened adults (mean age: 51.69 ± 16.8 years) with unilateral or bilateral cochlear implants were analyzed. Vestibular function in each subject was assessed by recording Vestibular Ocular Response (VOR) (videonystagmography with bithermal caloric and rotatory chair test) and by computerized dynamic posturography. Medical (e.g. deafness etiology, experience with CI, uni or bilateral implantation), and demographic (e.g. gender, age at implantation) data were also recorded and analyzed.

Result: Statistical analyses showed dissociated outcomes, with a deterioration of VOR in rotatory chair tests on the one hand, and some improvement in caloric response as well as in balance control on the other hand.

Conclusions: These results suggest that improvement in low-frequency vestibular reflectivity after cochlear implantation (as assessed though caloric testing) may be related either to a reinforced vestibular compensation phenomenon or electrical cochlear stimulation. Furthermore, whenever deterioration of VOR was observed (i.e. for mid-frequency stimulation) no substantial changes in the balance control as assessed by CDP was noted. A possible role of the restored binaural auditory cue may be hypothesized.

S35-4

Electrooculography assessment of vestibular function in patients before and after cochlear implantation

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By using computerized electrooculography (CEOG) to investigate the baseline state of the vestibular system before cochlear implantation (CI) and the influence of unilateral CI on vestibular function.

39 consecutive patients (25 women and 14 men) received unilateral CI and were examined preoperatively and postoperatively (in 1 week and 1 month after CI) by means of CEOG. Patients were aged 11-65 years (mean 36.6 years).

Vestibular function was assessed using computerized registration and automatic analysis of oculogyric reactions. Voluntary saccades, pursuit eye movements, and spontaneous and optokinetic nystagmus were recorded and analyzed.

Preoperatively, 15/39 patients suffered from bilateral vestibulopathy and 6/39 were diagnosed with signs of central vestibular dysfunction (at the brainstem level) without any complaints of vertigo. The salient electrooculographic signs were abnormalities of horizontal optokinetic nystagmus in the form of tonicity, absence of rhythmicity, violations of nystagmus shape and nontrivial asymmetry, pursuit gaze impairments (due to the overlapping of bilateral regular involuntary saccades of different amplitude), and central spontaneous nystagmus.

Symptoms of vestibular dysfunction were revealed 1 week after CI in 6/39 patients. According to CEOG assessment, however, the number of the patients with postoperative unsteadiness decreased to 3/39 at 1 month after CI. 2/39 patients experienced vestibular discomfort with spontaneous nystagmus after the implant activation during program switch. 8/39 patients underwent vertigolytic therapy (glucocorticosteroids, betahistines, benzodiazepines, non-loop diuretics) after CI with positive effect; in so doing, possible balance disorders in the early postoperative period were diminished and postoperative audiological performance did not deteriorate.

Absence of saccades impairments, smoothness of horizontal pursuit gaze, and symmetry of optokinetic nystagmus ruled out both the pathology of reticular formation of brainstem and functional disorders of cortical and subcortical brain structures (in 84% deaf patients before cochlear implantation). Horizontal spontaneous nystagmus was recorded in 7% of the patients who had not reported vestibular problems. The presence of spontaneous nystagmus increases the likelihood that they do have abnormal vestibular function. Electrooculographic evidence of vestibular dysfunction was rarely elicited after cochlear implantation: 16% of patients in the early postoperative period, 8% in the later postoperative period, and 5% in the course of implant activation.

S35-5

Vestibular function in cochlear implant recipients

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Introduction: Cochlear implantation (CI) is currently the method-of choice for the rehabilitation of patients with severe to profound hearing loss. The vestibular system could be disturbed during CI surgery because of the intraoperative loss of perilymph, endolymphatic hydrops, or electrical stimulation of the electrodes. The vestibular evoked myogenic potential (VEMP) response is a useful tool which is sensitive to the saccular function. Additionally, computerized dynamic posturography (CDP) is a reliable objective method of differentiating sensory, motor, and central adaptive functional impairments of balance. The aim of the current investigation was to examine the influence of CI on vestibular function through VEMP and CDP assessment.

Materials and methods: In a cross-sectional design, 20 unilaterally CI patients and 20 age and sex matched healthy volunteers participated in this study. All subjects were evaluated for vestibular function by using the VEMP and CDP. The latencies and amplitudes of the p13-and n23 waves and the inter-aural amplitude difference (IAD) ratio between the two ears were recorded. Sensory organization test (SOT) protocol of CDP was used to analyze the balance function in CI recipients**.** Parameters measured were equilibrium scores in the six SOT conditions, composite score, and sensory analysis ratios (somatosensory, visual, vestibular and visual preference). Statistical analysis was done by SPSS v.18 software.

Results: SOT analysis revealed that 40% of CI subjects (8/20) had some kind of sensory abnormalities: 5 cases (25%) vestibular, 2 cases (10%) visual, 1 cases (5%) vestibular and somatosensory involvements. Furthermore, we found a higher composite score in the control group than in the CI group ($p < 0.001$). All subjects showed VEMP responses bilaterally. The comparison of mean p13-n23 amplitude values between CI and control groups revealed statistically significant difference ($p=0.001$). Furthermore, IAD ratio was greater in the CI group than in the control group. However, the comparison of the mean P13 and N23 latencies values between CI and control subjects revealed no significant difference ($p>0.05$). There was a statistically significant correlation between CDP and VEMP results ($p=0.001$).

Conclusion: The present study has shown vestibular abnormalities in CI patients as revealed by the CDP and VEMP findings. Findings of the present study will add to the scanty literature to increase the accuracy of the data relating to the need of vestibular testing in this population.

Key words: Cochlear implantation, Computerized dynamic posturography, vestibular evoked myogenic potential

S35-6

Vestibular effects of cochlear implant and its surgical approach. Review

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Background: Although usually transient and mild, cochlear implantation (CI) can produce transitory vestibular symptoms even in patients with intact labyrinthine function. Its incidence varies between 0.33% and 75%. Preservation of not only residual hearing, but also the peripheral labyrinth organ, is currently an increasingly important target in CI. The advancement of minimally invasive cochlear insertion techniques has reduced residual hearing damage considerably. However, the impact of CI on vestibular function and its severity according to the insertion technique applied is still relatively unexplored.

Objective:

1. Clarify and summarize the existing scientific evidence for vestibular disorders after CI,
2. characterize vestibular exploration after a CI and
3. study the existence of differences in vestibular function after CI depending on the insertion technique applied.

Evidence review: Literature review based on published evidence-base data using Medline Database with the Key words cochlear implant, dizziness, vertigo, unsteadiness, instability and vestibular function. The selection criteria included: title consistent with the purpose of this review, participants necessarily being adults with severe to profound prelingual or postlingual hearing loss using CI and data regarding participants' performance on vestibular test including dizziness handicap inventory, caloric tests, cervical and ocular vestibular evoked myogenic potentials (cVEMP, oVEMP) and video head impulse test (vHIT).

Findings: Temporal bone studies show insertion of an electrode into the vestibular scale implies a damage to the spiral lamina, the basilar membrane and the vestibular receptors, being the saccule the most frequently injured organ, followed by the utricle and the semicircular canals. Several studies attempt to quantify the changes induced on the vestibular function after CI but there is some incongruence between them: Parmar *et al* were able to objectify these changes by performing caloric tests, showing that they are usually mild and short duration. Conversely, Jutila *et al* and Migliaccio *et al* found that CI rarely affects the vestibule ocular reflex (VOR). The use of minimally invasive techniques seems not only contribute to residual hearing preservation, but also reduces vestibular disorders after implantation when insertion is made in scala tympani. Todt *et al* found significant differences in vestibular evoked myogenic potentials (VEMP) and caloric tests according to insertion technique, with better outcomes in round window approaches. Tsukada *et al* report similar results, adding the importance of a smaller diameter and more flexible insertion.

Conclusion: Currently, there are a limited number of high quality studies of vestibular function after CI. However, existing studies suggest a lower vestibular impairment in round window insertion. Further randomized and controlled trials with larger patient samples and standardized inclusion criteria are needed.

S35-7

Vestibular dysfunction related to cochlear implantation

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Objective: To assess risk factors for vestibular dysfunction in deaf patients and changes in vestibular complaints before and after cochlear implantation (CI).

Study design: The patients were examined 3 times: preoperatively, 1 week postoperatively, and 4 weeks postoperatively.

Patients: 48 patients were included in the study. All patients 1) underwent CI at the St. Petersburg ENT and Speech Research Institute in 2013, 2) were aged 7-57 years, 3) had profound bilateral chronic sensorineural hearing loss, and 4) had complaints of postural unsteadiness, oscillopsia, or had previously suffered from these senses of disequilibrium and vertigo. 38 patients were implanted via round window; 10 were implanted via cochleostomy.

Results: Bilateral vestibulopathy after meningitis (10/48), craniocerebral trauma (10/48), and drug-induced ototoxicity (9/48) resulted in preoperative vestibular dysfunction in equal proportions. Acute meningitis and serious brain trauma provoked severe vertigo (3 cases) and, consequently, prolonged postural imbalance. Oscillopsia was initiated from combined (meningitis or trauma with aminoglycoside ototoxicity) causes of deafness (11/48 and 8/48, respectively) rather than isolated etiologies. Patients with skull base fractures had the most refractory vestibular disorders. Patients with unsteadiness in walking or, especially, oscillopsia, immediately prior to CI (14/48), continued to experience these variants of imbalance postoperatively. Acerbation of chronic bilateral vestibulopathy occurred postoperatively in only 2/14 cases. In the 34/48 patients who experienced vestibular disturbances only at the onset of bilateral deafness and not in the few months before surgery, only 2/34 experienced a slight unsteadiness in darkness 1 week after CI. After 1 week, 4/38 patients who were implanted via round window and 7/10 patients implanted via cochleostomy complained of dizziness. Patients implanted via cochleostomy were estimated to have experienced more severe postoperative dizziness than did patients implanted via round window. After 4 weeks, both implant groups experienced an equally slight deterioration of vestibular function.

Conclusions: The salient features of vestibular dysfunction in the majority (90%) of deaf patients were oscillopsia and unsteadiness in walking, rather than vertigo.

The probability of vestibular disorders continuing postoperatively increased in the presence of the following factors: 1) combination of ototoxicity either with meningitis, or with trauma, and 2) the existence of vestibular complaints just before cochlear implantation. Vestibular dysfunction after cochlear implantation was less frequent in patients implanted via round window (10%) than those implanted via cochleostomy (70%).

S35-8

Posturographic measurements in cochlear implant patients with vertigo

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Cochlear implant patients frequently suffer from post-operative short term vertigo. In some of these patients the vertigo persists over several months and affects the daily life significantly. An estimation of the patient's postural control is crucial for the evaluation of the vertigo related handicap and for the determination of individual rehabilitation needs.

Old fashioned ankle-sway-referenced posturographic systems (platforms) are helpful to screen patients for balance deficits, but the low diagnostic specificity is well known (approximately 55%). Current posturographic systems allow the estimation of the patient's mobility in daily life tasks (Mobile Posturography) for a variety of vestibular disorders with a very high sensitivity (approximately 85%). The present study investigated the application and the sensitivity of the Mobile Posturography in cochlear implantees with chronic post-operative vertigo. Fourteen cochlear implant patients performed the Mobile Posturography with the Vertiguard-D system. With the small device fixed by a belt at the hip (close to the centre-of-body-mass), the subjects had to undergo the standard-balance-deficit-test (SBDT). This test consists of 14 daily-life tasks. Each task was performed for 20 s. During the measurement the angular velocity in the roll and pitch planes were sampled and analyzed by the software using the median of all data-points. The median of body sway in roll and pitch direction was compared for each task with age and gender related values in the database of the system. Furthermore, a composite score was calculated for the evaluation of the overall performance during the SBDT.

The most frequent pathological results could be found in those tasks which are known as difficult to perform for otolith disorders. The sensitivity of the Mobile Posturography, based on the SBDT-composite score, was 92.9 %.

Due to the very high sensitivity of the Mobile Posturography with the Vertiguard-D-system the method seems to be well suited for the detection and objective evaluation of the postural control in cochlear implant patients with post-operative vertigo.

S35-9

Management of benign paroxysmal positional vertigo in patients after cochlear implantation surgery

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Aim: Benign paroxysmal positional vertigo is one of the most popular cause of otorynolaryngological vertigo.

The aim of the study was to analyze the problem of BPPV in patients after cochlear implantation surgery.

Material and methods: A group of patients with vertigo after cochlear implant surgery was evaluated. The BPPV diagnosis was established after clinical examination. Videonystagmograthy was performed later one to eliminate vestibular injury. Repositional manoeuvres such as Epley, Semont manoeuvres and Brandt-Daroff exercises were performed. Control group with BPPV in patients without history of otological surgery was added to the study.

Results: Different repositional manoeuvres were performed in both groups. The efficiency of treatment was assess during follow up.

Conclusion: BPPV should be considered in first place in patients with vertigo both after the cochlear implant procedure or not. The role of repositional manoeuvres is crucial in management of benign paroxysmal positional vertigo in both groups.

S35-10

The Skull vibration-induced nystagmus test in cochlear implanted adults

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Objectives: Skull vibration-induced nystagmus test (SVINT) can be considered as a vestibular Weber (tuning fork) test. Residual vestibular function after cochlear implantation is difficult to evaluate. The aim of this work is to determine the presence or lateralization of the vibration-induced nystagmus (VIN) in the cochlear-implanted patient and to correlate the results with the patient's vestibular symptoms.

Material and methods: Prospective, monocenter study of 40 adult patients with profound hearing loss, without morphological labyrinthine abnormality, undergoing unilateral cochlear implantation in 37 patients and bilateral, sequential cochlear implantation in the remaining 3 patients. Inclusion criteria were absence of subjective vertigo/dizziness and absence of VIN preoperatively. All insertions were performed through the round window membrane. Mean age was 62 years (34-88) and sex ratio 1. The implants used were a long, straight electrode array (MED-EL) in 20 cases (among which 2 bilaterally implanted patients) and a precurved, perimodiolar electrode array (Cochlear) in 20 (among which 1 bilaterally implanted patient). There were 18 cases of right side implantation, 19 cases of left side, and 3 cases of bilateral implantation. Criteria of positivity of the SVINT were a nystagmus (VIN) beating towards the same direction upon stimulation of both mastoids and the vertex, and a slow-phase velocity > 2°/sec. A subjective evaluation test which is the Dizziness Handicap Inventory (DHI) was used as well. Statistical analysis was done through Fisher's exact test to compare variables. Mann-Whitney's test was used to compare the DHI score in the VIN + group and the VIN - group.

Results: With the exception of 2 patients, all patients were operated on in one-day surgery setting. None of the 3 patients undergoing bilateral cochlear implantation showed a VIN. For unilaterally implanted patients, 2 out of 37 (5.4%) showed a VIN which was horizontal and beating towards the operated side. The DHI score was moderate in all cases (0-30). No correlation could be found between, on the one hand, the occurrence of postoperative vertigo/dizziness, patient's age, sex, side of implantation, type of implant, and on the other hand, the presence or absence of postoperative VIN.

Conclusion: Functional vertiginous complaints are rare and transitory after cochlear implantation. The SVINT is a rapid clinical evaluation test aiming at revealing an eventual vestibular asymmetry. However, as other vestibular tests, its positivity or negativity is not correlated with postoperative vertigo/dizziness.

S36 Robotic surgery: Structured Session and Panel Discussion

S36-5

Controlled minimal invasive multichannel access to the petrous apex or the cochlea

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Objective: Due to the patients wish for a less traumatic, minimal invasive cochleostomy or opening of the internal auditory canal without any mastoidectomy, we generate a surgical multiport approach at the temporal bone. In contrast to other studies here we developed for the first time a multichannel approach to the surgical target at the temporal bone.

Study Design: Feasibility study performed by cadaveric temporal bones.

Subjects and Methods: Drilling of three channels were performed on different cadaveric temporal bone specimens. The drilling procedure was realized by a special developed frame, srew fixed at the bony head, with a high precision mechatronic positioner. The drilling procedure was controlled by a new developed CT imaging technique: to reduce the radiaton dose the presurgical diagnostic scan will be improved by superresolution algorithmen technique. The deviation of the drilled paths from the desired path was radiologically and metrolgocially analyzed.

Results: In all procedures the target was reached without damaging critical structures like facial nerve, brain or ossicles. The precision of the drill procedure was comparable to the predictive value.

Conclusion: The multiport approach would be a possible alternative to different targets at the temporal bone without any mastoidectomy. Furthermore we consider, that the evaluation should be based on metrological data.

S36-6

Navigation-guided transmodiolar approach for auditory nerve implantation via middle ear in human

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Objectives: Auditory nerve implantation appears as an interesting alternative to cochlear implantation since it reduces the electrical consumption and enhances tonotopy in the cochlear nucleus. This implantation raises technical issues since modiolus could not be accessed in its whole length in a reproducible manner, and to our knowledge, this approach has never been reported in clinical studies. The aim of this study was to investigate the feasibility of a navigation-guided approach to modiolus through middle ear cavities in human.

Materials and methods: Six adult human temporal bone specimens (3 left and 3 right) were included in this study. In each specimen, 4 titanium screws were placed in the mastoid cortex and served as fiducial markers. A high-resolution CT-scan was then performed. Images were loaded on the neuronavigation system (Digipointeur, Collin, Bagneux, France). The system was coupled to a piezoelectric drill equipped with an angled insert (Mectron, Bois-D'Amon, France). After a radical mastoidectomy and removal of malleus and incus, the drill (1 mm diameter) entered cochlear apex and progressed in the modiolar axis. Its position was monitored in real-time by neuronavigation. A stainless steel wire (0.6 mm diameter) used as a sham electrode array was introduced in the modiolar axis. All specimens underwent a CT-scan after the procedure. In the second part of the study, 122 temporal bone CT scans from patients were analyzed for anatomical parameters relevant to this approach.

Results: The transmodiolar approach was feasible in all temporal bones. However, the angle of the insert did not allow an optimal trajectory in all cases and consequently, the entry point was slightly deviated backward from the modiolar axis in 2 temporal bones. The array was completely implanted down to the inner end of the modiolus in 4 temporal bones with an average intracochlear length of 3.6 ± 1.11 mm and partially in the 2 remaining specimens. The mean vector distance of the target accuracy at the entry point ($\sqrt{(X^2+Y^2+Z^2)}$) was 0.065 ± 0.0583 mm. The study of anatomical parameters relevant to transmodiolar approach on CT-scans showed a significant inter individual variability. The modiolar length or orientation did not seem to be influenced by age, but the distances between the cochlear apex and the posterior aspect of the carotid wall or the temporomandibular joint were shorter in children than in adults.

Conclusions: A transmodiolar approach through middle ear cavities for an auditory nerve implantation is feasible in human under neuronavigation. Anatomical parameters relevant to this approach in children show a modiolar length and orientation similar to adults but shorter distances to neighboring anatomical barriers.

S36-7

Implantation of the completely ossified cochlea: an image-guided approach

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Objectives: To report a novel modification of the cochlear drill-out procedure that uses customized microstereotactic frames as drill guides.

Interventions: Image-guided cochlear implantation using customized microstereotactic frames to drill linear basal and apical cochlear tunnels.

Main outcome measures: Transfacial recess cochlear drill-out procedure with full electrode insertion.

Results: Two linear paths were drilled using customized microstereotactic frames targeting the proximal and distal basal turn followed by a full split array insertion. Postoperative imaging confirmed 2 cochlear tunnels straddling the modiolus with adequate clearance of the facial nerve and internal carotid artery. The patient received auditory benefit with device use and did not experience any surgical complication.

Conclusion: Successful cochlear implantation in the setting of total scalar obliteration poses a significant challenge. Image guidance technology may assist in navigating the ossified cochlea facilitating safe and precise cochlear tunnel drilling.

S36-8

Preliminary clinical evaluation of surgical planning for cochlear implantation surgeries

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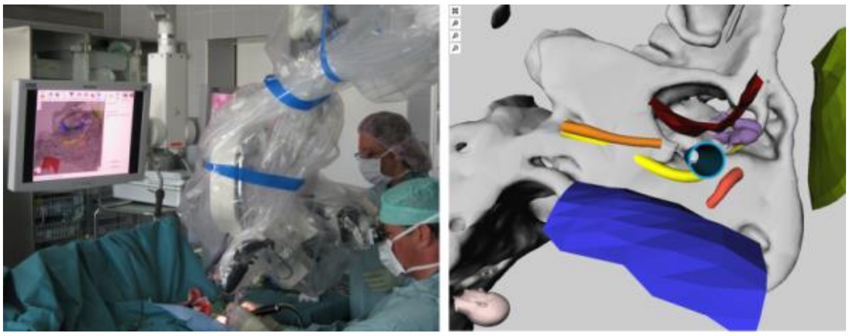
Introduction: The identification of underlying critical anatomy, such as the facial nerve, during cochlear implantation surgery, is challenging for the surgeon. The current display of 2D preoperative image slices for intraoperative guidance remains insufficient, due to the complexity of the required 3D anatomical understanding [Rodt et al. 2002]. Previous research suggests that in case of malformation, the intraoperative display of 3D anatomical models could reduce cognitive load during cochlear implantation (CI) procedures [Hara et al. 2012], however, validation on normal anatomy was not performed. This study aims to investigate the efficacy of displaying 3D patient-specific anatomical models, relative to the intraoperative milling progression, for the support of CI procedures in clinical routine.

Methods: Our previously described planning software tool for robotic CI [Gerber et al. 2013] was adapted to generate mastoid layers for intraoperative visualization. The efficacy of the tool was validated within a prospective single arm clinical pilot study in eight CI procedures performed by three surgeons. A preoperative plan, including sensitive anatomical structures of the ear, created from CT images, was displayed to the surgeon intraoperatively. Mastoid layers were progressively removed in order to adapt the plan as milling progressed. Surgeons rated the usefulness of the display postoperatively on a five point scale questionnaire.

Results: Seven cases were successfully completed. The eighth was aborted prior to posterior tympanotomy due to chronic inflammation within the tympanic cavity and the mastoid.



[Figure 1]

Surgeons indicated that the plan predominantly aided in 3D understanding of the anatomy (54 %) and in locating the facial nerve (62%). In the first three cases, the plan was reported to only “slightly” improve confidence during surgery while in the five later cases, surgeons reported that the plan improved their confidence on average “very much”.

Discussion: Results of this pilot study suggest that intraoperative display of 3D patient-specific models may improve surgical confidence and 3D anatomical understanding during CI procedures and that observed benefit may increase with use.

Conclusions: When employed frequently, computer assisted planning and intraoperative plan visualization may aid in the conduction of CI procedures in case of malformation and in routine cases. Future clinical trials will aim to statistically validate the observed trends.

S36-9

Laser-cochleostomy controlled by optical coherence tomography (OCT) - An experimental approach at a native cochlea of a pig

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Intro: The computer-assisted laser surgery at the cochlea requires a high accuracy of the navigation of an ablating system and a high precision control of the osseus ablation process for less than 100µm.

Methods: In our workgroup we used OCT as a sensory system for online imaging of the ablation area and developed a closed-loop control of the contactless osseus ablation with a carbon dioxide laser (CO_2-laser). Both systems are integrated using a coaxial setup, where the optical paths of both lasers are aligned with each other and a registration between both working spaces was performed. After the correction of image distortions and enhancement of the image quality the cochlear lining membrane (endosteum) beneath the bone surface is automatically segmented. The ablation is planned online according to the resulting thickness distribution of the residual osseus tissue. A tracking mechanism of the osseus surface with OCT was developed so that the relative movement between the patient and the laser system can be compensated and the planned ablation pattern can be precisely executed by the CO_2-laser. The whole workflow was evaluated at a native cochlea of a pig.

Results: The performance of the laser ablation enables a constant and defined residual osseus layer until the cavity of the perilymph is opened. The thickness of residual osseus layer can be arbitrarily chosen by the surgeon and is actually defined as 100µm to avoid an impairment of the inner structures of the cochlea. A precise approximation of the geometric shape of the scala tympani at the bottom of the ablated cochleostomy is for the first time achieved with the high accuracy of approximately 30µm.

Discussion: As the described system shows the possibility of an most atraumatic opening of the cochlea some more treatment options of even other ear diseases may become available in the future by this approach.

Conclusion: The whole workflow from the OCT-scan to the laser-chochleostomy is experimentally successfully realized. The accuracy can be further improved by optimization of the ablation strategy and a complete removal of the overlying osseus layer above the endost is expected. The integration of OCT with a CO_2-laser could be seen as a first step to gain a mechatronic assisted and standardized atraumatic contactless cochleostomy. A transfer from an experimental to a real operation room setting has to be made.

Learning outcome: To inform about future technical options for an atraumatic contactless cochleostomy.

S38 Quality of life

S38-1

Clinical experiences with implementation of a voluntary registry of real-life patient-related benefits following treatment with implantable solutions at the Hannover Clinic

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Aim: To consistently and longitudinally assess the self-perceived benefits following treatment with hearing implant(s) for our ever growing adult population, in a standard, efficient manner that, is both clinically feasible and sufficiently valid to support medical-based evidence of the effectiveness of patient management.

Method: Voluntary enrolment of prospectively implanted adult patients treated routinely at our clinic in a patient outcomes registry commenced in October 2011. Each subject acts as their own control and is assessed, immediately after implant prior to first switch-on of their sound processor and repeatedly at annual intervals up to 3 years postimplant. Via the use of a web-based electronic registry platform, Cochlear-Implanted Observational Study (Cochlear-IROS), validated self-evaluation tools in the patient's native language: the Health Utility Mark III scale, (HUI Mk III), a quality of life questionnaire and the Speech Spatial Qualities scale, (SSQ), a hearing-disease specific questionnaire, are available for completion to reflect the impact of hearing treatment upon the individual's daily function over time. In addition, audiometric hearing threshold configurations and customized patient profiles are completed to describe individual patient characteristics in detail including aspects related to: hearing history, previous hearing aid experience and employment status.

Results: To date 53 adult implantees have been enrolled in the registry with over 55% having completed their one year postimplant follow-up, and 5% at their 2 year follow-up to date. With a mean age of 52 years at implant, patients ranged from 13 to 82 years at implant. Patients have been implanted with a range of cochlear implants and acoustic implant devices. Almost 100% of patients at baseline and those at their 1year follow-up have completed the patient questionnaires, SSQ and HUI Mark III. The paper will discuss both the practicalities of implementing a web-face voluntary patient registry and describe the data derived.

Conclusion: Patients report improvements over time for both, quality of life in general and for hearing ability. A patient registry of patient outcomes can provide the option to consistently collect and collate patient-related benefits as reported through self-assessments to validly represent the effectiveness of implant treatment in a relatively efficient manner within the routine clinical situation. Nonetheless, the implementation of such a registry requires nonetheless resources in the clinic to be successfully implemented.

S38-2

Preimplantational evaluation: Prognosis estimation by data mining system

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Introduction: Prediction of speech recognition and quality of life (QoL) outcome after a cochlear implantation (CI) is still one of the most important challenges for otologysts.

Data mining (DM) is an interdisciplinary subfield of computer science. DM uses artificial intelligence techniques, neural networks, and advanced statistical tools to reveal trends, patterns and relationships which might otherwise have remained undetected. There are identifiable preimplantational factors such as profound hypoacusis duration, age at the moment of cochlear implantation and sociodemographic or educational factors that condicion CI outcome. So an objective initial analysis of multiple known variables could allow us to predict CI benefits. Our objective is to design a DM system to predict and classify in each patient the CI predictable benefits in terms of speech recognition and QoL.

Material and methods: Observational study of 29 adults, randomly selected, CI users during at least one year. Audiological benefits and its relation to QoL are analyzed using two specific questionnaires: the Glasgow Benefit Inventory (GBI) and the Hearing Aids Specific Questionnaire (HASQ). Data is recorded in SPSS Statistics 19.0, and MatLab, and then processed in Weka system. By Nearest Neighbor, Decision Tree algorithms and logistic regression, classifiers and estimators are designed so, based on preimplantational attributes, they indicate postimplantational predictable outcome.

Results: *Clasifiers.* By Nearest Neighbor, selecting the best algorithms (IB1), the interesting attributes to classify speech recognition in words are category (unilateral CI vs bimodal), voice identification in noisye embironment and being able to use the phone usebefore CI (HASQ), (with a success percentage of 80,7%). Decision tree J48 showed that influencing variables for GBI are the marital status, living situation, age at the moment of the hearing impairment and the previous use of hearing aids, with a success of 81%. For HASQ, J48 selected as the influencing variables are education level, voice recognition at phone and HASQ index before CI, with a success percentage of 85%. *Estimators,* disclose a precision of 85%, 68.43% and 71,16% for words perception, GBI and HASQ respectively.

Discussion: DM has been used in market analysis to identify new product bundles, , prevent customer attrition and acquire new ones, cross-sell to existing customers and even identify the features of their most successful employees. In medical field, DM has contributed in decision making and problem solving like detecting drugs´ quantitative adverse effects or predicting stroke's risk. In otoneurology, DM has predicted hearing impairment in children, profile Meniere´s disease patients or foretell its evolution.

Conclusion: Our study propose new system to classify and estimate speech perception outome and QoL improvement based on our first clinical evaluation in order to decision making and patient’s information.

S38-3

Cochlear implantation among older adults: does advanced age impact speech understanding and quality of life?

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Intro: The aim of this study was to examine the impact of age on speech understanding and quality of life in a group of adults with cochlear implants. To date, studies disagree as to whether older adults perform equally well as younger adults on speech understanding. It is possible that age related differences exist on some measures, and not others, depending on the complexity of the task. Subjects were evaluated preoperatively as well as 12 months after initial activation using a variety of tasks. Outcome measures included hearing sensitivity, CNC word recognition and AzBio sentence recognition in noise, and Quality of Life.

Results: Forty subjects were implanted with a mean age of 56.2 years (range 22 to 92 years). Results demonstrate significant gains in performance for speech understanding for CNC words ($p < .001$), AzBio sentences, ($P < .05$) and quality of life ($p < .001$) Age related differences were found for CNC words and AzBio sentences, but not quality of life.

Discussion: Results confirm that older adults derive significant benefit from cochlear implantation. Further, age related patterns of speech understanding seen among hearing adults also exist for adults with cochlear implants.

Conclusion: Age should not be a contraindication to implantation, though older adults require specific counseling on expectations. Also, intervention for this group requires special attention to illimuinate opportunities for maximizing performance.

S38-4

20 years of cochlear implantation in the Slovak Republic: Long term results, what we have learned

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The first CI was realised in June 1994, since that 350 patients were implanted some of them bilaterally. In this paper different groups according to the period of implantation throughout 20 years, different etiopathogenesis of deafness, inclusion of implantees in the real life are discussed

Material: Only patients operated before 2010 are included into the series. Questionnair evaluating QoL, audiological results, education, work classification is distributed and evaluated. Patients with syndromic deafness and inner ear malformation were not included into the study, they will be subject of different evaluation.

Results: The results are being processed and will be presented during the congress

Conclusion: From the preliminary results we can see different approach in different time period throughout those years, not all the children were suitable for main stream education, majority of our patients could complete their education and become workers paying their tax.

S38-5

Self-rated quality of life after unilateral cochlear implantation and its correlation with audiological findings

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Introduction: Despite wide variation in post-CI speech recognition methods, all published studies agree to show an improvement in hearing performances. Numerous studies using assessment of quality of life (QoL) through self-rated questionnaires showed also an improvement thanks to CI, even though QoL is still not routinely evaluated after CI, because questionnaires are time-consuming. Tinnitus and phone use are two additional important factors, not routinely assessed, that also may impact QoL. This study aimed to evaluate the impact of cochlear implantation (CI) on quality of life (QoL) with general and CI-specific questionnaires, and to determine its relationship with speech recognition performances, phoning abilities and tinnitus.

Methods: Twenty-six volunteer adults had monaural CI for post-lingually profound deafness and used implant for at least one year. The Glasgow benefit inventory (GBI) and Nijmegen cochlear implant questionnaire (NCIQ) assessed QoL. Speech recognition was tested with phonemic Lafon´s lists and Subjective tinnitus severity scale questionnaire was used. Patients were split into four groups according to their phone ability.

Results: Both QoL questionnaires detected an improvement following CI but moderately correlated between them ($r=0.47$). A significant relationship between phone ability, QoL and speech recognition was found. Improving phone ability led to higher QoL ($p< 0.05$) and speech recognition ($p< 0.01$) scores. Post-CI occurrence of tinnitus significantly decreased, but its severity was not correlated with QoL.

Discussion: QoL questionnaires and speech recognition assessment both provide information of great interest in evaluating patient's rehabilitation in daily life, but the one cannot replace the other. Specific and general HRQoL questionnaires are both moderately correlated to speech recognition but when related to phone ability, the NCIQ seems to be more fine-tuned than the GBI to assess the QoL of CI patients. Tinnitus severity does not impact on the use of phone and on QoL of post-CI patients, probably through a reprioritization of symptoms due to hearing rehabilitation, the benefit in hearing performances lessening the impact of any tinnitus on QoL. The questioning about phoning ability might provide a valuable approach to assess hearing abilities and QoL after CI, QoL and speech recognition performances being all the more high than abilities to phone in post-CI patients reached normal-hearing subjects one's.

Conclusion: Post-CI assessment should be realized through speech recognition and QoL evaluation. NCIQ appeared more efficient than GBI to detect an improvement in QoL when related to phone ability. The assessment of post CI patient´s phoning ability represents an easy and fast approach to evaluate hearing performances and QoL and consequently reflect the global outcomes of the cochlear implantation.

Learning outcome: It could be a very helpful tool for clinicians in their daily clinical practice.

S38-6

CI in patients with single sided deafness- positive effects on various areas of life

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Intro: Recent studies have demonstrated a significant improvement of speech perception in patients with single sided deafness (SSD) following CI. On the other hand, we know that bilaterally deaf patients benefit from implantation by improvement in the health-related quality of life (HRQoL) and reduction of tinnitus and stress. Here, to determine changes in further parameters following cochlear implantation, we have assessed the HRQoL, tinnitus, perceived stress and psychological comorbidities in patients with SSD.

Methods: Twenty one adult patients, who were unilaterally implanted with a CI for at least 6 months prior to this study, were included. We have evaluated the HRQoL, tinnitus impairment, perceived stress and depressive and anxiety symptoms using 5 validated questionnaires: the Nijmegen Cochlear Implant Questionnaire (NCIQ), the Tinnitus Questionnaire by Göbel and Hiller, the Perceived Stress Questionnaire and finally the General Depressions Scale and the General Anxiety Disorder- 7 questionnaire. In addition, speech perception for the implanted ear and in the binaural condition in quiet and noise was tested using the Freiburg monosyllable test and OLSA-test. The Oldenburg Inventory (OI) was used to quantitatively evaluate the subjective hearing after CI.

Results: CI in SSD patients resulted in a statistically significant improvement of HRQoL, as measured by the NCIQ and its 6 subscales. The subjective assessment of auditory abilities measured by the OI also revealed significant improvements for hearing in noise and localization. There was a significant decrease of tinnitus-related distress in patients with higher severity of tinnitus (TQ>30). In addition, psychometric tests revealed a significant reduction of anxiety and decrease in the number of patients with depressive symptoms. The stress level was before and after CI in the normal range.

Discussion: CI in SSD- this is a developing area. However, through electrical stimulation via a cochlear implant the deaf side can be activated and a true binaural hearing is possible. In addition patients benefit from CI by improvement in HRQoL and reduction of tinnitus and psychological comorbidities.

Conclusion: The present study provides evidence that cochlear implantation constitutes a very successful procedure of auditory rehabilitation for SSD patients. In addition, an additional advantage of implantation in SSD patients was manifested by increased quality of life and reduced tinnitus and psychological comorbidities.

Learning outcome: Cochlear implantation represents a very successful procedure of auditory rehabilitation, also for SSD-patients. In addition, SSD patients benefit from CI with increased quality of life, a reduction in tinnitus and psychological comorbidities.

S38-7

Confrontation of quality of life to hearing performances in cochlear implantees

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Objectives: The quality of life (QoL) after cochlear implantation is one of the most significant outcome parameters. It depends on multiple social, economic and psychological factors in addition to their hearing performances. The aim of this study was to evaluate the importance of hearing performances in the QoL after cochlear implantation.

Materials and methods: This prospective study included 112 patients who received a unilateral cochlear implant (CI) between 1996 and 2009. In this population, 59 completed all tests and were analyzed. This group was composed of 34 females and 25 males. The mean age was57 years (range: 15 to 85 years). Twenty-five patients had a contralateral hearing aid (HA) with a sever hearing loss. Hearing performances were evaluated by a free-field audiometry in quiet and noise, with and without lip-reading. The QoL was evaluated by the Nijmegen Cochlear Implant Questionnaire (NCIQ). The mean delay after CI was 63 ± 7 months (range: 1-170 months).

Results: Dissyllabic word discrimination (at 60 dB) in quiet was 11 ± 23.8 % before, and 43 ± 33.9% after implantation with CI only and reached 52 ± 42.4% with CI + HA. In noise (cocktail party, SNR=0), dissyllabic word discrimination was 18 ± 26.7 % with CI only, and 27 ± 31.1% with CI + HA. Average NCIQ scores ranged from 41 to 62% depending on the domains. Age, sex and etiology did not seem to influence the scores. There was no correlation between the scores and the hearing performances. Although patients with hearing deprivation above 10 years had poorer hearing performances, their QoL was similar to those with shorter periods of deprivation.

Conclusions: QoL after implantation is not correlated to hearing performances and probably depends on multiple other factors (e.g. social, economic, and psychological). This study underlines the crucial role of preoperative evaluation and postoperative support in all these domains.

S38-9

Long-term Quality-of-Life Outcomes (QOL) after cochlear implant

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Background: The World Health Organization defines QOL as an “individual's perceptions of their life in the context of the culture and the value systems where they live, and in relation to their goals, expectations, standards, and concerns” (WHO, 1997). The ability to communicate effectively is considered a major component of QOL. The most common problem faced by hearing impaired adults is reportedly the difficulty in understanding conversations (Davis, 1989). More than 5.3 million people in the world suffer from at least a severe hearing loss (Stevens et al., 2013). Over the past few decades, cochlear implantation is considered an effective treatment for those who with severe to profound hearing loss (McDermott, 2004). The evaluation of QOL outcomes of cochlear implant (CI) recipients pre-and post-implantation could provide a better understanding of effect of cochlear implantation on its recipients (Looi et al., 2011).

Aims: To investigate the QOL of postlingually deafened adult CI recipient’s pre-and post-implantation and to determine the effect of time up to 24 months, age and type of electrode array on QOL of implant recipients.

Methods: The abbreviated profile of hearing aid benefit (APHAB) (Cox, 1995) was administered on participants pre-implantation and 3, 6, 12 and 24-months post-implantation (n=158). It was administered using paper-based or computer-tablet based versions. CNC Word and Phoneme Scores were collated pre-implantation, and 3, 6, 12 and >12 months post-implantation (n=232 with contour array, n=24 with straight array). Analysis investigated effects of age, time, and the type of the electrode array.

Results: CNC-word and phoneme scores significantly improved pre-to post implantation and remained stable over time, with no significant difference between contour and straight arrays. There were significant effects on APHAB related to age group (p=0.003) with the older recipients showing worse outcomes than the younger recipients. Similar findings were observed for three subscales of APHAB (ease of communication, Background noise and reverberation); however, no changes across time were observed for the aversion subscale. Overall, best outcomes were evident at 6 months post-implant and there was an apparent regression between 12-24 months. It is speculated that the observed regression could have resulted from the survey losing sensitivity over a long period of time.

Conclusions: Overall, increase in QOL scores were obtained from CI recipients pre- to post-implantation. Better outcomes were observed with the younger age groups compared to older age groups. The regression in QOL over a longer period of time since implantation requires further investigation.

S38-10

Speech recognition and quality of life one year after cochlear implantation in adults

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An increasing number of adults with severe to profound hearing impairment are referred to cochlear implantation (CI). The aim of the study was to assess speech audiometric results in CI-users and their health-related quality of life (HRQL). All CI recipients who were ≥ 18 years at implantation and who had been implanted in the CI program at the Linköping University Hospital, Linköping, Sweden between May 2011 and August 2012, and who had had their CI for at least 1 year were eligible for the study. In addition to audiological tests, the pre-operative assessment of adult patients included tests of working memory capacity, phonological and lexical processing skills. The HUI3® was used to assess HRQL before and 1 year after unilateral CI and was mailed to the CI recipients. Response rate was 73 % (n = 24, 13 females). Six patients were implanted with a MedEl EAS® implant and 18 with implants manufactured by Cochlear Corporation®. The mean age at implantation was 72.3 years (range: 57.0-87.5). The mean maximum monosyllabic speech recognition score with optimally fitted hearing aid in the ear to be implanted was 17.7% (range: 0.0- 62.0), and one-year follow-up with CI 51.0% (range: 16.0-86.0). Speech in noise test (Hagerman's sentences) with CI was available for 9 patients and the mean result was -0.8 dB S/N (range: -5.2-1.8). HRQL scores were comparable to previous reports in CI populations. Measured as HUI3 the mean change for the single attribute of hearing at 1 year after implantation compared to preoperative was 0.34 (range: -0.71 - 0.71).

The results will be discussed with respect to age at implantation, duration of severe to profound hearing impairment, pre-implantation speech recognition scores and cognitive factors. In conclusion, based on our preliminary results, CI gives good benefit (speech recognition scores and health-related quality of life) in the whole group of CI-users one year post-implantation.

S38-11

Quality of life in young adults with cochlear implants

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Intro: The age range in quality of life (QoL) studies on adults with cochlear implants (CIs) has been wide, sometimes including children as well as young and older adults. As studies that examine QoL in young adults with CIs are lacking, the study purpose was to examine QoL in this group.

Methods: Participants (18-26 years old) comprised 10 prelingually deafened users of CIs (5 binaural, 5 monaural without a hearing aid in the contralateral ear) with 7-19 years of CI use. The Nijmegen Cochlear Implant Questionnaire (NCIQ) (Hinderink et al., 2000) was administered.

Results: In the current study, median NCIQ performance was highest for the speech production (SP) and activity limitations (AL) subdomains. Median performance was lowest for advanced sound perception (ASP) and basic sound perception (BSP) and social interaction (SI) subdomains.

	Basic sound perception (physical domain)	**Advanced sound perception (physical domain)**	**Speech production (physical domain)**	**Activity limitations (social domain)**	**Social interaction (social domain)**	**Self esteem (psychological domain)**
Current study: median (range)	73 (53-93)	69 (25-83)	91 (60-100)	90 (67 - 98)	73 (60-94)	76 (48-88)
Hirschfelder et al: mean (SD)	71.6 (16.6)	65.4 (16.0)	85.7 (13.6)	64.5 (16.6)	67.8 (16.5)	60.8 (17.8)
Damen et al - Group I: mean (SD)	60.7 (25.1)	54.4 (20.0)	83.3 (17.7)	73.6 (19.6)	63.7 (14.8)	66.8 (19.2)

[Table 1]

Discussion: All of the studies reported highest performance for the SP subdomain. Findings were most divergent for the AL, self-esteem (SE) and ASP subdomains. The mean length of CI use was 4.0 years in the Hirschfelder et al. (2008) study (mean age = 54 years, range = 22 - 76 years) and 9.9 years in the Damen et al. (2007) study (mean age for Group I = 55 years, SD = 16 years). Performance for AL and SE was markedly higher in the current study than in the other studies. Perhaps QoL related to AL and SE is higher in young adults as compared with the general adult population (largely older adults) and/or the beneficial effects of implant technological advances have accrued over time from the older studies to the current study.

Conclusion: Median QoL scores were excellent for the SP and AL subdomains, suggesting that these subdomains are the ones most beneficially impacted by CI use in young adults. Median QoL scores were lowest for ASP, BSP, and the SI subdomains, suggesting that CI use in young adults has a lesser benefit on these subdomains than on the other subdomains. The beneficial effect of CIs in older adults may be more limited than in younger adults for the AL and SE subdomains.

Learning outcome: Listeners will be able to describe, in adults with CIs (a) the findings of health-related QoL questionnaires; (b) QoL findings in young adults versus older adults and study limitations.

S39 Music and CI II

S39-1

Perception of emotions and movements in music by children with cochlear implants

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Intro: Cochlear implants (CI) are effective in transmitting temporal information, but less so with spectrally complex sounds. Thus, regarding music, CI users are quite accurate in perceiving tempo or rhythm patterns, but significantly less accurate than normal hearing listeners (NH) in perception of melody, harmony, and timbre. This has implications for effective communication of symbolic content in music, including recognition of emotional or movement cues. Prior studies indicate that mode (e.g., major or minor harmony) and timbre as well as tempo are primary cues for conveying emotions (Juslin & Sloboda, 2010); rate of movement is conveyed by tempo, but direction of melodic patterns convey changes in elevation, such as climbing. Prior studies with pediatric CI users (Hopyan et al., 2011) revealed recognition of happy vs. sad music at levels above chance, though still significantly less accurate than in NH children. This presentation expands upon prior research, examining a more diverse group of 5 emotions as well as physical movements.

Methods: 26 pediatric CI users and 31 NH peers were tested on recognition of 5 basic emotions and 4 movements conveyed through 27 short musical excerpts. Responses were gathered on a computer screen via pictures and labels of emotional expressions or movements. Chronological age, age of onset and implantation, device type, strategy, and device configuration (i.e., bilateral, unilateral, bimodal) were evaluated for prediction of performance.

Results: The CI group performed significantly less accurately than the NH group ($p< 0.0001$) in recognition of both emotions and movements. CI users had similar levels of accuracy on all emotional categories, (45-65% accuracy). The movement of climbing, which included melodic cues, was significantly less accurate ($p< .001$) than the other 3 movement categories. Hearing profile did not predict outcomes.

Discussion: CI users were able to recognize both emotions and movement at above chance levels, but their accuracy was significantly poorer than that of NH peers. These findings confirm and expand upon prior research (Hopyan et al., 2011). The lack of access to melodic and harmonic cues, possibly compounded by less exposure to symbolic uses of music in educational settings, likely contributed to poorer recognition.

Conclusions: The findings confirm that children with CIs are less adept than NH children for decoding symbolic cues of music. For pediatric CI users, tempo and rhythm cues provide more useful input than pitch or harmony for identifying emotional meaning or movement cues.

Learning outcome: Attendees will (a) be able to describe the impact of degraded representation of pitch and timbre on recognition of emotional or movement cues in music and (b) describe which musical cues are more accessible to CI users.

S39-3

Perception of spectrally complex music and speech sounds: The impact of musical training on behavioral and CAEP outcomes

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Intro: While cochlear implants (CI) are remarkably successful in conveying segmental features of speech in quiet, the CI is less suited for conveying spectrally complex sounds of speech and music (e.g., speech in noise; pitch and timbre). Interestingly, CI recipients using similar technology vary considerably in perceptual accuracy for spectrally complex sounds. Among factors associated with greater perceptual accuracy are: parameters of the auditory input, more efficient central processing, and life experiences believed to enhance perceptual efficiency (e.g., musical training). Behavioral measures commonly used to assess perceptual accuracy include frequency difference limens, pitch ranking, timbre recognition, ripple density, and speech in noise. More recently, the Auditory Change Complex (ACC), a cortical auditory evoked potential (CAEP) used to assess discrimination between two acoustic signals, has been explored as an objective measure of coding auditory input within the auditory system. It is hoped that the ACC may provide insights into the variability among CI users on perceptual measures, as well as predict potential benefits from formal musical training. Initial steps have included an examination of ACC in conjunction with behavioral measures in adults with normal auditory systems, assessing outcomes as a function of the parameters of the auditory input and amount of musical training.

Methods: 20 normal hearing (NH) adults differing on musical training (10 musicians; 10 non-musicians) were tested on spectrally complex stimuli, including: AZ Bio (speech perception in background noise), ripple density (spectral resolution), frequency difference limens (200, 800, 1600 Hz), complex pitch change thresholds, and 3 tasks of timbre recognition (original, spectral cues, vocoder/ CI simulation). The ACC was measured in response to pitch change and ripple density.

Results: The behavioral data showed that musicians detected smaller pitch changes ($p< .001$ at 1600 Hz; $p< .0022$ for pitch change), had more accurate timbre recognition ($p< .012$), had better ripple discrimination thresholds ($p< .0019$) and more accurate speech recognition in noise ($p< .046$ at 0 SNR) than non-musicians. Parallel trends were evident in the ACC data (pitch change, $p< .048$; ripple density, $p< .018$). Results from the NH listeners will be compared to preliminary results from CI users.

Discussion: These results suggest that music training can impact both the way spectrally complex signals are coded within the auditory system and perceived by the listener. The results have implications for clinical benefits of auditory training for CI recipients, as well as for clinically viable measures.

Conclusion: Musical training may enhance perceptual processing of spectrally complex stimuli, and ACC may help explain variable perceptual outcomes of CI users.

Learning Outcome: Listeners will be able to describe the impact of music training on perception of spectrally complex stimuli.

S39-4

Development and evaluation of a music rehabilitation program with adult cochlear implant users

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Music perception is known to be challenging for many cochlear implant (CI) users. Although there is evidence to suggest that training can improve CI users' perception and appraisal of music, provision of interactive music rehabilitation materials that have been developed with and tested by CI users remains limited. The objective of this study was to evaluate the efficacy of a prototype interactive music awareness program (IMAP) developed with adult CI users (Oliver et al., 2012; van Besouw et al., in press).

Twenty-one CI users were recruited and allocated to two groups. Group 1 received the IMAP first, followed by a retention of learning phase. Group 2 were given the IMAP after 12 weeks. Participants were instructed to undertake two half-hour sessions per week at home over 12 weeks. Both groups attended appointments at the start, halfway through, and at the end of the trial. At each appointment participants completed tests of speech perception, melodic contour identification (MCI) and instrument recognition, rated the sound quality of music, and indicated their music listening habits. Adherence data and feedback for each session were collected using an online survey system. Sixteen participants attended all three assessment appointments and 14 of these completed ≥20 sessions, spending on average 41 minutes per session.

Following training both groups showed a statistically significant improvement in instrument recognition and retention of learning was observed 12 weeks following training. The interaction for MCI between the groups at 12 weeks was statistically significant, with group 1 showing greater improvement; however, ceiling effects were observed for group 2. A non-statistically significant increase in music listening habits was observed for both groups throughout the course of the trial. Feedback suggested that the IMAP had further positive impact on participants' lives. Despite the relatively small sample size, the findings suggest that the IMAP is beneficial for music perception and in particular, instrument recognition. This is consistent with previous findings suggesting that with practice, adult CI users are able to relearn the timbre of musical instruments (Driscoll, 2012). Trial feedback has been used to improve and extend the IMAP, which is now available online.

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S39-5

Participation of children with cochlear implants in music education and activities: Effects of family involvement

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Intro: While enjoyment of music remains elusive for many postlingually deaf adults CI users, who compare sound quality to experiences prior to deafness, congenitally deaf children who have grown up using CIs know how music sounds only through the implant. Thus, many describe the quality of the sounds differently from their adult counterparts. Despite well-documented limitations in perceptual accuracy for pitch and timbre, many children with cochlear implants (CIs) are involved in music in some form, whether formal or informal. Prior studies of the musical activities of adolescent CI users have attributed extent of involvement and appreciation in part to the familial environment (Gfeller, et al 2012; Darrow, 1993); those adolescents with families more involved in music placed higher personal value on music. These issues have not yet been explored systematically for preschool and school-aged CI recipients.

Methods: Parents of preschool (n=16) and elementary school-aged (n=17) CI users were administered a questionnaire regarding their child's enjoyment of and involvement in music. Additional questions focused on musical involvement of normal hearing (NH) siblings in their household (preschool NH, n= 12; elementary NH, n=16). Questions addressed the importance of music in the home, the child's interest and involvement in music, and comparisons between the children with and without CIs. Other questions pertained to initiation of musical activities, musical preferences, social factors, and participation in ensembles (elementary-aged children).

Results: For elementary children, there was no significant difference between the involvement of the CI user and NH sibling ($p>.05$). NH and CI children had similar extent of participation in formal music activities (e.g., taking music lessons, singing groups, attending music programs). Both preschool and elementary children (CI and NH) were similarly engaged in informal music activities such as listening to music at home, social play with friends, singing/playing music together with family, watching music videos, and playing with musical toys, musical video games, and making up songs during play.

Discussion: Similar to studies with adolescents (Gfeller et al., 2012), preschool and elementary school-aged children whose families place value in musical involvement, were more involved in music.

Conclusions: Despite a less than ideal musical signal through the CI, preschool and school-aged children do enjoy musical experiences and involvement. Those who spend a greater amount of time involvement in music are typically from families more involved in music.

Learning outcome: Those attending will be able to describe typical forms of musical involvement in preschool and elementary school children who use CIs.

S39-6

Toward a model of music complexity for cochlear implants

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Many CI users are unsatisfied with their music perception after implantation. One reason to explain that might be the poor transmission of fine temporal and frequency information to the auditory nerve. Several studies investigating the different properties of music tried to identify the major difficulties for music perception with CI subjects. The outcome of these studies showed that

1. rhythmical structures are perceived almost as good as by normal hearing listeners,
2. melody recognition is much worse than in normal hearing listeners and
3. timbre perception seems to be poorer than in normal hearing listeners.

Given the above limitations in melody and timbre perception one could hypothesize that CI users might prefer to listen to music that is mostly based on rhythmic information rather than on melody or timbre. Additionally, one could also hypothesize that the more complex is the melody (more pitches and variability) and the timbre (more instruments) the worse will be the music perception/enjoyment.

In order to investigate these hypotheses we propose to assess music appraisal and complexity in a group of CI users. Subjects will be asked to rate particular music excerpts in terms of their complexity and their liking. The same music excerpts were analyzed by feature extraction algorithms to determine their complexity.

A questionnaire, adapted from the version of Streich (2006), had to be filled by the CI users. CI users had to rate 30s music excerpts in terms of their familiarity with the music, their complexity judgment and their liking of it.

The total number of music excerpts of the collection was 82, out of which a maximum of 30 were randomly selected for each participant. The database (Streich 2006) had a balanced number of styles including classical music, pop and rock, techno and electronic dance music, Jazz and world music. Furthermore, the database was constructed such that it covered a wide range of complexity. Each music except was analyzed by a set of feature extractors based on the Streich, 2006 model. In total twelve features were extracted from the audio: four measures relating to the dynamic, one measure of timbral complexity, three measures of tonal strength, ánd four measures of rhythmic complexity. These measures were used by a statistical model to predict the subjective ratings given by the CI users.

Preliminary results from 20 CI users recruited showed a correlation between the complexity and the liking ratings. Additionally the correlation between the feature extractors and the subjective ratings was analyzed. The highest correlation was obtained by the rhythm complexity extractors. This could suggest that CI subjects made their judgments based mostly on the rhythmic aspects of music. Tonal descriptors, on the other hand, obtained the lowest correlation scores, maybe confirming that these components of music are not well perceived by CI users and therefore are not used make their judgments.

S39-7

An analysis of the music perception and appreciation of pre- and postlingually deafened adult cochlear implant recipients

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Aim: The aim of this study was to assess the music perception and appreciation of prelingually deafened adult cochlear implant (CI) users in comparison with postlingually deafened adult CI users. To date, there has been limited research available on the music perception of prelingually deafened CI recipients.

Materials and methods: Eight (8) prelingually deafened and ten (10) postlingually deafened CI recipients attended two test sessions at the Royal Victorian Eye & Ear Hospital Cochlear Implant Clinic in Melbourne, Australia. Participants completed a music perception test battery involving closed-set tests of pitch, timbre (single instrument and ensemble identification) and melody recognition. Participants were also asked to complete the University of Canterbury Music Listening Questionnaire for CI users (UCMLQ-CI) in order to collect information on their musical background and listening habits and musical appreciation.

Results: The postlingually deafened group demonstrated better performance than the prelingually deafened group on the music perception test battery, with significantly better scores on pitch perception tasks ($p=0.023$) and single instrument identification ($p=0.031$). There was no significant difference found between the groups for performance on the ensemble identification task ($p=0.083$), although there was a trend for the postlingually deafened group to perform better. Performance on the melody identification task could not be compared between the two groups as a number of the participants in the prelingually deafened group were not familiar with the melodies in the task. The UCMLQ-CI questionnaire results found no significant difference between the groups for time spent listening to music or the level of music enjoyment between both groups when using their CI ($p=0.921$, $p=0.898$).

Conclusions: The results indicate that postlingually deafened adult CI recipients perform better than their prelingually deafened peers on select tasks of music perception, however as this study demonstrates, this does not necessarily lead to an improvement in music appreciation. It must be noted that this is a small sample size with large variation, particularly in the prelingually deafened group. Clinically, it is important to be aware that the prelingually deafened CI recipients potentially share similar levels of musical enjoyment to their postlingually deafened peers, and this may influence the way in which clinicians introduce music to their patients in the rehabilitation stage post-implant. Further research in this area with greater participant numbers is warranted.

S39-8

A qualitative assessment of pitch-perception skills of cochlear implant and hearing aid users

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Background: Cochlear implant (CI) and hearing aid (HA) users demonstrate excellent open-set speech discrimination in quiet (Ching et al., 2006; Fetterman & Domico, 2002). However, perception of pitch-related speech and music perception skills remain a challenge to them (Looi et al, 2008, Jayakody, 2012).

Purpose: This study developed and administered questionnaires to compare ease of performing pitch-related speech and music tasks of pre-and post-lingually deafened cochlear implant (CI) recipients and post-lingually deafened adult hearing aid (HA) users before and after completing a pitch-training program.

Method: Sixteen postlingually deafened adult CI recipients (mean = 59.06 years), 20 postlingually deafened adult HA users (mean = 64.75 years) and six prelingually deafened children using CIs (mean = 16 years) took part in the study. Firstly, participants were asked to complete a pre-training questionnaire. The pre-training questionnaire was organized into five areas: music listening preference, formal music training experience, informal music training experience, ease of performing pitch-related identification tasks, and attendance at music-related activities. Based on the results obtained from the pre-training questionnaire, a home-based computer based training program was developed to help CI recipients and HA users improve their pitch-related speech and music skills. Participants were asked to this training program over 10 weeks. Following completion, a post-training evaluation questionnaire was administered to obtain a qualitative evaluation of participants' perception of pitch related speech and music tasks post-training.

Results: The results obtained from pre-training musical background questionnaire suggested that both pre-and postlingually deafened CI recipients and postlingually deafened HA users have difficulty in perceiving pitch-related aspects of speech and music skills in their daily life. Results also revealed that since receiving the CI, a majority of postlingually deafened CI recipients stopped taking part in music related activities. However, 70% of the CI children reported that the music sounded better through their implant over the years. 25% of the HA users reported that music sounds different through their HA. Post-training evaluation questionnaire results revealed that both post-lingually deafened adult CI and HA users found significant ($p = 0.005$) improvement in pitch-related aspects of speech and music skills after the training. The CI children reported no significant improvement in any of the pitch-related speech and music tasks with training.

Conclusion: Overall, pitch- related speech and music skills of both postlingually deafened adult CI and HA users can be improved with training.

S40 The single sided deaf child (SSD)

S40-2

Management of Single Side Deafness in the Paediatric Population: A survey of current UK practice

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Introduction: Practice in managing single side deafness (SSD) within the UK is not standardized and varies among centres. Current management options include (i) fitting a CROS aid or Bone Anchored Hearing Aid (BAHA), and (ii) monitoring the child's progress without fitting amplification. Currently, cochlear implantation is not an option for most of these patients in the UK.

Research from adults with SSD has shown positive outcomes from cochlear implantation. In preparation for a UK paediatric SSD study, we collated information from targeted audiology centres about their current management of these children.

Methods: A questionnaire was designed and circulated to targeted paediatric Audiology Managers across the UK. The questionnaire probed understanding of SSD and its prevalence. It also addressed their departmental protocols and management of amplification for this population.

Results and conclusions: Results and conclusions of the survey will be presented, which add evidence to support a UK paediatric study into cochlear implants in children with SSD.

S40-3

Unilateral hearing loss in infants: Why one ear is not enough

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Intro: The risk of difficulties arising from unilateral hearing impairment is well documented. For audiologists and allied professionals, the immediate challenge is in articulating the benefit of fitting hearing devices and accessing early intervention services when faced with families with very young paediatric clients. This study aims to determine the current state of children with unilateral hearing impairment in a single early intervention service, and reviews device use, age at device fitting, and results on formal assessment.

Methods: Demographic information, formal speech, language and listening assessment results and informal results from regular Auditory-Verbal Therapy sessions recorded on file were reviewed. Parents were interviewed about their perceptions of the information provided at the time of diagnosis and the availability of services and support for children with unilateral hearing impairment.

Results: Of the 196 children enrolled in early intervention, 16% had a unilateral hearing impairment. Devices used included no device, devices to contralaterally reroute the signal, acoustic hearing aids and cochlear implant. Formal outcomes across the group were excellent; however parent report of the guidance and information they received was varied. All reported concern about the lack of action following on from such early diagnosis.

Conclusion: If UNHS is to continue to identify unilateral hearing loss specific and appropriate management needs to be consistently offered and professionals at all points in the service chain need to understand and articulate the likely impact of audiological management, device use and early intervention.

Learning outcomes: Participants will have a clear understanding of the audiological, surgical and rehabilitative options for unilateral hearing loss in infants and the feedback from families related to this.

S40-4

Single sided deafness in children - a first case study

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Method: A mentally normal developed 6 years old girl with a single sided deafness was implanted with a CI (cochlear implant) (MED-EL Concerto) and fitted with OPUS 2.

Result: After several fitting sessions she showed an aided threshold between 30 and 35 dBHL at 250 - 8000 Hz after two months (contralateral ear masked).

At this time she already achieved a speech understanding with the CI of 20 % at 70 dBHL (Göttinger Speech Audiometry II) and was able to repeat many words of the presented word list (70 dB) similar to the original phonological word structure. Two months after her first fitting she improved her speech understanding in noise from 20 % without CI to 90 % with CI (Göttinger Speech Audiometry presented with 65 dBHL, 0°, and bilateral noise with 60 dBHL, 90°). More detailed data will be presented on the poster.

Conclusion: With the cochlear implantation of Single Sided Deafness sufficient aided thresholds together with a significant improvement of speech understanding in noise were achieved already after two months. These results are encouraging further treatment of Single Sided Deafness in children with cochlear implants.

S40-5

Cochlear implant for rehabilitation of unilateral deafness in children: First experiences

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In the pediatric population, unilateral deafness have been linked to delayed speech and language development, and poorer academic performance. Similarly to the adult population, bone conduction devices have been used as a rehabilitation option for children older than 5 years of age. However, hearing rehabilitation encounters further challenge with young children who are unlikely to wear CROS and/or FM systems.

To date, there is very limited data regarding cochlear implantation for hearing rehabilitation of unilateral deafness in children. This study was designed to investigate the implication of cochlear implantation in children with congenital and acquired unilateral deafness, following “the earlier the better” intervention approach. This is an ongoing prospective study with 5 children (age 1.5 to 9 years old) implanted so far. All patients were implanted with a Flex Soft MED-EL electrode and complete insertion.

Localization test and age appropriate speech perception in noise were performed on the 3 older children. For the younger child, behavioral observational testing in the sound proof room was performed with the normal-hearing ear masked with speech noise 65dB. The sound-field hearing thresholds of 20dB were obtained at 1000Hz and 4000Hz. Up to date, there is a good subjective acceptance of the implant and 4 children are full time wearers. Localization and lateralization skills as well as speech perception in noise scores have improved through the first 12 months of CI usage.

Cochlear implantation may represent the only option that will fully assist children with unilateral deafness to make usage of binaural hearing benefits. It is possible that “the earlier the better” approach is the most suitable path for cochlear implantation in the pediatric population.

S40-7

Audiological results of single sided deaf children with cochlear implants

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Intro: Several studies demonstrated a benefit for adult patients with acquired single sided deafness (SSD) after cochlear implantation (CI). In particular, this was shown for speech understanding in noise and localization abilities. SSD is known to affect educational opportunities in children. Thus, children with SSD have been implanted at the University ENT department in Würzburg since 2011.

This cross sectional study gives an overview of the current and ongoing audiological studies of SSD children implanted with a CI.

Method: Seven children were implanted at the ENT department of the university hospital Würzburg. The age at implantation was 3 - 16 years. Their listening experience with CI ranged from 3 to 36 months. The children participated in speech understanding tasks with spatially separated signal and noise. Localization abilities were tested with a semicircular loudspeaker array in the frontal horizontal plane. All tests were conducted in normal hearing ear alone (NH) and normal hearing ear plus CI (NH+CI) listening conditions.

Results: A benefit can be shown for some of the children.

Discussion and conclusion: While there is a positive evaluation of the CI by the majority of parents, speech understanding in noise performance varies a lot. A reason for this may be that a subgroup of children had difficulties with one or both tasks, potentially because of age or their stage of development.

S40-8

Pschological/audiological follow up in unilateral deaf children with cochlear implant

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Hearing therapy with hearing aids (HAs) or cochlear implants (CIs) are the prerequisite for optimal speech and language development in hearing impaired children. It is well known that language development is affected by factors such as general development, presence of other handicaps, and psychological factors, specifically neuro-functional weaknesses in language development. Since 2010, the Würzburg standard follow-up program for hearing impaired children includes systematic psychological and logopaedic diagnosis in addition to standard audiological and medical evaluation in defined time intervals. The results of the evaluations are documented in a child booklet, providing an easy flow of information among the different care takers. Data are analyzed in order to detect and evaluate factors that affect language development. Out of a total of 140 children that have been included since 2010, 75 children wear HAs and 65 are implanted with CIs, of which 7 children have normal hearing in the contralateral ear (single-side deafness, SSD). The SSD group includes 2 boys and 5 girls with an implantation age of 3 to 16 years, CI use for up to 3 years and an actual age range between 4 and 17years.

The presentation will give an overview on the follow-up program and will specifically describe the individual evaluation of the 7 implanted unilateral deaf children, with a focus on psychological and speech therapy data and audiological outcomes.

S40-9

Detection of partial deafness during hearing screening in school age children

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The prevalence of hearing loss in children increases with age and may involve different types of hearing problems that cannot be identified by neonatal hearing screening. It is estimated that 9-10 per 1000 children will have identifiable permanent hearing loss in one or both ears by school-age.

The early detection of hearing impairments in school-age children enables the effective implementation of medical and rehabilitation procedures or preventive treatment. These lead to lessening or eliminating various kinds of communicational disorders and dysfunctions in this way creating equal opportunities for personal and social development.

In the speech we will present the results of hearing pure tone threshold screening (.5, 1, 2, 4, 8 kHz) in the context of Partial Deafness Classification proposed by Skarżyński in 2010. Testing was performed in the group of first and six-grade students (n=20 464) in primary schools in Warsaw (year 2010/2011). Majority of children with positive screening result constitutes individuals with minimal hearing loss. However, there is a concern that even minimal high frequency hearing loss - probably due to noise exposure - is more likely to progress in the course of ageing to the levels that can be considered for Partial Deafness Cochlear Implantation.

S41 Maturation and plasticity

S41-1

The role of the auditory cortex in paediatric cochlear implantation - A need for focused research

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Objective: Successful paediatric cochlear implantation (PCI) depends on the ability of the implant to stimulate the auditory cortex, which then permits the development of hearing and speech. Failure results from any factor that damages the cortex or that prevents auditory stimuli from accessing the cortex. To prognosticate during PCI assessment, the presence of any such threat must be identified and assessed. It follows that valid research should likewise be focused on such specific pathology.

Method: Adverse PCI factors were classified as **primary** (direct cortical damage), **secondary** (denial of transmission from the CI to the cortex) or **tertiary** (denial of the PCI itself). Using 174 PCI files, these influences were evaluated regarding the precise sites of action by which the cortex was damaged, whether by direct damage or stimulus denial. As commonly used research descriptors appeared poorly adapted to identifying such sites, several such examples were deconstructed into more relevant pathological components to illustrate the need for better focus on the effect of pathology upon the cortical stimulation during the prognostic process.

Results: Primary (CNS) influences caused 25% of the 60 poorer outcomes, secondary (cochlear or eighth nerve origins) 8%, tertiary (family / social, delayed implantation) 36%. Multifactorial difficulties were evident in 31%. Frequently, case aetiology did not indicate the true case pathology. Current descriptors, e.g. “meningitis”, “age at implantation” and inner ear malformations” were inadequate terms for focused research; the need for substantial modification of current terminology in research and clinical practice was noted.

Conclusion: The distributions of perceived adverse prognostic factors in PCI, and their affect upon the maturation of the auditory cortex, whether directly or indirectly were demonstrated. The core prognostic requirement of defining the nature, site, severity and probability of adverse effects on the auditory cortex requires an accurate evaluation of pathology and valid research based on precisely described clinical situations. Current prognostic methodology lacks such focus and requires revision.

S41-3

Molecularly regulated neuroplasticity in childhood deafness treated with cochlear implantation - results of first study

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Introduction: Cochlear implantation is a unique and successful treatment giving possibilities to deaf children avoid being excluded from acoustic environment and verbal communication. Still, cochlear implants do have their considerable limitations: like outcomes varying among patients. One of possible mechanisms of diversification of brains responsiveness after cochlear implantation is molecular regulation of neuroplasticity and duration of critical period. Among many neurotrophines two are considered to be of relevant influence on these processes: Brain Derived Neurothrophic Factor (BDNF)and Metalo-Matrix Proteinase -9 (MMP-9).

Material and Method: 10 children with prelingual deafness of unknown or genetically confirmed etiology, unilaterally implanted before 1 year of life, were tested as for speech outcomes after 4 years of CI using. Molecular tests were performed to assess polymorphism of BDNF and MMP-9 as well as activity of these proteins (zymography) in blood serum. EEG were performed in all cases to asses coherence - integration between auditory cortex and other cortical brain areas.

Results: In all subjects the above tests were performed and correlation between their results were drawn. There is a positive correlation between activity of the two neurotrophines and performance in speech tests, as well as results of coherence calculation. Polymorphism is examination and will be finished before presentation.

Conclusions: Molecular regulation of plasticity is one of key points of research interests in deafness and cochlear implantation filed. Our study is a preliminary one giving a good scope over future development of a research problem. For detailed conclusions further studies are required.

S41-4

Neuronal coding of interaural time differences in the long deaf auditory system: Effects of age at deafness onset

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Introduction: Interaural time differences (ITDs) are important cues for directional hearing and speech understanding in noise. Precise ITD discrimination in the microsecond range is assumed to be dependent on normal auditory experience during development. To explore the effects of severely distorted auditory experience on neural ITD coding, the present study investigates the effects of age at deafness onset on neural ITD coding in long deaf animals.

Methods: Mongolian gerbils were deafened either around hearing onset (P12, early-onset deafness) or as adults (~P70, late-onset deafness). After prolonged deafness durations of ~8 weeks, animals were bilaterally implanted with cochlear prostheses (CI), and single neuron responses to electric ITDs were recorded in the dorsal nucleus of the lateral lemniscus and in the inferior colliculus. Adult, acutely deafened gerbils with prior normal auditory experience served as controls.

Results: The incidence of ITD-sensitive neurons in the two long-deafened groups was similar to that in normal hearing controls. Independent of age at deafness onset, long-term deafness resulted in a greater variability of all ITD parameters tested (ITD at maximum spike rate, best ITD; ITD at maximum slope, ITDms; physiological modulation depth, PMD; half width; half rise). In contrast to the narrow distribution of best ITDs that are biased towards contralateral-leading in normal hearing animals, both deafened groups had broad distributions of best ITDs around the midline. These results were paralleled by a lower incidence of ITDms, thus a reduced sensitivity to changes in ITDs, within the physiological range. Moreover, both deafened groups demonstrated a reduced sharpness in ITD tuning (broader halfwidth and halfrise), lower PMD, and a reduced neuronal ITD discrimination ability. When compared across the two deafened groups, neurons in juvenile deafened animals revealed significantly poorer ITD sensitivities (ITD signal to total variance ratio) than those in adult deafened animals.

Conclusion: Results indicate that prolonged periods of both early- and late-onset deafness cause various degradations in neuronal ITD coding. These deficits may be physiological correlates for the poor ITD discrimination performance in human bilateral CI users. Moreover, the findings suggest the importance of temporally correlated binaural hearing experience early in life in order to optimally benefit from binaural stimulation.

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S41-5

Evidence of electrophysiological changes in deaf children of Cuban Cochlear Implant Program

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Introduction: There is a significant number of deaf children with other disorders and diseases, for example visual, and often omitted while evaluating hearing loss.

Objective: Identify electrophysiological alterations in deaf children cochlear implant candidates through studies of EEG and Evoked Potentials.

Methods: 66 deaf children were studied with Evoked Potentials: Auditory, Visual (VEP) LEDs, Somatosensory (SEP) and EEG. Electrophysiological findings, the results of ophthalmological examination, severity and time of evolution are correlated. Also, we make a study of mapping of the cortical response of the SSEP to evaluate neuroplastic changes as a result of hearing loss.

Results: The total sample had a profound bilateral deafness according to Electroaudiometría. While the VEP showed significant alterations, being the more frequent impaired increased of bilateral latency the wave P1. these findings were correlated with the alterations to eye examination. The PESS showed normal characteristics in the entire sample. EEG evidenced alterations of electrical activity of base, presence of paroxysmal activity, fundamentally in children with neurological symptoms. Topographic distribution maps of the SSEP-N20 showed expansion of activation, although in deaf children the over-representation was less extensive -area temporal.

Conclusions: These findings show that the VEP and AEP is of interest to the functional study of sensory pathways in suspected of visual damage associated with deafness, putting into evidence neuroconduction alterations in the visual pathway and / or eye diseases, it could help characterize visual disturbances, especially from very early ages, when the eye exam is difficult. While that evaluating the EEG provides comprehensive information on functional status in the brain. Moreover, the expansion of the cortical response of the SSEP-N20 to the left temporal region in deaf and deafblind children with 7 o more age was interpreted as evidence of Cross-Modal-Plasticity, effect that may to have the use of the hands for communication in these children, with consequent implications to the optimal use of the CI during rehabilitation auditory.

S41-8

PET scan evidence of prognostic value of visual cross-modal reorganisation after adult cochlear implantation

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Intro: the authors hypothesize that speech comprehension in post lingually deaf cochlear implanted patients relies on visual and visuo-auditory synergy. To investigate whether activity in specific cortical regions would account for the recovery of auditory speech comprehension, the authors analyze the relationship between individual brain activity at the time of implantation and performance in auditory word perception at least 6 months after CI.

Methods: 6 Normal Hearing control subjects and 10 post-lingual adults CI were included. They had H2O15 PET neuroimaging early after activation of CI (mean 8 days) with a task of word/non-word discrimination. Speech intelligibility was evaluated by Fournier French list of disyllabic words on open lists with a minimum follow-up of 6 months.

Results: Mean auditory performance was 62±16% at 6 months. The overall performance for PET scan sessions was 68,9±9,7% for visual conditions, and 80,4±12% for audio-visual task. The highest positive correlation was found in the occipital cortex involved in visual processing, and the posterior-temporal cortex involved in audio-visual integration.

Discussion: The beneficial commitment of the visual cortex for auditory recuperation after CI corresponds to the important role of visual input for speech comprehension in post-lingually deaf patients concerning both phonological and lexical access. After CI, the visual counterpart of audio-visual objects increases the capacity for auditory discrimination. The correlation score in the posterior temporal cortex reflects the initial capacity of patients with CI for audio-visual integration and semantic processing.

Conclusion: The influence of the visual cortex on the efficiency of auditory speech perception suggests some long term neural facilitation mechanisms, creating a synergy between the two modalities. This inter-modality facilitation should be used during rehabilitation programs to improve and accelerate the process of restoring auditory performance.

S42 Outcomes in children incl. multihandicaped children

S42-1

Auditory perception in cochlear implanted children with additional disabilities

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Background: Additional disabilities are important problems that have restricted the child´s candidacy for cochlear implantation for many years. These days the number of cochlear implanted children who have other difficulties like attention deficiency, cerebral palsy, has increased significantly. Although it is needed to study on the results of cochlear implantation in this group, the available studies about them are much limited. As a result, the main focus of this article is to evaluate the level of auditory perception in cochlear implanted children with additional disabilities.

Method and material: In order to compare cochlear implanted children with and without additional disabilities, the Spondee test which includes 20 two syllable words was performed. The data analysis was done by SPSS version 19.

Results: 31 cochlear implanted children, who were about 7.5 years old and had been implanted at least 3 years before, were compared by Spondee test. 15 out of 31 samples had one or more additional disabilities. The data analysis indicated that the mean score of auditory perception in this group was approximately 30 scores less than other cochlear implanted children who had no additional disability.

Conclusion: According to different studies about 30% to 40% of deaf children have additional disabilities Too. In spite of the fact that most of published articles have omitted them from their samples, the results of other literatures indicate that the development of an additional disable child who has received cochlear implant devise, is weaker than other children who are deaf alone. As an example a study in 2005 depicted that children with cognitive delay had noticeably lower scores especially in receptive and expressive language.

Key words: Cochlear implant, Auditory perception, Additional disabilities, Spondee test children

S42-2

Predictors of language and auditory skills in Egyptian children with cochlear implant

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Introduction: Cochlear implantation is associated with significant improvement in comprehension and expression of spoken language with varying degrees of success. This study investigated predictors contributing to the comprehension and production of Arabic language as well as auditory abilities after cochlear implantation of Egyptian children.

Methods: One hundred and fifty children with severe to profound Sensory neural hearing loss of congenital origin implanted with multi-channel cochlear implant (Different brands; Medel, Cochlea & Advanced Bionic). Children had received their implants 3 months to 2 years prior the onset of study. They were implanted at age ranging from 3 to 6 years, coming from across most of the Egyptian governorates. Tests of receptive, expressive language and set of auditory abilities (dependent variables) were administered without any visual cues. Characteristics of the child and the family (Age prior to implant and duration of implant use, Pre-implant use of hearing aids and language therapy, parents' involvement in therapy, mode of communication at home, type of the implant & geographic distribution) were considered the predictors (independent variables)**.** Predictors of total language and auditory abilities were determined using statistical analysis.

Results and discussion: Multivariate analysis revealed that significant predictors of language and auditory abilities included increased duration of implant use, auditory mode of communication is much better than mixed gestural and auditory followed by gestural only mode, parents' involvement in therapy and optimal level of parental talking with the child, preoperative hearing aids fitting and regular prolonged language therapy exhibited significant advantages in prognosis. There is a positive correlation between total language age and both individual and total auditory abilities scores.

Conclusion: Longer duration of the implant use, auditory mode of communication of optimal level of parent's speaking to their child, early fitted hearing aids with good language stimulation preoperatively are the main predictors of language and auditory abilities in this study.

Learning outcome: These predictors help us to know the prognosis of cases to acquire their language and can achieve well in their mainstream schools like their normal hearing peers.

Key words: Predictors, auditory abilities, receptive, expressive language, multi-channel cochlear implants.

S42-3

Comparison of the speech syntactic features between hearing-impaired and normal hearing children

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Introduction: The present study seeks to describe and analyze the syntactic features of children with severely hearing loss who had access to the hearing aids compared with children with normal hearing, assigning them to the same separate gender classes.

Materials and Methods: In the present study, eight children with severe hearing impairment who used a hearing aid and eight hearing children matched for age and gender were selected using an available sampling method based on the principles of auditory-verbal approach. Hearing children had an average age of 5.45 ±1.9 years and subjects had a mean age of 5.43±2.17 years and their rehabilitation had begun before they were 18 months old. The assessment instrument of the study included the language development test, TOLDP-3. The syntactic skills of these children were analyzed and compared with the hearing children of the same age based on gender.

Results: There was a significant difference between the syntactic scores of the hearing-impaired children and the scores of the hearing children of the same age in the “sentence imitation” (t=−2/90, P< 0/05) and “grammatical completion” (t=−3/39, P< 0/05) subtests, with no significant difference in the “grammatical understanding” subtest (t=1/67, P>0/05). Moreover, there was no significant difference between male and female children with hearing impairment in terms of syntactic skills development.

Conclusion: With early diagnosis and timely rehabilitating intervention, children with hearing loss can perform in a similar way to children of their age with normal hearing in some syntactical areas. Furthermore, the gender factor in the present study had no effect on the development of syntactical skills of children with hearing loss.

Keywords: Auditory-verbal therapy, Children, Hearing loss, Syntactic skills.

S42-4

Auditory feedback of speech production in children with cochlear implants and hearing AIDS

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Background: Modern cochlear implants (CI) and hearing aids (HA) provide to deaf children the possibility to use hearing for auditory feedback of speech production. Aim of the study was to compare the ability to control of pronunciation and voice by hearing in children using CI and HA.

Methods: Two groups of prelingually deaf children (aged from 7 to 12 years) with HA and CI (OPUS 1, OPUS 2) participated in the study. Only children without additional disorders were included. The duration of CI wearing varied from 1 till 8 years. It was assessed: 1) tonal thresholds in sound field with HA/CI; 2) mobility of organs participating in articulation; 3) maximal distance of detection of phonemes with different frequency characteristics (low /a/, middle /sh/ and high /s/ frequencies); 4) phoneme recognition (isolated and in syllables); 5) the quality of phoneme pronunciation with support of reading; 6) identification of temporal structure of speech and non-speech stimuli; 7) auditory feedback of phoneme pronunciation and voice.

Results: The tonal thresholds with HA and CI were 20-35 dB in all children. They detected phonemes with low /a/, middle /sh/ and high /s/ frequencies at the distance over 5 m. Under auditory perception children with HA could correctly repeat only 10% of phonemes, children with CI - 92%. In recognition tasks the children with HA identified 28% of phonemes, CI children - 100%. At the same time the score of phoneme pronunciation with support of reading in children with HA was rather high - 66% of correct phonemes. The score of CI children was 98% of correct phonemes. There were significant individual differences in the ability to distinguish and control of voice characteristics in children with CI and HA.

Conclusion: All prelingually deaf children participated in the study had possibility to develop auditory feedback of phoneme pronunciation and voice owing their HA and CI. However, not all of subjects realized it. Most of CI children effectively used auditory feedback for control of pronunciation and voice. Children with HA had very restricted ability to control pronunciation and voice by hearing. The possible reasons of differences between deaf children with CI and HA are discussed.

S42-5

Early Cognitive and Listening Links: Early CaLL. The development and implementation of a profile to record the long term progress following cochlear implantation of children with severe to profound and multiple learning difficulties

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It is well documented that children with a permanent hearing loss are more likely to have additional needs than the general population. In order to allow for these additional needs when counseling families about expectations following cochlear implantation, we need to take account of their nature, severity and how they may inter-relate. This profile is designed for those children whose main challenge, in addition to their deafness, is severe to profound and multiple learning difficulties. We now have over 60 children with this level of difficulty on the program and a need has been identified to develop a framework which can effectively measure the benefits of cochlear implantation for this population and which therefore supports expectations counseling.

The profile is designed to provide a clear visual representation of the inter-relationship between the child's overall cognitive and interactive development, their tolerance of the signal, the extent of equipment use, auditory progress and the development of early language skills in speech and sign if appropriate. By recording small steps in a number of key areas, it is possible to demonstrate changes linked to the use of the cochlear implant, alongside a picture of the child's strengths and difficulties.

The framework enables us to collect relevant evidence on long term outcomes across this broad population. It also enables us to have conversations with families about the relationship between thinking skills, use of the signal, and language development. It provides us with an effective tool to share realistic expectations, both pre and post cochlear implant.

S42-6

Results of cochlear implantation in children with auditory neuropathy spectrum disorder

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Objective: To discuss the perceptive and linguistic results after cochlear implantation in children with Auditory Neuropathy Spectrum Disorder (ANSD)

Patients: Among the 1065 implanted children, 18 children had bilateral ANSD; 10 of them had nerve anomalies (Ga), and 8 had no nerve anomaly (Gn). The mean age at implantation was 2.9 years. Etiologies were Kallman syndrome, Charge syndrome, Otoferlin mutation or unknown. The perceptive and language development where analyzed at 6,12,24,36,48,60 months of follow up, using MAIS, CAP, Closed/Open Set Words and Closed Set Sound scores, and language production with speech level. Results were compared in the 2 groups.

Results: In Ga, perceptive and language development were poorer in all categories. 1/3 of the Ga group could reach some perception of sound and some speech recognition with visual support at 48 months. 3 children had some oral production (words) at 48 months follow up. In the Gn group, all children could access to sound and speech recognition. At 48 months follow up, all had some oral language, and ½ of them had good oral level.

Discussion: Various etiologies are discussed. Counseling CI candidacy for children with ANSD should include reviewing the etiology and a close analysis of the VIII nerve, as it impacts on the long term perceptive and linguistic results.

S42-7

Perception, speech and intelligibility rate in profound deaf children with cochlear implantation after congenital cytomegalovirus infection

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Goal: To evaluate the perceptive and speech development results in profound deaf children after cochlear implantation (CI) in congenital cytomegalovirus infection (CMV).

Patients and methods: 15 children with profound deafness linked to congenital CMV were implanted before 3 years of age and with a minimum of 3 years follow up (FU). Diagnosis of infection was made few days after birth, because of clinical signs or because of systematic virological evaluation. Medical and radiologic context were analyzed: type of deafness, motor skills, vestibular testing, ophthalomological signs, brain MRI. All children were implanted unilaterally. At 3 years FU, the speech perception was evaluate using closed and open set words (SW/OSW), the Nottingham intelligibility rate (SIR), and the language development using a 6 grade scale (pre linguistic to complex language).

Results: At 36 months FU, the mean perceptive scores were 74 % and 48 % in CSW and OSW. Bilateral vestibular dysfunction as well as delayed motor skills was linked to poorer speech perception in OSW scores ($p = 0{,}04$). At 3 years follow up, 20 % of children had no language development, 41,6 % had words and 48,4 % could produce sentences. Factors as post-operative hearing thresholds ($p = 0{,}01$), motor delay ($p = 0{,}007$) and schooling ($p= 0{,}03$) were statistically linked to the speech production. At 3 years FU, 40 % had a SIR≤2 while 33,3 % had a SIR=5. Factors as post-operative hearing thresholds ($p = 0.007$), motor delay ($p = 0.01$), vestibular areflexia ($p=0.03$) and MRI brain anomalies ($p= 0{,}04$) were statistically linked to the SIR.

Conclusion: Although progress can be seen in most cases after CI in CMV children, some factors may impact on the results, perceptive, as well as linguistic. Those factors are discussed, looking at speech and motor therapy.

S42-8

Evaluation of quality of life, vertigo and audiotory and language development in paediatric CI-users

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Aim: To gather and evaluate retrospectively full data set with a focus on quality of life, vertigo assessment as well as the auditory and language development.

Material and methods: Demographic and epidemiological data were gathered. Benefit in quality of life was recorded based on the Glasgow Benefit Inventory. The post-operative vertigo was measured via Head Impulse Test. The linguistic and auditory development data from the Integrated Scales of Development were collected.

Results: 25 paediatric patients implanted in Bydgoszcz Children's Hospital since December 2010 were included in the observation. Demographics and aetiology were studied in detail. Quality of Life significantly improved based on the Glasgow Benefit Inventory that was collected postoperatively. Integrated Scales of Development was used to assess the progress of hearing and speech rehabilitation in children under 4 yoa. The Scale outlines the typical levels of the development in the areas of listening, receptive and expressive language, speech, cognition and social communication. The observation was conducted since the first sound processor fitting till 48th month of life of the child in intervals of 3 months up to 18th month of life and afterwards every 6 months. In terms of vertigo evaluation, there was an initial difficulty to obtain relevant measurements with the Head Impulse Test in small children. Some data were gathered and did not show any vertigo symptoms postoperatively.

Conclusions: Cochlear implantation in children significantly improves quality of life according to the GBI as well as enables substantial auditory and language development and does not cause additional vertigo risk.

S42-10

Outcomes of cochlear implantation in children with CHARGE syndrome

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Background: CHARGE is a mnemonic term for coloboma, heart defects, choanal atresia, retarded growth and development, genital abnormalities, and ear anomalies. CHARGE syndrome is one of the leading causes of congenital deafness and blindness in children.

Patients and methods: Nine CHARGE syndrome patients underwent a cochlear implant (CI) at the Asan Medical Center in Seoul between 2002 and 2014. The mean age of these CI patients was 4.1 years (range, 1.2 to 9.8 years). All 9 patients had inner ear malformations; eight children had an auricle anomaly and otitis media with effusion; five of these cases showed ossicle anomalies and five patients had downward displaced of facial nerve (FN) toward the promontory; eight patients showed delayed development; six had cryptorchidism and seven had cardiovascular malformations; six patients had choanal atresia and there was three case of coloboma.

Results: In the initial operations, five patients received CI24RE(CA) and two patients in each case were implanted with a CI512, CI24R, and CI422 device. Two patients received bilateral CI devices, while one patient firstly received a CI24R and then CI24RST device in the right ear due to poor performance, but this was eventually removed due to exposure of the electrode from adhesive otitis media and continuing poor performance. When we analyzed post-CI performances except for three patients who had received CI in 2013, assessment of the meaningful auditory integration scale (MAIS) showed that four patients reached a score above 95%, and one patient achieved 60%. The categories of auditory performance (CAP) score showed that one patient reached CAP 7 at two years postoperatively, two cases showed CAP 5.5 at one year after implantation, whilst the remaining two patients had CAP scores of 3 at 12 months and 4.5 at 4 years, respectively. The speech intelligibility rating (SIR) score at 18 months post-surgery was 4.5 in two patients, 2.5 in two patients, and 1.5 in one case. The remaining patient who was explanted showed no meaningful speech improvement.

Conclusion: Regardless of the extent of inner ear anomalies and intellectual faculties, CI with careful treatment planning can be a highly effective option for hearing rehabilitation in children with sensorineural hearing loss and CHARGE syndrome.

S42-11

Bilateral hearing in pre-school children with cochlear implants

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Aim: The aim of the study is to assess the speech perception capacity in bilaterally implanted children by comparing the results of three groups of children: bilaterally implanted, unilaterally implanted, and normal hearing.

Material and methods: Three groups of patient were included in the study. First group - 30 bilaterally implanted children, second group - 59 unilaterally implanted children and third group - 60 normal hearing children. Age of implantation matching was obtained in first and second group. The Polish version of the Adaptive Auditory Speech Test (AAST) was used in order to assess the level of speech discrimination and to facilitate the within and between group comparison.

Results: Bilaterally implanted children perform significantly better than unilaterally implanted ones but still worse than normal hearing.

Conclusions: Two implants reduce the gap in speech outcomes between one implant users and normal hearing subject.

S42-12

Pediatric patients with high frequency hearing loss: Considerations for sequential bilateral cochlear implantation

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Intro: This study examines the outcome of sequential standard cochlear implantation for children with high-frequency hearing loss, who have limited aided benefit and have successfully undergone unilateral cochlear implantation, discontinued use of contralateral amplification following the initial unilateral cochlear implantation then pursued a sequential, standard cochlear implantation in the contralateral ear.

Methods: Retrospective analysis of 734 implantations at a tertiary care pediatric hospital including patient demographics, pure-tone audiograms and word/sentence recognition pre-and post-implantation for the second, contralateral implant. 2 patients with bilateral precipitously sloping, severe-to-profound, high-frequency hearing losses received a unilateral cochlear implant. In both subjects, standard array was chosen versus short array because of the history of progressive hearing loss. Both subjects, who discontinued amplification in the contralateral ear after the initial cochlear implant, later received a contralateral cochlear implant. Pre-operative word and/or sentence recognition using no amplification was compared to post-operative testing using a cochlear implant processor.

Results: In one subject, subject A, speech recognition using the cochlear implant processor in the contralateral ear was markedly improved over the unaided conditions. Subject A continues to have residual low frequency hearing in the contralateral implanted ear. Both subjects have improved soundfield thresholds with the contralateral cochlear implants in comparison to the unaided thresholds on the contralateral ear. Hearing sensitivity will continue to be monitored.

Discussion: Cochlear implantation is a widely accepted procedure for pediatric patients with severe-to-profound hearing loss. Patients with precipitously sloping, high-frequency severe-to-profound hearing loss do not meet FDA guidelines for cochlear implantation but have successfully benefited from unilateral cochlear implantation. These patients may not benefit from hearing aid amplification despite residual low-frequency hearing and are not currently candidates for a hybrid option (a short array with electroacoustic stimulation). The benefit of cochlear implantation on the contralateral ear is questionable. The risk of losing any low-frequency residual hearing should be considered when pursuing contralateral cochlear implantation.

Conclusion: For those patients with precipitously sloping high-frequency sensorineural hearing loss and limited hearing aid benefit, bilateral cochlear implantation may provide substantial benefit. Pending further research, expansion of FDA candidacy criteria may be advisable. Further study regarding best practices for age of implantation and bimodal use for this population should be explored.

S42-13

Mental health problems in adolescent CI users

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The present study aims to evaluate the mental health status of deaf adolescents with cochlear implants (CI). In this multi-center study, mental health problems as assessed with the “Strengths and Difficulties Questionnaire” (SDQ) were compared between 140 German adolescents with CI (mean age 14.7 years) and 140 normal hearing pears, matched for age, gender and social background. CI users showed significantly more emotional symptoms (SDQ teacher ratings) and more peer problems (SDQ self-parent-teacher ratings), compared to normal hearing peers. The increased incidence for emotional problems vanished, when we excluded 35 CI users with the risk factors intellectual disabilities/ learning disorders, visual impairment and inner ear malformations. Apart from that we did not find any significant difference (conduct problems, hyperactivity, total difficulties, social behavior problems) between CI group and normal hearing group. Stepwise multiple regressions revealed, that hearing variables predict SDQ self- and teacher ratings, and social background variables predict SDQ parent ratings. CI age was not found to be a predictor. The results indicate that emotional, behavioral and social problems of CI-adolescents are comparable to normal hearing peers. However, there are more peer problems.

S43 Genetics & gene therapy

S43-2

Genetically determined hearing loss - perspectives and diagnostic capabilities of next-generation sequencing

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Approximately 50-60% of cases of hearing loss are due to genetic factors. The genes responsible for the occurrence of hearing loss usually encode proteins located in the inner ear. Majority of patients with autosomal, recessive deafness harbor mutations in only one gene- *GJB2*. Mutations in other genes, which products are directly involved in the hearing process, may also result in hearing loss. To date, approximately 300 genes involved in the processing of auditory information has been described, and still the new one are discovered. Efficient search for variants in the gene structure requires the use of the most modern techniques of molecular biology, such as the next-generation sequencing. Owing to the innovative technologies of high throughput, whole genome analysis are possible. High accuracy of the obtained data combined with sophisticated bioinformatics analysis allows the detection of sequence variation in the whole genome. The data obtained from next generation sequencing are processed with advanced bioinformatics tools, which finally lead to detection of pathogenic variants in the analyzed material. The introduction of genomic technology is a breakthrough in the field of medical biology. Its influence on the broadening the biology knowledge and molecular physiology of many processes, including the process of hearing, is revolutionary.

S43-3

The pattern of distribution of the 35delG mutations across Europe

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Congenital hearing loss is a major health problem all over the world affecting 1 in 1000 of the newborns. Approximately one third of the congenital deafness is due to the mutations in GJB2 gene, one single mutation - 35delG - being responsible for the majority (70%) of GJB2 related deafness in Europe. A medical literature research on PubMed using keywords:"35delG","GJB2" and "carrier" was done. Data from 29 European countries were obtained including 25422 healthy random choose individuals from which 517 were 35delG carriers. The mean carrier frequency of 35delG for Europe was 2.1%. In the East part of the Europe we found a rate of 35delG carriers higher (Estonia - 4.5%, Belarus -5.73%) or at least similar (Ukraine - 3.3%, Romania - 3.38%) with those found for the South of Europe (Greece being considered until now the country with the highest carrier frequency in the world - 3,54%). We found also that the highest carrier rate of 35delG mutation was in Belarus (5,73%).The lower carriers frequencies were found in countries from North (Norway - 0.52%, Sweden - 1.51%), Central (Austria - 1.3%, Slovenia - 0.55%, Bulgaria 0.64%) and West of Europe (UK 1.34%). Our study confirm once more the south-to-north gradient in the carrier frequency of 35delG in Europe and brings in the attention the East part of the Europe where was found a rate of mutation at least similar with that found in the South suggesting an east-to-west European gradient.

S43-4

Audiological profile of patients with the mutation m.A1555G

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Many commonly used medications may be in a transient and reversible, or permanent adverse effect on the ear in humans. It is believed that some aminoglycoside antibiotics can damage the inner ear sensory epithelium. In case of ototoxic aminoglycosides (e.g. gentamicin, amikin, streptomycin) causing the damage to the bacterial ribosome, mitochondrial ribosome may be destroyed because of its similarity to the bacterial ribosome. Susceptibility to such antibiotics action is passed in the maternal line, indicating the mitochondrial type of inheritance.

Many mutations in the mitochondrial genes 12S rRNA and tRNASer related to "aminoglycoside" hearing loss were described. One of them is m.A1555G mutation which occurs in a highly conserved region of 12SrRNA molecule, leading to reduced production of ATP in the cells of the cochlea.

The aim of this study was to assess the level of hearing loss among patients with the mutation m.A1555G.

We studied a group of 1933 patients of the Institute of Physiology and Pathology of Hearing for the presence of mutation m.A1555G using RealTime PCR technology. In the studied group 25 patients with this mutation were found.

S43-5

The prevalence of GJB2 mutations in a large Western European cochlear implant program

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Sensorineural hearing loss is the most common congenital sensory deficit in humans. It is estimated that between 1 and 5 newborns worldwide are affected by congenital hearing gloss, with 50-70% of these having a monogenetic cause. The gene GJB2 produces the gap junction protein, connexin 26, and is believed to responsible for up to 63% of cases of autosomal recessive hereditary hearing loss in some populations. The prevalence reported in the literature runs the gambit from approximately 10% to nearly 40%, varying with regard to geographic region, and more importantly, the ages of the patients tested. Comparatively few reports on the frequency of GJB2 pathologies in hearing impaired patients in Western Europe have been published to date. Our study examined the prevalence of mutations in the GJB2 gene in a large cochlear implant program at a tertiary referral center in northern Germany. Our cohort was comprised of 457 patients ranging in age from 5 months to 95 years with varying degrees of hearing loss, but overwhelmingly consisting of patients who were eventually implanted. The prevalence of pathologic homozygotes or compound heterozygotes in the total collective was found to be 12%. When the subset of younger patients, aged up to 30 years, were examined, we found a prevalence of 22.9%. Our data show that mutations in the GJB2 gene are a major cause of hearing loss in young persons in Western Europe.

S43-6

Whole- exome sequencing and linkage analysis to identify a novel N714H mutation in WFS1 gene associated with autosomal dominant hearing loss

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Hearing loss (HI) is a significant medical problem in Poland and worldwide, occurring in 1 of every 500 newborns. The cause of hearing loss can be genetic or environmental. Currently the background of genetic hearing impairment is an area of intensive research conducted by many groups. Because of more than 40 genes involved in pathogenesis of nonsyndromic hearing loss, it is also an extremely heterogeneous trait. The most common variants responsible for an isolated recessive HI are mutations in the *GJB2* gene, but there is no single gene accounts for the majority of cases of autosomal dominant (AD) HI. To date, more than 60 loci of ADHI were mapped, but particular genes were identified for only 25. However mutations in 4 of these genes (*WFS1, KCNQ4, COCH,* and *GJB)* are more frequent as a causes of ADHI in comparison to the other.

For searching the reason of HI among family members with AD pattern of inheritance, we performed linkage analysis using Affy 10K chip and exome sequencing on Illumina platform. Data analysis revealed novel N714H mutation in WFS1 gene as a plausible reason for HI. Direct sequencing of fragment of 8th exone of WFS1 gene showed perfect co-segregation between N714H mutation and HI among members of this family. N714H mutation is localized in exon 8, which contains the conserved C-terminal domain. Considering fact that the majority of deafness causing mutations have been identified particularly in exon 8, this domain seems to have a crucial function in the cochlea.

S43-7

Postlingual late-onset hearing loss as a m.3243A>G mutation phenotype

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Mitochondrial encephalomyopathy, lactic acidosis and strokelike episodes- MELAS, is one of several mitochondrial diseases. Clinical features also may include: short stature, seizures, episodic vomiting, sensorineural hearing loss and others. Symptom onset can occur protean, also incomplete or milder phenotypes are recognized.

We studied 1478 Polish subject recruited from a consecutive cohort of 7000 treated at the Institute of Physiology and Pathology of Hearing between 2000 and 2010. Patients were unrelated and suffered from nonsyndromic, postlingual, bilateral sensorineural HI ranging from mild to profound. All individuals were previously tested for the presence of common GJB2/GJB6 mutations.

Searching for the mutation A3243G was performed using different molecular techniques (direct sequencing, RealTime TaqMan Assay, PCR-RFLP, dHPLC). MELAS mutation was found in 15 unrelated patients. Tests were conducted also in their family members, among whom another 13 cases of MELAS were found. Molecular tests were performed on DNA samples isolated from blood leukocytes, buccal swabs, hair follicles, urine sediment cells and nails. In our group of MELAS patients A3243G mutation ratio is significantly higher in urine than in blood and other type of material. Measurement of A3243G mutation ratio in urine is a non-invasive, convenient and rapid method with its diagnostic meaning superior to blood testing. Direct sequencing might not be sufficiently sensitive method for detecting A3243G mutation.

S43-8

Identification of novel functional null allele of SLC26A4 associated with enlarged vestibular aqueduct and its possible implication for future drug therapy

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Introduction: Mutations in the SLC26A4 gene, which encodes pendrin, cause congenital hearing loss as a manifestation of - Pendred syndrome‖ (PS) with an iodide organification defect or - non-syndromic enlarged vestibular aqueduct‖ (NSEVA, DFNB4). There have been reports of differences between PS and NSEVA, including their auditory phenotypes and molecular genetic bases. For appropriate genetic diagnosis and counseling, it is important to functionally characterize SLC26A4 variants. In this study, we identified and evaluated a novel null mutation of SLC26A4, and report our method of assessing the pathogenic potential of mutations in SLC26A4, one of the most frequent causative genes of deafness in humans.

Material and methods: A 3-year-old female with progressive sensorineural hearing loss and her parents were recruited. They underwent clinical, audiological, radiological, and genetic evaluations, which revealed that the female patient had EVA and an incomplete partition type II anomaly in the cochlea bilaterally. Sanger sequencing of the SLC26A4 gene was also performed. For a confirmatory genetic diagnosis, we first characterized the anion/baseexchange ability of mutant pendrin products in HEK 293 cells and, if necessary, evaluated whether the mutant pendrin traffics to the plasma membrane in COS-7 cells. We also expressed a null-function mutant, p.H723R, and a previously documented polymorphism, p.P542R, as controls.

Results: The pure tone average was 66 dB HL in the right ear and 75 dB HL in the left ear. Sequencing of SLC26A4 revealed a known pathogenic mutation (p.H723R) and a novel missense variant (p.V510D) as a compound heterozygote. When we expressed the p.V510D mutant pendrin in mammalian cells, the rate constants for Cl-/HCO3- exchange were 10.96±4.79% compared with those of wild-type pendrin. This figure was comparable to that of p.H723R, indicating p.V510D to be another pathogenic mutation with a null function. The p.V510D pendrin product was shown to be entrapped in the ER at 24-30 h after transfection, and not trafficked to the plasma membrane in COS-7 cells, suggesting retention in the ER and abnormal trafficking as the pathogenic mechanism. This was similar to p.H723R, which is a null function founder mutant in this population but is a candidate variant for future drug therapy to rescue the abnormal cell trafficking.

Conclusions: Impaired cellular trafficking due to ER retention and abolished exchange activity of the newly detected p.V510D indicates the pathogenic potential of this variant. These missense variants may be a good candidate variant for drug therapy if the intrinsic exchange activity is not damaged by the change.

S43-10

Generating induced neurons from cochlear cells to replace lost or damaged auditory neurons in the mammalian inner ear

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Primary auditory neurons (spiral ganglion neurons) in the mammalian cochlea play a critical role in hearing as they transmit sound information in the form of electrical signals from mechanosensory hair cells in the inner ear to the brainstem. Similar to most other neurons, once lost, auditory neurons do not regenerate. While their loss has been considered secondary to hair cell loss, an increasing body of evidence clearly indicates that auditory neurons can degenerate as a result of noise exposure and aging while hair cells remain intact. Thus, auditory neurons are a primary target for regeneration, and replacement therapy would have significant impact on research and advancement in cochlear implants and the amelioration of hearing impairment.

We have utilized two target endogenous cell populations in the cochlea for neuronal induction: non-sensory epithelial cells and spiral ganglion glial cells in the mouse cochlea. We have used neurogenic transcription factors known to be required for the generation and survival of auditory neurons (*Neurog*1, *Sox2*, *NeuroD1*) as well as other neurogenic transcription factors (*Ascl1*, *Brn2*, *Nurr1*, *Neurog2*) known to directly reprogram cells and induce neurons in several other systems. Overexpression of these factors in the endogenous cell populations induced neurons at high efficiency at embryonic, postnatal and juvenile stages. The induced neurons expressed neuronal markers (bIII-tubulin, MAP2), synaptic proteins (Synapsin I, SNAP 25), and were electrophysiologically functional capable of producing action potentials.

Our data indicate that overexpression of neurogenic transcription factors is sufficient to re-program non-sensory epithelial cells and spiral ganglion glial cells into functional neurons. As gene therapy is emerging as a viable treatment for hearing impairment, our future investigations will continue to focus on converting spiral ganglion glial cells into neurons. We will investigate combinatorial transcription factors and extrinsic factors such as brain-derived neurotrophic factor and neurotrophin-3 that induce phenotypes that resemble auditory neurons. Furthermore, we will examine connectivity to hair cells and cochlear implants in the periphery and cochlear nucleus neurons in the central nervous system. These studies will be carried out *in vitro* initially then *in vivo* utilizing a neuropathy mouse model.

S43-11

BDNF gene therapy rescues auditory neurons in connexin 26 null mice

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Intro: Sensorineural hearing loss due to mutations in the connexin 26 gene (*GJB2*) is common in several populations. The typical treatment is cochlear implantation, which is successful party due to adequate preservation of the neurons. In some cases, however, patients experience progressive deterioration in residual hearing and cochlear implant function.

We generated a mouse model for a connexin 26 (Cx26) mutation, in which cre-Sox10 drives excision of the Cx26 gene from supporting cells of the auditory epithelium. These conditional knockout mice, designated *Gjb2-CKO*, have severe hearing loss at P28 and their auditory epithelium and neurons degenerate rapidly over the first few months of life. The goal of the experiments was to determine if BDNF gene therapy can rescue hair cells, supporting cells or auditory nerve cells from degeneration.

Methods: To elevate levels of BDNF in the cochlear fluids, an adenovirus with the *BDNF* gene insert (Ad.*BDNF)* was injected into the cochlea at 1 month of age. The viral vector was injected either into the scala media endolymph or scala tympani perilymph at the cochlear base. One month later, when mice were 2 months old, ears were obtained for histology. They were embedded in plastic, sectioned, and analyzed with light microscopy.

Results: Loss of hair cells was noted with highest severity in the basal turn and gradually lower severity towards the apex. Spiral ganglion neuron density in Rosenthal's canal was also reduced, in a gradient from the base (most severe) to the apex of the cochlea. In control ears (mutants that did not receive Ad.*BDNF*) the base of the cochlea was nearly completely devoid of neurons. In contrast, Ad.*BDNF* treatment rescued auditory neurons in the basal cochlear turn. Ad.*BDNF* had no protective effect on the organ of Corti, where the auditory epithelium became flat in the base of the cochlea.

Discussion: In Cx26 null mice there are degenerative changes in the epithelial cells of the organ of Corti and in the auditory nerve. In both structures, degeneration progresses from base to apex. Ad.*BDNF* gene therapy via the scala media or scala tympani rescues SGNs in the base of the cochlea but has no influence on survival of hair cells or differentiated supporting cells.

Conclusion: Gene therapy can be used to enhance the preservation of neuronal structures in ears that are candidates for cochlear implantation

Funding: Hirschfield Foundation and NIH/NIDCD grants R01-DC011835 and P30 DC-05188.

S43-12

New mutations in the gene for otoferlin (OTOF) in Argentinean patients with cochlear implants and auditory neuropathy

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Introduction: Neurosensorial Hearing loss Nonsyndromic autosomal recessive (NSSHL) is a heterogeneous condition for which have been reported to date 40 142 loci and recessive genes. One of these genes, OTOF, DFNB9 locus, encodes otoferlin, intracytoplasmatic binding protein calcium, which is involved in exocytosis synaptic vesicles in the inner hair cells in the cochlea. OTOF mutations are the cause of hereditary Auditory Neuropathy.

Material and methods: Thirty Argentinen families with NSSHL for the mutation p.Gln829X were studied. This implies analyzing the 48 exons + UTRs (untranslation regions). These patients comprise the cohort of a multicenter study by Spain, Colombia and Argentina.

Result: Only four of the thirty Argentine families, showed mutations in the gene OTOF. Three of them are heterozygous compounds: two compound heterozygous for mutations

p.Gln829X/c.2905_2923delinsCTCCGAGCGCA and one compound for c.4227 +1 G> T/c.2905_2923delinsCTCCGAGCGCA heterozygous. A family with three deaf children from the same cohort, was homozygous for the mutation c.4227 +1 G> T/c.4227 +1 G> T.

The latter two (c.4227 +1 G> T / c.2905_2923delinsCTCCGAGCGCA), new pathogenic mutations were not reported until now in the literature. Mutation c.4227 +1 G > T resulting from a change in the splicing site of attachment of exon / intron 35, while the mutation is an insertion c.2905_2923delinsCTCCGAGCGCA deletion in exon 25. Haplotype analysis for markers linked to the gene OTOF suggests a founder effect for the novel mutation c.2905_2923delinsCTCCGAGCGCA

Five patients were cochlear implanted ,and 3 of them are brothers who inherited the new homozygous mutation (c.4227 +1 G> T/c.4227 +1 G> T).

Conclusion: These results confirm that mutations in the gene OTOF correlated with non-syndromic, prelingual and profound sensorineural deafness, and further suggest that these mutations are the major cause of hereditary auditory neuropathy, so genetic diagnosis in these individuals should be directed to OTOF gene. In the implanted patients were observed in audiological tests good hearing thresholds and moderate to good performance in disyllabic and tri-syllabic words discrimination, in direct relation to the time of use of the device and the quality of rehabilitation performed.

Keywords: Hearing loss; DFNB9; OTOF; otoferlin; Auditory Neuropathy CI cochlear implant.

S43-13

Neurotrophin gene therapy in deaf ears: correlating neuronal survival and re-sprouting with the condition of the auditory epithelium

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Intro: Cochlear implants (CI) rehabilitate hearing by directly stimulating the remnant auditory neural structures. However, regression of peripheral auditory fibers (PAFs) and loss of spiral ganglion neurons (SGNs), which sometimes occur after hair cell loss, may decrease the functional benefits from the CI stimulation. Enhanced survival of remnant auditory neural structures, which may lead to improved CI outcomes, can be accomplished by neurotrophin therapy. BDNF and NT3 have been shown to enhance SGN survival and induce PAF regrowth following deafening in animal models. The goal of these experiments was to compare the effects of BDNF or NT3 on adult guinea pig ears deafened systemically with kanamycin and furosemide or locally with neomycin.

Methods: Young adult guinea pigs were deafened by either local administration of neomycin into the cochlea or systemic administration of kanamycin and furosemide. Adeno-associated viral (AAV) vectors with the *BDNF* or *NTF-3* gene inserts were delivered to the guinea pig inner ear one week following deafening. Animals were sacrificed three months following the treatment. Some ears were processed as whole mounts to assess the extent and pattern of PAF regrowth. The remaining ears were embedded in plastic and sectioned to assess SGN somata survival in Rosenthal's canal.

Results: There was no significant difference between the two neurotrophin treatment groups in the number of re-grown PAFs in the basilar membrane area, under either of the deafening methods. In systemically deafened animals, some areas of the auditory epithelium displayed differentiated supporting cells and other areas had a flat epithelium. There was a negative correlation between the presence of re-grown PAFs and the presence of differentiated supporting cells. In neomycin deafened ears, BDNF had significantly more SGNs in the basal turn as compared to NT3 treated or untreated neomycin deafened control ears. SGN survival with NT treatment appeared variable. Higher cochlear turns were not assessed due to occasional presence of surviving hair cells.

Discussion: Gene therapy with either *BDNF* or *NTF-3* leads to PAF re-growth, and treatment with *BDNF* leads to enhanced SGN survival. Through these effects on PAF and SGN survival, neurotrophins may lead to improved CI outcomes. The extent of SGN survival was lower than that seen in previous studies using adenovirus gene therapy, possibly due to the delay in the onset of gene expression with AAVs used here. The presence of supporting cells may inhibit PAF regeneration into the basilar membrane area.

Conclusion: Therapeutic means for changing the cochlea can influence the biological substrate in the implanted ear.

Support: MED-EL, The University of Michigan Center for Organogenesis and NIH/NIDCD grants DC-010412, T32 DC-005356, and P30 DC-05188.

S43-14

Study of genetic background of hearing loss among group polish CI patients

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Hearing loss (HI) is a significant medical problem in Poland and worldwide. The cause of hearing loss can be genetic or environmental. Currently the background of genetic hearing impairment is an area of intensive research conducted by many groups. Recently worldwide intensive studies are conducted to clarify the genetic basis of hearing loss. To date, more than 60 non-syndromic deafness genes and more than 1000 deafness-causing mutations have been described. The most common variants responsible for an isolated HI with recessive type of inheritance are mutations in the *GJB2* gene (in particular the deletion of guanine at position 35 (35delG)) and therefore the search for genetic basis of hearing loss for diagnostic purposes usually includes only analysis of *GJB2* gene, whereas mutations in each of the remaining genes associated with the process of hearing which can also cause hearing loss are not investigated.

According to the preliminary functional analysis, pathologic changes (caused by mutations of GJB2 and GJB6 genes) did not comprise spiral ganglion cells, which are crucial for the results of cochlear implantation.

The aim of our study was to estimate the prevalence of genetically related HI among patients with cochlear implants (CI). We have analyzed 1218 patients diagnosed with congenital hearing loss who received CI. Search for mutations was performed by various molecular methods. Our results shows that genetic defects of various genes are the most common reason of HI among patients with cochlear implants.

S44 Support & aftercare in assistive listening devices growing populations

S44-3

Cochlear implantation-what it takes to sustain & maintain?

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Introduction: This study aims to investigate the costs associated with cochlear implantation in India by means of a phone survey, including not only the costs of procuring the implant but also the costs associated with maintaining the device post-surgery.

Methods: A structured telephonic interview was administered to parents of pediatric recipients or recipients themselves (>18 years old).The interview was divided into 4 sections. 1.Demographic data 2.Costs related to procuring the implant, surgery and post-operative audiology and therapy 3.Costs associated with maintaining the device 4.Satisfaction and planning for future expenditure. This interview was performed at. Hinduja Hospital,Mumbai,India by an audiologist & took about 20 minutes to complete.100 randomly selected recipients implanted between 1996-2007 were taken. A cut-off date of 2007 was applied to restrict data collection to recipients with at least 5 years of device usage & therefore out of warranty for their external device.

Results: Out of the 100 very few were completely self-funded, rest were either completely or partially funded through loans, mortgages, employer/company assisted, individual donors or with financial assistance from relatives and friends. Other costs borne by the recipients for audiological, radiological tests, hearing aid trial & training, surgery, mapping & habilitation (3 years post surgery), upgrades, batteries & chargers, coils & cables, microphones & servicing & repair of processors was found out. The total average expenditure borne by a recipient, excluding the cost of implant and surgery was found to be Rs.4,60,586(US $7489).

Discussion: In our experience we have found that many patients obtain sufficient funding for the initial device and surgery, but forget to consider the ongoing expenditure post-implantation.

Conclusion: These results will enable us to counsel patients about the expected expenditure from pre-operative to post-implant management. Clinicians clinics,patients,Government departments & donating agencies should understand the long term expenses related to implantation. This information should help families to budget the total expense not just for a CI surgery but also post implant mapping, therapy, servicing of implant, maintenance of device, as well as to upgrade their device when new technology is available. This is particularly crucial in a self-funded market and/or when the average wage is low in relation to the cost of intervention.

Learning outcome: As a cochlear implant is a lifelong commitment, patients must also be able to maintain the device post-implantation & be counseled on appropriate maintenance & post-operative costs in addition to the costs of the initial implant procedure. Hence this survey aimed to collect data on actual costs and breakdown of these costs incurred by recipients/families in the 5 or more years since their surgery.

This information will be vital to counsel current and future recipients and to allow them to budget appropriately.

S44-4

HELP! My sound processor does not work: Cochlear Connect, a new technology to enhance service support

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Cochlear implants have shown to provide great improvement in the quality of life of cochlear implant recipients. Because of this recipients are highly dependent on their implants. Any disruption in sound perception through their implant can be devastating. It is important to ensure that each recipient receives the best possible outcome with their cochlear implant with no discontinuity in sound perception.

Currently, Cochlear along with many service partners offer direct support to recipients where a recipient can contact the support centre and get advice on troubleshooting of their device. This relieves the clinician from spending time on performing troubleshooting activities and lets them focus on their core capability of fitting, evaluating etc. This is also great benefit for the recipients as they can get greater access for troubleshooting support and quicker resolution for the issues. When the troubleshooting requires replacement of parts like the battery, cable or coil the service centre is able to send the part direct to the recipient. However, when a sound processor needs to be replaced, then the service centre needs to obtain the maps for the recipient from the CI clinic. This often requires the clinic to email the recipient's CDX file to the service centre.

Cochlear Connect is a new technology developed by cochlear that enables automatic exchange of data from the clinic to Cochlear so that when a replacement processor is required to be sent by the service centre, the latest maps for the recipient can be obtained instantaneously. Cochlear Connect synchronizes the database at the clinic and sends it to a secure server that can be accessed by Cochlear. Due to the connectivity to Cochlear's systems Cochlear Connect can also in future enable other services like automatic registration of implants and sound processors and also enable automatic data sharing between clinics for clinics performing remote programming or with Hub spoke setup. The presentation will cover the technology involved in Cochlear Connect and explore the potential applications of this technology in future to enhance clinical care. Preliminary experience with Cochlear Connect at few CI clinics with regard to the impact for recipients and clinical efficiency will be discussed.

S44-6

Wireless, portable, paediatric cochlear implant fitting via the Nucleus Remote Assistant: Transforming service delivery

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Intro: This presentation reviews over 6 months of experience using Remote Assistant Fitting in a clinical setting. The usage, opportunities and clinical implications of wireless fitting have been studied in detail.

Methods: The hand-held, wireless cochlear implant fitting tool was used with a diverse group of paediatric clients in a day-to-day specialist paediatric setting. Children were at different stages of their CI journey when the fitting tool was used ranging from initial activation right through to many years after activation. Fitting with the mobile, wireless platform was closely monitored via regular Auditory-Verbal Therapy sessions with a trained Listening and Spoken Language Specialist, or via the client's own feedback for teenagers.

Results: Clinical guidelines for the appropriate use of wireless fitting were extrapolated from this early experience and are currently being further refined as they are implemented in the clinic and various other settings. These guidelines will be reviewed in detail in the presentation.

Conclusion: Fitting with the mobile, wireless platform provides the opportunity for a variety of clients to have greater comfort, flexibility and speed during fitting sessions. For the clinicians involved, greater emphasis can be placed on the functional use of the child's listening and working directly with the family to improve this, rather than the technical, prescriptive and rigid nature of traditional programming sessions. Clinicians can also spend a greater amount of clinical time with more complex clients using standard programming tools. Overall, the wireless platform allows the greatest opportunity to date for the professionals working with children with CIs to be client and family-centered in the provision of CI services.

Learning outcomes: Participants will develop an understanding of the benefits of wireless programming for remote and face-to-face appointments for experienced inexperienced clinicians and recipients and review the experiences of a specialist paediatric setting in using this new approach.

S46 Bimodal hearing

S46-2

Benefit of a CROS device for unilateral cochlear implant users

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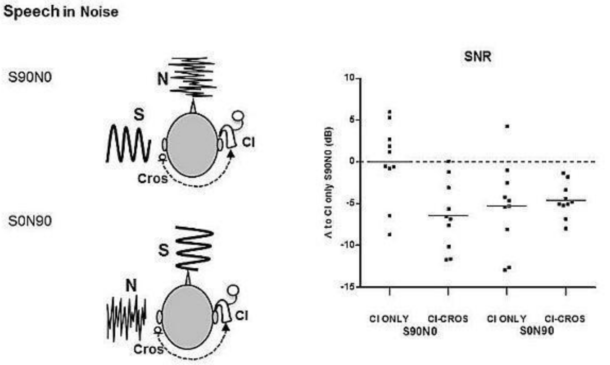
Objective: Investigate objective and subjective effects of an adjunctive CROS device at the untreated ear in patients with a unilateral Cochlear implant (CI). The CROS device submits microphone signals from the untreated ear to the opposite CI.

Design: The prospective study included 10 adult experienced unilateral CI users with bilateral severe-to-profound hearing loss. All of them were using the same CI processor (OPUS2, Medel). Speech in noise reception and sound localization was measured with and without the additional CROS device (Croslink Receiver CRX, Phonak). Speech in noise was measured by applying speech signals at the untreated i.e. CROS side while noise signals came from the front (S90N0). For the setting S0N90 signal sources were switched. Sound localization was measured in a 12-loudspeaker full circle setup with 30° between each loudspeaker. To evaluate the subjective benefit, patients tried the device for two weeks at home. Afterwards they filled out the abbreviated Speech, Spatial and Qualities of Hearing Scale as well as the Bern benefit in single-sided deafness questionnaires [1,2].

Results: In setting S90N0 all patients showed a highly significant SNR improvement when wearing the additional CROS device (mean 6.4dB, p< 0.001). In the unfavorable setting S0N90 there was no deterioration of speech understanding (p=0.54).



[Speech in Noise]

Sound localization did not improve substantially with the CROS. Subjectively the hearing effort was significantly reduced using the CROS device (p=0.048). Other questionnaire items did not show significant differences.

Conclusion: Patients with one CI profit from an additional CROS device particularly in noisy environment when speech comes from the CROS ear side.

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S46-4

Listening effort in bimodal cochlear implant users

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The quality of a speech signal can be affected in many stages along the way from production to comprehension. For cochlear implant (CI) users, speech perception is also affected by factors related to the implant; the limited number of electrodes, the electrode-nerve interface, and front end processing. This results in a signal with relatively poor spectral resolution and temporal fine structure, leading, e.g., to the poor pitch perception often observed in CI users. Despite these limitations, many CI users can understand speech quite well. However, even if speech heard through a CI can be fully comprehended, the reduced quality is not without cost. Degradations of the signal impose an increased load on the cognitive system when trying to interpret the speech.

The cognitive load of interpreting an incoming auditory signal is referred to as listening effort. Assume cognitive resources are limited and shared across tasks, then effort expended on a task is defined as the proportion of limited resources required to perform the task. Increased listening effort results in reduced cognitive resources available for concurrent tasks and can lead to problems with, e.g., selective or divided attention, verbal short-term memory, or even long-term memory. The CI user may, for example, be able to extract the meaning of speech, but have difficulties retaining the meaning. This illustrates the importance of listening effort and why it should be optimized for CI users.

CI users with residual hearing can benefit from the acoustic signal, which can provide additional spectral and temporal information to complement the electric signal of the CI. Bimoadal hearing, i.e. a hearing aid (HA) combined with a CI, has been shown to improve speech understanding in noisy conditions. However, even without improved intelligibility, there may be benefits in listening effort. Prior research has shown, in normal hearing listeners presented with simulated CI speech, that simulated bimodal hearing can result in reduced listening effort compared to simulated CI alone, even for unchanged intelligibility.

We hypothesize that the improved signal quality due to the added acoustic signal in bimodal hearing reduces the load on the cognitive system when interpreting the speech, resulting in reduced listening effort. The current project investigates whether bimodal hearing reduces listening effort for CI users, specifically in situations where no intelligibility benefit is observed. This line of research will provide a deeper understanding of listening effort in CI users, and development of tools for its quantification and new potential strategies for its optimization.

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S46-6

Preliminary results of a bimodal fitting formula

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Intro: A new fitting formula designed for bimodal fitting has been developed and shall be launched as a new feature in the Phonak Target fitting software. Before implementation, the current version of the Bimodal Formula was evaluated and optimized in a field test with professionals who regularly see bimodal patients.

Methods: The primary goal was to compare the new fitting formula with the default Phonak fitting formula in 10 CI (AB) recipients with contralateral hearing. The testing consisted of audiometry, spectral discrimination and speech audiometry in quiet and in noise. Also the sound quality and subjective preference were investigated.

Results: Free field audiometry yielded better thresholds with bimodal stimulation than with either acoustic or electric stimulation alone. The new fitting formula yielded better thresholds in the low frequencies. The new formula improved the spectral discrimination in the low frequencies. Speech audiometry in quiet and in noise was not improved on average. It was noteworthy that patients who did not benefit from the new formula showed significantly higher indications of hydrops.

Discussion: The addition of acoustic stimulation to electrical stimulation mainly aims at adding low frequency temporal finestructure (TFS). This would be complimentary to electrical stimulation only which intrinsically fails in conveying this information. The presence of serviceable low frequency thresholds however does not guarantee a good capacity to code for TFS. It may be beneficial to measure the capacity for TFS coding in residual hearing to predict the benefit of acoustical stimulation in both bimodal and hybrid stimulation.

Conclusion: The hearing aid new fitting formula for bimodal stimulation may be beneficial in CI recipients who still have residual TFS coding capacity in the contralateral ear. In the absence of such capacity, bimodal stimulation may not be beneficial.

Learning outcome: to understand the distinction between low frequency thresholds and low frequency TFS coding; to consider low frequency TFS coding as a predictor of benefit of bimodal stimulation.

S46-7

Optimization of a bimodal fitting formula

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Introduction: CI users with a contralateral hearing aid often report improved speech understanding, particularly in noisy situations, better sound quality and improved lateralization of sound sources. The individual bimodal benefit, however, varies considerably. A potential reason for this is that conventional hearing aid fitting does not account for certain specific characteristics of bimodal listening. Of particular importance are: low-frequency audibility, spectral overlap of electric and acoustic stimulation, loudness balance and (dynamic) synchronization of adaptive signal processing. In order to improve the efficiency of bimodal fitting, a bimodal fitting formula has been developed that aims at accounting for the specific characteristics of bimodal listening. A first version of this formula has been successfully evaluated in two clinical studies with typical bimodal users with sloping profound hearing loss. Compared to standard hearing aid fitting formulae, the Bimodal Fitting Formula (1) maximizes low frequency-audibility, (2) minimizes spectral overlap and (3) aligns static and dynamic behavior of electric and acoustic AGC systems.

Method: In order to further evaluate and optimize this novel fitting formula, a field trial with hearing aid dispensers who regularly see bimodal patients has been conducted in Belgium, France and Germany. In contrast to previous studies, a large variety of hearing loss configurations (flat, reverse, moderate-severe) was included. The primary goal was to compare the new fitting formula with the default Phonak fitting formula (“Adaptive Phonak Digital”). Outcome measures included speech understanding, sound quality ratings and subjective preference. Secondary goal was to investigate how much additional fine-tuning was necessary for individual optimization and whether further optimization of the prescription algorithm could reduce the amount of fine-tuning. Testing comprised two sessions and one home trial. Audiologists were instructed to apply the fitting formula within their routine fitting workflow and their clinical test methods (e.g. local speech test, questionnaires) were used.

Results: The majority of the subjects preferred the new bimodal formula when compared to the default Phonak formula. Fine-tuning was minimal for sloping profound losses; for other hearing loss configurations (e.g. reverse loss, flat moderate-to-severe), however, sometimes modifications towards standard fitting formulae were required. Based on these findings a new version of the bimodal fitting formula has been developed and is currently being evaluated in complementary studies.

Conclusion: The new bimodal fitting formula which respects the special demands of bimodal hearing like low-frequency audibility, spectral overlap and dynamic synchronization was preferred by subjects compared to a standard hearing aid fitting formula.

S46-8

Cochlear implantation in adults with asymmetric sensorineural hearing loss

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Intro: Cochlear implantation has become a standard treatment for patients with bilateral severe- to profound hearing loss. In the Netherlands the criteria for a cochlear implant (CI) in adults have changed over the years. At the moment adults with speech recognition scores below 50% in the best hearing ear are candidates for cochlear implantation. Speech recognition is tested in quiet, in the best aided situation and using short meaningful words. Due to these criteria and the way of testing, patients with a functionally deaf ear and moderate-to-severe sensorineural hearing loss in their contralateral ear are not standard candidates for cochlear implantation. However, these patients would very likely benefit from a CI in their deaf ear for speech recognition in noise, localization abilities and probably music perception. This study aimed to investigate the benefits of cochlear implantation in this group of patients with asymmetric sensorineural hearing loss.

Methods: Patients were enrolled if they demonstrated best aided speech recognition scores of < 30% in their worst ear and 60-85% in their better ear. Patients had to be older than 18, all had post-lingual onset of their hearing loss and less than 20 years of audiological deprivation. Patients were evaluated with their CI alone, their hearing aid alone and with both CI and hearing aid (i.e., bimodal stimulation). Evaluations were made preoperatively and at 3, 6 and 12 months after cochlear implantation. The test-protocol included: speech recognition in quiet, speech recognition in noise, spatial speech recognition in noise, sound localisation, music perception and quality of life questionnaires.

Results: Seven patients participated in this study and received an Advanced Bionics cochlear implant in their functionally deaf ear. The preliminary study results will be presented. In all patients, cochlear implantation resulted in a significant increase in speech recognition of the implanted ear. Measurements at different time intervals after cochlear implantation illustrate the improvement in speech recognition over time.

Conclusion: The preliminary results of this study suggest that cochlear implantation is a successful method to rehabilitate subjects with asymmetric sensorineural hearing loss. It seems that the current criteria for CI are too stringent and are not appropriate for patients with asymmetrical hearing loss.

S46-9

Benefits of bimodal hearing in adolescents and adults with pre-lingual deafness after MED-EL cochlear implant

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Introduction: Adolescents and adults with pre-lingual deafness, despite the restricted indication for cochlear implants (CI) and limited results, can benefit from this surgery. Furthermore, in the presence of usable residual hearing in the contra lateral ear, bilateral stimulation can be achieved with bilateral-bimodal fitting - cochlear implant (CI) in one ear and hearing aid (HA) in the other ear.

Objective: Evaluate improvement in speech perception in adolescents and adults with pre-lingual deafness after cochlear implantation and evaluate the benefits of bimodal fitting in this group of patients.

Patients and methods: Seventeen adolescents and adults with pre-lingual deafness that underwent cochlear implant and who used HA in the contralateral ear were evaluated. They were tested for speech perception preoperatively and postoperatively with CI alone and CI associated with HA.

We also evaluated improves in own speech, lip reading and the advantages of the use of HA associated to CI in understanding in noise, in location of sound source and perception of better sound quality.

Results: Significant improvement in speech perception was measured after cochlear implant surgery either with CI as with CI and hearing aids. Bimodal fitting showed better results with statistical significance for most of the speech perception tests performed compared to the isolated use of cochlear implants.

There was improvement of the lip reading and speech quality, and also in understanding in noise and sound localization ability.

Conclusion: Adults and adolescents with pre lingual deafness benefit from cochlear implant when subjected to appropriate selection criteria. This group also benefit from bimodal hearing.

S47 Outcomes in adults

S47-2

Cochlear implant outcomes in the geriatric population

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Intro: Severe hearing loss is a common presenting complaint in the elderly population. In the United States of the 40.3 million people 65 years and older, approximately 500,000 have severe to profound hearing loss. Advanced hearing loss is associated with significant psychological disturbances, social handicaps and reductions in mental and physical functioning in the elderly. Whether cochlear implantation can address these concerns for elderly patients merits further investigation. Cochlear implantation in this group of candidates should be seriously considered in light of the severity of impairments it places on this demographic. Despite the popularity of this procedure it remains controversial in the elderly population due to surgical risk and uncertainty of benefit.

Methods: Postoperative clinical and audiologic data extraction from the medical record. Audiologic preoperative and postoperative evaluation consisted of speech recognition scores (CNC, AzBio and HINT scores). Each patient had at least a 6 month post implant evaluation included in study. Complications were retrospectively collected after each cochlear implantation.

Results: Of the 102 patients, 67 (65.7%) were female and 35 (34.3%) were male. The average age of the patients was 73 (range of 65-92 years at age of implantation). Patients in this study experienced a significant improvement in audiologic performance as seen with speech recognition scores ($p < 0.0019$). The mean speech recognition score post-implant was 71% (at 6 months) at 50dB compared to average pre-implantation unaided score of 16%. There were very few surgical complications (no wound dehiscence, hematoma, seroma or infection), but 16 patients had minor post-operative complications (vertigo, tinnitus, and hyperacusis). One patient had the implant removed and was re-implanted due to recall from company.

Conclusion: This is one of the most extensive studies on hearing outcomes for patients aged 65 years and older who received a cochlear implant. The audiologic benefit in this population is clearly demonstrated. It is a well-tolerated surgery in this population with relatively low risk.

Learning outcome: Cochlear implantation in the geriatric population is relatively low risk with significant audiological benefit.

S47-3

The quality of life after cochlear implantation in adults

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Introduction: An assessment of trends in current clinical practices revealed that there is a published evidence of clinically observed benefits from the use of implanted devices providing various types of stimulation in hearing impaired patients. However, the reported data shows wide disparity in clinical experience, clinical practices and the subsequent outcomes. Evident is a distinct lack of patient-related data gathered for prospectively implanted patients including true baseline interval data and subsequent longitudinal follow-up at consistently timed evaluation intervals. International multicenter initiative was undertaken with the aim to prospectively, longitudinally compare repeated measures of benefits for implanted hearing-impaired subjects, acting as their own intra-subject control, using the subjective evaluation tools provided via an electronic platform for data entry within a secured environment.

Methodology: Evaluations at baseline and annual follow-up for up to 3 years after implantation. Evaluation tools include subjective self-assessment scales (clinically standardized: SSQ - Speech Spatial Qualities of Hearing and HUI Mk III - Health Utility Index Mark 3), patient profile forms, as well as the hearing threshold measures. Patients were included in the study 4 weeks after the surgery, but prior to the first switch on session.

Results: This is to present the single centre results inclusive preliminary demographic, epidemiological and the self-assessment data from the baseline and follow up evaluation of the adults patients with the cochlear implant prospectively included in the study since October 2012. There are 27 patients implanted with cochlear implant entered into the study. There are 12 females and 15 males in the average age of 48 years (min 17, max 80). In this group there are 10 subjects over 60 years of old. Twenty six of 27 patients used hearing aid before surgery (50% in the right ear, 19% in the left ear and 31% in the both). The benefit of hearing aid usage was in 54% patients 54% moderate or lower. All the patients are implanted unilaterally (41% in the right ear, 59% in the left ear).The aetiology of hearing loss was in 8 cases unknown, ototoxic drugs - 3, familial - 3, noise exposure - 2, bacterial infection - 2, trauma - 2 and individual cases of viral, rubella and otosclerosis. In four cases there are no data.

Conclusion: Data is consistently gathered as a part of the multicenter international initiative in order to provide statistically valid data to support patient management decisions at the clinical, administrative, reimbursement and regulatory levels locally, nationally and internationally.

S47-6

Effective use of sensitive period in hearing disabled adults: Success of cochlear implantation in adult prelingual /perilingual recipients

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Objective: Cochlear implantation is an effective treatment option in individuals with severe to profound sensorineural hearing loss. Speech perception outcomes for people with a prelingual hearing loss, implanted with a cochlear implant in adolescence or adulthood, are characterized by a large degree of variability. In studies to-date, mean speech perception scores were typically substantially poorer than those recorded for implant recipients with a postlingual hearing loss. Despite this, the majority of recipients with a prelingual/perilingual hearing loss implanted with a cochlear implant in adolescence or adulthood reported satisfaction with their implant and used it regularly. Although there have been a number of studies in the area, none has taken a holistic approach and investigated both objective and subjective outcomes. The objectives of the study were to examine speech perception and cortical auditory response (CAR) using HEARLab System in people with a bilateral prelingual or perilingual hearing loss, implanted with a cochlear implant as an adolescent or adult.

Study design: Repeated-measures single subject analysis of speech perception in auditory-alone condition. The design of this study consisted of a prospective examination of both speech perception outcomes and aided cortical assessment for 5 recipients, diagnosed with a bilateral hearing loss before age 3, and implanted with a cochlear implant at 18 years or older. All participants were implanted with a Neurelec Digisonic SP device at a University Hospital (Adana- Turkey).

Results: The median for speech perception scores were as follows: auditory-alone, 74% (range, 65-88%) for single syllable words; and 72% (range, 55-90%) for tree syllable words. Pure tone hearing threshold evaluation was carried out in free field with the purpose of patient evaluation before and after cochlear implantation. Cortical auditory responses were obtained from 4 of 5 cochlear implanted adult recipients without earplugs, using three natural speech sounds (/m/, /g/, and /t/) presented at 55, 65, and 75 dB SPL.

The findings from this study gives the answers, is a cochlear implant a viable option for adults and adolescents with a prelingual hearing loss? Recently, the majority of participants gained benefit from the cochlear implants and were satisfied with it.

S47-7

Impacts of cochlear implantation on the lives of prelingually deaf adults who received a cochlear implant during adulthood: a qualitative study

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Intro: Benefits of cochlear implants (CI) in adults with a post-lingual deafness have largely been studied. In comparison, congenitally and prelingually deaf individuals who are implanted in their adolescence or adulthood, have received less attention from researchers, and remain a preoccupation for professionals in clinical settings. These individuals are not usually considered good candidates for cochlear implantation. Recent data on prelingually deaf adults suggest that auditory performance can still improve after cochlear implantation during adulthood despite wide interindividual variability. In addition, cochlear implantation in this population may provide positive benefits other than auditory performance. It is likely that the examination of outcomes from a speech perception point of view does not fully capture the impact of cochlear implantation in everyday life for prelingually deafened adults (PDA). We need to obtain a more comprehensive picture and acquire a deeper understanding of PDAs' experience with the implant. The purpose of this qualitative study was to explore the benefits (and limits) experienced by prelingually deaf adults with their implant in everyday life.

Methods: Seven (7) PDAs participated in in-depth 45-minutes semi-structured interviews with a trained psychologist. Analysis of the interview transcripts adopted a phenomenological methodology. A thematic analysis was performed with *QSR NVivo 10* software.

Results: The following themes emerged from a preliminary analysis of the interviews:

1. PDAs reported having to rely less on lip-reading (leading to the impression of being less exhausted at the end of the day);
2. They reported an improved detection and recognition of environmental sounds (leading to an increased feeling of security);
3. They reported an improvement in communication (leading to the feeling to be less of a burden for their families and friends).

Overall, PDAs expressed a significant improvement in their self-confidence during communicative interactions: they are more prone to signal communication break-ups and more willing to use the telephone (even if it remains difficult) with their close relatives.

Discussion: Results suggest that relatively subtle gains (e.g. improved environmental sounds detection and recognition, enhanced lip-reading abilities) can have a significant impact on the lives of PDAs.

Conclusion: There is a need for assessing outcomes differently in adults with prelingual deafness. A better understanding of the benefits provided by cochlear implants in this population, beyond speech recognition performance, is of considerable clinical interest: it will allow professionals to better help these candidates to establish appropriate expectations regarding the benefits that can be anticipated from cochlear implantation.

Learning outcome: Participants will reflect on implant candidacy issues and expected outcomes for this population.

S47-8

Outcomes of cochlear implantation for long-term unilateral deafness

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Rehabilitation of unilateral deafness is the newest application of cochlear implant which is gaining acceptance rapidly. The selection criteria for this group of patients are still under research. This study aimed to investigate the impact of deafness duration on the progress of rehabilitation of unilateral deafness utilizing cochlear implantation.

Out of the ongoing prospective cochlear implantation in unilateral deafness study, six adults, who received a cochlear implant for long-term unilateral deafness, were selected. The patients had unilateral hearing loss greater than a 4-frequency pure tone average (0.5-4kHz) of 70dBHL and duration >27 years. All patients were implanted with a Flex soft electrode array and received an Opus 2 speech processor (MED-EL, Austria).

Speech perception in noise scores were obtained using the adaptive Bamford-Kowel-Bench speech-in-noise test (BKB-SIN). Three spatial configurations were used in the study: speech and noise from the front (S_0/N_0), speech from the front and noise from the normal hearing ear (S_0/N_{HE}), and speech from the implanted ear and noise from the normal hearing ear (S_{CI}/N_{HE}). The standardized Speech, Spatial and Qualities of Hearing (SSQ) questionnaire was used to assess the patients' perception of the benefits of cochlear implantation in their daily life. These measures were obtained at 3, 6 and 12 months post-implantation.

Analysis of speech perception in noise revealed significant improvement for 3 spatial configurations: speech and noise from the front, speech from the front and noise from the normal hearing ear, speech from the implanted ear and noise from the normal hearing ear. Results of the SSQ subscales showed significant improvement of subjective perception of overall hearing in challenging listening situation. The results indicate that deafness duration does not represent the determinant factor for success of CI in post-lingual unilateral deafness. Others factors might be more important such as the patients' age at the onset of hearing loss.

S47-9

Musician effect: Does it matter for cochlear-implants?

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Background: Normal hearing (NH) musicians have been shown to have better speech understanding in noise, better musical pitch and timbre perception, better working memory, and enhanced cognitive linguistic processing at cortical, subcortical and brainstem levels, compared to non-musicians. However, the benefits of music training are sometimes quite modest for speech perception. It is unclear whether music training could also improve speech and music perception in cochlear implant (CI) users, who experience significant signal degradation with electric rather than acoustic stimulation. This study investigated the musician effect, the combined effect of past and current musical training and involvement, in NH musicians and non-musicians listening to an acoustic simulation of CI. We hypothesized that the musician effect would persist under conditions of spectral degradation.

Methods: Twenty-five musicians and twenty-five non-musicians participated in the study. The test battery included speech intelligibility tests (CVC-words and sentences presented in quiet and in noise), perception of voice pitch cues in speech (voice gender categorization and vocal emotion recognition) and music perception (melodic contour identification with multiple instruments). Performance in all tasks was measured with unprocessed stimuli and with an 8-channel sine-wave CI simulation.

Results: A small positive musician effect was shown for recognition of CVC-words with the CI simulation, but not with unprocessed speech nor for sentence recognition in quiet or noise (with or without the CI simulation). There was a significant musician advantage for voice gender categorization and vocal emotion recognition, although post-hoc testing did not reveal specific advantages in any of the test conditions, apart from the normal emotion recognition condition. There was a significant advantage for musicians in the melodic contour identification task for both unprocessed signals and the CI simulation.

Conclusions: Literature showed that the musician effect does seem to have an overall positive effect on both speech and music perception and cognitive processing in young and, some situations also older, normal-hearing listeners. Our test battery, however, showed a modest overall musician effect for speech related tasks and a strong positive effect for the melodic contour identification. Taken together this could indicate that musical training might have beneficial effects on the perception of pitch in speech related tasks and on melodies and timbre in CI-patients.

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S47-10

Identifying prosody expressed in New Zealand English - A study on cochlear implant and hearing aid users

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Background: In non-tonal languages, pitch cues primarily have a para-linguistic function, such as determining the identity of a speaker and differentiating between question and statement or among different emotional states (Luo et al., 2007). Both cochlear implant (CI) recipients and hearing aid (HA) users show better performances in perception of the segmental speech information (Ching et al., 2006; Fetterman & Domico, 2002), however, perception of pitch related speech perception tasks seem to be a challenge to them (Jayakody, 2012).

Purpose: This study aims at identifying the acoustical parameters that aid in recognizing different emotions and differentiating questions from statements in New Zealand English.

Method: This study was carried out in two phases. Firstly, emotion identification (EI) and question/statement identification (QSI) tests were developed. Thirty two sentences in four target emotions (angry, happy, sad and neutral) and 12 utterances as a question and a declarative statement were recorded for both male and female voices. Acoustic analysis of the sentences was carried out by using the TF32 time-frequency analysis software. For both tests, calculations were made for the total duration of the utterance, words per second, mean fundamental frequency (F0), minimum F0, and maximum F0, amplitude differences between the first and the second harmonics (H1-H2), and the frequencies of the first three formants (F1, F2, and F3). For the second phase of the study, 16 postlingually deafened adult CI recipients (mean = 59.06 years), 20 postlingually deafened adult HA users (mean = 64.75 years), six prelingually deafened children using CIs (mean = 16 years), 19 normal hearing (NH) adults (mean = 29 years), and 12 children (mean = 15 years) were tested on a set of 24 EI and QSI sentences each.

Results: Phase one: Significant differences were found for time duration, intensity, mean and SD of F0, intensity, frequencies of F1 and F2, P1-P2, and H1-H2 in EI sentences. In QSI sentences there was a significant difference in the mean F0 range between questions and statements for both female speakers ($p < 0.001$), but not for the male speakers. Phase two: A post-hoc pairwise comparison of EI test results revealed significantly higher scores ($p < 0.001$) for both NH groups compared to the hearing impaired participants. For the QSI test, no significant difference in scores was observed between NH and HA participants. However, the HA group scored significantly better than the adult CI recipients ($p = 0.05$) and the NH children scored significantly better than the CI children ($p < 0.001$).

Conclusion: These acoustical analysis results may explain the underlying reasons for the poor EI and QSI abilities shown by cochlear implant recipients. These findings also highlight the need for habilitation/rehabilitation options to help improve the pitch-related speech perception skills of both adult and pediatric CI recipients.

S47-11

The comparative study of reading comprehension in hearing and deaf Persian students

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Aim: In Different language approaches, reading is considered as a skill. Language skills are fully interlinked together. Thus, if children apply listening and speaking skills actively, they will learn reading and writing skills easily. The aim of this research is a comparative study of Reading Literacy among Deaf Students Studying at Exceptional Schools beside Normal Students in different degrees.

Method: The research is done Posttraumatical and using standardized 2006 PIRLS test which was tested on 80 5th grade primary school, 1th grade high school, 4th grade high school deaf students which selected using randomly sampling method and 80 normal students which selected using available sampling method.

Result: A significant difference was observed between reading perception of deaf and normal students among all three grades($p< 0.001$). Also there was significant difference between male and female students. there was no significant difference between deaf students among all three grades($p< 0.001$).

Discussion: This study shows that one of the significant problems among deaf students is reading perception. As respects reading literacy is one of the most important acquisitive abilities of students at school, So the need of evaluation, and recognition of strengths and weaknesses of students, especially deaf students is essential.

Keywords: Deafness, Literacy, Reading comprehension.

S47-12

Selective auditory attention: Can successful long-term users of cochlear implants match performance of normal hearing peers on this cognitive demanding task?

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Introduction: Despite the amazing benefit cochlear implant (CI) devices have provided individuals with severe-profound congenital hearing loss (HL), there remains a considerable amount of variability in performance that cannot be accounted for. One source of variability may be related to central cognitive abilities that are necessary for tasks with increasing demands such as selective auditory attention, i.e., the ability to attend to one aspect of the signal while ignoring another. The purpose of the present study was to compare auditory selective attention ability of good CI users to that of normal hearing (NH) peers using a lexical-prosody emotional auditory stroop task.

Methods: The study included 13 hearing-impaired young adults (mean age=19 years old) who are good CI users (mean perception of AB words=76%), and 13 young NH adults (mean age=25 years old). HL was congenital and age at implantation was under 6.5 years with the exception of two CI with progressive HL. Test stimuli consisted of 80 different words judged as having a sad or happy meaning. Forty of these words were produced with the appropriate (congruent) sad/happy prosody and 40 words were produced with inappropriate (incongruent) happy/sad prosody. Baseline performance of lexical and prosodic emotion recognition was measured with neutral prosody or neutral meaning. Listeners were instructed to either ignore the lexical content and decide whether the tone of voice was happy or sad, or, ignore the prosody and make a lexical decision. Performance measures were % correct and reaction time. (RT). CI users were also tested on memory, language and speech perception abilities.

Results: While NH performed at 100% correct recognition on baseline testing, CI had good but reduced lexical and prosody recognition compared to NH when the other dimension was neutral. On tested items, NH continued to perform near 100% whereas CI showed further significant reduced performance in the incongruent condition compared to the congruent one (i.e., a significant stroop effect). Also, CI users showed 2-3 times longer RTs compared to NH in all conditions. Auditory selective attention in CI was significantly correlated with visual attention.

Discussion: Young long-term CI users show difficulties in selective auditory attention which may explain some of the variance in tasks of increasing demands (e.g., speech in noise). The finding of a strong stroop effect for the lexical incongruent stimuli as well as longer speech processing time, supports the notion that the difficulties of the CI are also at the central executive level and do not result only from the degraded speech signal and poor prosody information provided by the CI.

Learning outcome: Successful long-term CI users with congenital HL showed deficits in a cognitive demanding auditory selective attention task. Use of CI may not be sufficient to overcome the impact of early auditory deprivation and of degraded input on executive functions.

S47-13

There is a fluctuating outcome of cochlear implants in hearing loss caused by vestibular schwannomas

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Introduction: Cochlear implants in NF2 patients can give good outcomes and results. We have had success implanting tumor-affected ears without removal of the primary tumor, even with large tumours. However, the utility of the implant may vary over time in ways that are quite different from more conventional implant candidates.

Methods: A retrospective review of the first 5 cochlear implants in NF2 patients on the Oxford Cochlear Implant Program who have used their implants for more than 12 months.

Results: Improvement in hearing thresholds and communication were obtained in all patients but this was not always maintained. 1 patient obtained environmental sounds only, but had interrupted use caused by device failure and reimplantation. 4 patients had significant improvements in hearing thresholds and speech reading, although this was maintained in only 1 patient. In two there were difficulties caused by magnet dislodgement during an MRI investigation, and neurological deterioration respectively, although implant use was re-established. In the final patient there was an improvement in thresholds in the unimplanted ear after treatment with avastin, and the contralateral hearing aid became more effective than the CI, which has now become a 'sleeper' CI.

Discussion: All of the patients have used the implants and found benefit. However, 4/5 patients have had periods where they could not benefit from the implant or had 'complications' from the CI or their neurological conditions. However, only 1 has become a non-user, and this is because of improved contralateral hearing, which may be temporary.

Learning outcome: CI in patients with NF2 are effective and useful, but the outcome may be limited by disease. Many patients may have 'time off' from their implants, but can return to them when their condition improves.

EPOSTER PRESENTATIONS

P1-1 Anatomy beauty of the cochlea

P1-1-1

Optical coherence tomography guided inner ear decalcification and cochlear anatomy

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Introduction: The labyrinth including the cochlea is a membranous organ encapsulated with the bony wall, called otocapsule. For evaluation of the potential of different Cochlear Implant electrodes in violation of the intracochlear structures it is mandatory to visualize the membranous intracochlear structures e.g. the basilar membrane. Scanning Laser Optical Tomography (SLOT) imaging is one method for evaluation of the intracochlear structures, that Laser light transmits the probe for 3D imaging. For acquiring SLOT imaging of the cochlea needs to be decalcified. Decalcification is a time consuming and difficult procedure. During the micro dissection of the cochlea it may break in several pieces if the Otocapsule didn't care well. Optical coherence tomography is a light base imaging system, which can show the reflected light from subsurface till 3mm. OCT have a great potential to use as a real time navigation system. In this paper we want to describe our methodology for decalcifying the cochlea in preparation for anatomical and interventional studies by SLOT and OCT.

Materials and methods: Four labyrinth organs of human body donors were explanted. The cellulae around the Otocapsula was drilled away, but the bony structure around the vestibular dusts and the cochlea was stayed intact. The specimen was infiltrated with EDTA solution. This resulted in decalcification of the surface of the specimen and softening of the surface parts. The softened parts were drilled intermittently. The drilling was controlled under OCT-control to keep the specimen safe. After each drill session different parts of the cochlea were caned by the OCT and the thickness of the residual boney wall of the labyrinth and cochlea were measured.

Result: The complete decalcification of the labyrinth was performed within 7 hours by controlling the progress of the drilling with the OCT. OCT and the following SLOT images showed the intactness of the membranous border of the labyrinth organ in all cases and valuable anatomical image. Using OCT the internal membranous structures of the cochlea could be visualized with varying quality. The thinner the boney structure of the cochlea was the better was the visualization of the basilar membrane.

Conclusion: The study has shown that OCT is valuable technology for navigation to decalcify the temporal bone safely without inner ear destruction. Basilar membrane can be demonstrated with OCT if the bony capsule is less than 350 µmeter thin.

P1-1-2

Cochlear Coverage - Objective metric parameters in cochlear implant imaging for the individual cochlear length

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The individual size of the cochlea and their inclusion in the cochlear implant (CI) treatment is not yet a solved problem. Insertion angle determination is the gold standard in postoperative radiological CI imaging. However, this is a descriptive procedure and lacks of metric insertion depth evaluation. Novel measurement parameters in CI imaging will be discussed.

Methods: 116 patients who were treated either with a MED-EL Flex 20, Flex 24, Flex 28 or MED-EL standard electrode were retrospectively evaluated for Cochlear Length (CL) in preoperative cone beam computed tomography (CBCT). Postoperatively insertion parameters as Cochlear Coverage (CC) and insertion success have been determined.

Results: Statistical significant differences can be shown between CC of the evaluated electrode groups. It can be shown that there is a measurable correlation between CL, CC and electrode length. Different electrodes do lead to the same CC if the CL is accordingly different in its extent. Data shows positive correlation between CC and speech performance.

Discussion: Postoperative evaluation of insertion parameters in a metric setting is feasible by using CBCT and 3D cMPR. It could be shown that different insertion depths can lead to the same CC inasmuch as CL is taken into account. The CC is a crucial parameter for individualized CI treatment and is a predictor for speech performance.

P1-1-3

Cochlear duct length estimation: Adaptation of Escude's equation

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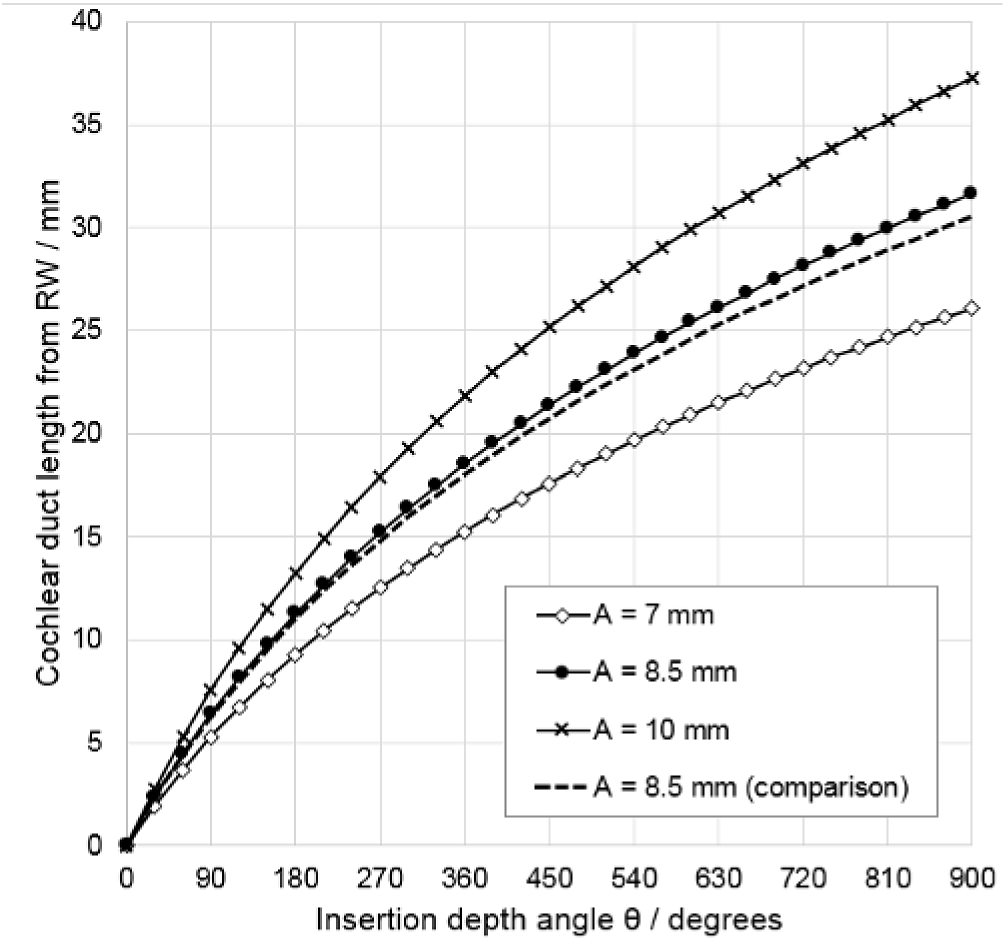
Introduction: In order to take into account morphological variations, patient-specific CI electrode array selection involves the preoperative estimation of the cochlear duct length (CDL). Escude et al. presented a function for estimation of the lateral wall length for different cochlear sizes and insertion depth angles. Nevertheless, free-fitting electrode arrays are placed close to the organ of Corti. This work aims to adapt Escude's equation in order to enable estimation of the CDL at the organ of Corti for a given cochlear size and insertion depth angle.

Methods: In high-resolution datasets (n=15, microCT imaging, 18 µm) of human cochleae with implanted free-fitting electrode arrays, the largest diameter *A* as well as the CDL was measured at 360, 540 and 720° (Wimmer 2013). Using MATLAB (MathWorks, Natick, MA, US) a parametric equation based on Escude's function was fitted to the measured data. Fitting results were compared with Escude's original equation for the lateral wall length multiplied by the ratio between the CDL and the lateral wall length (CDL/LWL = 0.87, Kawano 1996).

Results: The following equation with parameters *p1* and *p2* was found for CDL estimation (in mm) at the organ of Corti for a given cochlear diameter (*A* in mm) and insertion depth angle (*θ* in degrees):

$CDL_{OC} = p_1 \cdot A \cdot \ln(1 + \theta/p_2)$



[Figure 1]

Figure 1 shows the CDL curves for three different cochlear diameters as well as comparison values.

Fitting residuals were found to lie within ±1 mm. For cochleae with diameters *A* of 7, 8.5 and 10 mm, a CDL (2.5 turns) of 26.1, 31.7 and 37.2 mm, respectively, was found.

Discussion: This work presents an estimation of the CDL for arbitrary insertion depths and cochlear sizes based on Escude's previous approach. Estimated values of the CDL at 2.5 turns lie within the distribution reported in literature (Hardy 1938, Lee 2010). Using this equation, the electrode array insertion depth may be predicted with an accuracy of ±1 mm, provided that the cochlear diameter *A* was measured as defined in Verbist 2010. Subject to further validation to improve statistical power, this estimate could be used in the future as a tool for the surgeon to enable preoperative electrode arrays selection, accounting for the patient's anatomy and residual hearing.

Conclusion: The derived equation seems to be a practical approach for preoperative patient-specific electrode array selection and will be validated in further studies to strengthen statistical power.

P1-1-4

Estimation of Cochlear Duct Length by a logarithmic spiral model

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The Cochlear Duct Length (CDL) has been described in various studies from histological, radiological and morphological points of view. The absolute values of the Cochlear Duct Length differ among these studies, which can be partly explained by the divergent methods - the comparability is thus limited.

We developed a logarithmic spiral model by statistical analysis of specific cochlear dimensions obtained from the "Hanover Cochlea Database" (a library of 108 corrosion casts of human cochleae), which gives a good approximation of the individual cochlear shape. This model can give an estimation of the Cochlear Duct Length and can be adjusted for the different methodical ways of CDL-registration.

The influence of various assumptions (cochlear size, radial length, registration method) on the absolute Cochlear Duct Length are shown. Final insertion depth angles of miscellaneous cochlear implant arrays (straight, contour) can be forecasted for individual cochleae.

P1-1-5

Review of cochlea anatomy

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The cochlea (plural is cochleae) is a spiralled, hollow, conical chamber of bone, in which waves propagate from the *base* (near the middle ear and the oval window) to the *apex* (the top or center of the spiral). Its structures include:

- Three *scalae* or chambers:
  - the scala vestibuli (containing perilymph), which lies superior to the cochlear duct and abuts the oval window
  - the scala tympani (containing perilymph), which lies inferior to the scala media and terminates at the round window
  - the scala media (containing endolymph), or cochlear duct, a region of high potassium ion concentration that the stereocilia of the hair cells project into
- The helicotrema, the location where the scala tympani and the scala vestibuli merge, at the apex of the cochlea
- Reissner´s membrane, which separates the scala vestibuli from the scala media
- The basilar membrane, a main structural element that separates the scala media from the scala tympani and determines the mechanical wave propagation properties of the cochlear partition
- The Organ of Corti, the sensory epithelium, a cellular layer on the basilar membrane, in which sensory hair cells are powered by the potential difference between the perilymph and the endolymph
- hair cells, sensory cells in the Organ of Corti, topped with hair-like structures called stereocilia or (more properly) stereovilli.

The cochlea is a portion of the inner ear that looks like a snail shell (cochlea is Latin for snail.).The walls of the hollow cochlea are made of bone, with a thin, delicate lining of epithelial tissue. This coiled tube is divided through most of its length by an inner membranous partition. Two fluid-filled outer spaces (*scalae*) are formed by this dividing membrane. At the top of the snailshell-like coiling tubes, there is a reversal of the direction of the fluid, thus changing the scala vestibuli to the scala tympani. This area is called the helicotrema.The lengthwise partition that divides most of the cochlea is itself a fluid-filled tube, the third *scala*. This central column is called the *scala media*, or cochlear duct. Its fluid, endolymph, also contains electrolytes and proteins, but is chemically quite different from perilymph. Whereas the perilymph is rich in sodium ions, the endolymph is rich in potassium ions, which produces an ionic, electrical potential. The hair cells are arranged in four rows in the organ of Corti along the entire length of the cochlear coil. Three rows consist of outer hair cells (OHCs) and one row consists of inner hair cells (IHCs). The inner hair cells provide the main neural output of the cochlea.

P1-1-6

High resolution computed tomography based length assessments of the cochlea - an accuracy evaluation

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Intro: The length of the cochlea can be determined with good precision using 3D-curved MPR analysis technique and linear reconstruction of the cochlea. The method is not excessively time-consuming and could be applied during clinical routine.

Background: A preoperative prediction of the best cochlear implant electrode length can help reduce the risk of intraoperative cochlear trauma in patients who need to retain residual acoustic hearing for electric-acoustic stimulation or in patients with anatomical anomalies or malformations. The goal of this study was to evaluate accuracy and reliability of length measurement of the cochlea after linear reconstruction using 3D-curved MPR analysis of high resolution computed tomography scans.

Methods: Human cadaveric temporal bone specimens underwent cochlear implantation using custom-made electrodes with two radiopaque markers of a defined length before computed tomography scans were made. Length measurement was performed by four readers and the results were compared to the true value. Interreader reliability was calculated. The time needed for analysis was recorded.

Results: The mean time needed for analysis of one specimen's radiologic data was 6.1 (± 3.4) minutes. The mean deviation of the length measurement from the true value was 0.8 (± 0.7) mm. Interreader reliability was excellent (0.76, p = 0.006).

P1-1-7

Numerical simulations of the cochlear implant electrode insertion

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Cochlear implant electrodes can be placed in the patients with use of different surgical strategies and placed in different positions. This calls for development of tools which can be used to simulate these different approaches. To this end the finite element method (FEM) model has been developed, which can be used to study behavior of different types of cochlear implant electrodes under different boundary conditions. The geometry of the analyzed inner ear was obtained using the computer tomography imaging and used to build a parametric FEM model. Such a model enables modifying the parameters of the cochlea and electrode to evaluate various scenarios of the surgical intervention, taking into account different boundary conditions of electrodes of different sizes and shapes.

The simulations we performed demonstrated the influence of the coefficient of friction between an electrode and cochlea inner structures, as well as initial directions of implantation, on the analyzed process. Three different initial directions of the electrode insertion were considered: tangential to the cochlear surface and deviated in the two opposite directions. The calculations considered frictionless conditions and high friction.

The simulations allow studying the implantation force in time, the contact force on tip of the electrode and its final position, stress and strain distributions. We demonstrate that the model developed in this study may serve as a background for decision making about the techniques of implantation and their influence on the electrode insertion trauma.

P1-1-8

Human cochlea: Semi-automatic anatomical measurements on µCT 3D surface models

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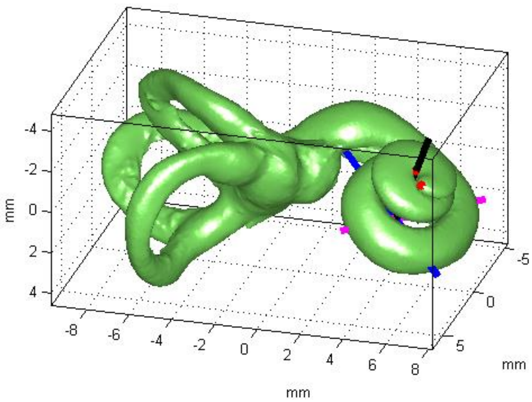
Intro: Variations in cochlear anatomy remain a topic of active research. Reported methods for measuring cochlear dimensions require heavy manual interaction which limits the accuracy and precision of measurements, even though the data holds the potential for giving more detailed information. In this study we built 3D surface models of the inner ear from µCT data. We show that with little manual labor and by using mathematical and computer graphic concepts, we are able to reproduce previously reported anatomical measurements of the cochlear. Extensions to these methods could easily provide other relevant measurements for various Cochlear Implant (CI) applications.

Methods: 8 human temporal bones were excised and dried. The bones were scanned with a µCT system providing data with isotropic voxel sizes ranging from 0.16-0.24 µm. The inner ear was manually segmented, reconstructed into 3D surfaces and post processed using publicly available computer software (Figure 1). Our measurements follow consensus definitions. We manually place a landmark at the helicotrema, the apex and the center of the round window (RW) niche. The key is to determine the central axis and the basal plane of the cochlear. This can be achieved with the helicotrema landmark and by fitting a plane to three manually selected points on the bottom of the basal turn. From these landmarks and points the remaining measurements are a matter of vector mathematics to define: The length and the width axes are orthogonal to each other and parallel to the basal plane. The length axis is defined as the direction from the RW to the central axis. The width and length of the cochlear can be calculated from the intersections between the axes and the surface model, which can be found efficiently with an algorithm. The apex landmark and the length axis can be used to calculate the number of turns. Finally, the cochlear height is the orthogonal distance from the apex to the basal plane.



[Figure 1: Cochlear with landmarks (red) and axes.]

Results: The mean and standard deviation of total height, number of turns and basal length and width were respectively 4.0 ± 0.36 mm, 2.5 ± 0.07 turns, 9.4 ± 0.43 mm and 6.8 ± 0.3 mm.

Discussion/Conclusion: Representing the cochlear as a 3D surface model allows for measurements to be done with minimal manual interaction. The reported numbers are consistent with previous results. This approach further allows for other measures to be carried out automatically, for instance measuring the width of the cochlear at an arbitrary angle.

P1-1-9

Multichannel cochlear implant in the Mongolian Gerbil

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Introduction: Primates, cats and guinea pigs are frequently used in cochlear implant (CI) research because of their relatively large sized cochleae. Here we introduce the Mongolian gerbil as another rodent model for multichannel CI research. The Mongolian gerbil is an established animal model for acoustic signal processing in the central auditory system. Unlike guinea pigs, the gerbil is born deaf which is advantageous for evaluating the role of prelingual deafness in animal models.

Methods: We implanted a custom-made five-channel CI in the gerbil. A reference electrode was located in the neck muscle. In chronically implanted animals a low-insertion-force connector was fixed to the cranium. Electrically evoked auditory brainstem responses (eABR) and electric impedances were measured regularly for five weeks after implantation. In acute electrophysiological experiments, multiunit (MU) responses to contralateral bipolar electric stimulation and ipsilateral acoustic stimulation were recorded in the primary auditory cortex (AI) and the inferior colliculus (IC). At most recording sites, both characteristic frequencies to acoustic stimulation and neuronal thresholds in response to electric stimulation with four different bipolar pairs of electrodes were determined. Acoustic and electric tonotopic gradients were correlated.

Results: The usual CI insertion depth was 4 mm. For chronically implanted animals, electric impedances of the single CI contacts and eABR thresholds were stable over five weeks. Rarely, contact loss of the reference electrode occurred. Spread of neuronal activation in AI and IC was clearly distinguishable between stimulation of apical and basal electrode contacts.

Conclusion: Our results show that the Mongolian gerbil is a useful animal model for multichannel CI research. Despite the small cochlea, this model allows electric channel separation in the central auditory system.

CI electrodes manufactured and provided by MED-EL

P1-1-10

Pax2 and Sox2 can induce hair cell fate in inner ear progenitors

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The cochlea harbors cells with regenerative properties, but after damage they do not appear to be recruited for hair cell replacement in mammals. Cochlear implants (CI) bypass nonfunctioning hair cells to provide sound sensations to the deaf patient, but outcomes on average do not approximate normal hearing and most CI users have difficulty in noisy environments and with musical appreciation. Targeted regeneration of endogenous cells of the inner ear into hair cells could supplant surgically implanted options for the deaf patient and improve hearing outcomes.

A single transcription factor, Atoh1, is sufficient and essential for the formation of a hair cell from a sensory progenitor cell, but not much is known about its regulation. Two transcription factors, Pax2 and Sox2, play an important role during early inner ear morphogenesis. Our data suggests synergistic effects for Pax2 and Sox2 at the time of hair cell formation. Only mouse inner ear progenitors that co-express Pax2 and Sox2 in vitro, will differentiate into hair cells. Overexpression of Sox2 or Pax2 alone slightly increases Atoh1 expression and the number of hair cells in vitro, whereas co-transfection of both leads to robust up-regulation of Atoh1 and increased numbers of hair cells. Based on our biochemical data, both transcription factors are needed simultaneously in the same cell, where they bind to the regulatory region of Atoh1 to activate Atoh1 expression. We demonstrate for the first time that Pax2 and Sox2 have a role in cell fate specification and that both factors act together to activate Atoh1 expression. Our approach could be used in the future to regenerate hair cells after trauma in the inner ear to provide hearing without the need for cochlear implantation.

P1-1-11

Towards a stem cell-based “ototoxic hearing loss-in-a-dish” model

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Introduction: Ototoxic insults combined with the lack of hair cell regeneration in the mammalian organ of Corti cause irreversible hearing loss. Towards a rational therapy for the cure of hearing loss, an *in vitro* culture model of ototoxic hair cell loss that can be used to screen for otoprotective or otoregenerative drugs is needed. To establish a “ototoxic hearing loss-in-a-dish” model, we aimed at an increase in the number of *in vitro* differentiated otic hair- and supporting cell like cells and the subsequent neomycin induced hair cell loss.

Materials and methods: The *in vitro* proliferative capacity and the potential to re-differentiate into otic hair and supporting cell like cells were investigated by immunohistochemical and qRT-PCR analyses. Further, the potential of the notch-inhibitors to induce otic cell differentiation was analyzed in *in vitro* cultures of the murine P0 organ of Corti. As a “hearing loss in a dish model” Neomycin was added for 24 h and the number of supporting and hair cell like cells were analyzed after 48 h, 72 h, 96 h and 120 h.

Results: Treatment of *in vitro* cultured cells from the P0 organ of Corti for 24 h with notch-inhibitor increased the absolute number of hair cell-like cells and supporting cell-like cells *in vitro* to up to 10% and 30%, respectively. Addition of neomycin (1 mM, 24 h) *in vitro* 120 h before the end of the culture period resulted in an almost complete loss of hair cell-like cells, while the number of supporting cell like cells remained constant.

Conclusions: Treatment of *in vitro* cultured cells from the murine P0 organ of Corti with L-685458 (0.5 µM, 24 h) increases the number of hair and supporting cell like cells and allows quantitative analyses. Neomycin (1 mM, 24 h) selectively kills hair cell like cells *in vitro*, and therefore can be used for an “ototoxic hearing loss-in-a-dish” model.

P1-1-12

Regenerative stem cell therapy with Umbilical Cord Mesenchymal Stromal Cells in deaf animal model

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Objective: This study was performed to confirm the effect of transplantation of human umbilical cord blood mesenchymal stem cells (UCB-MSCs) on hearing restoration in deaf animal model.

Material and methods: UCB was collected after obtaining consent, and mesenchymal stem cells (MSCs) were extracted. We established a deaf animal model and transplanted UCB-MSCs through the brachial vein of the guinea pigs. The animals were divided into 4 groups: animals with normal hearing, animals with SNHL, animals with SNHL and injected with saline, and animals with SNHL and transplanted with UCB-MSCs. Hearing tests were conducted at 1,3,5 weeks, and the results were compared by auditory brainstem response (ABR) and distortion product otoacoustic emissions (DPOAEs). Lastly, cochlear pathological features were examined.

Results: In SNHL group, disappeared DPOAEs and increased ABR threshold were noted. The transplanted UCB-MSC in SNHL group showed a significant improvement in hearing threshold (40 dB) compared to that in all the SNHL group (80-90 dB) & restoration of OAE. Examination of the SNHL animals, cochlear morphological features demonstrated a noticeable lack of spiral ganglion cells and also showed degenerated hair cells. However, the transplanted UCB-MSCs group showed an increase in spiral ganglion neurons and hair cells.

Conclusion: Intravenous transplantation of UCB-MSCs can enhance hearing function and regeneration of hair cells and spiral ganglion neurons.

P1-1-13

Auditory nerve plasticity follow up by ECAP in patients with AN/AD after cochlear implant

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Introduction: AN/AD decrease processing ability of speech that may be accrue with hearing loss. In these cases there may be no sufficient benefits with hearing aid & no improvement of hearing & speaking abilities so in these cases cochlear Implant may be chosen. Because of AN/AD the eECAP test results are not so well but on the other hand there is a hypothesis that with continuing of VIII nerve stimulation via CI this nerve function & synchronization gets better.

Method: The eECAP test (NRT/NRI) performed in 4 phases (intra-operative , 40 days , 6 months, 12 months after implantation) for 38 patients with AN/AD. Results as threshold of eECAP & Amplitude of these waves were analyzed.

Results: 11 patients had clear eECAP during the surgery, after 40 days it was the same. After 6 months, 8 other cases showed eECAP, after 12 months 17 other cases showed eECAP. In 2 cases eECAP still were not detected after 12 months but their hearing levels with CI were at 20-35 dBSPL.

Conclusion: CI & electrical stimulation of VIII nerve in AN/AD cause neural plasticity & improved auditory synchronization & so cause better recognition & comprehension of speech & this can followed with eECAP tests.

P1-1-14

Cochlear implant users show an auditory attentional filter in an acoustic listening task

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In an effect known as the attentional filter, near-threshold tones are more detectable if they are presented at frequently occurring expected frequencies over rarely occurring unexpected frequencies (Greenberg and Larkin, 1968). Previous work on vestibular neurectomy patients showed that the loss of the efferent connection from the medial olivocochlear system (MOCS) to its cochlear target decreased the depth of the attentional filter, implicating the MOCS in its formation (Scharf et al, 1997). Recent research has shown a similar decrease in filter depth in individuals with SNHL (Bester et al, unpublished). The present study investigated the role of non-MOCS auditory structures in forming the attentional filter using individuals with cochlear implants. Cochlear implant recipients present a unique group with normal auditory thresholds, but in whom the MOCS efferent targets are bypassed. Attentional filter measurements were made in 6 cochlear implant recipients, using acoustic stimulation and a customized speech processor, with the results compared to attentional filters measured in normal hearing participants. Cochlear implant recipients showed a significant decrease in the detection rate of rarely occurring unexpected tones relative to a frequently occurring expected tone, consistent with the presence of an attentional filter. This result suggests that cochlear implant recipients have the ability to suppress unexpected auditory stimuli more effectively than individuals with SNHL, and therefore non-MOCS components of the auditory system are able to form a significant attentional filter in some conditions.

P1-2 Radiology

P1-2-1

Virtual endoscopy to plan transcanal and transtympanic approaches to labyrinthine windows

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Introduction: Virtual endoscopy based on CT-scan provides images close to the intra operative vision. The aim of this study was to evaluate the position and the accessibility of labyrinthine windows which are highly variable through the external auditory canal by virtual endoscopy based on CT-scan images.

Materials and methods: Thirty-four adult patients undergoing high-resolution CT-scan for various ear diseases were included in this study. The population comprised twenty-one males and thirteen females. The mean age was 53 years (range: 21 to 87 years). Sixty-three temporal bone CT-scans considered as normal were finally included (32 right and 31 left). Images were analyzed by virtual endoscopy function included in the Osirix software (v.5.6, 32-bit, downloadable at http://www.osirix-viewer.com). The virtual endoscope was placed 5 mm outside the umbo and its axis in the external auditory canal was optimized to visualize first the oval (OW position) and subsequently the round window (RW position). The angle between the virtual endoscope and the tympanic membrane in the axial (α) and coronal (β) planes was measured for each position. In addition, the visibility of the pyramidal process, the anterior and the posterior stapedial *crus* were noted in the OW position. The visible surface of the incus, of the stapedial footplate and the round window niche, and the distance between stapes and incus were measured on multi-planar reconstruction views.

Results: There was a significant inter individual variability of all anatomical parameters with no correlation between the left and the right ears. With a straight line of view inside the external auditory canal, at least a part of the stapedial superstructure was visible in 91% of the cases, and a part of the footplate in 19%. Round window niche was accessible in all cases. Based on these results an anatomical staging of the oval window accessibility through the external auditory canal was proposed: 1. Invisible stapedial superstructure, 2: stapedial posterior crus partly visible, 3: entire posterior crus and pyramid visible, 4: posterior and anterior crus visible.

Conclusion: Virtual endoscopy provides practical information for transcanal and transtympanic procedures. Its combination to the images obtained by operative microscope will provide useful augmented reality. Virtual endoscopy will potentially help to select patients and conduct minimally invasive cochlear implantation.

P1-2-2

Cochlear rotation: Preoperative radiological evaluation and significance

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Introduction: Cochlear rotation has been a surprise finding in many cochlear implant surgeries. This makes electrode insertion difficult and also enhances trauma to inner ear, thereby resulting in destruction of fine inner ear structures and loss of residual hearing. Preoperative diagnosis of this anomaly will make a lot of difference to surgery and its results, but research in this area is still a virgin field.

Methods: Radiological evaluation was done in our preoperative patients. Multislice CT machine was used to obtain HRCT temporal bone axial cuts. Using computer software, long axis of basal turn of cochlea was drawn and its angulation from mid saggital plain was calculated on both sides. This angle was called "A". Also a line was drawn along the proposed line of axis of cortical mastoidectomy, posterior tympantomy and cochleostomy. The angle which this line made with the long axis of basal turn of cochlea was also calculated. This angle was called "B". These values were calculated by two independent radiologists and average was taken. These values were compared to difficulty in electrode insertion and results analyzed.

Results: 84 cases were radiologically evaluated. 7 were excluded in view of cochleovestibular anomaly. Therefore, 154 ears were analyzed. Mean A value was found to be 57.02 degrees (range: 46.7 - 66.7 degrees). It was found that cases with A< 50 degrees (4 cases) were associated with difficulty in electrode insertion. However opposite was not true; that is, not all cases with A>50 degrees had easy electrode insertion. Cases with B>20 degrees were associated with difficult electrode insertion, despite having A>50 degrees (3 cases).

Discussion: Lower A value indicate posteriorly rotated cochlea and more recessed round window and therefore, difficult electrode insertion. Higher B values mean more angulation between long axis of basal turn of cochlea and surgical axis of posterior tympanotomy-cochleostomy, indication a difficult electrode insertion. We found only one study (Lloyd etal, 2010) in literature about basal turn angulation. However, results of our study donot match the results of Lloyd etal. They found difficulty in electrode insertion with higher A values and did not calculate B values.

Conclusion: Preoperative radiological evaluation of cochlear rotation is possible and gives a good indication towards difficulty in electrode insertion.

Learning outcome: Radiological evaluation for cochlear rotation should be made mandatory in preoperative evaluation. Patient with low A values and/or high B values should be explained about incomplete electrode insertion preoperatively.

P1-2-3

Radiologic sings of dwarf cochlea and its implication in cochlear implant surgery

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Introduction: Dwarf cochleae are rare abnormality, encountered by radiologists and surgeons. Little detailed information is available in the literature.

Objective: To present the radiologic sings of dwarf cochlea through high resolution computed tomography (HRCT) and MRI imaging and its implication in cochlear implant surgery.

Design: Retrospective Study

Methods: We evaluated the cochlear height in 200 patients who underwent cochlear implant surgery between March 2008- December 2013. Cochlear distance and, width of middle and apical turns were calculated .Height of cochlear turns ,in axial double oblique coronal slices and 3-D reformatted slices were evaluated. The distances between oval and round windows were evaluated. Exclusion criteria; post meningitis and not fully developed cochleae.

Results: HRCT and MRI measurements showed no statistical differences in all cochleae measurements. Cochlear height was reduced than normal by more than -2 SD.The cochlear distance was also reduced. The distance between oval and round window was reduced.

Conclusions: In dwarf cochlea one must be prepared to use the short compressed electrodes and the site of cochleostomy is more superior than normal.

P1-2-4

Cone beam CT vs micro CT of the temporal bone to determine cochlear size measurements for electrode choice in cochlear implantation surgery

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Intro: Preoperative temporal bone CT scans are now a routine imaging modality used to determine surgical operability in cochlear implantation. With the availability of different electrode lengths, it is becoming increasingly recognised that assessing the cochlear size accurately is important. Standard high resolution 32 slice CT scans of the temporal bone offer limited accuracy in determining cochlear size and duct length parameters. Cone beam CT scanning offers a portable and rapid imaging technique. The aim of this study is to compare the accuracy of cone beam CT with high resolution micro CT in determining cochlear metrics and insertion depth of different sized electrodes.

Methods: 10 human cadaveric temporal bones with completed posterior tympanotomy and round window exposure were scanned sequentially with portable cone beam CT followed by micro CT. The following parameters were measured - the diameter of the basal turn of the cochlea, the cochlear duct outer wall and mid-scalar lengths, and sequential segments of the cochlea from the round window to two turns (360 degrees, 450 degree, 540 degrees and 720 degrees). Customized 3D software was used to analyze the images from each modality. Sequential insertion of 3 different length electrodes (MED-EL Flex 24,28 and 31) were then performed in 5 bones to determine degrees of insertion.

Results: The basal diameter of the cochlea is positively correlated with the cochlear duct length both in its outer wall and mid scalar measurements. Sequential segments of the cochlear duct length varies between individual bones, indicating that the spiral of the cochlea is not uniform from base to apex. Bony contrast windows affect size measurements when using cone beam CT. The insertion angles of differing electrode lengths are presented.

Discussion: Micro CT scans offer significantly higher resolution and offer more accurate cochlea measurements but have high radiation doses. A correction factor applies for each length measurement when using the cone beam CT scanner. This study offers a surgical view of the temporal bone which is more clinically relevant. Different electrode lengths result in different depths of insertion which is dependent upon the cochlea size and characteristics.

Conclusion: Cone beam CT is a valuable and accurate technique for imaging the cochlear duct length and segmentation. Validation with micro CT is of the surgical temporal bone is presented here. Customized electrode length selection is possible with cone beam CT.

Learning outcome: To discuss the role of cone beam CT scanning in cochlear implant electrode choice.

P1-2-5

Pre-operative CT assessment of candidates for the Bonebridge system

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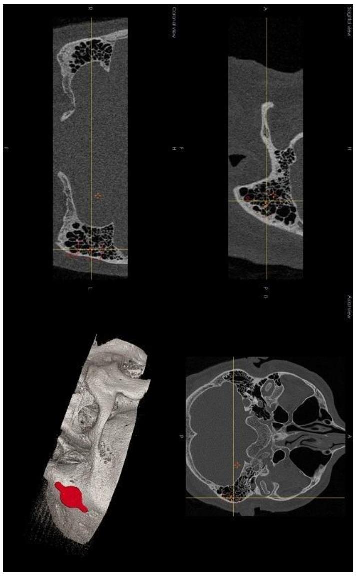
Introduction: Bonebridge is a new solution launched by MED-EL, recommended for conductive or mixed hearing loss, as well as single-sided deafness. This partially-implantable active device transmits sounds directly to the inner ear via bone conduction. The surgery is brief and gentle, and the device can be activated within a month post-operatively. In clinical practice, however, anatomical limitations can often prevent potential candidates from the surgery.

Materials and methods: Twenty adult patients, candidates for the Bonebridge system, had pre-operative CT examination, on a 64-row SOMATOM Definition AS scanner. The imaging parameters were as follows: 196 mA, 120 kV, DFOV 16.5x16.5cm, TA=1000ms, 300 slices with 0.4mm thickness.

Results: After CT-evaluation ten patients received the Bonebridge system. Ten patients were excluded due to the following anatomical findings:

- Hypoplastic mastoid process;
- Post-operative reduction of the mastoid process;
- Lateralised sigmoid sinus;
- Unfavorable location of the emissary vein;

Conclusions: High-resolution computed tomography is a valuable method of assessment prior to Bonebridge implantation. Careful diagnostic work-up is essential, due to high anatomical variability of the ear structures.



[Bone Bridge]

P1-2-6

Radiological and surgical planning: Evaluation of two different placement strategies

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Many patients with mixed hearing loss have been already operated before with canal wall up or down techniques. For those patients who have a radical cavity the positioning of the BB in the retrosigmoid area may have benefits as this area is normally less affected by the pathology and the extrusion and infection risk is lower. In the present work a strategy and the rational is presented in order to reduce the compression of the Dura and Sigmoid Sinus to a minimum.

Patients suffering from single-sided deafness, as well as patients previously operated through the external auditory canal, have a normal anatomy of the mastoid. A new method for placing the Bonebridge in the sino-dural angle as well as the analysis of compression of the dura and sigmoid sinus is presented for adults with a well-developed mastoid bone.

P1-2-7

The comparison of the insertion results in patients implanted bilaterally with the Cochlear Contour Advance™ and the Slim Straight™ electrode

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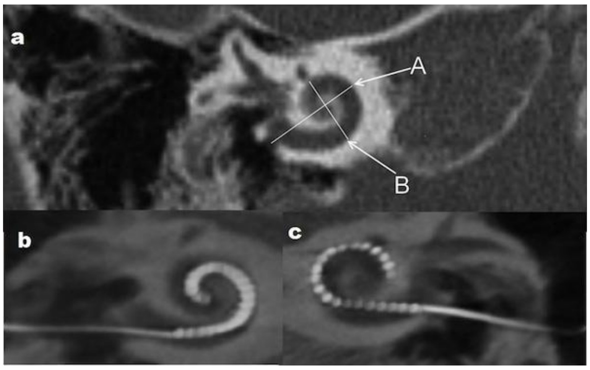
Intro: In Cochlear Implant Surgery two main types of electrode arrays are available, peri-modiolar and straight arrays, which differ in the required surgical technique and in the position inside the cochlea. The aim of the study was to compare the insertion results of patients implanted with the peri-modiolar Cochlear Contour Advance™ array (CA) in one ear and sequentially with the Cochlear Slim Straight™ array (SS) in the opposite ear.

Methods: We reviewed 16 patients implanted with the CA in one ear and the SS in the opposite ear. The CAs were inserted through cochleostomy using the recommended advanced off-stylet insertion technique. The SSs were inserted through the round window membrane. Cochlear size was measured using the preoperative HRCT. DVT was performed postoperatively to review the placement of the array and to examine a possible dislocation of the array from the scala tympani into the scala vestibuli. We measured the insertion depth and the insertion depth angle.

Results: The cochlear measures A and B varied from 8.20 mm to 10.10 mm (mean 8.98 mm; ±0.53 mm) and from 5.8 mm to 7.2 mm (mean 6.35 mm; ±0.4 mm), respectively. No significant variations of the cochlear size were found between the two ears of each subject. Insertion depth for the CA array varied from 16.0 mm to 18.7 mm (mean 17.84 mm; ± 0.78 mm), resulting in an insertion depth angle of 360° to 540° (mean 475°; ± 57°). For the SS array the insertion depth varied from 20 mm to 23.4 mm (mean 21.46 mm; ± 1.15 mm), which resulted in an insertion depth angle of 335° to 445° (mean 377°; ± 34°). The differences in the insertion depth and the insertion depth angle between the arrays were statistically significant. In 12 ears implanted with the CA a dislocation of the array from the scala tympani into the scala vestibuli was found, usually occurring after ¾ of turn. We found no array dislocations in the ears implanted with the SS.

Conclusions: Imaging after cochlear implantation is necessary to check accurate electrode placement and it serves as a reference if problems arise. The CA provides a significantly deeper insertion angle than the SS, thus covering sufficient ganglion cells for optimal electric stimulation. We, however, observed a very high rate of dislocations into the scala vestibuli with this array, even with the AOS technique. With respect to the SS, careful preoperative measurements are necessary in order to achieve a sufficient insertion depth angle, especially in a large cochlea. No scala dislocation was found for the SS. The SS is therefore suitable for hearing preservation implantation and for structure preserving surgery in pediatric patients.

Learning outcome: The confirmation of the correct electrode placement after Cochlear Implant surgery is very important to ensure an optimal outcome.



[Figure 1]

Legend to Figure 1: a) Cochlear measures A and B b) CA array c) SS array

P1-2-8

Evaluation of the intra-cochlear position of the new HiFocus MidScalar electrode array

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Objective: To evaluate the intra-cochlear position of the round window inserted HiFocus MidScalar (also called HiFocus V) electrode array compared to the HiFocus1J electrode array.

Design: Thirty three patient with a normal cochlear anatomy were implanted via a round window approach with the new HiFocus MidScalar electrode array (Advanced Bionics, Valencia, CA). Pre- and postoperative multi-section CTs were obtained and multiplanar reconstructions perpendicular to the modiolus were used to evaluate the angular insertion depth and the intra-scalar position. The reference group consisted of 107 patients implanted with the HiFocus1J electrode array, using the extended round window approach.

Results: All surgeries were uneventful and in all cases a full round window insertion was possible. The average maximum insertion depth (from the round window, in line with the international consensus; Verbist et al., 2010) was 418°, which was significantly less than with the HiFocus1J electrode (479°). The spread of insertion depth with the HiFocusMS electrode array was reduced (SD of 37° compared to a SD of 67° with the HiFocus1J electrode). Comparison of the modiolar position of the electrode array showed a clear shift towards the medial wall with the HiFocus MS electrode.

Conclusion: In line with its design, the HiFocus MS array can be inserted via the pure round window approach, leading to a basally perimodiolar position and a midscalar position elsewhere. The insertion depth is more predictable, but approximately 60 degrees less than with the HiFocus1J electrode.

P1-2-9

Cone beam computed tomography in postoperative imaging of cochlear electrodes

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Introduction: Cone beam Computed Tomography (CBCT) has been introduced into Otolaryngology about 10 years ago. Whereas CT goes faster (acquisition time less than 2 seconds) than CBCT (acquisition time at least 7s) it has a higher average irradiation (about 2 to 3 times more). Furthermore, CBCT can realize a higher resolution and lower metal artefacts (figure 1). Until now, conventional x-ray examination or CT is predominating. CBCT has been come up and is now used in centers available. Aim of the current study is to show possibilities and limits of cochlear electrodes in CBCT.

Methods: All adults and cooperative children (down to age of 5) of the past 7 years underwent a postoperative visualization of their implant by CBCT at the day of operation or one after. Figure 1

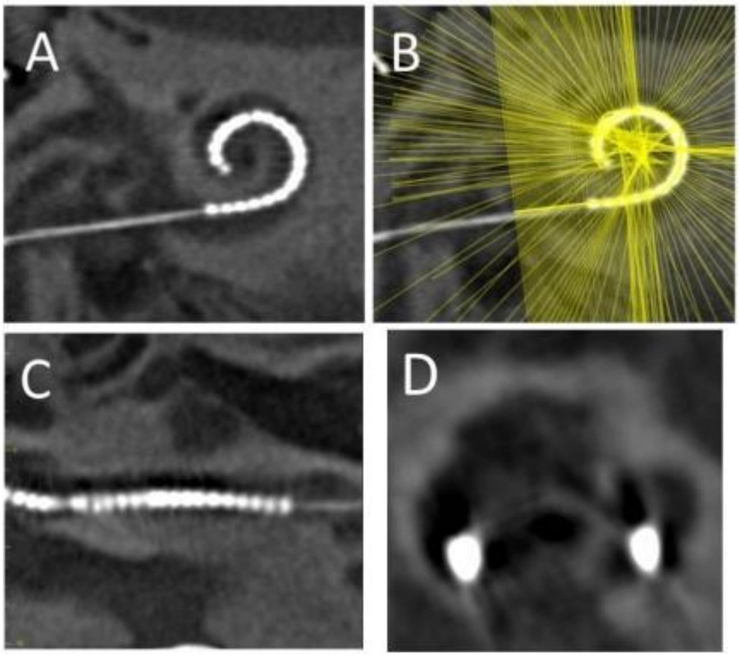

Figure 1: Electrode in complete visualisation (A). Reconstruction allong the electrode (B). It results an enrolled electrode (C) with correspondig cross section through the cochlea (D)

All data set were evaluated regarding the intracochlear position of the electrode and the safety of this evaluation by one observer. For evaluation, reconstructed enrolled electrodes with corresponding cross section through the cochlea were used (figure 1).

[figure 1]

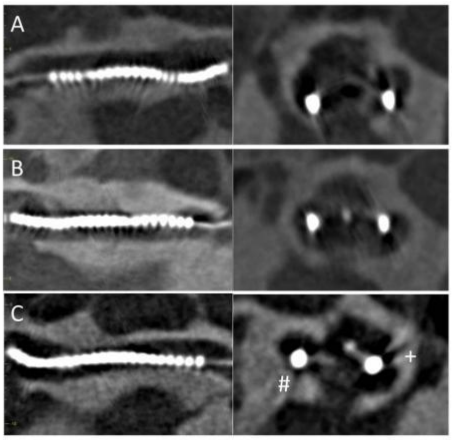

Figure 2, A – implantation into tympanic scale; B – implantation into vestibular scale; C – dislocation between the scales).

All cases were discussed between observer and corresponding surgeon, if not the same. Intracochlear position was determined in the basal and medial turn of the cochlea. Three different positions could be evaluated (tympanic scale, vestibular scale, dislocation between the scales) (figure 2). The safety was graded into: 1 = sure, 2 = relative sure, 3 = unsure, 4 = not evaluable.

[figure 2]

The different kinds of implants with the corresponding typical electrodes were as following: Cochlear = 173; MedEl = 90; Advanced Bionics = 14. Regarding operation technique, in former times (before 2008) in general a cochleostomy was performed. Then, by changing the main surgeon, the inseration switched to a round window approach in principle. Two more surgeons started the implanting program later on. Overall, 277 patients could be analyzed. Over the whole period, a safe evaluation of the electrode could be seen in about 97% at the basal and only of about 44% at medial turn of the cochlear. Regarding intracochlear position, a dislocation between scales could be seen in 8% (figure 3 below). These cases were mainly in these one of the first implantations of the new surgeons of the Contour Advance electrode. But the information about the dislocation was essential to improve their operation technique. So an adoption of the technique could be realized and the learning curve shortened. As expected, no dislocation between scales could be seen in medial cochlear turn.

Basal positon of the cochlear electrode

	Frequency	Percent
not evaluable	7	2,5
tympanic scale	211	76,2
vestibular scale	37	13,4
dislocation between scales	22	7,9
Total	277	100,0

Position of electrode in medial turn

	Frequency	Percent	Valid Percent	Cumulative Percent
not evaluable	13	4,7	4,7	4,7
tympanic scale	67	24,2	24,2	28,9
vestibular scale	1	,4	,4	29,2
dislocation of scales	1	,4	,4	29,6
EAS	8	2,9	2,9	32,5
not responsable (e.g. Cochlear, AB)	187	67,5	67,5	100,0
Total	277	100,0	100,0	

quality of evaluation of position in the basal turn

	Frequency	Percent
sure	230	83,0
relative sure	38	13,7
unsure	2	,7
not evaluable	7	2,5
Total	277	100,0

quality of evaluation of positon in the medial turn

	Frequency	Percent	Valid Percent	Cumulative Percent
sure	2	,7	2,2	2,2
realive sure	38	13,7	42,2	44,4
unsure	29	10,5	32,2	76,7
not evaluable	13	4,7	14,4	91,1
EAS	8	2,9	8,9	100,0
Total	90	32,5	100,0	
not responsable	187	67,5		
Total	277	100,0		

Figure 3: Overview of the detailed intracochlear positions of the electrodes in the basal (left sided) and medial (right sided) turn of the cochlear. Additionally, the safety of this evaluation is given in the lower row.

[figure 3]

Conclusion: CBCT can visualize cochlear electrode in sufficient way in basal turn of the cochlear way. In our hand, a safe evaluation of the intracochlear electrode in the medial turn of the cochlear is only possible in about 45%. From our point of view, the detailed evaluation of the intracochlear position of the electrode is mandatory to improve the own operation technique and to give a helpful feedback to new surgeons, especially with the goal of hearing preservation implantation.

P1-2-10

Evaluation of the cochlea duct anatomy and of the electrode array placement by cone beam computer tomography

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Hypothesis: Size and shape of the cochlea duct may affect the electrode array placement of cochlear implant.

Methods: Eight human cadaveric temporal bones provided from four donors were collected. Cone beam computed tomography (CBCT) was performed before and after cochlear implantation with a straight electrode array (CI422, Cochlear®) and histological study documented the exact position of the electrode array. Cochlea duct anatomy and electrode position using CBCT were also evaluated in 20 adult patients implanted with the CI422.

Results: Radiological evaluation of the temporal bones revealed large intersubject and intrasubject (between right and left sides) variability of the length and diameter of the cochlea duct. The horizontal diameter of the cochlea duct ranged from 1.6 to 2.5 mm and the vertical diameter varied from 1.6 to 2.1 mm at 180° and 1.3 to 2.2 at 360°. Compared to histological analysis (available in 7 out of 8 specimens), the radiologic examination accurately determined the scala tympani position in 2 cases and the scala vestibuli position in 2 cases. Two cases of spiral ligament tearing were not identified and considered as a scala tympani and vestibuli placement respectively. In one case of rupture of the basilar membrane and scala media position, the radiologist described a middle position of the electrode. Scala vestibuli and scala media electrode array position were observed in cases of narrow cochlea ducts. In patients, at 180°, the horizontal diameter ranged from 2.1 to 2.6 mm, and the vertical diameter from 1.6 to 1.9 mm. A correlation was found between the length of the cochlea duct and the insertion angle of the electrode array. In most of cases, the radiologist could not determine the exact electrode array localization because of the middle position of the electrode.

Conclusion: In cochlear implanted patients, precise position of the electrode in the cochlear duct is difficult to evaluate using CBCT with straight electrode arrays. However, CBCT is a reliable tool to determine the size and length of the cochlear duct, two parameters that may influence the electrode position.

P1-2-11

In vivo measurements of the insertion depth angle and its variability depending on cochlear size for Nucleus CI422 recipients

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Hypothesis: Cochlear size and linear insertion depth are main factors for the insertion depth angle of cochlear implant electrode arrays. Aim of the study was the investigation of this relationship in CI422 recipients to establish a method for predicting the insertion depth preoperative.

Background: Preoperative estimation of insertion depth angles might help surgeons to avoid exceeding an intended insertion depth, especially with respect to low frequency residual hearing preservation.

Methods: Postoperative high-resolution 3D-radiographs provided by Flat Panel Computed Volume Tomography were used to investigate insertion depth angles in 37 CI422 recipients. Diameter of basal turn and distance d between first basal electrode and round window, which is fixed related to the linear insertion depth, were measured in addition.

Results: A considerable variation of measured insertion depth angles ranging from 306° to 579° was identified. The distance d ranged from -1mm to 6.7mm and correlated positive with the insertion depth angle. Between insertion depth angle and cochlear diameter - ranging from 8.11mm to 10.42mm - a negative correlation was found. Reducing the impact of the distance d on the insertion depth angle by means of considering data with a certain distance separately yielded to a stronger correlation between insertion depth angle and cochlear diameter.

Conclusion: The results suggest that preoperative measurement of the cochlear size might allow an estimation of insertion depth angle with the option of different array positions acting as an additional parameter for achieving an intended insertion depth angle.

P1-2-12

Evaluation of MRI artifacts caused by hearing implants in cadaver heads: Assessment of the internal auditory canal

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The assessment of the internal auditory canal (IAC) in MRI scans is a topic of high interest in cochlear implantation because broadened indication criteria nowadays allow implantation for patients with vestibular schwannomas, neurofibromatosis and other disorders. The aim of the present study was to evaluate the possibly observed correlation between the implant position and visibility of the IAC in MRI scans in cadaver heads.

In this study recent cochlear implants of 4 manufacturers, a MedEl Vibrant Soundbridge and a MedEl Vibrant Bonebridge were implanted into a cadaver head and MRI scans with various sequences were performed with various positions of the receiver-stimulator magnet. In a second series for evaluation of artifacts caused by the metallic parts of the implant alone the holding magnet was removed. A direct correlation between assessment of the internal auditory canal and the angle of the implant magnet to a horizontal plane as well as its distance from the external auditory canal was found. The evaluation of the internal auditory canal in an MRI scan seems to be possible if the cochlear implant is positioned in a specific way.

VSB-FMT and BB-BFMT make an assessment of the internal auditory canal impossible.

P1-2-13

Radiological estimation of length of basal turn of cochlea in Indian population

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Aim: To establish normative data on the size of basal turn of cochlea using high resolution CT of temporal bone in Indian population.

Material and methods: Fifty cases were randomly selected from the patients who had undergone HRCT of temporal bone for various indications. The cases with cochlear anomalies were excluded from study group. Reconstruction of the full basal turn of cochlear was performed for both ears using a 1.6-1.5mm thickness minimum intensity projection (Min IP).The largest distance from the round window to the lateral wall of basal turn was obtained (labeled distance A).The perpendicular to distance A was also measured and labeled distance B.The results were tabulated and the mean, SD and range of variation calculated for distances A,B and C.

Results: Mean distance A was 8.65mm (SD= 0.43,range 7.6-9.5mm). The mean perpendicular distance B was 6.35mm (SD=0.38,range 5.0-7.0mm).

P1-2-14

CT and MRI findings of the temporal bone in CHARGE syndrome: aspects of importance in cochlear implant surgery

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Intro: The primary purpose of this study has been to systematically investigate CT and MRI images to provide an overview of anomalies of the inner and middle ear in CHARGE-syndrome. Specific anatomical features of this syndrome have its impact on the surgical approach for cochlear implantation.

Material and methods: In this retrospective study, 45 CT's and 15 MRI's (digital and analogue) of the temporal bone of 47 patients with CHARGE-syndrome were reviewed in consensus by two head-and-neck-radiologists and two otologic surgeons. The assessment was based radiologic criteria of sizes and aspects of the structures and anomalies of the temporal bone according to literature.

Results: Abnormalities on the surgical access route were seen, such as petrosquamosal sinus (13,3%), underdeveloped mastoid (7,8%) and aberrant course of the facial nerve, crossing the round window (8,9%) or the promontory (17,8%). The appearance of the inner ear is widely variable ranging from dysplasia of one semicircular canal (21,1%) to absence of all semicircular canals (72,2%) and from a normal to hypoplastic cochlea, with 26,7% a the cochlea having less than 2,5 turns. The middle ear was often affected with a stenotic round (13%) or oval window (68%). The ossicles were frequentlydysplastic, of which the stapes was affected most (47%).

Discussion and conclusions: In this relatively large group of patients with CHARGE-syndrome, radiologic imaging of the temporal bone showed a large variety of the anatomy. Emissary veins, an aberrant route of the facial nerve and a stenotic round window may complicate cochlear implantation.

Learning outcome: Our findings will improve the awareness of different anomalies and the possible surgical risk.

P1-2-15

Exostoses of the internal auditory canal: 10 years follow-up

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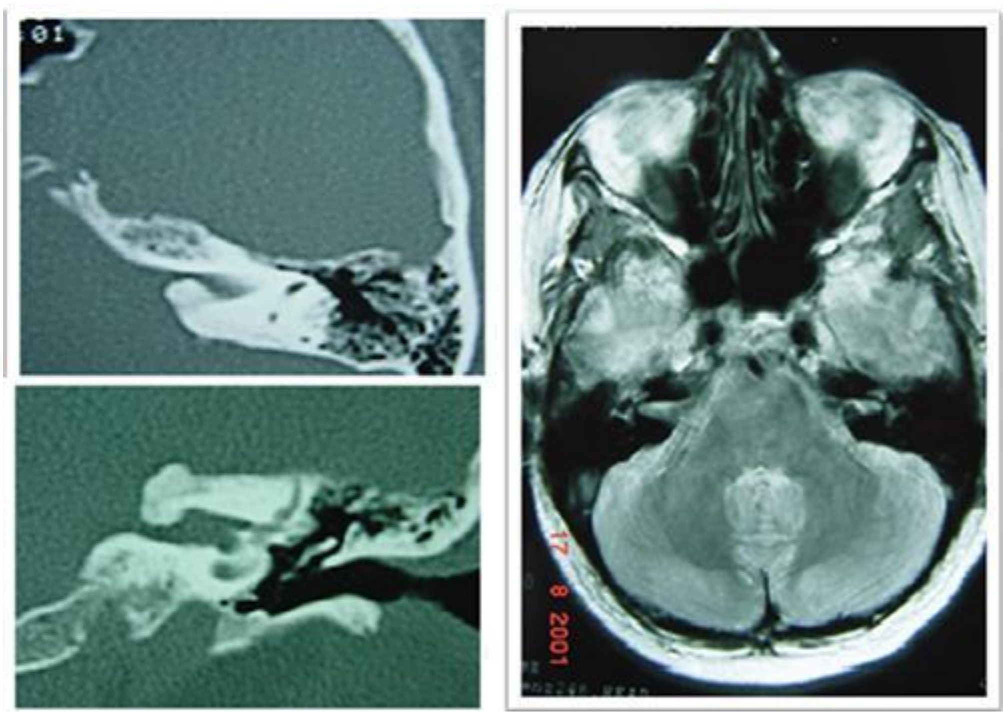
Introduction: Exostoses are benign and slow growing lesions that can develop in the head and neck region, most commonly in the external auditory canal but rarely in the internal auditory canal. Clinical presentation is variable, mostly asymptomatic, but can cause tinnitus, vertigo, hearing loss and even brainstem compression, thus mimicking symptoms of vestibular schwanommas.

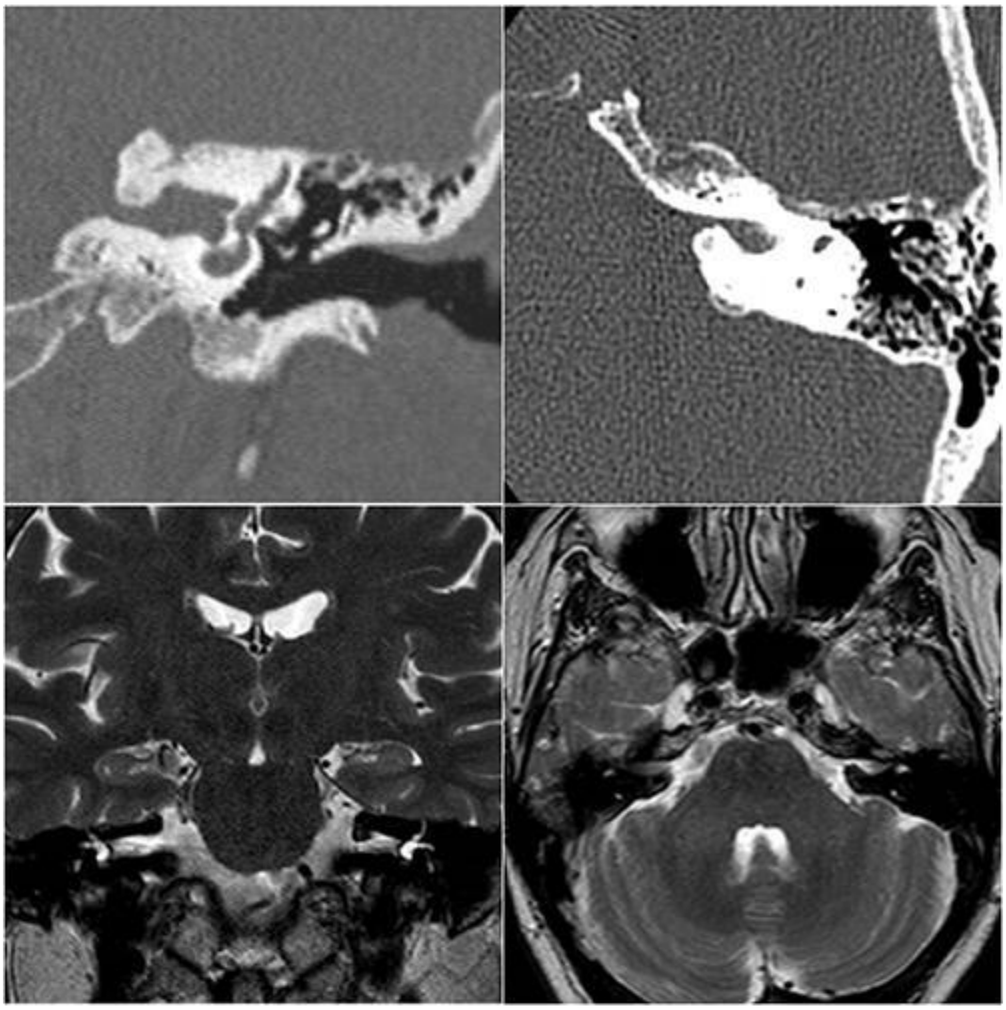
Case study: Female patient, 45 years old, complaining of a right pulsatile tinnitus that appeared two years ago. There were no other symptoms, such as hearing loss, dizziness, or pain. Physical examination and audiometry were normal. CT and MRI of the skull base and temporal bone (2002) showed a bony lesion in the left internal auditory canal, narrowing the canal. Radiological assessment 10 years later remained unchanged.

Discussion: There are few articles in the literature related to internal auditory canal exostoses, with only 14 papers published in PubMed. In asymptomatic cases, the lesions may be accompanied with regular CT scans, since they generally are slow growing. For symptomatic lesions, surgical removal should be considered.

Final Comments: Although rare, exostoses of the internal auditory canal should be considered as a differential diagnosis in patients with tinnitus or vestibular disorders, conservative management can be applied and the lesion can stay unchanged for many years.



[figure 1 - CT and MRI of 2002]



[Figure 2 - CT and MRI of 2012]

P1-3 Hearing & structure preservation I

P1-3-1

Hearing preservation; expanding criteria in paediatric cochlear implantation

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Introduction: Hearing preservation is a new exciting development that not only allowed preservation of low frequencies and acoustic hearing but also, patients who would not have been considered for a cochlear implant a few years ago, were implanted with very satisfactory outcomes. We discuss our experience in using this fascinating technique and how it affects current criteria and referral patterns.

Methods: Between 2011 and 2013 nine patients were assessed and offered a cochlear implant with the hearing preservation approach. Patient ages ranged from 23months to 11 years. Post-implantation, unaided sound field audiometry was performed at intervals between 6 weeks and 12 and 24 months according to clinical need. Hearing preservation was defined as conservation of postoperative unaided hearing thresholds within 15dB of pre-implant thresholds, across at least four audiometric frequencies. Categories of Auditory Perception scale (CAP2) and Speech Intelligibility Rating (SIR) tests were conducted prior to and following implantation.

Results: Preliminary results revealed hearing thresholds to have been successfully preserved in 7 of the 9 patients post-operatively. Both CAP2 and SIR scores improved following implantation ($p=0.001$ and $p=0.327$) respectively.

Discussion: Mid-to-high frequencies are an essential component of speech and language perception, whereas preservation of the low - frequencies is also important not only in speech and music awareness but in sound localization. The present study and other studies in children with CI and partial deafness have shown significant benefits, overcoming many of the challenges of conventional hearing aids previously encountered. Unfortunately, the perception that a cochlear implant damages all residual hearing is still the main reason of children with good hearing in the low frequencies, not being referred for a cochlear implant assessment early.

Conclusion: In paediatric cochlear implantation this new development allows implantation in children with partial deafness that would not have a received an implant a few years ago, mainly because of previous perception that a cochlear implant will damage all residual hearing. Paediatric cochlear implant teams should take a leading role in educating referring colleagues (primary care, audiology, ENT, teachers of the deaf) about this technique, which expands criteria for paediatric cochlear implantation and offers improved outcomes in comparison with conventional hearing aids in children with partial deafness.

Learning outcome: We would like to look at hearing preservation as a new development that affects current criteria and clearly includes children with partial deafness that do not benefit by conventional hearing aids. However, this knowledge has not reached referring teams and therefore children with partial deafness are not frequently referred in the UK. Early referrals for assessment and hearing aid trials under the supervision of paediatric CI teams should be encouraged.

P1-3-2

Round window and cochleostomy approaches for hearing preservation in cochlear implantation

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Introduction: Hearing Preservation (HP) is becoming increasingly important in cochlear implantation (CI) as it improves hearing and speech outcomes in noise. HP consist in an atraumatic insertion and pharmacologic hair cell protection. This study aims to describe the outcome of two different surgical approaches of the electrode insertion, through cochleostomy and round window.

Methods: A retrospective study was performed in a tertiary referral center, Manchester Royal Infirmary, between 2010 and 2013. Patients underwent cochlear implantation with a soft surgical technique via round window (RW) and cochleostomy (C) insertion. Preoperative and postoperative (6 to 8 weeks after CI) air conduction thresholds were used to assess the degree of hearing preservation and were used to compare the HP outcome in both groups.

Results: Consecutive patients who underwent HP CI were included (n=45 patients) from 2010 to 2013, 16 patients in the RW group and 29 patients in the C group. The average age was 40±29 years in the RW group and 49±24 years in the C group. The hearing preservation was similar in both groups throughout all frequencies. In 125 dB the difference between preoperative and postoperative threshold was 11.2 dB in RW and 14.7 in C group (p=0.057), 250 dB 16 dB in RW and 19 dB in C (p=0.870), 500 dB 22 dB and 13 dB (p=0.132) respectively, and in 1000 dB the difference was 4 in RW and 5 dB in C goup (p=0.561).

Discussion: Hearing preservation appears successful in a high number of subjects, and offers excellent speech perception abilities in quiet and in noise. The low frequency hearing thresholds are higher than in high frequencies as shown in previous studies. Our results show there is no difference between the surgical approach used for CI, therefore the decision to introduce the electrodes through the RW or the C should depend on the anatomy of the cochlea.

Conclusions: Our study suggests that there is no significant difference in hearing preservation regardless the surgical approach used for the electrode insertion during a cochlear implant.

Learning outcome: Different surgical approaches lead to similar results in hearing preservation CI, therefore the decision whether to use cochlesotomy or round window approach should be based on the anatomy and surgeons skills.

P1-3-3

Does the place of the electrode insertion influence the average insertion depth: A multicentric study on HiFocus 1j electrode?

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Introduction: Different variety of electrode types are available with a range of features and designs to fulfill various anatomical and geometrical variations of cochlea. While there is an aim to stimulate a wide range of the spiral ganglion cells across the cochlea, deep insertions on the other hand may induce significant trauma to the delicate cochlear structures and lead to a deterioration of the residual hearing and the speech performance. There appear to be a trade-off between depth of insertion and risk of trauma. Insertion depths can be measured as linear length of the electrode in mm or in degrees of rotation. The later takes into the account the position of the cochleostomy, size of the cochlea and the position of the electrode array within the scala. Round window Insertion will likely position the electrode closer to the modiolus in the basal part of the cochlea as against traditional cochleostomy. The HF1j electrode developed by Advanced Bionics LLC is a lateral wall electrode designed to cover up to 1.5 turns or up to app. 540° of the cochlea. The HiFocus 1j electrode was developed for controlled insertions using dedicated insertion tools offered by AB. It has been reported by Aschendorf et.al that above 30% of variations in the insertion depth is based on the placement of the cochleostomy and the individual insertion technique.

Objectives: The primary objectives of this study are to evaluate the average insertion depth of the HiFocus 1j electrode and to evaluate how it is influenced by the variation of the modiolus diameter and the location of the cochleostomy. Further it shall be investigated if the insertion depth and location of cochleostomy is influencing the NRI thresholds and the level of residual hearing preserved.

Methods: In a group of postlingually deafened children and adults aged 1 year or older with regular anatomy who will receive the HiRes90K implant and the Hi Focus 1j electrode will undergo a plain radiography (x-ray) investigation shortly after the surgery to determine the angular insertion depth. Pre OP CT imaging of the cochlea will be used to measure the individual dimensions of the outer and inner (modiolus) diameter of the basal turn of cochlea. The NRI thresholds at four electrodes will be obtained for the clinical records. Audiometric thresholds determining the amount of residual hearing will be performed as per clinical routine prior surgery and then monitored at device activation, one, three and six Months later.

Results: The study has just started and first subjects are being included. The preliminary results will be presented and discussed.

P1-3-4

Electrocochleography during cochlear implant insertion from extracochlear and intracochlear locations

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Intro: Monitoring cochlear responses to sound during implantation can potentially be used to reduce cochlear trauma and improve outcomes. Different recording locations can provide distinct information. An extracochlear electrode at a fixed location is best suited to provide information about cochlear trauma. An intracochlear electrode can provide a larger signal and help identify electrode position in the cochlea. It is hypothesized that simultaneous extracochlear and intracochlear recordings will allow for detection of damage and approximation of electrode position.

Methods: Auditory stimulation (500 Hz tones at 85-95 dB HL) and ECoG recordings were made intraoperatively in patients receiving a CI from an extracochlear electrode placed next to the stapes, and a temporary flexible electrode inserted into the cochlea. Recordings were collected during insertions up to 20 mm. Response magnitudes were measured as the sum of the first and second harmonics, while a signal analysis algorithm calculated the Compound Action Potential (CAP) in patients with sufficient nerve activity. An animal (gerbil) model was also used to test recording through actual standard implants, in response to a variety of stimulus amplitudes and frequencies, in order to characterize the signal quality of intra-CI recording and assess feasibility for future human use.

Results: It was technologically feasible to record ECoG signals from extracochlear and intracochlear locations simultaneously. The extracochlear signal was up to an order of magnitude smaller than the intracochlear signal, but had a smaller variance from baseline due to its fixed location relative to the cochlear generators. The intracochlear signals generally increased as the tip electrode advanced towards the generators in the apex. In the animal model, proprietary software provided by the manufacturers to record from the tip electrode showed comparable sensitivity in the same timeframe to recordings with our standard equipment.

Discussion: Simultaneous recording through a cochlear implant and a custom extracochlear electrode is possible, each providing complimentary but distinct information. The intracochlear recording can be obtained through the implant electrode itself and collaborations with manufacturers to achieve this capability in humans are ongoing with concurrent testing in an animal model.

Conclusions: It is technologically feasible to record ECoG signals from extracochlear and intracochlear locations simultaneously to provide information relating to cochlear trauma and electrode position.

Learning objective: The reader will learn that intracochlear electrocochleography through a standard cochlear implant is now possible, and how the addition of an extracochlear electrode provides distinct information in detecting cochlear trauma during CI insertions.

P1-3-5

Hearing preservation in adolescents

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Introduction: Soft surgical techniques are increasingly being used in an attempt to preserve residual low frequency hearing in adults undergoing cochlear implantation. We describe our experience of cochlear implantation with hearing preservation in adolescents.

Methods: Attempts at cochlear implantation with hearing preservation in adolescents were identified from the Manchester Auditory Implant Centre, UK. A retrospective case note review was performed, with emphasis on; functional hearing deficit pre-operatively, surgical technique, age at implantation, type of electrode implanted and functional hearing ability at sequential follow up. Functional outcomes were evaluated with the aim of evaluating both, the potential benefit of preserving residual low-frequency hearing and the maintenance of preserved hearing over time.

Results: 16 adolescents (10 girls, 6 boys) received 18 cochlear implants over a 5 year period. The average age at implantation was 13 years, 5 months (range 10.5 to 17 years, 11 months). Average follow up was 2.5 years (range 1 year to 4 years, 3 months). Varying degrees of hearing preservation were achieved across the group, with hearing preservation being successful in all cochlear implantations. Detailed analysis of the audiological outcomes will be presented. Functional hearing significantly improved in all patients over time, including 3 patients whose low frequency hearing diminished with time.

Discussion: Adolescents may require several re-insertions of their cochlear implants over a life-time and therefore increasing emphasis is being placed on atraumatic electrode insertion, in order to limit intra-cochlear scarring.

Conclusion: Residual hearing can be preserved in adolescents using a soft surgical technique.

Learning outcome: Adolescents should be considered as candidates for hearing preservation cochlear implant surgery.

P1-3-6

Lamb temporal bone as a surgical training model of round window cochlear implant electrode insertion

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The preservation of residual hearing in cochlear implantation opens the door for optimal functional results. This atraumatic surgical technique requires training; however, the traditional human cadaveric temporal bones have become less available or unattainable in some institutions. This study tests the suitability of an alternative model, utilizing cadaveric lamb temporal bone, for surgical training of atraumatic round window electrode insertion. A total of 14 lamb temporal bones were dissected for cochlear implantation by four surgeons. After mastoidectomy, visualization and drilling of the round window niche, an atraumatic round window insertion of a Medel Flex[24] electrode was performed. Electrode insertion depth and position were verified by CT-scans.

All cochleas were successfully implanted using the atraumatic round window approach; however, surgical access through the mastoid was substantially different when compared human anatomy. The mean number of intracochlear electrode contacts was 6.5 (range 4 - 11) and the mean insertion depth 10.4mm (range 4-20mm), which corresponds to a mean angular perimodiolar insertion depth of 229 degrees (range 67°-540°). Full insertion of the electrode was not possible due to the smaller size of the lamb cochlea in comparison to that of the human. The lamb temporal bone model is well suited as a training model for atraumatic cochlear implantation at the level of the round window. Due to substantial differences to human anatomy, it is not an adequate training model for other surgical techniques such as mastoidectomy and posterior tympanotomy.

Learning outcome: To know a new alternative to human and artificial temporal bones for teaching of atraumatic round window electrode insertion technique.

P1-3-7

Correlation between force measurement during insertion of cochlear implant electrode and intracochlear violation of the basilar membrane

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Introduction: To find out the correlation between insertion forces and intracochlear trauma of the basilar membrane, 10 temporal bone specimens were inserted with the Hybrid-L electrodes. Post interventional µCT scans were acquired to validate the intracochlear position of the electrode and possible change of the scala. Force measurement was performed during the insertion.

Material and method: For being able to have a free range of movement during the insertion, canal wall down mastoidectomy has been performed on 10 human temporal bone specimens. A one dimensional force measurement setup was installed underneath the specimen to record the forces during the insertion process. Different insertion angles were chosen during insertion to induce crossover of the electrode from scala tympani to scala vestibuli during the insertion process. All insertions were performed by the same Cochlear Implant surgeon. The insertion process was videotaped. After the insertion, µCT scans have been performed for validation of intracochlear violation. In cases with possible bypass of the electrode, histological validation (µ-grinding) was performed to verify the µCT finding.

Results: The average number for the maximum forces measured outside (underneath) of the cochlea during the insertion was 0.0200 ± 0.0102 N. The forces applied to the cochlea increased continuously during the insertion process. In 4 cases we could induce bypass of the electrode from scala tympani to scala vestibuli. In our preliminary review of the video tapes and force measurement data, we could not find any other remarkable events.

Discussion: As previously reported, manual insertion can cause intermittent peaks in forces, which may mask the peak due to intracochlear trauma. Using an automated insertion tool might lead to more constant data. The verification of the setup, using a three dimensional force measurement system or measuring the forces applied to the electrode during the insertion at the electrode side, might be more beneficial and needs to be examined.

Conclusion: Based on our preliminary results, measuring the insertion forces outside of the cochlea in our setup did not reveal any noticeable marks for early detection of intracochlear violation of the basilar membrane.

Learning outcome: Using an automated insertion tool, and verification of the force measurement setup, might be more beneficial.

P1-3-8

Hearing preservation in adult patients with Advanced Bionics MidScala electrode implant

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Advanced Bionics MidScala electrode was designed especially to preserve hearing in patients selected for CI implantation and with hearing residuals. The aim of the study was to present own experience with new electrode and show hearing preservation in adult patients to whom the new electrode was implanted through round window. Typically surgical steps include: conservative mastoidotomy, which is proceeded by a removal of a mastoid cortex with the use of a chisel and a hammer, posterior tympanotomy, very delicate puncture and incision of the round window membrane, insertion of the electrode directly to the scala tympani, stabilizing the electrode array in the niche close to the membrane with fibrin glue and periostium or fascia, fixing the inner body of the implant and covering the mastoid with the cap removed at the beginning. We present the ratio of hearing preservation which is promising. In conclusions we point that this new MidScala electrode has become a chance for a significant group of patients. It is of crucial importance that the method of Partial Deafness Treatment (PDT) has been validated with the use of a new cochlear implant system. Current surgical experience suggests that there is a possibility to extend indications for this new electrode.

P1-3-9

Mechanisms of trauma with lateral wall electrodes and considerations for atraumatic insertion

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Objectives: To characterize the insertion dynamics of straight lateral wall electrode arrays and their interactions with intra-cochlea structures to identify potential mechanisms of trauma.

Study design: Surgical and clinical data was reviewed to identify variables associated with known intracochlear complications and/or potential contributors to intracochlear trauma. Analytical and experimental models were developed to characterize and verify electrode/cochlea interactions to establish models to improve surgical outcomes and reduce trauma. Modeling was extended to human temporal bones to validate both improved surgical outcomes and to evaluate intracochlear trauma via acrylic fixation and histologic sectioning.

Results: Reports of surgical and clinical complications with straight lateral wall electrodes were successfully used to identify causal effects for insertion trauma. This information was used to define and implement features to minimize trauma which were verified on the bench and in human temporal bones.

P1-3-10

HiFocus™ Mid-Scala electrode use case results on residual hearing preservation

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Background/Purpose: The HiFocus Mid-Scala electrode array was designed to offer the surgeons the flexibility of contemporary surgical techniques that have been shown to enable easy insertion and to minimize cochlear trauma (see, e.g., Adunka and Buchman, 2007; Friedland and Runge-Samuelson, 2009; Roland et al., 2007). Temporal bone experiments have shown the HiFocus Mid-Scala electrode array to be easy to insert while preserving the internal cochlear structures during and after implantation (Lenarz et al., 2010; Rebscher et al. 2013; Aschendorff et al., 2013). Safety and efficacy were established by Lenarz, Frijns, Huber et al. 2013. The purpose of this study was to investigate the potential of the HiFocus Mid-Scala electrode array in adults with mild to severe hearing loss in the high frequencies (2-8 KHz).

Material and methods: The HiFocus Mid-Scala electrode array is a thin pre-curved on-stylet electrode array. Its 16 contacts are situated on a thin silastic carrier that tapers toward the proximal end of the array. Within this study 15 postlingually adults with normal cochlear anatomy were enrolled. They were implanted with the HiFocus Mid-Scala electrode array under standard surgical procedure. It was the aim to evaluate preservation by comparing audiograms pre and post implantation. We also evaluated functional residual hearing by comparing unaided speech perceptions test pre and post intervention.

Result and conclusion: Surgeries were successful and uneventful despite of some demanding anatomical situations. Both extended and pure round window approaches have been applied with and without the use of the dedicated insertion tool allowing a one hand insertion. 3 subjects had a near complete preservation (threshold shift < 15 dB HL); 3 had at least moderate hearing preservation (threshold shift 16-30 dB HL); 9 patients had a marginal preservation of hearing (threshold shift more than 30 dB). The preoperative to postoperative low-frequency pure-tone average had a mean change of 18.4 dB and median change of 20 dB.

Preservation of residual hearing is feasible using the HiFocus Mid-Scala electrode array.

P1-3-11

On the borderline between direct acoustical stimulation and a cochlear implant: Codacs case studies

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Introduction: The Codacs Direct Acoustic Cochlear implant was developed for treatment of patients with severe-to-profound mixed hearing loss. The actuator of this new implantable device is attached to a conventional stapes prosthesis and thereby provides mechanical amplification through a stapedotomy of the oval window to the cochlea. A successful Codacs treatment requires sufficient cochlear reserves and the verification of this reserve is a major challenge within the targeted patient group.

Methods and patients: Here we report on two selected patients with profound mixed hearing loss that were implanted at the Medical University of Hannover with the Codacs hearing system. The averaged bone conduction thresholds (0.5, 1, 2 and 4 kHz) of the reported patients were 53 and 58 dB HL. The first patient had a moderate air-bone gap of 25 dB HL (average of 0.5, 1, 2 and 4 kHz) and was able to achieve 85% WRS at 110 dB SPL with headphones prior to implantation. The average air-bone gap of the second patient was nearly maximal (48 dB HL) and no pre-operative word recognition could be measured with headphones.

Results: The bone conduction thresholds did not decrease after the implantation in both cases, indicating that the function of the inner ear was preserved. In aided condition with the Codacs both patients had 80% WRS at 65 dB SPL in quiet and approx. + 1.5 dB SNR (OLSA S_0N_0) three month after activation.

Conclusion: In mixed hearing loss patients, similar results in aided benefit can be obtained in mechanical stimulation even in cases with highly different starting point in terms of monosyllable intelligibility. Although pre-operative testing of intelligibility is desirable to estimate the potential cochlear reserve, currently only bone conduction thresholds appear to be a reliable parameter for the indication of direct acoustical stimulation in profound mixed hearing losses.

P1-3-12

Hearing and patient satisfaction in 19 patients receiving cochlear implants intended for hybrid hearing - A two-year follow-up

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Background: We performed a patient satisfaction survey and retrospective, two-year follow-up study on patients intended for hybrid/EAS hearing. Patient satisfaction was rated and hearing and its solidity over time evaluated.

Method: Nineteen partially deaf patients intended for hybrid hearing and subjected to hearing preservation surgery participated in the study. Pure tone audiogram, monosyllables (MS) and hearing in noise test (HINT) were analyzed. After the use of device for at least one year they responded to a questionnaire consisting of the IOI-HA, EQ-5D visual analogue scale and nine questions about residual hearing and music. At the time of the patient survey, six patients used unamplified low-frequency hearing and CI with cut-off frequency. Nine patients used amplified low-frequency hearing and CI (Duet) and four conventional full frequencies CI.

Results: There was no incidence of total loss of residual hearing in any of the patients but a certain ongoing deterioration of residual hearing was distinguished in the operated ear that surpassed the contra-lateral ear. At one month mean low frequency hearing loss (125, 250 and 500 Hz) was -17 dB (min 3, max -40, SD 11) and after two years the loss was -25 dB (min 3, max -57, SD 16). The questionnaire indicated a high degree of patient satisfaction independent of hearing preservation rate. Eighteen patients were “very satisfied” with their CI and one was “satisfied.” All patients recommended CI to a person in the same situation. IOI-HA mean score was 29 out of a possible 35 (SD 3.6, range 22-35). The mean value of the EQ-5D™ VAS was 78 out of a possible 100 (SD18.9 range 27-100). The patients claimed improved speech perception in silence and noise which was also reflected by a gain reached in MS and HINT. At two-year follow up patients scored 58 % MS (SD 17, max 90, min 22) and HINT showed a mean SNR of 4.6 dB (SD 3.4, max -1.7, min 12.5). There were no correlations between residual hearing and MS or HINT. Eleven of 15 hybrid hearing patients claimed that music sounded well or very well. All patients, using full frequency CI without useful low frequency hearing did not appreciate music.

Discussion: Hearing preservation surgery gives high frequency hearing to a new group of patients. This study shows the possibilities even for patients with normal low frequency hearing. Still we need more studies of the stability of the preserved hearing before bilateral implantations of partial deaf patients.

Conclusions: Hearing preservation surgery with hybrid hearing strategies provides high patient satisfaction and considerable improvement in speech perception. This gain widely exceeded the negative aspect of deteriorated residual hearing.

Learning outcome: High frequency deaf patients including children add quality of life with hybrid hearing.

P1-3-13

The Clinical outcome of electric acoustic stimulation

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Introduction: There is a significant group of patients whose hearing impairment is characterized by normal or slightly elevated thresholds in the low frequency band with nearly total deafness in high frequency range. These patients remain beyond the scope of effective treatment by hearing aids. EAS have produced large improvements in the speech reception abilities of these patients. Although EAS have been established as highly effective procedures, questions remain about surgery and optimal combinations of electric and acoustic stimuli.

Purpose: We want to clarify the selection of ideal candidates, types of the electrode array, and whether the reliability of hearing preservation in an implanted cochlea can be increased beyond the present high levels. So, the purposes of this presentation are to review results of our cases from three points of view : (1) The stability of hearing preservation (2) Acoustic benefit according to postoperative hearing preservation status (3) Mapping optimization of EAS.

Method: 21 patients (22 ears) with preoperative residual hearing(< 85dBHL) at 125Hz~500Hz were enrolled in this study. Various atraumatic electrodes (Hybrid L (n=1), CI422 (n=13), Flex28 (n=3), Flex 24 (n=5)) were used. We compared postoperative hearing with preoperative residual hearing with respect to affecting factors such as patient and surgical factors. Also acoustic benefits according to available residual hearing level or frequency range were evaluated by measurement of acoustic and electric-acoustic performance in music, noise and different mapping conditions.

Results: Preservation of the residual hearing at 125, 250, 500Hz was possible with high degree (Complete(n=9):< =10dB in all three frequencies, Partial(n=8):< =10dB in two frequencies or Average < =30dB, Incomplete(n=3):>10dB in two frequencies and Average >30dB, Total loss(n=0)). Using all types of atraumatic electrodes, it was possible to get higher rate of hearing preservation. In most cases (21/22), acoustic stimulation contributes better auditory performance than electrical stimulation only except one who used CI only mode. Even subjects with poorer residual hearing at 125~500Hz beyond recommended hearing limit by company preferred CI with acoustic sound. In contrast with conventional CI patients, music perception, melody contour identification, and HINT showed higher rates. Proper acoustic range and mapping optimization were different according to postop. residual hearing frequency range and speech processor.

Conclusion: Our results showed preservation of the residual hearing is highly expectable and acoustic stimulation can contribute better auditory performance than electrical stimulation only. Even though HP was not successful, some residual acoustic hearing might be helpful for the better performance.

P1-3-14

Structure preservation in partial deafness cochlear implantation witch Nucleus CI422 in patients with substantial low frequency hearing

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Objectives: Preservation of residual hearing in cochlear implantation comes along with preservation of intracochlear structure. Surgery in this type of cases requires special atraumatic approach and attention. 6 steps surgical procedure for partial deafness treatment was designed and applied for this purpose being applicable in adults as well as in children. Estimation of preservation of cochlear structure can be assessed by mean of radiological evaluation (CT scans) and by means of tonal audiomtery.

Methods: 19 children and 35 adults with substantial residual hearing underwent cochlear implantation with Nucleus CI422 cochlear implant. Minimal invasive surgical procedure with round window approach for partial deafness treatment was applied in every case. High resolution CT scans of temporal bones were performed to estimate position of electrode in scala tympani.

Results: In any of implanted cases dislocation of electrode was observed in CT scans. Angular depth of electrode position was calculated in every case and compared with hearing preservation rate. Preservation of hearing was assessed in several follow up visits - mean elevation of hearing threshold across frequencies did not reach 10 dB at activation visit and 15dB up to 36 months visit.

Conclusions: Electrode of Nucleus CI 422 is proved to be a good atraumatic tool for hearing preservation surgery. Stable results in hearing thresholds in tonal audiomtery were obtained both in children and in adults cases.

P1-3-15

Nucleus Hybrid-L electrode and hearing preservation

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Selected group of patients with hearing loss at high frequency and still preserved hearing at low frequencies do not benefit from the classic hearing aid. Nucleus Freedom Hybrid-L system - concept of electro-acoustic - stimulation was introduced into the clinical practice in 2009.

The cochlear implant program in Poznan started in 1994. Till now we have performed 1076 cochlear implantations. The first Hybrid-L system was implanted in Poznan in Dec 2009. Till now we have 31 patients implanted with this system (age 16.5-77.5). At the moment all 29 patients use the device and 2 are waiting for speech processor switch-on. Pure tone thresholds were recorded before to the surgery, at the time of speech processor switch-on, and during follow-up. Patients were subdivided into two groups with due to indications: group A - classic (n=21), group B - extended ones (n=10). After surgery during speech processor switch-on in 24 cases hearing was preserved (19 in A group, 5 in B group). In 5 patients loss of hearing was observed (1 patient in A group, 4 in B group). 17 patients use the hearing aid the opposite side, 12 did not use it.

With over 2 years of observations hearing threshold are stable in 12 patients, we have no information about 6 patients (people from abroad). Our observations in 29 patients show good hearing results. All the patients use electro-acoustic stimulation, even patient with loss of hearing.

P1-3-16

Is ear after cochlear explantation really deaf?

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Since several years one of the aim of the soft surgery during cochlear implantation is preservation of residual hearing, but at the beginning of the 21st century we have not been focused on it.

The cochlear implant program in Poznan started in 1994. Till now we have performed 1076 cochlear implantations. We present a case of a 15 years old girl, who was implanted at the left side in Jan 2001 at the age of 2.5 due to bilateral deafness. She was a very good CI user and attended the mainstream school. 12 years after surgery patient started to complain of temporary headache, decrease of speech understanding. The radiological evaluation (CT, MRI with magnet removed) did not reveal any pathology. There were no neurological symptoms. In July 2013 we decided to reimplant the patient. Unfortunately, there were some difficulties to insert a new device into the cochlea, so we decided to implant second ear, which was totally deaf and patient did not use even a hearing aid at this side. The girl very quick reached appropriate level of communication to continue learning at school. After 6 months we have decided to try a hearing aid at the primarily implanted side, maybe to get some vibrations. It was a total surprise, when after hearing aid fitting the girl told us the she can hear at this side, can discriminate a several simple words without lip-reading only from the acoustic amplification from the ear after cochlear explantation. This patient is just under control and will be monitored carefully.

P1-3-17

Electrophysiological monitoring of residual hearing during and after cochlear implantation

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Introduction: Improvement in electrode design and surgical techniques has increased the rate of hearing preservation after cochlear implantation. However, in a considerable amount of patients complete or partial loss of residual hearing after cochlear implantation still occurs. The underlying mechanisms are poorly understood so far. Besides acute mechanical and non-mechanical trauma delayed events such as foreign body reaction and molecular activation leading to delayed neural injury seem to play a major role. Our goal was to further assess time and mechanisms of postsurgical hearing loss by electrophysiological monitoring of residual hearing during and after cochlear implantation.

Methods: Patients with some degree of residual hearing undergoing cochlear implantation were included. Electrophysiological monitoring of residual hearing during surgery was conducted by recordings from the round window. Therefore a monopolar electrode was placed at the round window through the posterior tympanotomy. Electrocochleographic responses to sinusoid tone bursts of different intensities at 250, 500 and 1000Hz before and immediately after electrode insertion were recorded. In the days and weeks after surgery further recordings were conducted with the cochlear implant electrode itself as measurement electrode. Changes in amplitude and threshold of electrocochleographic potentials were correlated with findings in psychoacoustic tests including pure tone audiogram and speech perception tests. Postsurgical fluid conditions in the middle ear were monitored by tympanogram.

Results: Electrocochleographic potentials were detected in all patients with residual hearing in the presurgical pure tone audiogram. During surgery relevant changes in electrocochleographic potentials were rare and showed no correlation with changes in hearing thresholds 4 weeks after surgery. No complete loss of electrocochleographic potentials occurred during surgery. In the first days after surgery progressive hearing loss and a decrease of amplitude in electrocochleographic potentials at least partly due to conductive hearing loss from hematotympanon occurs in all patients. Further monitoring after 4 weeks and more showed recordable cochlear microphonics in some patients despite loss of residual hearing in pure tone audiogram.

Conclusion: Severe intracochlear trauma (e.g. rupture of basilar membrane) during cochlear implantation seems to be rare. The prognostic value of round window recordings during surgery regarding hearing preservation after 4 weeks is limited. Changes causing hair cell loss or neural injury in the first few days and weeks seem to be responsible for loss of residual hearing in a considerable amount of patients. Detectable cochlear microphonics after 4 weeks in patients with complete loss of residual hearing further indicate neural or synaptic injuries.

P1-3-18

Acoustic hearing correction in patients with chronic suppurative otitis media

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Hearing level of patients after chronic suppurative epitympanoantral middle otitis treatment surgical treatment is currently becoming more and more important. Hearing gain is not always sufficient for full social adaptation due to pronounced neurosensory component of hearing loss, small bone-air reserve and poor postoperative speech intelligibility (hearing loss in the area of low and middle frequencies).

The aim of the study was to enhance hearing rehabilitation efficiency in patients after sanifying surgery on a middle ear.

Materials and methods: Hearing rehabilitation was performed to 52 patients after sanifying surgery on a middle ear who applied to the National Centre of Otorhinolaryngology with complaints on hearing loss.

All patients were differentiated into 4 clinical groups according to pathological process activity in the ear and hearing loss degree:

1. Patients with hearing loss of II-III degree and periodic suppuration from the ear (n=11). Hearing correction was made with hearing aids of bone sound conduction (n=5), BAHA-type hearing aids of bone sound conduction (n=4) or BONEBRIDGE hearing aids (n=2).
2. Patients with hearing loss of II-III degree without suppuration symptoms (n=20). Hearing correction was made with hearing aids of air sound conduction.
3. Patients with hearing loss of II-III degree (n=11) with pronounced neurosensory component. Hearing correction was made with vibroplasty of round window (n=6) and stapes (n=5).
4. Patients with IV degree of hearing loss (n=2).

Results: Socially adapted hearing was restored in all patients.

Conclusion: The choice of acoustic correction method is determined by the degree of hearing loss, the pathological process activity, the severity of damage in tympanum and the nature of surgical intervention.

P1-3-19

Hearing preservation in partial deafness treatment

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Aim: Several studies have shown that with appropriately designed and inserted electrodes, acoustic hearing can be preserved in the majority of subjects during cochlear implant (CI) surgery. Having increasingly higher number of cochlear implant patient with hearing preserved, there is a need for hearing preservation classification. The aim of this retrospective study was to applied the HP classification, which was recently proposed by the group of HEARRING centres, in assessment of children after Partial Deafness Treatment (PDT)

Material and method: The already published hearing preservation data from PDT patients implanted in the Institute of Physiology and Pathology of Hearing were re-evaluated using the HP classification system

Results: The individual hearing preservation results were stratified into 4 categories: Complete, Partial, Minimal hearing preservation and Loss of Hearing.

Conclusion: The Hearing Preservation Classification System allows for a larger overview of hearing and structural preservation and should be used as universal standard for reporting.

P1-3-20

Hearing preservation surgery for cochlear implantation - Hearing and quality of life after 2 years

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Objective: To study the benefits of hearing preservation surgery in cochlear implantation after 2 years.

Study Design: A retrospective cohort study

Setting: Performed at a single academic institution between 2008 and 2010

Patients: 13 patients (1 bilateral), 43% male and 57% female. Mean age at surgery was 51 years (range from 32 to 72 years). Average duration of deafness was 25 years (range from 5 to 62 years).

Intervention: Hearing preservation cochlear implantation surgery performed with the MED-EL Flex EAS electrode

Main Outcome Measures: Pure tone thresholds, speech in quiet and noise measures and quality of life (Abbreviated Profile of Hearing Aid Benefit (APHAB) and Glasgow Hearing Aid Benefit (GHAB) Scales) up to and including two years after surgery.

Results: At the first postoperative audiogram the hearing preservation rate was 100% (Complete (42.9%), partial (50%) and minimal (7.1%)). After 24 months the breakdown was complete (25%), partial (12.5%), minimal (37.5%) and complete loss (12.5%). There was a trend in improvement in all areas of APHAB) with significant improvements in the background noise and reverberation categories as well as the global scores. The GHAB scores showed high levels of use, benefit and low levels of residual disease.

Conclusion: Hearing preservation can be achieved in the short term but deteriorates with time over the medium term at a rate greater than that can be expected with the natural progression of the disease. Patients show benefits in speech outcomes and quality of life regardless of whether hearing preservation was achieved in the medium term.

P1-4 Hearing & structure preservation II

P1-4-1

Hearing preservation in older adults with cochlear implants

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Introduction: Hearing preservation cochlear implant surgery is well established and the benefits of this are well recognised. We present our results of hearing preservation surgery in older adults using a cochleostomy approach and deep insertion using MED-EL Flex electrodes (28mm and 31mm).

Methods: A retrospective study was undertaken of older adults undergoing CI with hearing preservation at our institution. 10 patients were included in the study, and the main outcome measure was pure tone thresholds after surgery.

Results: The study group consisted of 10 adults with an average age at implantation of 72.1 years (range 68 to 76 years). All of the patients had electrode insertion via the cochleostomy approach. 4 patients had a Flex Soft electrode (31mm) and 6 had a Flex 28 electrode (28mm). One patient had a complete loss of residual hearing after surgery and all of the remaining patients had preservation of hearing. The average deterioration at 125Hz was 17.8dB, at 250Hz was 18.9dB, at 500Hz was 12.2dB, and at 1000Hz was 4.2dB. None of the patients had a deterioration in hearing of >40 dBHL

Discussion: Preservation of residual hearing has been documented in young adults and adolescents, however some questions have been raised in regards with older adults. This study shows that in older adults hearing preservation con be achieved using a soft technique and therefore speech perception ability will be gained as well.

Conclusions: This study demonstrates that residual hearing can be preserved in older adults using a cochleostomy approach and deep insertion of Flex electrodes. The results are comparable to those seen in younger adults and adolescents.

Learning outcome: Hearing preservation is a possible option in older adults who need cochlear implantation

P1-4-2

Is it possible to preserve hearing with the new electrodes guides without a "soft" surgery? - Implications for the selection of candidates

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Introduction: In last year's two cochlear implant companies incorporated very thin and flexible electrode designs into the market, with the objective of increasing hearing preservation, even in common cochlear implant candidates

Methods: Analysis of 6 patients who were implanted with these guidelines electrode (5 Medel - Cochlear Flex 28 , 1 - 422).

Results: Even performing a traditional technique of implantation was possible to preserve residual hearing in all implanted patients that had residual hearing prior to implantation. Hearing thresholds have been maintained in the same levels during more than one year of follow-up.

Discussion: Our findings stress the importance of electrode designs in successfully preserving residual hearing. Currently available systems are well designed to stay in the scala tympani without damaging the basilar membrane. Hearing preservation should become common.

These results have implications at three levels:

1. Expanding selections criteria for implantation
2. Achieve better and longer lasting hearing results
3. Exploring the benefits of hybrid stimulation even in patients priorly considered only for standard cochlear implant use.

We are at the moment undertaking different tests with our patients in order to find if they benefit using a hearing aid together with their implant.

P1-4-3

Development of hearing preservation surgical procedure for partial deafness treatment

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The development of implant technologies and growing expertise in surgery and rehabilitation have changed cochlear implant candidacy criteria. Increasingly, younger children are undergoing implantation. Not only are individuals with a bilateral profound hearing loss receiving cochlear implants, but also those with considerable residual hearing. The implementation of a cochlear implantation program that preserves residual hearing is an ambitious challenge.

The round window technique, originally used in cochlear implantation, was abandoned because of concerns that the angle of insertion may lead to trauma of the osseous spiral lamina, due to the stiffness of electrodes at that time. Our surgical team decided to use the round window surgical approach in an attempt to limit loss of residual hearing that might be caused by creating a cochleostomy. The aim of the paper is to present the developed and constantly refined surgical procedure based on the round window approach.

The proposed surgical procedure includes the following steps:

1. antromastoidotomy
2. posterior tympanotomy to allow visualization of the round window niche
3. puncture and incision of the round window membrane
4. approach to the scala tympani directly through the round window membrane
5. electrode fixation in the round window niche with fibrin glue (membrane must be left partially uncovered to preserve its mobility)
6. fixation of the device in the well in temporal bone

P1-4-4

Comparison of two cochlear implantation techniques and their effects on the preservation of residual hearing. Is the surgical approach of any importance?

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The goal of this work was to review the pre-and postsurgical auditory thresholds of two surgical implantation techniques, namely the mastoidectomy with posterior tympanotomy approach (MPTA) and suprameatal approach (SMA), to determine whether there is a difference in the degree of preservation of residual hearing. In a series of 430 consecutive implanted patients 227 patients had measurable pre-operative hearing thresholds at 250, 500, and 1,000 Hz. These patients were divided into two groups according to the surgical technique that was used for implantation. The SMA approach was followed for 84 patients in Amsterdam, whereas the MPTA technique was adhered to 143 patients in Maastricht. The outcome variables of interest were alteration of pre- and postoperative auditory thresholds after cochlear implantation. Complete or partial preservation of residual hearing was obtained in 21.4 and 21.7 % in the SMA and MPTA group, respectively. No statistical differences could be found between the SMA and MPTA group ($p = 0.96$; Chi-square test). The SMA technique is correlated with a similar degree of hearing loss after cochlear implantation compared to the MPTA technique. However, both techniques were not able to conserve a measurable amount of hearing in patients with a substantial degree of residual hearing. Therefore, both surgical techniques need to be refined for patients in which residual acoustical hearing is pursued.

P1-4-5

Structural and vestibular preservation after cochlear implantation, using the Flex^{28} electrode

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Background: Structural cochlear preservation surgery was developed in order to preserve residual hearing. This surgery comprises dedicated surgical techniques and the use of electrodes designed for electric acoustic stimulation (EAS). The Flex^{28} MED-EL electrode aimed to resolve the dilemma between structural and hearing preservation surgery, on the one hand, and full cochlear coverage on the other hand.

Aim: To investigate the effect of the use of the Flex^{28} electrode (Concerto Mi1000 pin Flex^{28} MED-EL) on the cochlear and vestibular outcomes in CI candidates with profound hearing loss.

Methods: 36 consecutive CI patients were implanted with the Flex^{28} electrode and 6 months outcomes are analyzed. The auditory outcome measures consisted of the minimal outcome measures (MOM) as defined by the HEARRING group. Vestibular analysis consisted of full caloric and rotation stimulation electronystagmographic analysis, c-VEMP and the Dizziness Handicap Inventory (DHI).

Results: Results at 6 months post-op will be reported and analyzed in view of the degree of realization of structural cochlear preservation surgery.

P1-4-6

Possible mechanisms for the delayed loss of residual hearing after cochlear implantation

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Introduction: The preservation of residual low frequency hearing and the use of a 'hybrid' speech processor which combines electrical and acoustic hearing have been shown in adults, to provide speech perception benefits for those with steep high frequency audiometric losses. For young children there may also be benefits in preserving the natural hearing for low frequencies, for example for music appreciation. Although hearing can usually be preserved at the time of the surgery, there are a number of recipients who lose hearing a few months afterwards. The mechanism for this delayed loss of residual hearing is unknown. Possible causes will be discussed.

Methods: a retrospective analysis of those recipients who lost hearing after 2 months was undertaken

Results: There were 15 subjects in the analysis. The loss of residual hearing was not associated with vestibular symptoms which suggest it is a purely cochlear problem.

Discussion: The most likely causes are:

1. Obstruction of the travelling wave due to increased stiffness of the round window membrane or intracochlear fibrosis, but this should only account for a loss of about 10-15dBHL. Furthermore, there is no evidence that a cochleostomy rather than a round window insertion is less likely to result in a delayed hearing loss.
2. Obstruction of the venous drainage of the apical hair cells. The venous drainage from the apical parts of the cochlea is very vulnerable. The venous return is along a single modiolar vein which winds around the surface of the helicotrema and there are areas with no bony covering. Eventually the vein passes as the common modiolar vein through the basal turn to enter the internal jugular vein. If this vein becomes obstructed it would lead to the engorgement and eventual death of remaining hair cells. The arterial supply of the hair sell is derived from a network of multiple capillaries passing from the helicotrema. There are multiple vessels and it seems unlikely these could become obstructed.

1 Perhaps delayed hearing loss can be accomplished by avoiding any direct contact with the modiolus and preventing intracochlear fibrosis.

P1-4-7

Our surgical experience with hybrid implant and hearing preservation outcomes

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Intro: In comparison to the human auditory system, current cochlear implants provide poor perception. Combined electroacoustical stimulation may provide a solution, since the low-frequency acoustic hearing can supplement the electrical stimulation of the high-frequency hearing.

Methods: Four adult subjects have been implanted with the Nucleus Hybrid implant. The outcomes of the surgery are evaluated by a pure tone audiometry and open set word discrimination.

Results: All implantees have very good speech discrimination scores with the Hybrid implant. One implantee has lost the acoustic component in a longer timeframe, but he is still using the electrical part of the implant.

Discussion: risks of intervening into the functioning cochlea are shown, stability of the acoustic component in a longer time horizon is discussed.

Conclusion: Hybrid implants represent a viable solution for partly hearing individuals, whose benefit from conventional hearing aids is limited.

Learning outcome: implantable hearing devices and cochlear implants represent a future possibility in people with a wide scale of hearing problems, not only completely deaf subjects.

P1-4-8

The observation of the status of residual hearing in patients with post-lingual hearing loss after the cochlear implantation - a pilot study

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It is critical to preserve the structures of the inner ear and the residual hearing function as best as possible during the cochlear implant procedure in patients with residual hearing and during therapy using the electroacoustical stimulation. The detailed mechanism of damaging hair cells and neurons of ganglion spirale cochleae caused by the inserting of the cochlear implant electrode is not known. In addition to the mechanical trauma, a significant cochlear noise burden is expected to develop in the course of the procedure, a possible side effect of the medication (ototoxicity) and other factors. The significance of the damage risk factors has not been fully established. Our pilot study is done in 15 patients with residual hearing in the cases of post-lingual hearing damage. In these patients the uncomplicated cochlear implant procedure was done by one surgeon using always the same electrode bunch and the same surgical technique. In all patients the results of the conventional pure tone audiometry and speech audiometry before and after procedure have been recorded. The postoperative audiometric observation was done at different time points in order to establish the dynamic of the hearing level changes. The intensity and duration of the noise burden during the operation have been recorded. We also observed the occurrence of surgical complications after the implant procedures and the laboratory parameters before and after the procedure in all patients with the emphasis on the renal function and inflammatory markers. The therapeutical and concomitant medication were recorded. In several patients corticoid treatment has been used as the otoprotective medication. Although we don´t consider the results statistically significant due to a small group of patients at this point, we plan to continue this research study. Hopefully, with the growing number of subjects, we will be able to define and predict the risk level as well as to assess a suitable system for timing of the residual hearing audiometric recording in patients after the cochlear implant procedures. Such data could contribute to the correct and the early approach to the otoprotective therapy and also help deciding about the most convenient surgical technique and the electrode bunch for the operation.

P1-4-9

Hearing with a cochlear implant: From bionic to bimodal listening

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Introduction: Currently, cochlear implantation (CI) is the standard procedure for bilateral severe hearing loss in both children and adults. However, a considerable number of hearing-impaired patients, who are candidates for CI, have residual hearing in the low-frequency range. In addition to the refinement of the surgical techniques by the application of the principles of soft surgery, the design of particular, atraumatic electrodes, which are thinner, shorter and more flexible, has contributed to electroacoustic stimulation (EAS). The use of these atraumatic electrodes has resulted in preservation of residual hearing in up to 90% of cases.Electroacoustic hearing is associated with potential advantages over pure electric hearing: better speech understanding in noise, and superior music appreciation and sound quality. In addition, patients with EAS have awareness of sound, even when not wearing their CI.

Methods: In the Ghent University Hospital, 6 severely hearing-impaired adult patients with sufficient low-frequency hearing were implanted with atraumatic electrodes. In 5/6 recipients, a Cochlear® Hybrid-L24 implant was used, whereas 1/6 received a Cochlear® CI422 implant.

Results: Low-frequency acoustic hearing has been preserved in 5/6 patients. Three out of 6 patients use electroacoustic amplification postoperatively; 2/7 are stimulated electrically for the mid- and high-frequency range and have residual low-frequency hearing without need of amplification; and 1/6 patients is exclusively stimulated electrically for the whole frequency range because of deterioration of preoperative low-frequency hearing thresholds.

Conclusion: In candidates for CI, application of soft surgery principles and the use of atraumatic electrodes should be raised to a standard because of the medical advantages, irrespective of the presence of residual hearing. In case of residual hearing, additional benefit is obtained in terms of better speech understanding in noise and a higher level of listening comfort.

P1-4-11

A systematic review on the effectiveness of hearing technologies, including electric acoustic stimulation implants, for people with a severe-to-profound high-frequency hearing loss

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Problem: The effectiveness of hearing aids for people with specific severe-to-profound sensorineural high-frequency hearing losses (HFHL) is known to be limited. Different technological alternatives have been developed to meet the needs of these individuals, such as frequency-compression and frequency-transposition hearing aids or electric acoustic stimulation (EAS) implants. To date, no study has shown which of these alternatives is the most effective to improve hearing abilities for this population.

Methods: A systematic literature review was conducted to answer the following question: Which technology among conventional, frequency-compression, frequency-transposition or electric acoustic stimulation hearing device is the most effective to improve auditory perception (speech recognition, music perception and localization) for people with a specific severe-to-profound sensorineural HFHL? Databases and search engines (*Cochrane Library, Medline, Embase, CINAHL, PsycInfo, ProQuest, Web of Science* and *Google Scholar*) were consulted, using keywords and MeSH terms, without any limitation. Registers of controlled trials were also searched and contacts were made with key researchers. All types of experimental designs were considered. To be included, studies had to be based on human assessments and been published in English or French peer-reviewed scientific journals. Book chapters and academic theses were also considered. Relevant information was extracted from the selected studies; guidelines produced by the *Scottish Intercollegiate Guideline Network* (SIGN) and the *Grading of Recommendations Assessment, Development and Evaluation* (GRADE) group were used for data collection, bias assessment and quality of scientific evidence quoting.

Results/Conclusions: 130 articles were selected. Preliminary results suggest that frequency-compression and frequency-transposition hearing aids offer from 10 to 20 % improvement in speech recognition scores compared to conventional hearing aids in cases of HFHL. The EAS implant offers an improvement in speech recognition from 8 to 17 % compared to electrical stimulation alone and up to 67 % vs conventional hearing aids. However, the benefit obtained with these technologies appears highly variable between individuals, ranging from the maximum benefit (100%) to no benefit at all. Few studies compared the effectiveness of the aforementioned technologies directly with each other. In conclusion, the EAS implant appears more indicated for people with a severe-to-profound sensorineural HFHL, at the cost of a more costly, invasive and risky intervention. Final results and conclusions will be presented at the conference.

P1-4-12

The benefits of using RONDO combined with in-the-ear hearing aid in patients using the MED-EL combined electric-acoustic system

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RONDO is the newest speech processors added to the MED-EL cochlear implant system portfolio. This study aimed to compare the objective and subjective outcomes provided by the DUET 2 with those provided by RONDO combined with an in-the-ear hearing aid.

Five patients, who received a cochlear implant to treat a ski-sloping high frequency hearing loss, and are currently using the combined electric-acoustic speech processor - DUET 2, were recruited for this study. They were all implanted with the Flex EAS electrode. All patients have preserved hearing in the low frequencies. Patients were provided with the new RONDO speech processor and a custom-made in-the-ear hearing aid. The patients' performance is assessed using the CUNY pre-recorded sentences in quiet and the BKB-SIN adaptive speech in noise test. Subjective performance is measured using the Speech, Spatial and Qualities of Hearing (SSQ) questionnaire. SSQ and speech testing scores are been obtained at the day of the fitting, and 3 months after swapping the speech processor. The results achieved with the DUET and with the RONDO will be compared and the results ready for presentation in the conference.

P1-4-13

Amazing summation: Electro Acoustic Stimulation in a patient with only limited residual hearing

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Amazing summation: Electro Acoustic Stimulation in a patient with only limited residual hearing

Electro Acoustic Stimulation (EAS) is a proven option in cochlear implant candidates with usable low frequency hearing. A problem is, however, that the combined soundprocessor/hearing aid provides only limited acoustic gain compared to high-power hearing aids. In a substantial part of implanted patients some residual hearing remains after implantation. We asked ourselves the question whether there is a way to use this hearing.

A 48 yr old patient with congenital profound hearing loss visited our clinic. Communication was based on lip reading with some signing. She used a hearing aid left. The right ear was never stimulated. Speech understanding was 0%.

She was implanted on the left side with a MED-EL Concerto flex28 electrode. The intension was to widen her sound awareness, not expecting better speech understanding without lipreading.

After implantation and fitting she was happy with the result, although she missed the low frequency timbre. We fitted the left ear with a high power hearing aid and moved the processor with a long headpiece cable to the right side. She was very satisfied with the result, ”she never had heard so much”.

When testing speech understanding in quiet we found an unexpected result, as phoneme scores in the combined situation total up to 57%. (CI alone 24%, hearing aid alone 6%)

The conclusion is that, even in cases of restricted residual hearing, CI users may benefit form additional acoustical stimulation. Fitting strategies, and further test results will be presented.

P1-4-14

The impact of anatomy on cochlear implant outcomes

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Introduction: Variations in cochlear anatomy have well been documented. These variations play an important role with cochlear implant electrode placement, hearing preservation and hearing outcomes. Anatomic differences will ultimately determine where in the cochlea the electrode lays and how it stimulates the ear. Despite length of the cochlear duct, the frequency range for the human ear is constant. The distribution of the frequency range can either improve or increase the pitch place mismatches. Identifying cochlear duct length pre-operatively can potentially assist in the selection of an electrode that will provide the most optimal placement and subsequently the best hearing outcomes.

Methods: Computed tomography (CT) scans were reviewed for cochlear implant recipients. Included were patients with hearing preservation and normal cochlear anatomy. Patients were implanted with either the MED-EL Corp medium or standard electrode. Cochlear duct length was estimated by measuring from the center of the round window to the lateral wall through the modiolus. This measurement was then compared to the insertion depth of the electrode as determined by the surgical report. Audiological outcome measures including change in pure-tone average and speech understanding were compared to insertion depth.

Results: Estimated cochlear duct lengths gathered from CT scans follow the same distribution curve as previously reported in other studies. Insertion depth was found to be independent of cochlear duct length, i.e. a longer cochlear duct length cannot predict electrode insertion depth. Interestingly, no relationship was found between insertion depth and change in hearing or speech outcomes.

Conclusion: Cochlear duct length can be estimated; however, does not correlate to insertion depth. During surgery, insertion ceased once resistance was met. This resistance may have been due to the curvature or lateral wall of the cochlea and not the apex preventing full insertion. With the methods used, when measuring cochlear duct length the height and width of each turn is not considered. Scans included in this study looked at the older electrode design and only included those with hearing preservation. Current electrode designs are thinner and more flexible potentially allowing for more complete insertion without resistance.

Discussion: Knowing the position of the electrode as it lies within a cochlea may aid in better programming strategies. Minimizing the frequency place/pitch mismatch may ultimately result in better speech understanding and music appreciation. Further studies are needed to correlate imaging with anatomic length.

Learning outcome:

1. Longer cochlear duct lengths do not correlate with insertion depth. Mores studies are needed to accurately define cochlear length and size.
2. Loss of residual hearing and speech discrimination scores are independent of insertion depth.

P1-4-15

Effect of protecting residual hearing on outcome of cochlear implantation

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Objective: To observe the residual hearing of implanted ear after cochlear implantation, and investigate the influence on post-operative rehabilitation outcome by retained residual hearing.

Methods: 63 cases participate this study, whose age are from 30 to 36 months when they got cochlear implantation. All the children received speech recognition test and play audiometry test by the implanted ear one year after switch-on. The average of T-level and C-level of No.1, 6, 11,16, 22 electrodes is collected. All the children are divided into 2 groups as residual hearing and non-residual hearing. The SPSS10.0 is used to compare the difference of the speech recognition scores and the average of T-level and C-level between these 2 groups.

Results: The speech recognition scores of residual hearing group are higher than that of non-residual hearing group. Also the children of residual hearing group have lower T and higher C level. There is statistical significance in the comparison of three projects（$p< 0.05$）.

Conclusion: We should pay attention to protect the residual hearing during cochlear implantation surgery. More hair cells reservation is beneficial to reduce the amount of current of stimulation, and to improve their hearing sensitivity. Children can obtain a better ability of speech comprehension.

P1-4-16

Electro-acoustic stimulation utilizing MED-EL FLEX-20 and FLEX-24 electrodes

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Introduction: Traditionally, cochlear implantation is used for the management of bilateral severe-to-profound sensorineural hearing loss. Residual hearing is typically lost when conventional surgical techniques and standard electrode arrays are utilized. In 1999, “electric acoustic stimulation” (EAS) was developed for the management of severe-profound high frequency sensorineural hearing loss. Although typical EAS candidates do not obtain adequate benefit from conventional hearing aids, they often have too much residual hearing to be considered for conventional cochlear implantation. In 2009 Health Canada approved the MED-EL Corporation EAS system.

Methods: Immediately prior to surgery, all patients received intravenous dexamethasone and prophylactic antibiotics. Intratympanic injection of dexamethasone was performed after induction of general anaesthesia. A cortical mastoidectomy-facial recess approach was utilized to visualize the round window. The bony overhang of the round window niche was removed with a Skeeter drill to completely visualize the anterior aspect of the round window. A drop of dexamethasone solution was placed on the round window membrane. The antero-inferior aspect of the round window was incised with a micro-lancette or fine pick. The FLEX-24 electrode was slowly inserted until the second last electrode contact was adjacent to the round window membrane. When the FLEX-20 electrode was utilized, a full insertion was performed. The electrode array was directed antero-inferiorly during insertion. A fascia graft was placed around the electrode array at the round window to seal the cochlea. Patients received oral steroids for one week after surgery.

Results: Thirteen patients between 31 and 84 years of age (mean age 59) have undergone implantation of the MED-EL EAS system with either the FLEX-24 or the FLEX-20 electrode array and DUET speech processor. Residual low frequency hearing was preserved during surgery in all cases. 10 patients had good long term preservation of their residual low frequency hearing after implantation. 2 experienced significant delayed loss of residual hearing in the implant ear requiring a change to the OPUS-2 speech processor. 1 patient had moderate late loss of low frequency hearing but still derives benefit from the DUET speech processor.

Conclusion: All patients undergoing implantation with the MED-EL EAS system with either the FLEX-24 or the FLEX-20 electrode array and DUET speech processor have experienced significant functional benefit. Residual low frequency hearing was consistently preserved during surgery. Two patients experienced significant delayed loss of residual hearing requiring a change to the OPUS-2 speech processor. Even without the benefit of the integrated hearing aid, these individuals derive benefit from the EAS device.

P1-4-17

Pilot evaluation of NFS for hybrid fitting

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Aim: Nucleus Fitting Software (NFS) is a new software tool developed by Cochlear as part of its Clinical Care Innovations program. The version for conventional Cochlear Implants (CI) is now released commercially. This study pilots a similar software offering for Hybrid devices. However, fitting for electro-acoustic stimulation is inherently more complicated, as there are additional parameters for the acoustic component, and these exist in a different paradigm to the electrical domain. Cochlear has developed a method that fits both the electric and acoustic components using the same Master Volume, Bass and Treble (MV/B/T) controls that are provided in the NFS software for CI fitting. The aim of this study is to see if the fitting obtained with this new paradigm can still deliver fitting of an equally high standard, when compared to the conventional fitting using Custom Sound 3.x, or whether the need for additional, Hybrid-specific controls is indicated. Two options were tested in this study of the NFS-for-Hybrid methodology: to use either the default population mean audiogram, or to use the recipient´s own audiogram, in combination with additional controls for explicitly checking electrode thresholds and balancing C-levels with the “Comfort Check”. This study investigated both options. It is an initial pilot study of the technique implemented in the Experimental Fitting Platform (EFP), as opposed to an early-development version of the actual NFS software with Hybrid Fitting capability.

Materials and methods: 16 adult subjects fulfilling the inclusion criteria were included in the study: Hybrid-L recipients with hearing thresholds < 85 dB HL in some audiometric frequencies below 1 kHz in the implanted ear; users of Freedom Hybrid SP +Acoustic Component. This was a prospective, within-subject study with comparisons between results from three sessions, over which the three MAP´s were created and given to the subjects for a minimum of one month´s take-home experience. The study tested for non-inferiority of the new fitting paradigm: the hypothesis was that there would be no significant difference in Speech Test results, both in quiet and in noise, and Subjective Quality Rating between fitting with the three methods. Speech was tested with Polish VCV words in quiet and Polish Sentences in +10 dB SNR speech-shaped noise. Subjective quality was assessed using the dimensions of clarity, pleasantness, intelligibility, and, naturalness. Each fitting was also assessed after at least one month of take-home use with the APHAB questionnaire.

Results: The programs were compared using separate ANOVAS for speech in quiet, speech in noise and subjective quality rating. No statistically significantly different results were found between the test programs.

Conclusions: These pilot results suggest that the NFS simplified fitting paradigm can offer a clinically acceptable alternative to conventional fitting with the Custom Sound software.

P1-4-18

A meta-analysis for predictors of hearing preservation after hybrid cochlear implant surgery

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Residual hearing preservation is essential for successful perception of acoustic stimulation delivered by hybrid cochlear implants (CI). This and a preserved neural interface are likely to give CI users more access to acoustic cues and electrically simulated information. Also, residual hearing is a good marker of atraumaticity and cochlear health after surgery. It is still not possible to ensure good residual hearing for all patients undergoing CI and there is large variability in the degree of hearing preserved and the timeframe over which it is lost. The implantation of patients with ever-increasing degrees of residual hearing means that understanding the variables affecting hearing preservation is more important than ever. Collated findings from publications concerning hybrid implants (2000 - 2013) are analyzed to determine how much of the variability being observed can be accounted for by factors individually, and collectively. Furthermore, we evaluate if there is sufficient knowledge about these devices to predict success or underperformance to within a reasonable degree. Finally, based on the raw data collected from published retrospective clinical outcome studies we produce as comprehensive a predictive model possible of residual hearing preservation in line with the HEARRING group consensus statement issued in 2013 and give suggestions on which data are essential and how to present them when reporting on new patients.

P1-4-19

Use of the Flex-EAS electrode in a child with residual hearing in low frequencies

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Attempts to preserve the residual hearing during cochlear implant's (CI) surgery are indisputable. Atraumatic techniques of insertion and the use of shorter and flexible electrodes that diminish the trauma in more apical areas of the cochlea, are well established indications for patients with residual hearing in low frequencies. Our object is to report a case of preservation of the hearing using the Flex-EAS electrode, complete insertion, in a child with residual hearing in low frequencies.

Case report: M.C.A., 33 months, pre-lingual hearing loss, idiopathic etiology. She was admitted in the ENT department with Otoacoustic emissions by distorcion products (EOA PD) and Auditory Brainstem Evokated Response (PEATE) with no response bilaterally, but the cochlear microphonic was present in right ear (Fig.1). Visual reinforcement audiometry is showed in Fig 2. The patient was followed by audiologists during 8 months, using hearing aids, but without appropriate functional gain. CI surgery was done, using modified soft surgery technique, that means convencional mastoidectomy for cochlear implant, posterior timpanotomy, cleaning of the cavity with antibiotic (ciprofloxacino), injection into the round window of corticosteroid and placement of the Flex-EAS electrode slowly. Once she had residual hearing in low frequencies, the implant activation was done by starting with the electrode number 5. The frequencies table was relocated, starting the stimulation in 750Hz. Functional gain with the CI and speech perception tests (Fig 3, Fig 4) show that the child is doing very well in terms of hearing and oral language.

Discussion: Residual hearing after CI surgery brings benefits to any patient[1]. Regardless of the level of the residual hearing, it is observed improvement in speech and music perception and sound localization[2]. The option for short electrodes, with minimum trauma to the cochlea's apex is established for increasing the chances of hearing preservation[3-4]. In this case, once it was concerned to a child with hearing loss whose etiology was non-defined, the choice of the electrode was for one with appropriate features such length, flexibility and thickness, that could completely cover the cochlea, providing the possibility of activation of electrodes in more apical position in the cochlea in case the hearing loss may progress, or even if the attempt of hearing preservation had failed.

Conclusion: The use of Flex-EAS electrode, associated to the soft surgery technique, can be a good option in children with severe to profound hearing loss, with some residual hearing in low frequencies, even if the etiology of the deafness is not clear, activating or not the apical electrodes. Thus, it is possible to avoid reimplant surgery, if occurs any reduction of hearing performance in progressive deafness, or even in case the residual hearing is not preserved.

P1-5 Rehabilitation

P1-5-1

A structured training for speech understanding in noise - preliminary results with experienced cochlear implant users

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Intro: Users of Cochlear Implants (CIs) are able to gain remarkable speech recognition in quiet listening environments after the initial accommodation or familiarization to the new hearing. Nevertheless, in background noise speech recognition is challenging and CI users usually report poor speech understanding in listening environments where normal-hearing listener's speech recognition is barely affected. This study was initialized to investigate if experienced CI subjects can benefit from a structured training which was especially designed for speech understanding in noise.

Methods: The training material in the presented study was especially designed to train the hearing abilities of hearing aid users in background noise conditions during their introduction to hearing aids. In this study six CI users with one or more years of implant experience were provided with this training material. The CI users solved speech related listening exercises at home in daily one-hour sessions over a period of four weeks. Every task was presented in background noise. The difficulty of the exercises was increased every day by increasing the presentation level of the background noise. The outcome of the exercise was not analyzed but the speech perception of the subjects was tested at our clinic in four sessions. At the start, during, at the end and 6 weeks after the training interval speech recognition was tested in quiet and in noise with a word and a sentence test.

Results: The preliminary results indicate improved speech recognition in some subjects which did not lead to significant differences in the group mean.

Discussion:

The familiarization to the CI listening even after more than a year of CI listening might be one factor which could explain improving speech recognition in some subjects.

Conclusion: At least in some subjects speech understanding could be improved by training after more than one year of CI experience.

Learning outcome: For the evaluation of the factors influencing the individual differences in the trainings effect further subjects have to be tested.

This study was supported by the terzo-Zentrum München/ISMA GmbH & Co. KG

P1-5-2

A long-term follow-up study on mandarin lexical tone identification and speech perception in postlingually deaf patients with cochlear implants

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Objectives: To investigate the development of mandarin lexical tone identification and speech perception ability for postlingually- deafened adult with cochlear implants.

Methods: 13 cases postlingually-deafened of speaking mandarin adult cochlear implants participated in this study. Mandarin tone identification and mandarin sentence identification ability in quiet and noise were assessed during 1-,3-,6-,12-months after switch-on. The test materials were used by Tone identification in noise test (TINT) and Mandarin Hearing in Noise Test (MHINT).

Results: The ability of tone identification and sentence identification in noise were worse than in quiet for cochlear implants ($P< 0.05$), and the sentence identification rate was decreased while the reducing of signal-to-noise ratio (SNR), but there was no obvious difference with SNR=15 and SNR=10; During the 12 months follow-up evaluation, the performance of tone identification both in quiet and in noise increased along with experience of cochlear implant use, especially in quiet($P< 0.05$); the performance of sentence identification both in quiet and in noise of different SNR significantly increased along with duration of cochlear implant use($P< 0.05$).

Conclusion: The ability of mandarin tone identification and mandarin speech perception had constantly improved in postlingually- deafened cochlear implant users after one year of switch-on. And the fast progress of mandarin sentence identification ability than the Mandarin tone identification.

Keywords: Cochlear implant; Tone identification; Speech perception

P1-5-3

Factors influencing outcomes in Romanian cochlear implanted children

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Aims: Cochlear implant is nowadays the best solution for patients with profound sensorineural hearing loss, who do not evolve favorable with hearing aids in the best auditory rehabilitation conditions. It is known, however, that not all patients reach maximum performance. Our study aims to assess the factors that could influence the rehabilitation outcomes in Romanian cochlear implanted children.

Materials, Methods: The study was conducted on a sample of 93 children cochlear implanted in our department since 2003 to 2013. We included in study only children with severe-to-profound sensorineural hearing loss with prelingual onset, with a minimum of 6 months experience with the processor. The assessment of the outcomes was based on CAP_R and SIR scores and the results were reported to the prognostic factors systematized in the Nottingham Children's Implant Profile.

Results: Besides of young age of implantation, good results were correlated with the permanent wearing of hearing aids in the preoperatively period, with no associated diseases, proper educational environment, child's cognitive abilities, learning skills and attention, which on depends the learning process that followed implantation. Poor auditory and verbal outcomes were associated with the presence of other diseases, inadequate educational environment with family or child exaggerated, unrealistic expectations, less developed cognitive skills, lack of language, lack of learning and attention training.

Discussions, Conclusion: Cochlear implant facilitates patient access to speech sounds but the performance to understand and produce speech depends largely on the child's intellect, the environment and how it is educated but also by desire to communicate.

P1-5-4

Efficacy of telerehabilitation patients after cochlear implantation in West Pomeranian Center of Hearing and Speech Medincus in coperation with the World Hearing Center in Kajetany, Poland

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The aim of the study was to evaluate satisfaction and efficacy telemedical solution in post-operative period after cochlear implantation. The analysis was fulfill in West Pomeranian Center of Hearing and Speech Medincus. Center is member of teleaudiology net in Poland where in cooperation with World Hearing Center at Kajetany telefitting is carried out. There is 206 patients under care of the center. 30 patients (20 children and 10 adults) undergo medical and rehabilitation more than 2 times per month. The rest in dependence on time after surgery, family background , individual progress and other factor, visit center from 1 to 15 times per year. Full audiological and ENT assessment could be accomplished. Telemedical connection is realize with data security program. Service of speech therapists, psychologists, physiotherapists. 86% of patients are very satisfied with possibility of fulfilling the rehabilitation program closer to their home. The distance between Szczecin and Warsaw is 550 km. It gives evidence that lower costs , saved time allow patients for better and more efficient rehabilitation. Future development of techniques is possible and could be very good chance for patients better results.

P1-5-5

Involving parents in the assessment of emerging language in young implanted children :A comparison between 3 methods

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Intro: The advent of cochlear implantation under the age of 12 months has presented professionals with new challenges, as they have had to adjust their intervention to very young children and their families. One of the challenges is how to systematically collect representative and reliable expressive language data on young children, in order to evaluate the impacts of cochlear implantation on the emergence of spoken language. Parents have become an increasingly valuable source of information regarding emerging language skills. Various methods such as parental questionnaires, language diaries, and language sampling are used to assess early expressive language and to monitor progress after implantation, each requiring different degrees of parental involvement. Studies have shown that the diary technique is especially effective for documenting early lexical development in deaf children (Nott et al., 2003, 2009).The goal of our study was to determine whether a language diary (in which parental involvement is maximized) was equally representative of children's lexical functioning as a parental questionnaire (in which their involvement is less important), and as a 20-minute language sample (in which parental involvement is minimal), over a 12-month period.

Methods: Eight (8) children and their families participated in the study. Mean age at implantation was 12 months. Materials accompanying the *Diary of Early Language* (*Di-EL*: Nott et al. 2003) was adapted to French. Parents were asked to record each new word spoken by their child daily for a period of 12 months, and to fill in the Quebec version of the *MacArthur-Bates Communication Development Inventories* (*MBCDI*) every 3 months. The children were also seen at 3-month intervals for a play session with a research assistant to collect language samples. Total number of words and vocabulary composition were analyzed across time and data collection method. The presentation will focus on data from each method at 3 time points: at the time of initial programming (T0), after 3 months (T3) and after 6 months (T6).

Results: All 3 methods reveal a progression in the number of words produced. The language sample, however, showed much lower lexical diversity than the other two methods. The lexical development curve was similar for the MBCDI and the Di-EL: more words were recorded on the MBCDI than the Di-EL at T0 and T3 whereas the number of words recorded in the Di-EL at T6 was considerably larger than in the MBCDI.

Discussion: Results suggest that the methods are not equivalent in terms of the quantitative and qualitative information provided.

Conclusion: Parents should be our principal source of language data in the early stages of lexical development after implantation. However, the demands imposed by each collection method should to be taken into consideration, as increased demands could result in lower validity and poor representatively of the data collected.

Learning outcome: To improve clinical practice.

P1-5-6

Adaptation of common object test in Sinhalese language

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Background: Common Object token Test (COT) was developed as a complex closed-set test for children with profound hearing losses in English by Geoff Plant and Alessendra Moore in 1992. This test was later assessed for its usefulness in assessing children with cochlear implants and has been documented to be a very useful tool with pediatric cochlear implant users (Anderson et al,2005). The test is useful for children who are able to complete closed set tasks but not quite ready for open test. Cochlear implant (re)-habilitation program for pediatric CI users' is a long term process with many factors contributing to overall success and testing them for speech perception skills is important to assess their functional use of CI. Standardized speech perception tests for hearing impaired children are widely available in English but not in Sinhalese language. The clinics resort to use informal translation of English assessment materials or native-language assessment materials that are not standardized CI users.

Objective: To adapt, standardize and assess the speech perception abilities of normal hearing and CI children using COT versions in Sinhalese language.

Methods: 70 children with normal hearing and 30 children using cochlear implants and of age 1 to 8 years were considered. The test-items of Level 2 of COT-English were translated in Sinhalese by professional. Subjects were administered translated version of COT. Familiarization of task was carried out to ensure that lack of vocabulary knowledge, poor understanding of the task and poor perception of colors do not affect performance. No informative feedback would be provided regarding the correctness of the response. Item-wise score, subtests' scores and overall scores were calculated and subjected to appropriate statistical analyses to understand differences in responses across and within the subtests and subject groups.

Results and conclusions: It is an ongoing project and the preliminary results on development of speech perception abilities in normal hearing children and usefulness of COT version in Sinhalese in measuring speech perception outcomes in CI users will be discussed in detail. Learning outcomes: The preliminary results shows that COT test is useful in assessing complex closed set auditory abilities of very young children. The results indicate that the subtests are arranged in order of increasing difficulty and that the test can reflect age related changes in speech perception abilities. The COT Sinhalese version can be considered to monitor long term outcomes in speech perception of CI user.

P1-5-7

Perception of music and speech in adolescents with cochlear implants - A pilot study on effects of intensive musical ear training

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The purpose of this study was to examine 1) perception of music and speech of pre-lingually deaf adolescent cochlear implant (CI) users, 2) the potential effects of an intensive musical ear training program and 3) these adolescents' music engagement. Eleven adolescent CI users participated in a short intensive music training program involving music making activities and computer based listening exercises. Before and after the program they completed music and speech tests. In addition, the participants filled out a questionnaire which examined music listening habits and enjoyment. A normally hearing (NH) group provided reference data at the same points of time, but received no training. CI users significantly improved their overall music perception and discrimination of melodic contour and rhythm in particular. The NH reference group produced marginally lower music discrimination scores at the second test. No effect of the music training was found on discrimination of emotional prosody or speech. The CI users described levels of music engagement and enjoyment that were comparable to the NH reference. The CI participants showed great commitment, but found computer based training less relevant than music making activities. The findings are an indication of not only the potential of training but also of the plastic potential in the young brain.

P1-5-8

The psychological actions in a cochlear implant team in Brazil

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Each person and family experiences hearing loss and the benefits of the cochlear implant in a different way. It depends on the objectives and the physical, emotional and social possibilities of each person, as well as individual and family expectations. Cochlear Implant Program developed at the Audiological Research Center (CPA) of the Hospital for Rehabilitation of Craniofacial Anomalies (HRAC), from the University of São Paulo (USP), campus Bauru, Brazil is carried out by an interdisciplinary team, with the purpose of seeing the patient as a whole, in addition to its hearing. This presentation aims to describe the psychological practice in the program, developed in 24 years of experience with the team. Currently, psychologists work on three areas: the psychological assistance to the patients and their families, the participation in clinical meetings with the interdisciplinary team, in teaching and research. On psychological assistance, the work involves five steps: receiving new cases welcoming; psychological assessment of patients and family; psychological preparation for surgery: decision-making process regarding the cochlear implant surgery and hospitalization process; postoperative follow-up in the hospital - visit and family support - and the activations of electrodes; follow up on the habilitation/rehabilitation. Regarding to the team activities, cases are discussed in a meeting with the interdisciplinary team to define treatment and subsequent routine assistance, according to the grupal decision. The psychological practice in teaching and research consists on the education and training of undergraduates from fellow Psychology Universities, the post graduate programs (specializing courses) of the HRAC-USP in the areas of Psychology, Audiology, Social Work and in Multidisciplinary Residency Program in Hearing Health in the three above-mentioned areas. The practice involves the supervision of care, guidance and co-supervision of monographs and research. As well as the cochlear implant program, the psychologist on the team builds and rebuilds his practice considering the social and political reality of the country, focusing on the under a perspective of humanization and interdisciplinary. Through this description, we aimed to consolidate the psychological practice in a cochlear implant team from Brazil and the contribution that the psychologists can offer on the assistance to patients and their families, in teamwork and in teaching and research.

P1-5-9

The social worker actions in a Brazilian cochlear implant team

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A team of experts from a variety of fields with different views is necessary to ensure integral health care. The interdisciplinary team responsible for the Cochlear Implant Program developed at the Audiological Research Center (CPA) of the Hospital for Rehabilitation of Craniofacial Anomalies, from the University of São Paulo, campus Bauru, Brazil comprises physicians - otolaryngologist, neurologist, pediatrician - speech therapist, audiologist, psychologist and social worker. Like the other members of the team, the Social Worker provides service/assistance, teaching and research. CPA, up to December, 2013, had 3,700 patients enrolled, totaling more than 1,100 implanted patients. In the CPA routine, the actions of the Social Worker are directed toward the diagnosis of socioeconomic and cultural reality of patients and families, taking into account family income, number of family members, educational and occupational level and housing conditions. Besides, it is taking in consideration the expectations, human resources, community and institutional resources in their cities, that is, their limits and possibilities for health care management. This knowledge is basic for the intervention in the expressions of social issues. Most patients belong to lower strata, coming from different regions of the country, demanding from the Social Worker mobilization of public health policies to support the rehabilitation. The Social Worker intervention is through individual and group activities such as: a) direct social assistance to users - socioassistencial actions, articulation with the health team; b) mobilization, participation and social control; c) investigation, planning and management; d) advice, qualification and professional training. Many actions are developed in partnership with other members of the interdisciplinary team so as to overcome fragmentation in daily services, for there is no integrality without knowledge exchange. The reality of patients, taking into account their socioeconomic condition, distance from their cities to the assistance center, lack of professionals or non-specialized ones in their hometown and other shortcomings, poses a challenge to Social Workers in their search of patients empowerment as citizens. Thus, self-empowerment and team work are fundamental to ensure a holistic view on patients, recognizing them as subjects who can take actions, decisions and transform their reality.

P1-5-10

Fundamental frequency of patient with bilateral cochlear implant: Case study

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Introduction: Cochlear implant is an electronic device that in addition to hearing improvement also affects voice quality in patients with severe-to-profound deafness. Fundamental frequency (F0) is one of the parameters for voice quality assessment in patients with cochlear implants. This study aims to determine the F0 of a patient with and without bilateral cochlear implants.

Materials and methods: Case Study with acoustic analysis of 3 vowels of the Portuguese Language (/i/ /a/ and /u/) in a quiet environment using a microphone Shure® and acoustic analysis software Praat© version 3.5.39.

Results: F0 values without cochlear implants were 236 Hz, 224 Hz, and 244Hz for vowels /a/, /i/ and /u/ and with both cochlear implants were 220 Hz, 218 Hz and 234 Hz for vowels /a/, /i/ and /u/ respectively.

Discussion and conclusion: The F0 values for the 3 vowels of the Portuguese Language (/a/, /i/ and /u/) are higher without the two cochlear implants. One possible explanation is that patients without cochlear implants lack the auditory feedback and need to increase the vocal folds and vocal tract tension to achieve the three vowels issue requested.

Keywords: Voice, Cochlear Implant, Acoustic Analysis

P1-6 Outcomes adults

P1-6-1

The experience of mothers of children after 10 years of cochlear implant use

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The family is always a major important factor in the habilitation process of the child with cochlear implant. The development of language depends on the parental involvement in the habilitation process and requires a continuous commitment, so that the child with hearing impairment may be benefited by the cochlear implant. The family has been assuming a significant overload during the process, causing repercussions in the family life and the needs and interests. This study is part of a P.h.D research conducted at the Hospital for Rehabilitation of Craniofacial Anomalies (HRAC) from University of São Paulo (USP). It shows the day by day of mothers, the main caregivers of their children, from the moment their children were diagnosed with hearing loss to the decision on the surgery for the cochlear implant, the habilitation process and the current moment of their lives. The goal of this study was to understand the experience of these mothers of children with ten-year cochlear implants by the activation of electrodes aiming to identify the meanings and feelings assigned by them in this experience. The study was qualitative and the method comprised phenomenological investigation, which consists of apprehension of the phenomenon as it is manifested to the person experiencing it. The interviews were applied to 12 mothers of the first children submitted to surgery in the cochlear implant program of the Audiological Research Center of the HRAC/USP. The reports submitted to the phenomenological analysis process, revealed the following thematic categories: the birth of hearing; experience the daily life in the habilitation process; the experience of critical moments in the habilitation process; family relationships; the school age: a new stage of coping; the process of adolescent experienced with overprotection and new challenges; the support of the psychologist, staff and others; temporality and life projects. The theoretical reference of existential-phenomenological psychology of Emilio Romero was used, which led us to understand the experience of these mothers, based on the affectivity, which is the way through which they are subjectively affected in their relationship with the world and, in that relationship, they showed how they link themselves and the meaning they assign to what comes to them, revealing the meaning of their existence with a child with cochlear implant.

P1-6-2

School integration in implanted children on a 13 years follow-up

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Aim: This study aimed to evaluate school integration following cochlear implantation in children, as well as specific adjustments needed for school and daily communication, speech therapy outcomes, and quality of life.

Material and methods: Questionnaires assessing school level, daily-life details and specific adjustments for communication were sent to families with a child implanted in Nantes hospital between 1996 and 2009. Medical information and speech therapy outcomes were retrospectively collected from medical records.

Results: 55 children have been included. Mean age at implantation was 56.3 months and mean follow-up 8.1 years. 2/3 of the children had normal schooling, with most of them in normal-hearing classes. Most communication assistance and school repeating was observed during kindergarten. Speech therapy outcomes showed constant improvements over time, as well as quality of life.

Conclusions: These results suggest that cochlear implant reduces the number of children in deafness-adapted schools, with better school results for early implantation.

P1-6-3

Auditory perception performance for post-lingually deaf adults after cochlear implantation with the Neurelec Saphyr® SP

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Pure tone audiometry and speech perception tests show that cochlear implant users exhibit restored hearing functions. By studying behavioral responses using subjective tests (audiometry) and a more objective test [auditory evoked potentials (AEP)], the transmission of an electric signal through auditory pathways can be assessed. Sound processor upgrades naturally aim to improve auditory capacities and thus the quality of communication for cochlear implant users. This study aims to track speech and auditory perception performances for post-lingually deaf patients implanted with a Neurelec device, the Saphyr® SP. Results from Saphyr® SP users will be compared with those published by Lazard et al. (2010) who compared speech perception skills for post-lingually deaf patients implanted with two less recent Neurelec sound processors: the Digisonic Convex, and the Digisonic SP. The study by Lazard et al. (2010) was conducted at the centre for cochlear implantation in Lyon, France at the Edouard Herriot Hospital. The data for the present study will be collected at the same centre and will thus allow for identical testing conditions. The second aim of this study is to compare AEP data with results published by Gallego et al. (1998) in order to show correlations between these measures and hearing test results.

Nine subjects suffering from severe to profound bilateral perceptive deafness took part in the study. During routine visits, auditory capacities were evaluated and compared to pre-implantation test results. Auditory perception was evaluated before implantation and at the 3, 6, and 12-month visits after activation. Speech perception was tested in silent conditions (disyllabic words and sentences) and in noise (disyllabic words) at 3, 6 and 12 months post-activation. Pre-implantation AEP measures were compared to 12-month post-activation AEP measures.

Results: Subjects using the Saphyr® SP obtained better speech perception scores for both words and sentences in silent conditions at 3 and 6 months post-activation (68% and 62% for words; 79% and 80% for sentences) than Digisonic users (53% and 62% for words; 58% and 69% for sentences) and Convex implant users (34% and 42% for words; 38% and 59% for sentences) 12 months post-activation (Lazard et al, 2010).

P1-6-4

Etiology of hearing loss in patients undergoing cochlear implant

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Introduction: The rehabilitation with cochlear implant in cases of profound sensorineural hearing loss is a consecrated and increasingly widespread practice among otologists. The selection of good candidates should be meticulous, and the determination of the cause of hearing loss contributes to enhance the medical and audiological planning in order to get the desired results.

Objective: To identify the most common etiologies in cases of bilateral profound hearing loss in patients selected for cochlear implantation.

Methods: A retrospective study. Review of medical records of patients from a tertiary referral center (Center of Hearing Impairment- UNIFESP) who underwent cochlear implantation between 2006 and 2013.

Results: The records of the last 92 implanted patients were reviewed. This sample was composed by 43 (46.74%) children and 49 (53.26%) adults all presenting profound hearing loss. Patients with bilateral implantation or revision procedures were considered only once in the computation of their data. Infectious causes accounted for 25% of our cases and among these patients 74% were due to meningitis. Other common etiologies, in descending order were: genetic (13.04%), ototoxicity (5.43%), consanguinity (4.35%), otosclerosis (4.35%), immune-mediated (4.35%), neonatal complications (3.26%), neuropathy (3.26) and inner ear malformations (2.17%). Thirty-two (34.78%) cases were designed as unknown etiology. In this group we could observed different expressions of hearing loss: congenital, progressive, sudden hearing loss and uncharacterized. Profound congenital hearing loss accounted for 55% of these cases and was the diagnostic in 87.5% of children who received cochlear implant up to 3 years of age.

Conclusion: The identification of etiologies of hearing loss is still a challenge in the rehabilitation process. In our department about one third of patients who underwent cochlear implantation did not have the primary cause of deafness identified. Among the identifiable causes infectious etiology was very important, meningitis being the most relevant. These results suggest that there is still space for the development of more effective prevention programs and diagnostic methods.

P1-6-5

Middle ear status after cochlear implant surgery and the implications for flying

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Introduction: During cochlear implant surgery, some bleeding occurs from the soft tissues and from the temporal bone. This is rarely a problem during the procedure but at the end of the operation as blood pressure rises, the middle ear fills with blood. The blood from the middle ear will subsequently clear probably from reabsorption and dispersal via the Eustachian tube. The current study presents data for postoperative middle ear status from adult cochlear implant recipients assessed at different intervals by tympanometry.

Methods: Tympanometry was performed on adult cochlear implant recipients at approximately two weeks, one month and two months following surgery.

Results: Preliminary results from 30 subjects show that approximately 69% of subjects have a flat tympanogram suggestive of fluid (i.e. blood) in the middle ear cavity at the first medical appointment two weeks after surgery. However, by one month after surgery, only 17% of the subjects had flat tympanograms. Of 14 subjects with data at two months after surgery, only one subject had a flat tympanogram, three subjects had peaked tympanograms with a negative middle air pressure and the remaining 10 subjects had peaked tympanograms with a normal middle air pressure.

Discussion: These data suggest that, in the majority of subjects, middle ear status returns to normal within two months after surgery. This has implications for patients who may wish to fly after cochlear implant surgery. There are no clear data to determine the relationship between static middle ear pressure as determined in a clinical setting by tympanometry and the risks of ear problems with flying. However, it seems likely that individuals with normal tympanograms are less likely to have problems than those with tympanograms showing a negative middle ear pressure. The latter suggests difficulty equalizing pressure at ground level without the additional difficulty of changes in surrounding atmospheric pressure. Based upon the findings of this study, the authors believe that adults should be advised not to fly for two months after cochlear implant surgery where possible.

Conclusions: To the authors' knowledge, this is the first time that middle ear status has been assessed in adults post-operatively. Our results indicate that the majority of subjects have a normal middle ear pressure two months after surgery and are therefore not likely to have ear problems when flying. However, in the minority of patients, the middle ear pressure remains negative which may indicate potential difficulty equalizing middle ear pressure during the flight. Such patients should be counseled accordingly.

Learning outcome: Attendees will learn the course of changes in the middle ear status with time in adults after cochlear implant surgery. Attendees will learn what advice should be given to patients with regard to flying after cochlear implant surgery.

P1-6-6

Speech reception in noise using roving-adaptive test technique (Italian starr test) in adults with AB clearvoice technology

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Despite advances in technology, speech recognition in noise still remains a big challenge for cochlear implant (CI) users. However, fixed level presentations can lead to ceiling and/or floor effects and therefore nowadays a roving-adaptive test technique is preferred in most Centres. The aims of the present study were to evaluate Speech Reception Level (SRL 50%) in a group of normal hearing (NH) adults and in CI users, as well as to assess the benefit of the ClearVoice (CV) algorithm provided by AB HiRes with Fidelity120 technology, in order to optimize fitting criteria.

15 patients with CI and 15 NH subjects participated in the study. The CI group underwent trials under the following 4 conditions: baseline with HiRes120 only, CV fitted with no change in T or M levels, CV with adapted M levels and CV with adjusted T and M levels. The Italian version of the STARR test was used for speech recognition tasks in all subjects, and Loudness Scaling in A§E was used to adjust optimal T and M levels specifically in the CI group. Preliminary findings will be presented in an attempt both to offer an alternative to speech material presently in use that may be a more reliable reflection of everyday listening conditions, and to establish fundamental criteria to be used for application of the ClearVoice algorithm in AB technology. Such results could provide useful information for optimizing fitting in the pediatric population.

P1-6-7

Clinical experience with Nucleus® 6 in adult cochlear implant users

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Intro: Cochlear™ recently launched the Nucleus® 6 system which includes two new sound processors (CP910 BTE with accessory connector, CP920 BTE without accessory connector), two remote controls (CR210 Remote Control, CR230 Remote Assistant with color LCD display) and clinical software (Custom Sound 4). Sound processors support new sound processing algorithms for improved sound perception and comfort (Wind Noise Reduction, SNR based Noise Reduction) and an environmental sound classifier (SCAN) which automatically activates appropriate processing strategies for different listening environments. In addition Nucleus 6 supports Usage Data Logs (Datalogging) to help clinicians with programming and counseling of their recipients. This study reports on comparing the speech performance and usability of the Nucleus 6 against the previous generation Nucleus 5 (CP810) system, and on testing the acceptability of SCAN as default program for Nucleus 6.

Methods: A comparative study in two clinics involved 30 adults actively using ADRO and ASC with their existing CP810 processor. Speech perception was tested with Dutch NVA words in quiet (50dB) and Dutch LIST sentences in noise (SRT50, speech: 65 dB). Usability was evaluated through the APHAB self-report questionnaire, patient diaries and customized comparative questionnaires on the use of the current versus new sound processor and remote assistants.

Results: Group mean speech in noise test results (SRT50) with CP900 series sound processors in SCAN mode were significantly better (1.2 dB SNR) than results obtained with the CP810sound processor. In quiet, mean scores were similar for the CP900 and CP810 processsors with an average score of 62%. The APHAB questionnaire outcomes were similar for CP810 and CP900 processors. Recipients successfully converted across to the CP900 processor and reported a preference for using SCAN for listening during daily life. Clinician were satisfied and confident about the Nucleus 6 system. Usage logs showed a variation in total daily use of CP900 ranging from 5 - 17 hours/day. On average recipients spent about 50 % of the time in a quiet environment, about 20% in a 'speech in noise' environment and about 10% in a 'speech only' environment.

Conclusions: Nucleus 6 provides superior speech in noise performance compared to Nucleus 5. Recipients and clinicians were highly satisfied with both the Nucleus 5 and 6 systems with a clear preference reported for the Nucleus 6 system.

Learning outcome: how to assess and interpret new speech processor features

P1-6-8

Upgrade from Auria to Harmony speech processors in postlingually deafened adults - audiological results

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Background/Purpose: To improve quality of hearing and minimize the possibility of speech processor failure it seems to be reasonable to exchange external device after some years of continuous use. Additionally patient could provide extra benefit if a new processor is more advanced and gives access to better speech coding strategies or noise cancelation techniques

Method: 10 postlingually deafened adults using AB CII and HiRes 90K cochlear implants participated in this study. Nine patients used Auria speech processor before upgrade, one of them used BTE speech processor. All of them were upgraded to Harmony speech processors. Patients were fitted with 3 different settings/strategies: his/her own old settings (MSP or CIS or HiRes), HiRes 120 and HiRes 120 with ClearVoice. After one month of familiarizing the strategy was changed. Changes between strategies were performed randomly. During each “change strategy” visit the speech understanding was tested for all three programs.

Results: All patients accepted new processor as well as new fitting strategies which were applied. Some of them preferred ClearVoice settings, some don't, but generally all of them were beneficial to the patients. There is no statistically significant correlation between strategy used and speech understanding due to small number of tested patients, but we found statistically significant correlation ($p< 0,01$) between processor type and achieved speech understanding results.

Conclusion: Presented results demonstrated importance of providing new, modern, fully functional devices to achieve better speech understanding results which allow to improve hearing benefit from cochlear implant use

P1-6-9

Multicenter evaluation on the experience of cochlear implant recipients with the first swimmable sound processor, Neptune™

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Intro: The Advanced Bionics Neptune™ sound processor is a freestyle design swimmable processor which makes it possible to hear underwater and enjoy an active life without worrying about the robustness of the processor. The objective of this project was to evaluate the practicality, comfort and ease of use of the processor and its various wearing configurations.

Methods: A multicenter evaluation was conducted in Europe and Asia. Both adults and children participated. They were asked to test the Neptune and the wearing options for at least four weeks before completing a questionnaire. Upgraded subjects compared their previous processor to the Neptune and both new cochlear implant users and upgraded users answered questions about wearing options, comfort, ease of use and sound quality with the Neptune.

Results: 93 questionnaires have been analyzed. The mean age of the subjects was 15.4 years old (SD=18.7; ranging from 1 to 66 years old). 23 adults and 70 children participated in this survey, with 53 subjects who were upgraded to the Neptune and 40 new cochlear implant users. Outcomes of this multicenter evaluation showed that the majority of Neptune features were very easy to use with mean scores above 6.4 out of 10. Subjects were very satisfied with the wearing options with a higher score for the clip (8.3 out of 10; SD=1.9). The sound quality was rated to be good under and outside water with mean scores above 6.8 out of 10. Subjects found that having a waterproof processor was very useful with a mean score of 9.1 out of 10 (SD=1.4). This criterion was selected by 31 out 36 subjects as the reason why they chose the Neptune processor. Most of the upgraded users rated the Neptune processor as being better than their previous processor, from a general point of view.

Discussion: Interesting outcomes were observed such as upgraded users who rated significantly higher the usefulness of having a waterproof processor than new cochlear implant users (Fisher's exact test: p=0.021).

Conclusion: Results collected in this multicenter evaluation through Europe and Asia showed that users were very satisfied with the Neptune processor which appeared to be easy to use for both adults and children and to provide good sound quality under and outside water.

Learning outcome: Neptune, the first swimmable sound processor for cochlear implant users provides high level of satisfaction.

P1-6-10

Experience with the new Advanced Bionics sound processor - Naída CI Q70: outcomes from a multicenter evaluation

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Intro: Advanced Bionics launched its latest ear level sound processor: the Naída CI Q70 (Naída CI). The design and improved technology of the Naída CI will lead to high benefit in Advanced Bionics users' everyday lives. New features such as UltraZoom enhance to superior hearing performance in noisy conditions.

Methods: Questionnaires are provided to both adults and children to evaluate the practicality, comfort and ease of use of the Naída CI. Subjects are asked to complete the questionnaire after at least one month of experience with the new sound processor. Upgraded users complete additional questions about the comparison between their previous sound processor and the Naída CI. This project is conducted in multiple centres and will lead to a large amount of feedback from cochlear implant users about the Naída CI.

Results: Subjects inclusion is ongoing. 10 subjects have been included so far. An overview of the new sound processor and the project as well as the results will be presented.

Conclusion: Preliminary subjective feedback showed a positive rating for the Naída CI. To confirm these results, data from a larger group of cochlear implant users of different countries and centres will be collected in this ongoing project.

Learning outcome: This multicenter survey will confirm the positive feedback already collected about the use of the Naída CI Q70 sound processor in everyday life.

P1-6-11

Cochlear Implantation after long duration of deafness

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Introduction: Outcome of cochlear implantation (CI) in patients with long deafness duration is generally poor. However, patients with maintained speech memory with symmetric or asymmetric SNHL can perform remarkably well with CI even after longer deafness duration. The reason is the endurance of the spiral ganglion in man. Here, we present seven cases; some with remarkable outcome.

Methods: This is a retrospective study based on patient archives and files. Seven patients and eight implanted ears were evaluated with a deafness duration ranging between 20-72 years. Data on pre- and post-operative speech perception, deafness duration in the ear implanted, hearing situation/deafness duration in the non-implanted ear, age at implantation and cause of deafness was extracted.

Results: All of the patients scored 0 % on monosyllabic and bi-syllabic words preoperatively in the implanted ear. When tested at 6 months to one year postoperatively, five of the patients scored on the bi-syllabic word test 12%, 16%, 52%, 56% and 65% respectively at 70-75dB HL. Three patients scored 24%, 40% & 52% at 65dB HL for monosyllabic words. Deafness duration in the implanted ear of the five patients achieving speech understanding with their implants varied between 20-47 years. One patient (72 years deafness duration) received severe tinnitus during implant use and could not use it. One patient with 50 years of deafness had only non-auditory sensations and one patient with deafness duration of 37 years with a successful implantation in the contra-lateral ear struggles with motivation to use the second implant. Speech understanding varied among the seven patients and seemed to correlate with deafness duration even though individual variations were significant.

Discussion: CI can offer the patient speech understanding even after longer deafness time than generally believed. Patients were followed between 6 months and one year. Speech scores continue to increase. Prediction of outcome with CI after long time deafness is difficult and 5 out of 8 implantations (63%) developed speech understanding. One exceptional patient with a deafness duration of 72 years (she had an extra-cochlear implant operated in 89 that needed extraction) got hearing sensations from the implant but regrettably severe tinnitus during CI use. One patient received no auditory sensations from the implant.

Conclusion/Learning outcome: Patients with long time deafness can achieve speech understanding and benefit from CI. Careful preoperative counseling is necessary since outcome may be hard to predict.

P1-6-12

Audiological findings in cochlear implantees affected by autoimmune disorders

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Aim: This paper was aimed to investigate the audiological outcomes and electrophysiological characteristics of patients with severe/profound hearing loss and coexistent autoimmune disease, who underwent cochlear implantation (CI).

Materials and methods: Study Group: 30 patients with severe/profound SNHL, Average age 58 (±8.7) years, implanted with silicon-titanium receiver devices: HiResolution® 90K (20), MED-EL®Concerto (6), Nucleus® 24 (4) subjects. At implantation 11 subjects were affected by autoimmune/disimmune diseases (AD-CI), such as: Relapsing Polychondritis (RP) (2), Cogan disease (2), autoimmune thyroiditis (1), aspecific systemic vasculitis (2), arthritis (3) and psoriasis (1). 19 CI subjects did no show signs or symptoms of autoimmune diseases, and cause of deafness was found to be: otosclerosis (4), chronic otitis (3), ototoxicity (2), viral (1), Meniere's Disease (1), unknown (8). Immunological evaluation was carried out to identify the presence of serum cytokines, systemic autoantibodies and to assess the co-presence of anti HSP-70 against inner ear proteins. Audiological evaluation was carried out for CI users under Free Field conditions both in Quiet and in Noise at 2.5 and 8 years average follow-up. The primary signal was presented constantly at 65dB, Speech/Noise (Speech Noise Ratios, SNR) used for data analysis were +10 and +5dB. A pre-trial list of 10 items was presented at +15 - i.e. easy listening conditions - in order to help subjects understand the procedure. Electric Impedance values and M-Levels (CU) (ML) were obtained in all patients and analyzed by means of non-parametric statistics.

Results: A low positivity for serum autoantibodies was found in CI subjects, not significantly different in autoimmune if compared to non-autoimmune patients. Pro-inflammatory cytokines IL-1β, IL-2, INF-γ, were significantly higher in autoimmune if compared to non-autoimmune CI subjects and the normal controls. Speech perception in quiet and in noise was not significantly different between the two groups and was stable over time (table 1). Impedance values showed higher values for AD-CI if compared to CI, with respectively: 16.9 vs 6.3 kOhm and average 82.4 % vs 96% active electrodes. Also the average number of fittings per year was higher for AD-CI (3,05) compared to CI (1,98) subjects.

Discussion and conclusions: AD-CI patients showed good audiological results, comparable with CI subjects matched for age and hearing deprivation. Nevertheless, the underlying local inflammatory process and fibrosis might be responsible for higher and more unstable electrical impedance values, with sudden changes followed by qualitative and quantitative alteration of the perceived sounds. These changes were more evident in RP subjects. Hence, follow up in these patients requires more frequent program adjustments and counseling.

	Words	Words	Words	Sentences	Sentences	Sentences
	Quiet	SNR +10	SNR + 5	Quiet	SNR +10	SNR +5
AD-CI	90%	68%	57%	84%	66%	54%
CI	93%	78%	74%	98%	88%	79%

[Table 1]

P1-6-13

Cochlear Implantation after 5 to 50 years of deafness

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It has been known for a long time that average speech understanding after cochlear implantation tends to be poorer after a long duration of deafness before implantation than after only a short period of deafness.

In clinical practice however, results vary substantially between different CI recipients. Unusual or unexpected developments can be seen, as well as different outcomes from seemingly similar baselines.

In order to put individual observations into perspective, we have analyzed speech understanding of all post-lingually defeaned CI recipients, in which the date of onset of the deafness was either known exactly, such as in meningitis or a sudden hearing loss, or reasonably exactly, such as a final drop in an otherwise progressive hearing loss. Monosyllabic word understanding scores 3 months, 6 months, 1 year, 2 years, 3 years and 4 years after cochlear implantation were analyzed. Data sets were excluded, if more than 2 of these data points were missing. In this way, we were able to analyze 25 subjects implanted after 5 to 10 years of deafness, 9 after 10-20 years, 8 after 20-30 years and 7 after more than 30 years of deafness.

Average speech understanding scores after 4 years were 52.2%, 50.8%, 22.5% and 20.0%, decreasing with increasing duration of deafness. The percentage of users who newer developed any monosyllabic word understanding increased from 12% in the 5-10 years group to 40.0% for a duration of deafness over 20 years. The etiology of the deafness was not known in all cases. In those cases, where it was known, no apparent association between the etiology and either a favorable or a poor outcome was found.

Although long duration of deafness is a negative predictor for speech recognition with CI, the variability of results is substantial.

P1-6-14

Assessment of spectral and temporal resolution in cochlear implant users: speech and psychoacoustic approach

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Spectral ripple discrimination (SRD) and temporal modulation detection (TMD) have been shown to significantly correlate with speech perception abilities in cochlear implant (CI) users. To evaluate speech perception outcomes, previous studies have generally utilized phoneme, word or sentence recognition. With such speech perception tasks, however, it is difficult to isolate the effect of specific cues on perception, because various components, such as spectral, temporal, linguistic, and contextual factors are combined in speech. It is not clear whether psychophysical abilities carry over to reflect abilities of listeners to glean specific cues in speech. Toward clarifying that relationship, we used speech perception measures where specific spectral or temporal cues were controlled exclusively, and measured the recovery of those cues vis a vis categorization.

Ten CI and 11 normal-hearing (NH) subjects participated. To evaluate the sensitivity to spectral cues in speech signals, we measured identification of a /ba/-/da/ continuum made from modified natural speech, featuring manipulation of formant transitions. To evaluate the sensitivity to temporal cues in speech, identification performance was measured using two continua (deer-tier, beer-pier) that varied in voice-onset time (VOT). Subjects' psychometric functions along the acoustic cue continua were modeled using logistic regression, and quantified using the model coefficients corresponding to the manipulated cues. The same group of subjects was also tested for SRD and TMD. Correlations between coefficients for the speech tasks and thresholds for SRD and TMD were computed.

Coefficients from both the spectral and temporal speech tests in the NH group were higher than those for CI subjects, indicating that NH subjects were generally more efficient at utilizing the cues for categorization. A significant correlation was found between the SRD scores and formant coefficients (/ba/-/da/ identification) in CI subjects ($r = 0.84$, $p=0.002$). However, while TMD thresholds were correlated with VOT coefficients of the temporal speech task, this relationship did not reach statistical significance. The current paradigm underscores the relationship between speech perception and non-linguistic psychoacoustic measures. Although speech is a complex signal with multiple cues, the ability to recover those cues bears some relationship with basic psychophysical abilities. These speech perception tasks, in which spectral and temporal cues are manipulated orthogonally in speech stimuli, may be a useful tool to evaluate CI performance with different encoding strategies or mapping parameters.

P1-6-15

Cochlear implant in patients with otosclerosis

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Objective: The purpose of this study was to evaluate the results obtained in a group of implanted otosclerotic patients. This was a retrospective case review in a tertiary referral center.

Methods: Seven patients were selected. All patients had bilateral profound sensorineural hearing loss in the post-lingual period. The diagnosis was based in clinical, audiometric and image exams criteria suggestive of otosclerosis. Patients underwent rigorous multidisciplinary assessment before the procedure. All procedures were performed by the same surgical team, with the same type of device (Medel, Opus 2, Sonata TI 100®). The devices were activated 30 days after the procedure. We reviewed the follow-up data of patients at 3, 6 and 12 months after implant activation (data for 12 months of follow-up were only available for six of the patients). The evaluated data were: puretone average (PTA), speech recognition index (disyllabic, trisyllable, sentences and nonsense syllables), number of active electrodes, electrodes impedance & field telemetry (IFT), intra and postoperative complications.

Results: The patients' mean PTA was 42.7, 38.5 and 33 at 3, 6 and 12 months respectively. The mean of trisyllable recognition index was (%) 68.7, 64, 79.3 at 3, 6 and 12 months respectively. The mean of sentence recognition index was (%) 59.7, 69.7, 80.3 at 3, 6 and 12 months respectively. The mean of recognition of nonsense syllables index was (%) 42.3, 48.4 and 67.8 at 3, 6 and 12 months respectively. At the end of one year, the mean of active electrodes was 88.89%. The mean of IFT (Ω) were 4.51, 7.44, 7.12 at the intra-operative, 6 months and 12 months measurements, respectively. Two patients had partial insertion due to resistance (inserted 83 and 75% of the electrodes in these patients). Two patients had facial stimulation in one of the electrodes. One patient had failed insertion in one ear (no cochlear lumen found), but had complete insertion on the contralateral ear. There were no major complications.

Conclusion: Cochlear implant in patients with otosclerosis had good hearing results in one year follow-up. Impedance testing showed an increase in the first months of follow-up, but remained stable after one year. Complications were rare and did not affect significantly the results.

P1-6-16

Patients with Pendred Syndrome; is cochlear implantation beneficial?

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The present study evaluates the benefit of cochlear implantation in patients with Pendred syndrome. Pendred syndrome is an autosomal recessive syndrome characterized by sensorineural hearing impairment and a defect in iodide organification, that can lead to goiter and hypothyroidism. This syndrome is associated with temporal bone abnormalities ranging from an enlarged vestibular aquaduct (EVA) to incomplete partition of the cochlea. Pendred syndrome clinically differs from non-syndromic EVA by the presence of thyroid iodine organification defects. It is relevant for pre-operative counseling to understand the differences in post-operative performance.

Patients implanted between 1999 and 2012 were retrospectively reviewed. Speech perception scores were measured with NVA Dutch consonant-vocal-consonant (CVC) list at a stimulus level of 70 dB. Postoperative phoneme scores at one year for adults and three years for children with Pendred syndrome were compared to patients with an enlarged vestibular aquaduct (EVA) but without the diagnosis Pendred and to the reference group of CI-recipients, without a hereditary cause of hearing impairment. The mean phoneme scores were adjusted for: age at implantation, duration of deafness, type of implant and onset of deafness. Quality of life was measured with the Nijmegen Cochlear Implant Questionnaire to evaluate the differences between pre- and post-implantation in patients with Pendred. All patients with Pendred syndrome improved significantly post-implantation in speech perception and in 4 of the 6 subdomains of quality of life. Despite the presence of anatomical abnormalities the outcome is good. Patients with Pendred syndrome perform as good as the reference group. The outcome of patients with Pendred syndrome and patients with an EVA without this diagnosis is not significantly different. The underlying syndrome does not seem to influence the outcome, so in CI counseling we do not have to distinguish between these two groups.

P1-6-17

Intraoperative electrocochleography predicts cochlear implant speech outcomes better than routine biographic and audiometric factors

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There is considerable variability in speech outcomes among cochlear implant recipients: while some patients attain open set speech recognition, many patients only achieve benefits in lip reading and detecting environmental sounds. Residual hearing and other preoperative biographic and audiometric factors can only account for less than a quarter of the variance in speech outcomes. It was recently shown that the magnitude of electrocochleography (ECoG) responses to tones can predict up to half of the variance in postoperative word scores. The goal of the present study was to determine if the addition of clinical factors (pure tone average, or PTA, duration of hearing loss, and age, among others) to the information from the ECoG improves the ability to predict speech outcomes.

Intraoperative round window ECoG was performed in adult patients undergoing cochlear implantation at the study institution. The magnitudes of the ongoing response across multiple frequencies at 85-95 dB nHL were summed to obtain the total response (TR). A variety of biographic and audiometric data were collected and used in a multiple regression analysis to compare the predictive capacity of these factors to that of the ECoG TR. The main outcome measure was speech performance, assessed by a CNC word test performed at 6 months post-activation.

The only biographic or audiometric factor found to have a significant relationship with CNC word scores was residual hearing, or PTA ($r^2 = 0.20$, $p = 0.018$, $n = 28$). The correlation between TR and CNC word scores was also significant and accounted for more of the variance ($r^2 = 0.43$, $p< .001$). The capacity to predict scores with a combination of TR and biographic/audiometric factors was not significantly different from using TR alone (extra sum of squares test: $F(3,23) = 0.96$, $p = 0.430$). Intraoperative ECoG alone accounted for 43% of the variance in speech outcomes in this adult population, over twice as high as the contribution of PTA alone. The addition of PTA and other clinical factors to the ECoG-only model did not significantly improve the correlation. The explanation of this result is that the ECoG, by directly assessing the residual function of the cochlear and neural substrate prior to implantation, largely subsumes whatever predictive information is gained from biographic and audiometric factors. Intraoperative round window electrocochleography (ECoG) can be used to predict speech outcomes in the adult cochlear implant population better than most routine biographic and audiometric factors.

The participant will learn how to use intraoperative electrocochleography to obtain a relatively simple measurement that can predict patient speech performance more accurately than a combination of routine preoperative clinical information.

P1-6-18

Speech recognition with the most recent technologies from the four major cochlear implant manufacturers; an update

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Objectives: This study follows a preceding one (Bergeron et al, 2012) where speech recognition abilities were compared between the four major cochlear implant manufacturers in a large cohort of users. At this moment, results showed no significant difference in speech perception between devices in quiet and in different noise conditions. While most devices appeared only slightly disturbed by the presence of a low to moderate noise level, one device appeared significantly more sensible to a degraded environment. As new devices and/or signal processing have been introduced since the first study, an update of the data has been initiated.

Study design: The transversal study involves a hundred adults who received the most recent device from one of the four major manufacturers of cochlear implant in a one-year time frame. All were tested following a minimum of three months experience with their device, in identical conditions and with the same speech recognition test, that is the HINT in quiet and in noise. A novel test (Immersound 360) assessing speech perception in a virtual environment that reproduces different everyday sound experiences and, consequently support a more realistic testing condition than the usual clinical setting, was also introduced.

Results: Descriptive analysis will specify the average and variance of the scores with each device; these metrics will be compared to the same metrics obtained with the other devices.

Conclusion: At the end of the study, speech perception from a large cohort of cochlear implant users would have been assessed in a common environment. This will support an updated comparison between the four most advanced devices currently available to clinical teams.

P1-6-19

The TV comprehension in adult cochlear implant users

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Object: To analyze the TV comprehension in a group of adult cochlear implant (CI) users.

Materials and methods: the TV comprehension was analyzed in 30 post lingual deaf subjects with cochlear implant (10 with bilateral CI, 9 with monolateral CI and 11 with CI and hearing aid) using an apparatus developed by Linear srl for modifying the playback rate of audio-video signals. The mean age at test was of 49.52 years (SD 15.95). The average of CI use was of 35.16 months (SD 23,80). An automatic test has been developed: a set of one hundred phrases from television programs with playback rate modifications (ranged between 0 and 40% of slowdown) was randomly proposed to the CI user having to watch audio-video signals and the TV speech understanding percentage was calculated.

Results: All patients had an improvement of TV comprehension applying the slowdown of audio-video signals. In particular, the average percentage of TV speech understanding without slowdown is 56,37%; with a slowdown of 10% the average of TV speech understanding is 63,28% and it is 69,28% with 30% of slowdown. The overall results were better for patients with bilateral implantation and bimodal stimulation.

Conclusions: The use of this apparatus seems useful for cochlear implant patients in order to and improve the comprehension of TV signals.

P1-6-20

Qualitative analysis on phonetic discrimination in a group of post-verbal adults with cochlear implantation

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Aim: We present the speech perception results in a group of adults with bilateral progressive severe or profound hearing loss who underwent cochlear implantation; we analyzed the perception of the individual phonemic features

Materials and methods: The study included 12 adults (6 females and 6 males), submitted to cochlear implantation at the University Hospital of Modena and Reggio Emilia and under the care of the Audiology and Phoniatrics Service. Patients (4 Advanced Bionics; 4 Cochlear; 4 Medel) were tested after 6 months from cochlear implant (CI) activation, treated with weekly auditory-oral therapy aimed to improve the perception skills. All the patients were Italian native speakers and did not show any linked diseases. Speech perception was tested by the phonemic confusion matrices, administering different phonemes in intervocalic position (VCV). The test was conducted in quiet conditions at the intensity of 70 dB (voice conversation) in silent room.

Outcome: All patients, after 6 month from the CI activation, were able to identify both the alveolar-palatal fricative and affricative phonemes; more than 75% of patients were able to identify the poly-alveolar vibrant phoneme /r/, the palatal lateral phoneme /ʎ/, the palatal nasal phoneme /ɳ/, the plosive velar sound /k/. On the contrary, the patients showed some difficulties in identifying both the dental plosive sounds /t/-/d/ and the bilabial /b/. In addition we recorded systematic errors consisting in the following substitutions: the dental fricative sound /s/ with the alveolar-dental fricative /ʃ/; the labio-dental fricative sound /f/ with the dental fricative sound /s/; the alveolar-dental voiced affricative sound /ʤ/ and the voiceless sound /ʧ/; the palatal lateral sound /ʎ/ and the nasal palatal phoneme /ɳ/ and vice versa.

Conclusions: The analysis of the phoneme discrimination (VCV) skills of the patients with CI provides indications to improve the speech therapy program and can be useful for the optimization of the fitting strategies. On the basis of these results we believe the phoneme discrimination analysis is an essential method for the post-surgery follow up.

P1-6-21

Initial clinical experiences with data logging among cochlear-implant recipients in Denmark

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Intro: In the past decade, data logging has become a standard feature in digital hearing aids. While data logging implementations between manufactures vary, the common uses of data logging are counseling at fitting sessions, troubleshooting recipient complaints, and using the results to do changes in programming. To ensure proper habilitation to aided hearing, overall device use and the characteristics of the recipient´s auditory environments may bear the most importance in the clinical routine. However, as a hearing aid can be turned and then left on, without the device being held in the ear, some uncertainty remains in the accuracy of these readings. In addition, differences in self-reported and data-logged hearing-aid use have been reported, perplexing the situation further. Recently, data logging has been introduced to Cochlear Nucleus CP900 series sound processors for cochlear implants. Due to the inherent two-way communication between the external processor and the internal implant, any periods of non-use are manifested either as "off-air" or "coil-off" states in the data logs. These can be due to the processor being turned off or not communicating with the implant. Thus, it is anticipated that these data logs represent hearing via the device more accurately than when compared to hearing aids. The aim of this study is to inspect the data logs of cochlear-implant recipients collected in normal clinical routine. The aim was also to form a baseline on how much cochlear implants are being used daily and to what sort of auditory environments the recipients are being exposed.

Methods: The data logs of 67 cochlear-implant recipients were analyzed. The average age of the recipients was 34 years (range 1-86), and 22 of them used their sound processors bilaterally. The data logs available at the most recent clinic visit were analyzed, including the total time in use, time on and off air, the proportion of different auditory environments, sound pressure levels in dB(A), as well as program and accessory usage.

Results: On average, the recipients wore their sound processors for 12.2 h per day. The most common environments were quiet (5.4 h/day) and speech in noise (2.2 h/day), and the recipients were exposed to speech on average 1.6 h daily. The most common sound pressure level in the environment was between 50-60 dB(A) for 26.9% of the usage time. Program usage, the need to adjust volume or sensitivity, and accessory usage varied between recipients.

Conclusion: In this study, cochlear implant usage data were analyzed. In addition to forming a baseline on average cochlear implant usage in different environments, the data logs can also be used on an individual basis in adjusting implant fitting parameters, such as stimulation intensity or microphone sensitivity, and in general counseling for an optimal outcome with the device.

Learning outcome: Further implications for use of data log information in everyday clinical practice will be presented.

P1-6-22

Cochlear implant outcomes and quality of life in adults with Nurotron cochlear implant

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Intro: To evaluate sound and speech perception and quality of life (Qol) in adults implanted with Nurotron cochlear implant.

Methods: Thirty subjects participated in this study. Subjects were implanted at a mean age of 30.4 (range, 20-59) years with a Nurotron cochlear implant (Nurotron Corp.). All subjects completed standard speech perception tests as well as quality of life measures (Nijmegen Cochlear Implant Questionnaire) at different points in time. Postoperative scores were compared with each other and with the baseline preoperative scores. Pair-wise comparison was also applied to evaluate Qol changes between the various test time points.

Results: Significant improvement was measured for speech perception scores and the quality of life measures. At 12 months, the subdomains “basic sound perception”, “advanced sound perception”, “speech production” and “self-esteem” improved significantly and no significant improvement occurred thereafter. The subdomains “activities” and “social interactions” improved significantly at 24 months.

Conclusion: With state of the art implants, speech perception and quality of life do improve in adults with Nurotron cochlear implant.

P1-6-23

Hearing development of hearing impaired children with different etiological background after cochlear implantation

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Background: GJB2 gene mutation resulting in prelingual sensorineural deafness is the most common cause of congenital hearing impairments. CI replacing the deficient auditory function may enable the affected children to understand the environmental sounds better. In addition, it supports integration into the society.

Patients and methods: Subjects aged 2-4 suffering from prelingual hearing loss were selected with confirmed GJB2 mutation, other genetic factors or unknown etiology. On the basis of intraoperatively evoked stapedius reflex threshold levels, impedance telemetry, postoperative threshold- and comfort levels as well as the results of auditory and speech tests, a comperative study was performed.

Results: Hearing and speech development of patients with GJB2 mutation shows better outcome results compared to children with other origin of deafness.

Conclusion: The findings indicate that the etiology of hearing impairments has a great influence on psychophysical and objective electrophysiological parameters of the speech processor as well as the postoperatively acquired communication skills of the children.

P1-6-24

Testing working memory capacity in patients with cochlear implant

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In the instance of speech discrimination, cognitive psychologists have studied language processing using extensively the models of working memory. Working memory capacity (WMC) represents the proficiency of assigning limited working memory resources. As this proficiency varies across individuals we are planning to demonstrate that the individual working memory capacity could account for the inter-individual variance in speech discrimination outcomes after cochlear implantation. The scope of current study is to rapport of preliminary results of WMC test in the group of adult CI patients.

Study group includes 20 patients - CI users and at least 20 volunteers with normal hearing Criteria of qualification to study groups was developed to include patients with hearing loss of different etiology, duration and different levels of residual hearing. As these factors influence higher and lower functions of the central auditory system, the appropriate qualification criteria will ensure the required cross-section of the brain function characteristics.

Patients' inclusion criteria

1. 18 years of age or older:
2. Post-lingual onset of profound bilateral sensorineural hearing loss.
3. Users of CI
4. Minimum of 30% open set word recognition with CI
5. Willingness to participate and to comply with all requirements of the protocol.

The test setup consists of a PC and dedicated software for test administration with personalized user interface. This study will use tasks constructed based on studies measuring the storage capacity and processing efficiency of working memory (span task).

Complex span tasks paradigm is used throughout the present investigations. We implement a methodology to make complex span test feasible to be administered in the group of CI patients. In a base reading span task participants reads a sentence and completes a task demonstrates that they have attempted to understand the entire sentence (by reading it aloud, repeating it, or judging it for some property such as its truthfulness). Following the presentation of a set of sentence, the participant is asked to recall the target word (often sentence-final word)of each sentence in the set. The number of sentences in the recall set is incremented and the span score reflects the maximum number of target words that are considered to called. Individuals with larger spans are considered to have better high brain processing abilities than individuals with smaller spans. Results of the CI patients will be compare to the results of normal hearing subjects.

P1-6-25

Long-term results of speech development after cochlear implantation in children from bilingual homes

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Intro: Children with migration background often grow up in bilingual families. We could already show that children with cochlear implant from bilingual homes perform worse than children from monolingual homes in all performed speech test after 36 months. The aim of this study was to collect long-term results after cochlear implantation concerning the development of language in both groups.

Methods: This study includes 93 profoundly hearing-impaired children, implanted before the age of 6 years with a Nucleus 22 or 24 Cochlear Implant between 1996 and 2007 at the Cochlear Implant Center Ruhr, University of Essen. 52 of these children reside in bilingual, 41 in monolingual homes. Speech and language skills were assessed by standard speech perception measures (Mainzer children speech understanding test (closed-set), Göttinger children mono-syllabic speech understanding test (closed-set), Freiburg speech test). Data on used primary and secondary languages were obtained by questionnaire.

Results: The mean age at time of implantation in both groups was 3 years (range 1-5 years). Almost all children with bilingual parents indicated German as main language. Children growing up in bilingual homes showed 5 to 10 years after cochlear implantation an approximation to the results of the monolingual group in all performed speech tests. In some cases the second language is used actively, but in most children the use is limited to single words and expressions. However some children from bilingual homes with cochlear implants achieve high skill level in their primary language and furthermore develop competency in the second spoken language.

Discussion: The language development after cochlear implantation of children from bilingual homes is often delayed. However according to our experience the use of the native language in the child´s home environment has a positive effect on their language skills. Other factors such as compliance with regard to rehabilitation, educational background of the parents also play an important role.

Conclusion/Learning outcome: Children from bilingual homes often need longer time and special support to achieve the same level of language skills after cochlear implantation as monolingually educated children.

P1-6-26

Cochlear implant in children after meningitis. Results

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Objective: Meningitis is one of the causes of Profound Bilateral Sensorineural Hearing Loss acquired during childhood. The illness can cause changes in the cochlear structure such as fibrosis, partial or total ossification. Evaluation of speech perception acquired with the use of Cochlear Implant in a sample of 80 children after meningitis.

Material and method: The development of speech perception skills was assessed after 36 months of the device use, through the use of ESP Categories (Geers & Moog) in pre-linguistic children and after 3, 6, 9 and 12 months of the device use in post-linguistic children.

Results: The sample analyzed was of 80 children : 62 pre-linguistic (younger than 3 years 6 months old at the moment of meningitis), 8 perilinguistic (3 years 6 months old to 6 years old at the moment of meningitis) and 10 post-linguistic (6 to 14 years old at the moment of meningitis). The germs causing meningitis were Streptococcus Pneumoniae in 37 cases, Haemophilus Influenzae in 4 cases, Meningococcus in 27 cases and with negative culture in 12 cases. There was total insertion in 64 children and partial insertion in 16 children, straight electrode was used and in 8 cases and double array electrode in 8 cases. The results in the development of speech perception skills were similar. The most prevalent germ was pneumococcus, 46 % (n=80) and it caused 94 % of the cases of cochlear ossification. Over the total number of children evaluated (n=80), in 30 cases (38%) Specific Language Impairment was detected; in the 100% of the cases, meningitis appeared before the age of 3 years and 6 months. In children with permeable cochlea, (64 cases), Specific Language Impairment was mild in degree in 20 children (31 % , n=80). In this group, 69 % attained speech recognition skills in Open Format after 3 year use of Cochlear Implant. In children with cochlear ossification and partial insertion of electrode, Specific Language Impairment varied from moderate to severe degree in 10 children (8%, n=80). In this group of children, only 38 % attained the development of speech recognition skills in O.F. after 3 year use of Cochlear Implant.

Conclusion: In 94% of the cases, Neumococo was the germ causing meningitis in children with cochlear ossification. All the children with cochlear ossification presented Specific Language Impairment of different degrees and they required specific therapy concomitantly to auditory therapy. The presence of Specific Language Impairment lengthened the time to acquire speech recognition skills or limited them. The evolution was variable, depending on the age at the moment of meningitis and the type of insertion.

P1-6-27

Speech perception performance trajectories of Mandarin pediatric cochlear implant users

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Objectives: The primary objective of the present study was to investigate the longitudinal performance on open-set word perception in Mandarin of congenitally deaf children with cochlear implant (CI). The secondary objective was to observe the effects of lexical factors and age of implantation on open-set word perception development over time.

Design: Longitudinal study. One hundred and five prelingually deaf children implanted with CI participated in the study. The Standard-Chinese Version of Monosyllabic Lexical Neighborhood Test (LNT) and Multisyllabic Lexical Neighborhood Test (MLNT) were used as open-set word perception evaluation tools. We examined open-set spoken word perception abilities at 6-month, 12-month, 24-month, 36-month, 48-month, 60-month, 72-month, and 84-month post CI stimulation.

Results: The results of this study showed that open-set word perception performance of congenitally deaf children with CI improved significantly over time. (1) The fastest improvement occurred in the first 36 months after initial activation. Average score of open-set word perception at 6-month was 30.89%, and the performance improved to 51.96% at 24-month, then developed steeply to 66.25% after 36 months of implant use. After 3 years, the improvement slowed down and the final peak score of 81.67% was achieved at 72-month after initial activation. (2) Lexical factors affected consistently in each evaluation session. Specifically, the best performance was always noticed in disyllabic easy words, followed by monosyllabic easy words, disyllabic hard words, and monosyllabic hard words. (3) Age of implantation had significant effect on the longitudinal open-set word perception performance; correlation analysis however revealed that age of implantation was significantly negatively correlated with recognition scores.

Conclusions: (1) The results suggested that CI continuously provides significant benefits in word perception to children with severe/profound congenital sensorineural hearing loss. Open-set word perception skills improved dramatically in the first 36 months of CI use. (2) The present study indicated that Mandarin-speaking CI children recognized words in context of lexical neighborhood, and proved LNT worked well in word perception of Mandarin-speaking CI children over time. (3) Age of implantation was significantly negatively correlated with open-set word perception skills over time. (4) For lexically harder words, such as monosyllabic hard words, there was substantial room for improvement even after long term CI use.

P1-6-28

Importance of apical stimulation in cochlear implantation

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By the application of markers, an attempt was made to demonstrate the importance of the apical region of the cochlea in relation to the discriminative complexity of the language, hearing in noisy situations and musical perception. Our observations with HRP (Horseradish peroxidase) and Cajal-de Castro stain are presented. The results of 32 cases implanted with MED-EL Cochlear Implants and a comparative study with standard electrodes are also included. Using this method, we try to demonstrate the improvement of speech perception in noisy environments and a more natural hearing quality.

P1-6-29

Intraoperative round window electrocochleography is correlated with speech perception outcomes in pediatric cochlear implant recipients

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Introduction: Speech perception performance following cochlear implantation (CI) varies substantially in children. The use of round window (RW) electrocochleography (ECoG) at the time of implantation was shown to account for over 40% of the variance in word score outcomes in adults (Fitzpatrick et al., Otol Neurotol 2014; 35(1): 64-71. The hypothesis for this study was that the ECoG measurements would also correlate with speech perception outcomes in children.

Methods: ECoG recordings were obtained from 72 children (82 ears) during cochlear implantation. A total response metric was derived from the summed magnitudes of significant ECoG responses over a frequency series of acoustic stimuli presented at 90 dB nHL in the ipsilateral ear. Implanted children were followed prospectively, and at 9-12 months postoperatively, children were evaluated with the phonetically balanced kindergarten (PB-k) open set speech perception test, if age- and developmentally appropriate (n=22). PB-k scores were compared to ECoG total response and other clinical and bioaudiometric variables using multiple linear regression analysis to construct a parsimonious model for predicting speech outcomes in implanted children.

Results: Postoperative PB-k scores were significantly correlated with ECoG total response (r^2=0.34, p=0.004) and to a lesser extent, with preoperative PTA (r^2=0.19, p=0.02). ECoG total response was weakly and inversely correlated with preoperative audiometric pure tone averages (PTA) (r^2=0.11, p=0.007, n=78). Other significant predictors of speech perception performance in univariate analyses included duration of CI use and age at testing. When all four of these predictors were combined in a multiple linear regression, only the ECoG total response remained significant. Hierarchical multiple linear regression identified a model for speech perception performance that included pre-operative PTA, duration of CI use, and ECoG total response that was able to predict about half of the variance in PB-k scores (adjusted r^2=0.49, p=0.002).

Discussion: Intraoperative ECoG recordings can account for a greater proportion of variance in pediatric speech perception outcomes than traditionally recognized bioaudiometric influences. The relatively weak correlation between total power and PTA and PTA and speech outcomes suggests that the ECoG recordings contain additional information about residual cochlear function than cannot be determined through behavioral audiometric testing.

Conclusion: RW ECoG is a useful perioperative measurement for predicting pediatric speech perception performance following CI.

Learning outcome: Despite the variability inherent in assessing pediatric speech perception performance, as a direct measure of cochlear function, the ECoG total response can provide important insight into postoperative prognosis in implanted children.

P1-6-30

Audiological results after cochlear implantation in patients with single-sided deafness (SSD)

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To date, patients with single sided severe to profound sensorineural hearing loss or anacusis (SSD) can successfully be treated with a cochlear implant (CI). Benefits like an improved hearing in noise and sound localization are observed in adults and also children with SSD using a CI. In addition, patients have reported a reduced listening effort. However, the duration of deafness at which audiological improvements by a CI can be expected seems to be limited.

Since 2011, 20 patients with SSD (15 adults and 3 children) have been implanted with a CI in our hearing and implant center. An extensive counseling and discussion in the interdisciplinary implant board preceded the respective indication. Alternatives, like a CROS hearing aid or a bone anchored hearing aid (BAHA softband) have also been tested. Speech intelligibility in silence and noise and sound localization were tested before and at several time intervals after the implantation.

Despite of a large variability of audiological results, all patients showed a benefit by the CI. Six months after of using the CI, speech intelligibility in silence was up to 90% (Freiburger monosyllables). Speech intelligibility in noise (Oldenbourg sentence test) and sound localization were significantly improved.

Cochlear implantation in SSD patients appears as a reasonable and meaningful option for hearing rehabilitation and in many cases exceeds the audiological results as provided by a CROS hearing aid or a BAHA.

P1-6-31

Two cases of successful cochlear implantation following gunshot trauma to the head

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Introduction: Two patients were referred to the Midlands Hearing Implant Programme (Adult Service) at the Queen Elizabeth Hospital Birmingham (QEHB), UK for cochlear implantation following gunshot wounds to the head. Based at the QEHB is the Royal Centre for Defence Medicine that provides medical support to military operational deployments. The Trust also provides medical services to personnel evacuated from overseas. In both cases the gunshot wound resulted in a profound loss of hearing in one ear. One patient retained normal hearing in their contra-lateral ear whilst the other patient has a moderate high frequency hearing loss and is aided in their contra-lateral ear. To date there are no other published reports in the literature of cochlear implantation following gunshot wound to the head.

Methods: These patients, who are both outside traditional UK NICE Guidelines for a unilateral implant, received a cochlear implant in their profoundly deafened ear.

Results: Medical, surgical and radiological case histories will be presented for both cases together with results of successful cochlear implant use; including results of speech perception and spatial hearing, and questionnaire results. The perceived benefits and any negative aspects will be reviewed. The challenges of isolating implant performance from the better hearing ear will be discussed.

Discussion: These two cases are highly unusual; however, our experience of implanting these patients has great implications for future research into cochlear implantation for profound, unilateral hearing loss in the UK.

Learning outcome: Presentation of outcomes of cochlear implantation in two unique cases following gunshot wound to the head.

P1-6-32

The quality of hearing after cochlear implantation - evaluation of adult patients as a part of multicenter study

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Introduction: The Cochlear Implanted Recipient Observational Study (IROS) is an international, multicenter, prospective and long-term study. The main aim of it is to collect subjective and homogeneous data of hearing implant users and to compare them at regular time intervals, i.e. at the time between surgery and the first fitting of sound processor; at one, two or optional three years after implantation. Dedicated online database was created especially for the IROS study. The ENT clinic in Lodz participates in this project since June 2012.

Methodology: The subjective evaluation of patients is performed in the first week after implantation (before first fitting of a sound processor) via validated standardized self-assessment scales: Health Utility Index Mark 3 (quality of life evaluation) and Speech Spatial Qualities of Hearing questionnaire (hearing-disease specific). To create a demographic profile of patients a general questionnaire is used (separate versions for clinicians and for patients). Such data as the usage of device and mobile phone, tinnitus, employment or dizziness are also collected. Follow up visits are performed during the standard clinical procedure in the hospital.

Results: There are 11 patients (5 females, 6 males) with cochlear implant under observation in the clinic in Lodz (number of subjects altogether in Poland - 62, in the world 282). An average age of implanted patients is 47,4 years (min 24, max 62). The aetiology of hearing loss was most commonly unknown (4), there were 2 subjects with chronic otitis media and individual cases of Measles Rougeole, noise exposure, sudden deafness and meningitis. Seven patients were using their hearing aids on the left ear and 7 on the right ear before surgery. Seven patients were employed, there is one retired patient in the database and one student. The results of follow up questionnaires show an improvement in each area: speech understanding, spatial hearing and quality of hearing.

Conclusion: Cochlear implantation increases the ability and quality of speech understanding, spatial hearing already after 1 year of the implant device usage. All the data are still being collected as a part of multicenter study, the patients are sequentially recruited to provide statistically significant data. This kind of database of all implanted patients is important and helpful for the clinic to manage the patients on the clinical, administrative and reimbursement level.

P1-6-33

Exploring the variance in cochlear implant outcomes as a function of information-processing ability

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Introduction: The modern cochlear implant (CI) is a medical prosthesis that restores to its hearing-impaired users the ability to hear speech. Despite the relatively crude auditory signal delivered by the CI, most recipients are generally able to achieve a good level of speech understanding. However, this is not true for all recipients, and there remains a substantial amount of variability in the speech perception outcomes of CI users. The current predictive model of outcomes is based on a number of limiting factors that are thought to have a negative impact on auditory performance post-implantation. In particular, some studies have identified a longer duration of severe to profound deafness to be related to poorer CI outcomes. There is a marked lack of consensus on the effects of other limiting factors, however, and these factors taken together account for no more than 22% of the total variance in performance ability (Blamey et al., 2012; Lazard et al., 2012). Given the importance of patient outcomes prediction in cochlear implantation, there is currently a need to develop a more comprehensive and accurate model of prediction based on variables other than those conventionally considered.

Methods: The purpose of this study is to identify additional sources of variability in auditory performance by quantifying the speech understanding process as a function of information-processing ability, looking in particular at postlingually-deafened adult CI recipients. Various cognitive processes will be preoperatively assessed with a test battery that has been designed to assess domains related to working memory, processing speed, mental flexibility, and verbal learning. Psychophysical measures will be used to assess the amount of useful speech information that is discriminable by the CI user. An information-processing model of speech perception has been developed to identify those areas thought to be integral to speech understanding in hearing impaired listeners.

Results: Correlation and multiple regressions will be used to investigate the relationship between these factors, in combination with demographic and audiologic variables, and a CI user's auditory performance outcomes as measured by clinical speech testing materials. Data collection is currently ongoing, and some preliminary results will be presented at the conference.

Conclusion: Being able to predict patient outcomes is an important part of the cochlear implantation process. It is hoped that the findings from this study will account for additional variance in speech perception ability, complement current knowledge of predictor variables, and ultimately form the basis for a novel and more accurate predictive model of CI patient outcomes.

P1-6-34

Predictive value of data mining in the second cochlear implant in postlingual adults

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Data mining is an interdisciplinary subfield of computer science. Sifting through very large amounts of data for useful information, data mining uses artificial intelligence techniques, neural networks, and advanced statistical tools (such as cluster analysis) to reveal trends, patterns and relationships, which might otherwise have remained undetected. In contrast to an expert system (which draws inferences from the given data on the basis of a given set of rules) data mining attempts to discover hidden rules underlying the data.

In medical field, data mining has contributed in decision making and problem solving Some examples are its contribution in detecting drugs´ quantitative adverse effects -designed for the Food and Drugs administration or predicting stroke's risk. In otoneurology, there are data mining based studies that predict and classify hearing impairment in children, profile Meniere´s disease patients or foretell its evolution

Our objective is to design a data mining system for predicting foreseeable benefits of a second cochlear implant in postlingual adult population. We did an observational study in patients older than 18 years, randomly selected from our database, bilateral cochlear implant users. Socio-demographic data (sex, age), medical variables (type of hearing loss, duration, previous use of hearing aids, etc.) data is recorded in SPSS Statistics 19.0, is preprocessed in MATLAB ®, and then processed in the Weka system.

The classifiers are created based on preimplantation attributes indicate postimplantacional predictable result. Through linear regression systems estimate the values of audiological tests used.

P1-6-35

Pitch perception in children with cochlear implants

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Introduction: Cochlear implantation has become standard for the treatment of hearing, listening and speech perception in the profoundly deaf. Following cochlear implantation subjects have shown considerable benefit for speech understanding especially under quiet listening conditions. However, postlingually deafened adults who have previous musical experience report poor music appreciation even with their cochlear implant (CI), mainly linked to poor melody recognition which is associated with altered pitch perception.

Previous studies on pitch perception have been carried out on adult users and there are limited findings for children owing to difficulties in testing children under difficult listening conditions as well as the limited number of pitch perception tests that are applicable to them. The present study aimed to evaluate if two new tests included in Auditory Speech Sounds Evaluation (A§E) that are called Harmonic Intonation (HI) and Disharmonic Intonation (DI) that use low-frequency harmonic complexes were clinically applicable in CI using children and adolescents, to investigate their pitch perception skills and to compare them to their normal hearing (NH) peers.

Materials and methods: Study group consisted of 20 congenitally deaf children and adolescents (6-17yrs) with at least six months of CI experience and 30 normal hearing peers. HI and DI tests of A§E were used to measure pitch perception skills. Individual Just Noticeable Difference (JND) was calculated.

Results: Low-frequency pitch perception was abnormal in deaf children and adolescents, and outcomes were better for HI than for DI (mean JND= 12Hz and 38Hz in CI group versus mean JND= 2Hz and 5Hz in NH group for HI and DI respectively). Bimodal CI users had better performance for DI test (mean JND= 18Hz, n=3).

Conclusions: HI and DI tests seem feasible and useful clinical tools for evaluation and monitoring of pitch perception skills as well as progress in CI technology. Further studies could be conducted to compare HI and DI results with music perception tests and music appreciation questionnaires in order to evaluate their clinical use and interpretation.

P1-7 Outcomes children

P1-7-1

Evaluation in the Greek language of implanted children

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Objectives: To compare speech detection, recognition and comprehension in Greek between children who underwent cochlear implantation in Greece.

Materials and methods: Measures of speech detection, recognition and comprehension were administered to cochlear implant users followed up longitudinally as part of an ongoing investigation on cochlear implant outcomes. The speech comprehension tests included the recognition of sentences in Greek language (Phonetically Balanced BKB sentences in Greek language) where the speech recognition tests included Phonetically Balanced words in Greek language. The tests were performed through speakers from a CD player compound in a quiet audio room at 65 dBHL. The experimental group was composed of 33 patients, between 6 and 17 years old, who underwent multichannel cochlear implantation in Greece.

Results: The average audiological assessment of the 33 patients on basic frequencies audiogram (500Hz, 1 KHz, 2 KHz and 4 KHz) was 20dB, 20dB, 25dB and 25dB HL respectively. Also their average recognition and comprehension on sentences and words in the Greek language was 87.12% and 83.09% respectively.

Conclusion: All patients had improved scores on audiological assessments (audiogram) and speech recognition tests.

P1-7-2

CHiP and outcomes of additional or complex needs children authors

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Introduction: Children's Implant Profile (CHiP) was used to assess the predictive value of the outcomes of cochlear implantation. The ChiP was also re-administered with our current knowledge of these children.

Methods: This was a retrospective study of thirty patients with additional or complex needs. The preoperative CHiP scores were collected. The outcomes reviewed were the MAIS (Meaningful Auditory Integration Scale), SIR (Speech Intelligibility Rating), and CAP (Category of Auditory Performance) scores at the pre-operative stage, 1, 2, and 3 years post implantation.

Results: The MAIS, SIR and CAP scores showed that by three years post implantation, all children showed good improvement. Patients who were rated by the team as having 'mild /moderate or great concern' in family structure and support had 15.2% poorer MAIS scores that those patients who were rated by the team as having 'no concern'. The re administered CHiP indicated that six out of thirty nine patients would not have been implanted based on our current concerns.

Conclusion/Discussion: The only category in the CHiP that was found to have a predictive value for cochlear implant outcomes was “family structure and support”. The predictive value of medical concerns was not applicable, as patients who had significant medical concern on the CHiP were not implanted. The six patients who we would not have implanted with the benefit of hindsight were later found to have more severe complex needs (e.g., ASD) than originally thought.

P1-7-3

Deafness awareness for the hearing impaired child undergoing general anaesthesia

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Objective: To educate the theatre staff about deafness awareness, so that they are empowered to provide care to the hearing impaired child during their journey through theatre.

Methods: Hearing loss affects more than 10 million people in the United Kingdom - that's 1 in six of the population. Birmingham Children's Hospital has a large ENT department where many patients have some degree of hearing loss, some of whom have implantable hearing devices. These children undergo various operations, not only directly relevant to ENT but other operations which are unrelated to their deafness pathology. The theatre staff expressed that sometimes they felt ill equipped to communicate or assist the children with a hearing impairment during their time in theatre, particularly children with cochlear implants. This is mainly because their exposure to hearing impaired children and cochlear implants is minimal and their understanding of communication modes with them was very poor. Also, the variety of implantable and non-implantable hearing aids, do cause concern to theatre and recovery staff as they are not familiar with them.

Teaching sessions were set up to educate the theatre staff regarding patients with hearing impairment and deafness who were undergoing general anaesthesia. The staff was educated about the various hearing aids and implants that the children may use and had the opportunity to handle the different implantable devices available to our patients. They were also informed how to communicate with the children with a hearing impairment, in order for them to allay the children's anxieties.

Results: The staff in theatre has a much better understanding of what hearing impairment means. They appreciate that there is a difference between sensori neural hearing loss and conductive hearing loss. They have also been introduced to the various hearing devices and implantable devices that are available in our Trust.

Conclusions: The theatre staff feels more confident when supporting a child with a hearing impairment for general anaesthesia. We recommend that ENT departments with a big practice in paediatric cochlear implants, bone anchored hearing aids and other implantable devices take a leading role in educating theatre staff, because numbers of patients with such devices and hearing impairment are increasing.

P1-7-4

Performance evaluation for a group of 61 HiRes 90K patients implanted in Annaba, Algeria since 2007

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Introduction: Cochlear implant patients regular follow-up and progress monitoring is key starting from the date of implantation. This poster aims to analyze data collected in CHU Annaba during the patient's evaluation January 2014. Evaluation aimed to monitor patients' performance and progress after the last evaluation in 2012. This analysis will then allow recommendation on actions to improve the monitoring of patients and optimize their performance over time.

Methods: Sixty-one out of Eighty patients implanted with Advanced Bionics Hires90k at CHU Annaba since 2007 attended CHU clinic for evaluation sessions between the 5th and 8th of January 2014. Patients' age ranged between 3-19 years. Fifty -one patients were implanted before the age of five years and 10 patients were implanted after the age of 5. Two patients implanted post meningitis and two post lingual progressive hearing loss patients. The process of evaluation included history taking, audiometry testing, speech evaluation using number of scales such as Categories of Auditory Performance (CAP), SIR, APCEI and the Infant-Toddler Meaningful Auditory Integration Scale (IT-MAIS). Parental involvement was given a score from 1 to 3, were 1 is the lowest involvement and guidance at number 3 is the best guidance for patients. Finally, external sound processors parts and accessories' failures were controlled and reported back to CHU Annaba.

Results: APCEI scoring was above average across all categories for the 61 patients; high acceptance of device (A scale) among all patients with a mean score of 4.87 out of 5. Auditory Perception (P scale), comprehension of oral communication (C scale), Spontaneous verbal Expression (E scale) and the Intelligibility of the oral productions (I scale) scoring mean average 3.88, 3.30, 3.20, 3.18, respectively. The mean score for parental guidance across patients was above 2 out of 3. The CAP and SIR scales results' means were 5.20/7 and 3.18/5. An improvement across all IT-MAIS categories was seen after 2 years of the last patient evaluation in CHU Annaba. Mean scores for all categories were above 3.60 out of 4. Sound processor parts and accessories control revealed two out of warranty processors' not working and one battery charger failure. No other parts failures were found at the day of evaluation.

Conclusion: Patients' evaluation allowed identification of patients with the poor and good performance. Specifically identify patients not attending speech therapy sessions or attend only one session a week and have poor performance. Recommendations were given for speech therapy and parental involvement necessity for performance development.

P1-7-5

Impaired hearing in children and the need for cochlear implants

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Objective: This investigation was aimed to determine the current status of sensorineural hearing loss in children from Mosul (north Iraq) and to report on those with sever to profound hearing loss who are in need of cochlear implant.

Methods: A comprehensive survey of 7500 Mosul children was carried out from Dec.2001 through to Dec. 2002.The subjects were randomly selected. The main objective was to screen these children for hearing impairment. A survey team included an ear, nose and throat specialist, a nurse, social worker and an audiologist. A questionnaire was completed; clinical examination and audiological assessment was performed. Those confirmed and in doubt cases were referred for further audiological and clinical assessment including computerized tomography scan and auditory brain stem response.

Results: The overall prevalence of hearing impairment was (10%). Those with sensorineural hearing loss (1.6%) and those with sever to profound bilateral senserineural hearing loss (0.15%.

Conclusion: The prevalence rate of severs to profound sensorineural hearing loss is high in our countery compared to developed countries. Cochlear implant is a useful procedure for those with severe & profound sensorineural hearing loss but hearing aid must be tried first. There is definitely a requirement for hearing and speech centers and the need for early detection of hearing loss is very important to improve the outcome of treating deaf children.

P1-7-6

Speech and acoustical perception progress in children after sequental bilateral cochlear implantation

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Objective: The world experience with bilateral cochlear implantation (CI) proves the advantages of this method for the audio-verbal abilities development and more rapid adaptation of congenitally deaf children. To date, significantly increased number of bilateral CI is observing Russia, and sequential performed cochlear implantation are more than simultaneous. According to the literature, this category of patients have a more rapid postoperative progress within 6 months after the second implantation and improvement of auditory speech perception. The aim of our study was to investigate the status of the acoustical perception, speech recognition and verbal communication at 6 and 12 months after the second processor activation in children underwent sequential bilateral CI.

Methods: The study involved 10 children (7 boys and 3 girls aged from 4 to 14 years , with an interval between CI from 12 to 36 months). All children underwent rehabilitation training courses with the speech therapist because of which have achieved the optimal speech processor parameters. Testing performed bilaterally and separately with both sides before the second implantation, then 6 and 12 months after the second processor activation.

Results: After 6 months, all children free field audiometry thresholds in when using two sound processors was much better in compare with data, obtained in the study of one ear. Statistically significant difference in the results of speech recognition in quiet and casual environment received with one and two processors. Thus in 6 months after the second processor activation a bilateral advantage speech in silence was 19% (62 % compare to 43% for the better ear), after 12 months - 25 % (70 % compare to 45 % in the better ear).

Conclusion: The formation and improvement of auditory perception in children with two cochlear implants has a significant advantage compared to that when using only one sound processor. Sequential BCI children showed rapid progress in the postoperative period at 6 months after the second implantation and more hearing advantages in noise and everyday environment with two implants. The interval between operations affect the duration of rehabilitation process after the second CI, but is not a key issue in assessing the prospects of bilateral cochlear implant using. Organization of an integrated rehabilitation program in children with two CI traditional and has a positive experience.

P1-7-7

Cochlear implantation with round window insertion in children with otitis media with effusion

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Purpose: To discuss the indications, surgical techniques of cochlear implantation in profoundly sensorineural hearing loss children with otitis media with effusion.

Methods: Between January 2003 and May 2013, a total of 550patients received cochlear implants in Anhui Provincial Hospital. Of these, 30 children with otitis media with effusion were performed cochlear implantation with round window insertion in one stage.

Results: One stage operations of cochlear implantation with round window insertion were carried out for 30 children with otitis media with effusion. All electrodes were implanted successfully, in which the cochlear implantation went normally and electrode array were protected well. All implant devices had worked normally and all patients had performed well during an average follow-up period of 0.5-3 years. None of the patients have experienced any immediate or delayed postoperative infection complication.

Conclusions: Profoundly sensorineural hearing loss children with otitis media with effusion could be performed cochlear implantation with round window insertion in one stage safely and effectively. It is unnecessary to delay implantation to control the otitis media with effusion, but it remains a challenging problem in operation.

P1-7-8

Cochlear implantation in children with cytomegalovirus

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According to the researches, approximately 30% of pediatric cochlear implant recipients passed universal newborn hearing screening. One of the causes is childhood progressive hearing loss, especially due to cytomegalovirus infection (CMV).Delayed onset of sensorial hearing loss limits early implantation. Asymptomatic CMV children with cochlear implant (CI) have not significant different results compared with general pediatric CI population in the development of auditory abilities. But specific indicators of central pathologies could affect speech perception and language development.

Objective: The purpose of this study is to investigate 1) auditory outcomes in prelingually CI children with congenital CMV 2) the incidence of handicaps associated and 3) influence of age at the CI.

Study design: Retrospective review

Subjects: The subjects of study are 18 prelingually deaf children (27 ears), implanted at the Cochlear Implant Center Professor Diamante, Buenos Aires, Argentina. The mean age at implantation was 5 years 9 month (1- 18 years). They all received the Nucleus Cochlear Implant System and are programmed with ACE speech processing strategy. They were evaluated with the Latin American Protocol (Cochlear Corporation) using vowels, consonants, disyllabic words and sentences.

Results: All subjects have full insertion of the electrode array without surgical complications. Outcomes vary in relation with the presence of handicaps associated and age at the CI. Statistical study will be presented.

Conclusions: A wide range of abilities in speech perception were observed in these children (from detection without identification up to recognition in open set). On average, general outcomes were poorer. Cochlear implantation is feasible, beneficial and variable in children with cytomegalovirus. Specific indicators of central pathologic state should be considered in child's prognosis. Neurological damages promote significant effect on speech development.

P1-7-9

Central nervous system tumours and children cochlear implant candidacy

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Aim: Neuroradiological CT Scan and MRI allow the detection of different asymptomatic Central Nervous System (CNS) tumours in children before cochlear implantation. This information gives to CI team the chance to perform an appropriate cochlear implantation and a safe follow up.

Methods: During the course of 2012-2013 CI programs Sant Joan de Déu University Hospital, three asymptomatic CNS tumours were detected during CI candidacy evaluation: bilateral intracranial arachnoid cyst, hypothalamic tumor and a classic medulloblastoma. Interdisciplinary CI committee indicates the proper time to realize CI surgery and it’s monitoring depending on present or future needs of each clinical case.

Results: *Medulloblastoma* in remission phase after surgical and oncological treatment and *bilateral intracranial arachnoid cyst* cases were treated with cochlear implant. Both of them were implanted with a device that allows removal of the magnet during surgery in order to perform periodic MRI follow up as indicated by neuroncologist and neurosurgeon respectively. The evolution of them is satisfactory. *Hypothalamic tumor* case is pendent of three months more clinical and radiological evolution for decision of implantation. If this happens CI device must be with the same condition as the cases described above.

Conclusion: Since the implementation of the newborn hearing screening (2010) in Catalonia (Spain) pediatric implantation is performed at an early age. The possible association of clinically asymptomatic neurological tumours in these children requires a comprehensive neuro-radiological study complementary. With this action protocol is possible to early detect other pathologies associated and select the appropriate CI device which must not be incompatible with its future needs.

P1-7-10

The effect of the cochlear implantation in teenagers with progressive hearing loss

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Background: Although the importance of the newborn hearing screening examination is well known, management of children with progressive hearing loss remains a problem. We investigated the outcome of cochlear implantation (CI) in teenagers with progressive hearing loss.

Methods: The teenager group consisted of 9 children who underwent CI because of progressive hearing loss from February 1999 to July 2013. All of them had received auditory verbal education. The time of the CI is when the effect of their hearing aids was lost. They were followed at least 6 months after surgery. All patients were operated in Nagasaki University hospital. Four of the 9 children had large vestibular aqueduct syndrome, while the cause of hearing loss was unknown in the other children.

Results: Pure-tone threshold level and speech discrimination score are compared. Almost all the children had good performance; the average threshold level was 29dB, and the speech discrimination scores were more than 70 percent in all but one child, whose threshold level was 40dB and speech discrimination score was 5 percent. The child had a long period of profound hearing loss. He once acquired language by auditory verbal education, but it was interrupted by lip reading one year before CI because he received no benefit from his hearing aid.

Conclusion: Most of teenagers with progressive hearing loss were found to get good CI performance. One child who showed insufficient result indicated the importance not only of the treatment and education but also the timing of the CI.

P1-7-11

The effect of cochlear implant in multi-handicapped children

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Intro: In recent years, cochlear implantations for the children with congenital hearing loss are increasing. Above all, cochlear implantations for the multiple-handicapped children are increasing steadily. The effect of cochlear implant for multiple-handicapped children is not explicit yet, and the indication to these cases is not accepted generally. Therefore the indication should be carefully considered. In this report, we evaluated behavior with sound and utterance in multiple-handicapped children who were performed cochlear implantation by using several questionnaires.

Methods: We analyzed 34 cases that were received cochlear implantation at Osaka University Hospital from 1993 to 2013 and continued the habilitation. Twenty-four had mental retardation (MR) and ten had pervasive developmental disorders (PDD). We adopted Meaningful Auditory Integration Scale (MAIS) and Infant-Toddler Meaningful Auditory Integration Scale (IT-MAIS) to evaluate behavior with sound and adopted Meaningful Use of Speech Scale (MUSS) to evaluate utterance. These questionnaires were answered by the parents in the interview with a therapist four times in time course, before surgery, and 3, 6 and 12 months after surgery.

Results: The results from multiple-handicapped children were compared with the results from children with only hearing impairment. It was revealed that the behavior with sound developed gradually even in the multiple-handicapped group. Although the development was slower than those in the children with only hearing impairment, it caught up at 12 months after surgery. Concerning utterance, development in the multiple-handicapped group was slower than those in the children with only hearing impairment and the difference still remained at 12 months after surgery.

Discussion: It was shown that it takes long time until their parents realize the effectiveness of cochlear implant in multiple-handicapped children. As for the progress of utterance, we have to wait longer. However, it is certain that cochlear implant is effective even for multiple-handicapped children to some extent. Long-term habilitation and appropriate education should be planned for these children, which will lead to good results.

P1-7-12

Cochlear implantation in deaf children with white matter abnormality

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Objective: To investigate the hearing and speech rehabilitation of deaf children with white matter abnormalities who underwent cochlear implantation.

Methods: 15 deaf children diagnosed with white matter abnormalities received cochlear implants from July 2012 to January 2013 in our hospital, including 9 males and 6 females, aged 3 -6 years old. White matter abnormalities were confirmed by magnetic resonance imaging(MRI). There were no other developmental abnormalities like intelligence development and body growth. The control group was composed of 15 cases with normal brain MRI results, which consist of 11 males and 4 females, aged 3-6 years old. After comprehensive preoperative assessments, cochlear implantation surgeries were performed via enlarged round window approach technique, and full electrode (COCHLEAR NUCLEUS CI24RE CA) insertion was achieved. Hearing and speech rehabilitations were evaluated one year postoperatively.

Results:

1. No complications occurred among the both groups, and all patients have hearing sensations after matching the sound processor.
2. The T level, the C level and the impedances of the electrodes are similar, and there were no significant differences between the two groups ($P > 0.05$).
3. One year after surgery, the results of hearing threshold, categories of auditory performance(CAP), speech intelligibility rating(SIR) and Infant-Toddler Meaningful Auditory Integration Scale (IT-MAIS) in the white matter abnormality group have no significant differences in compared with the normal control group ($P > 0.05$).

Conclusion: The early results of hearing and speech rehabilitation in implanted patients with white matter abnormality are similar with the normal group, but it is uncertain of the long-term effects, which requires further observation.

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P1-7-13

Importance of behavioral audiometery in young childs with sever inner ear abnormality in compare with objective measurements

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Inner ear abnormality is a very important & effective condition that can navigates the procedure & results of cochlear/ABI implant. In the other hand there is some infrequent cases with acute inner ear abnormality that there is no clear evidence that say us if the CI or ABI is suitable for this patient. in this cases if the team makes the incorrect decision for candidate for cochlear implant or Brain stem implant the procedure can go on in a wrong way & the results are unforgivable & incurable.

In this presentation we review some cases with so acute inner ear abnormality & no clear evidence of persist of VIII nerve with MRI that with careful & exact behavioral audiometry via new methods of Play audiometry, VRA or BOA test methods the decisions about surgery procedure changed & the results are satisfied now.

This abnormality includes patients with vesicle shape of Inner ear, Sever Common Cavity in added to CP, Metabolic disease, blindness, ADHD, Autism... that with exact & careful behavioral tests the results was so different from exceptions base on MRI, CT & ABR . if the audiologists & ENT men pay more attention on behavioral test many mistakes will not happened & the results will improved too much. This is again the old rule of medicine: "The important thing in diagnostic & cure is CLINIC of the patient"

P1-7-14

The development of auditory skills in infants with Mondini dysplasia after cochlear implantation

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Introduction: Although previous research showed a clear picture of successful outcomes in patients with Mondini dysplasia, there were few studies reported the results following a relative long period after cochlear implantation and the patients were almost adults or elder children.

Objectives: The aim of this study was to survey the development of auditory skills in infants with Mondini dysplasia within 3 years after cochlear implantation and compare their performance with those of infants with a normal inner ear.

Methods: A total of 545 infants with prelingual severe to profound hearing loss participated in this study. The age at cochlear implantation ranged from 7 to 36 months with a mean of 21 months. Based on whether or not there was a Mondini dysplasia within the implanted ear, subjects were divided into 2 groups. Group A comprised 514 infants with a normal inner ear, and group B included 31 infants with a Mondini dysplasia. The Infant-Toddler Meaningful Auditory Integration Scale (IT-MAIS) was used to assess their auditory performance. These assessments were performed at regular intervals, including pre-operation and at 1, 3, 6, 9, 12, 18, 24, 36 months after switch-on.

Results: The mean scores for overall auditory skills showed no significant differences between group A and B at pre-operation, 1, 12, 18, 24, 36 months evaluating intervals, however there were significant differences at 3, 6, 9 months evaluating intervals ($p < 0.05$). The mean scores for auditory skills in infants with Mondini dysplasia showed a significant improvement over time. Discussion Schmidt counted a number range of spiral ganglion cells from 7677 in the ear with severe Mondini dysplasia to 16,110 in the one with mild Mondini dysplasia. Although the minimum number of spiral ganglion cells necessary for response to electrical stimulation has not been ascertained, this number range of spiral ganglion cells is large enough to be triggered neural responses by electrical stimulation from cochlear implant system based on the study of Linthicum. This finding may be one of the reasons why the mean scores of auditory skills showed no significant differences between the two groups after 1 year use of cochlear implants.

Conclusion: Auditory skills of infants with Mondini dysplasia developed rapidly after cochlear implantation, in a similar manner to those of infants with a normal inner ear. Cochlear implantation is an effective interventional approach and an established therapeutic option for infants with Mondini dysplasia. Learning outcome These outcomes confirm that cochlear implantation is an effective intervention for infants with Mondini dysplasia if the amplification of optimal hearing aids is insufficient. In addition, the data of this study provide an auditory development baseline for infants with Mondini dysplasia within three years after cochlear implantation and can be used as a reference for speech and hearing habilitation programs.

P1-7-16

The results of rehabilitation of patients with prelingual deafness after implantation cochlear of CI in a group of preschool children

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Our task was to define effects of rehabilitation of implanted patients among group of 10 preschool children (5 with Medel implant, 5 with Nucleus implant). Many researches confirm fact, that early implantation has huge influence on hearing rehabilitation, although crucial role in process of rehabilitation has hearing raise of children, which helps children understand the world of sounds. The results of rehabilitation were rated by “Language progress of 60 steps program” by K. Bieńkowska, parents opinion and observation of children.

Variables taken under consideration while rating the results were: intellectual possibilities of a child (measured MWSL P-93), parenting method, age of children, age of implantation, frequency and duration of visits with speech therapist and psychologist, frequency of parent - children training and participation of a child in kindergarten.

The most important results of done researches could be expressed as:

Better progress in hearing rehabilitation achieved children which frequently participated on speech therapy and psychological therapy, trained with parents at home, are raised in democratic method, and participated in kindergarten (social training).

The results were not influenced by type of cochlear implant.

P1-7-17

Early intervention with cochlear implant for hearing impaired children referred by newborn screening: Evaluation of auditory and behavioral evaluation

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Introduction: In Japan, nobody has authorized the standard method for early intervening in hearing-impairment children, so only 30% - 60% of them can be mainstreamed even though they underwent cochlear implantation. But we have proven that early cochlear implantation made them mainstreamed.

Subject and Methods: We have operated on hearing impaired children, before they achieved 18 months old, referred by newborn screening. We evaluate their hearing ability with auditory and behavioral examinations: BOA (behavioral observation audiometry), COR (conditional orientation audiometry), SDT (speech discrimination test) and SRT (speech reception threshold). We made map based on these examinations.

Results: All of them could be mainstreamed. We are sorry that this is exceptional performance in our country.

Conclusion: It is fine examinations that can make fine map. We hope that the early intervention will be popularized and more hearing impaired children will be mainstreamed in Japan.

P1-7-18

A longitudinal study on speech perception as effect of age at implantation in 50 prelingually deaf children

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Introduction: Cochlear Implants (CI) provide direct stimulation to the central auditory nervous system of hearing impaired children allowing cortical development to progress. But CI intervention needs to take place in early childhood to be maximally effective to allow children to acquire speech perception and production and oral language. When children receive CI after the end of the sensitive period it was observed consequences for cortical re-organization (Sharma and Campbell, 2011)Published data indicate a wide range of performance among pediatric implantees. Waltzman et al (2000) categorized some variables affecting speech perception in children, and age at time of implantation was pointed as one of those variables.

Objective: The aim of the present study was to examine auditory development in relation with Speech Perception in children as a function of age at the cochlear implant.

Material and method: Prelingually deaf children implanted at the Cochlear Implant Center “Prof. Diamante”, Buenos Aires, Argentina, are subjects in this study. We evaluated 5 groups of children differing in age at implantation. They were 50 profoundly hearing- impaired children who received a CI between ages: prior to 2 years; between 2 y and 2 y 11 m ; between 3 y and 5 y 11m ; between 6 y and 8 y 11 m and between 9 y and 11 y 11m . All of them with full insertion of the electrode array without surgical complications. They had no additional disorders and receive similar auditory and educational placement, communication mode, attendance to evaluations and mapping. Children were evaluated pre-CI and 6, 12, 18, 24 months post-implantation using the Latin American Protocol, to include them in a CID Category of Speech Perception (Geers,1994).

Results: After 24 months of CI use, these 5 groups of cochlear implanted children demonstrated statistically significant pre to post-CI improvement on the speech perception tests. Rate of development in the younger group, was better in a significant way in relation with older groups.

Conclusion: In this study, children implanted before the age of 3 years demonstrated after 24 months of CI use, better speech perception skills than children implanted later, although all of them showed significant pre to post CI improvement.

Key words: prelingual deaf children, speech perception, sensitive period

P1-7-19

How effective has new born hearing screening been at reducing the age of referral for a cochlear implant: A comparative review

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Introduction: A comparative audit of the age at referral and time to assessment and implantation in children presenting to the Southern Cochlear Implant Programme (NZ) since the introduction of national New Born Hearing Screening (NBHS) in August 2010. To compare this data with a previous audit. To identify causes of delay in referral and implantation.

Method: All paediatric referrals to the Southern Cochlear Implant Programme from August 2010 to February 2014 were evaluated retrospectively. Comparisons were made with the audit of referrals from March 2003 to March 2008, prior to the introduction of national NBHS. Individual case notes were examined to identify causes of delay.

Results: Seventy eight children were referred, constituting 45 prelingual referrals and 33 post lingual referrals. The median age of referral for the prelingual group was 8 months (mean 14.8 months, range 1 month to 46months) compared with the previous audit where the median age of referral was 17 months. Thirty six (80%) of the prelingual group had been identified through NBHS. The remaining referrals, not identified through NBHS were following progressive hearing loss, meningitis and possible false negative screening results. For the NBHS group the median age of referral was 6 months (mean 10.6 months, range 1 month to 38 months). Reasons identified for the delay in referral included incorrect screening procedure, progressive hearing loss, diagnosis of auditory neuropathy spectrum disorder and parent not attending appointments. The median time from referral to assessment was 2 months (mean 2.7 months, range 2 weeks to 7 months). The median time from assessment to implantation was 2.5 months (mean 2.6 months, range 2 weeks to 7 months).Median age at implant for the prelingual group was 13.5 months (mean 21 months, range 8 months to 50 months) compared with the median age at implantation for the NBHS group of 13 months (mean 17 months, range 8 months to 42 months). Reasons identified for the delay, in addition to those above, included waiting for radiography and patient health issues.

Discussion: The median age of referral for children identified through NBHS was 6 months compared to 17 months for children referred prior to the introduction of NBHS. The median age at implantation for children identified through NBHS was 13 months compared to 21 months for children implanted prior to the introduction of NBHS. The program actions referrals in a timely manner and children proceed to surgery in a timely manner.

Conclusion: The implementation of New Born Hearing Screening has shown some positive results in lowering age at referral and implant, however some challenges remain.

Learning outcome:

1. The effect NBHS has on age of implantation.
2. Not all CI candidates will be identified through NBHS

P1-7-20

Acoustic function of premature children's different contingent

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Introduction: Acoustic analyzer function of premature children depends on its maturity degree determined by conceptual age and a number of other factors.

Goal: To give quantitative description of acoustic function's availability relating to different contingent of premature children under primary examination by method of distortion product otoacoustic emission (DPOAE).

Materials and methods: 289 premature children having been examined were divided into the following groups: A group (72) - children with intrauterine growth inhibition; B group (153) - children born due to plural pregnancy; C group (64) - premature children, body mass of whom corresponded to gestation period. Each group was divided into subgroups according to gestation periods: A 1 subgroup included 28 children born during gestation period of 32 weeks; A 2 subgroup - 24 children with gestation period from 32 to 34 weeks; A 3 - from 35 to 37 weeks. B 1 subgroup included 39 children with gestation period of ≤ 31 weeks; B 2 subgroup - 68 children with gestation period of 32-34 weeks; B 3 subgroup - 46 children with gestation period from 35 to 36 weeks. C 1 subgroup consisted of 23 children born till the 32-th week of gestation; C 2 subgroup - 24 children with gestation period from 32 to 34 weeks; C 3 subgroup - 17 children with gestation period from 35 to 37 weeks. Examination of acoustic function was conducted on “Eclipse” device (firm “Interacoustics”, Denmark) by method of distortion product otoacoustic emissions - DPOAE - at frequencies f2=1, 2, 4, 6 kHz, relation f2/f1=1,22. Audilogical examination was conducted depending on gestation period: children related to A and C groups were examined at 2 months, 1-2 months and 2 weeks-1 month of living; children of B group - at 2-3 months, 1-2 months and 1 month of living.

Results: In A group the ratio of children, having passed the test for both ears/for one ear/not having passed the test for either ear, makes: in A 1 subgroup - 29%/32%/39%; in A 2 subgroup - 46%/37%/17%; in A 3 subgroup - 40%/35%/25%, accordingly. In B group the ratio was the following: in B 1 subgroup - 25,6%/25,6%/48,7%; in B 2 - 45,6%/26,5%/27,9%; in B 3 - 42,2%/31,1%/26,7%, accordingly. In C group the ratio was: in C 1 - 48%/13%/39%; in C 2 - 54%/29%/17%; in C 3 - 71%/23%/6%, accordingly.

Conclusion: Under primary examination passing the test depends mainly on gestation period and, to a lesser extent, on mass-height index and plural pregnancy. Under intrauterine growth inhibition and plural pregnancy the quantity of children having passed the test for only one ear increases.

P1-7-21

Audition and speech intelligibility in children after ten years of cochlear implant surgery

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The communication skills of prelingually cochlear implant children develop over the years of device use. The aim of this work was to study the performance achieved by teenagers and young adults with at least ten years of CI experience with regard to speech perception and speech intelligibility, considering the duration of deafness and type of the device. The participants of this study were 61 teenagers and young adults prelingually deafened, who received different types of CI, on average at 3 years and 10 months of age. Recognition of two-syllable word lists, the Hint test, and recognition of Hint sentences in quiet and noise were the procedures used to evaluate the hearing performance. The speech intelligibility of the participants was evaluated by two judges, using the write-down intelligibility method and a five-point intelligibility rating-scale. After 10 years of experience with CI, 53 participants (86.9%) achieved open-set speech recognition. The average results obtained with the two-syllable word list were 49.4%; 54.7 dB with regard to the Hint test in quiet and 10.7 dB with regard to the Hint test with noise. The mean percentage of Hint sentences recognition in quiet was 54% and, with noise, it was 33.3%. Regarding the speech intelligibility of the participants, the average write-down intelligibility score was 76.2% and the average rating-scale intelligibility score was 3.3 points. Better speech performances in quiet and in noise were correlated with shorter durations of deafness. Nucleus 24 and MED-EL (Combi 40+) device users performed better than Nucleus 22 users with regard to speech perception in noise and speech intelligibility. More than 10 years after the CI surgery, 82% of children implanted with the first generation of the electronic device developed speech recognition in noise and 90.1% achieved intelligible speech. Considering the contemporary criteria of surgical indications in association with the new speech-coding strategies available, promising results were expected for the new generation of children who underwent CI.

P1-7-22

Long-term preliminary speech perception and language outcomes after sequential bilateral cochlear implantation in children

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Intro: In children with bilateral CIs (BiCIs) the primary benefits of bilateral hearing are obtained, although to a lesser extent than in children with normal hearing. The effects of BiCIs implanted simultaneously or with a short period between both implantations, are quite straightforward: children with BiCIs have better outcomes in spoken language skills than children with a unilateral CI, presumably caused by the benefits obtained in speech perception in noise and localisation. Most studies in children with BiCIs implanted sequentially report on bilateral benefits in speech perception and localisation, but would these benefits still lead to secondary benefits in language skills after extended unilateral deafness? The aim of the current study was to assess the long-term effect of sequential bilateral cochlear implantation in children on speech perception in noise and receptive vocabulary.

Methods: A cohort of 30 children with BiCIs implanted sequentially was followed longitudinally after the second cochlear implantation. After 5 to 6 years of BiCI use, 25 out of the 30 children were still consistent users of the second implant. Of these 25 children, 24 participated in the current study. For comparison purposes, speech perception and language outcomes in a matched reference group of 26 unilaterally implanted children were collected. The groups were matched on age at unilateral cochlear implantation, chronological age at testing and duration of first or only cochlear implant use. In both groups all children had non-verbal IQ scores higher than 80. All children received their first or only implant before the age of 3 years, with a mean age of 1.8 and 1.9 years for the bilateral and unilateral groups, respectively. The children in the bilateral group received their second implant between 2.4 and 8.5 years of age. Speech perception in noise was tested with a phoneme recognition test (NVA children's test) at a fixed signal-to-noise ratio of 0 dB presented at 0° azimuth. Receptive vocabulary for Dutch language was assessed with the Peabody Picture Vocabulary test (PPVT-III-NL).

Results: A language quotient (LQ) was calculated from the PPVT-III-NL scores by dividing the age-equivalent score by the child's chronological age. An independent samples T-test showed that the bilateral group had significant higher phoneme scores in noise than the unilateral group ($t[47] = 3.4$, $p < .01$) and that LQs were significantly higher in the bilateral group than in the unilateral group ($t[48] = 2.1$, $p < .05$).

Conclusion: This study showed that sequential bilateral cochlear implantation in children leads to long-term benefits in speech perception in noise and receptive vocabulary.

Learning outcome: After extended unilateral deafness, consistent users of BiCIs not only obtain the primary benefits of bilateral hearing, but they also obtain secondary benefits in language skills.

P1-7-23

The development of linguistic abilities in children with profound prelingual sensory-neural hearing loss. Comparison of cochlear implant and hearing aid users

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Aim: The aim of this paper is to compare the development of linguistic abilities of children using cochlear implants with those using hearing aid.

Material and methods: Sample of this paper was children with profound prelingual sensory-neutral hearing loss who attend primary education at the area of Central Macedonia. These children attend typical or integrating schools. Each group includes 12 students. Data had been collected with the Illinois Test of Psycholinguistic Abilities by John N. Paraskevopoulos and Samuel A. Kirk (1969) with individual examination.

Results: The results revealed that children with cochlear implants showed a better performance, from 5 until 21%, that those with hearing aid at auditory reception, auditory association, auditory memory, auditory closure, and verbal expression.

Conclusions: Cochlear implant appears much advantage in the process of auditory informations who improve the linguistic abilities that are being activated during the organizing process in language acquisition and the speech and language development.

P1-7-24

Assessment of auditory development in infants with use of questionnaires

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Introduction: Adequate questionnaires for parents are very useful diagnostic tools. They can be used both in diagnostic process and assessment of rehabilitation outcomes. LittlEARS® Auditory Questionnaire (LEAQ) assesses auditory behavior and changes in auditory development in infants up to two years of age.

Aim: The aim of the study is comparing auditory development as indicated by Polish version of the LEAQ with ABR thresholds.

Material and method: The group of children not older than 2 years, with hearing loss from mild to profound, with no additionally dysfunctions and without any previous experience with hearing aids was included to the study. Based on LEAQ total score, hearing age was estimated and the relative difference between corrected and hearing age was calculated, which we called relative Δ. As a measure of auditory function ABR audiometry was performed. Finally correlation between hearing threshold in better ear both for 500 Hz and click (2-4 kHz) and relative Δ was analyzed.

Results: Statistically significant correlations between ABR thresholds and the relative difference between corrected and hearing age were observed.

Conclusion: LittlEARS® questionnaire can be a very useful tool in hearing screening and hearing diagnostic procedure, in children up to 2 years of age.

P1-7-25

Auditory performance and language development in implanted children followed in Rabat

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Aim: The aim of the present study is to evaluate auditory perception, communication abilities, language production and school integration in cochlear implant children followed at Rabat military hospital.

Material and methods: 60 children implanted unilaterally with Neurelec cochlear implants have been evaluated on language perception and production using APCEI, CAP, SIR and MAIS questionnaires, and school integration. All children went out speech therapy every one or two weeks.

Results: Results showed very good results for language and school integration. Overall, auditory performances and communication abilities improved according to the age range, however children implanted earlier had better results.

Conclusions: In very young cochlear implant users, the oral language can develop rapidly and depends both on pre-verbal communication (oral and/or gestures) built before implantation and on early oral comprehension abilities developed after implantation. Those results support the idea of immediate cochlear implantation after deafness diagnosis with adapted monitoring of communication.

P1-7-26

Systematic newborn hearing screening program at Beni Messous hospital in Algiers

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Introduction: Newborn Hearing screening programs can enable early detection of hearing problems and consequently lead to early intervention. The aim of our study is to describe our screening protocol in the maternity ward, to evaluate the coverage rate, the incidence of neonatal deafness, and their management

Material and methods: We conducted a systematic hearing screening program in the maternity ward of our hospital during a 4 years period from January 2010 to July 2013. All newborns were tested using the strategy of measuring Oto Acoustic Emissions OAE. The screening started with OAE on the third day of life in the maternity ward. The same test was repeated either the 10th day after birth If the baby failed the first hearing test or were at risk of hearing impairment , or at one month of age for the other infants. The neonate was referred for further investigations if he failed the second test.

Results: During the program period a total of 28470 babies were born in this clinic. Among these neonates, 20214 underwent systematic hearing screening test with otoemission. The screening coverage rate was 71% (20214/28470). A rate of 3% of newborns failed to pass the second screening test. The follow-up rate was 96.8%. The incidence of bilateral moderate to severe and unilateral hearing loss was 1.14 per 1000 (23/20214). Of the 23 testing positive,10 were confirmed as bilateral profound hearing loss and are candidates to cochlear implantation, 13 were diagnosed as respectively 7 bilateral severe hearing loss and 6 unilateral hearing loss requiring hearing aids.

Conclusion: Systematic newborn hearing screening program is effective and feasible. However some difficulties could be encountered particularly for the confirmation of the deafness and the follow up.

Learning outcomes: Description of the screening protocol

Evaluation of the incidence of profound and severe hearing loss among neonates

P1-7-27

Impact of universal newborn hearing screening program on early intervention and cochlear implantation

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Introduction: Impact of Universal Newborn Hearing Screening Programme (UNHSP) on early intervention program (cochlear implantation) is investigated during 4 years in region Tuzla canton, Bosnia and Herzegovina.

Material and methods: Three-step screening by automated otoacustic emissions is performed on newborns in three delivery units in region of Tuzla-canton. If abnormal responses on first and second OAE test, or risks factor for hearing impairment are found, auditory brainstem response audiometry is performed. Descriptive analyses of newborn population, coverage rate (first and second), referral rate and cochlear implantation were presented for period 1.4.2009. to 31.12.2012. The patients was divided in two groups: experimental group (consisted of children from Tuzla canton, where UNHSP implemented from 1.4.2009.), and control group (consisted of children outside from Tuzla canton, where UNHSP not implemented).

Results: From 18.119 newborns, only 4180 were screened in the delivery units (initial coverage rate 23.06%). Second screening performed at Audiological department and from 15.019 newborns screened 6826 (second coverage rate 45.44%). After second screening, 359 children had negative OAE. Deafness confirmed for 11 children, and 5 children were implanted. Before of implementation of UNHSP, average age of children at time of confirmation of deafness was 30 months, and after implementation UNHSP, average age of confirmation of deafness was 7 months (experimental group). For control group of children, relation was 39 months- 34 months. Before of implementation of UNHSP, at ENT clinic Tuzla were implanted 29 children with average age at time of implantation 64.74 months, and after that were implanted 7 children with average age at time of implantation 31.15 months. From 18.119 newborns, only 4180 were screened in the delivery units (initial coverage rate 23.06%). Second screening performed at Audiological department and from 15.019 newborns screened 6826 (second coverage rate 45.44%). After second screening, 359 children had negative OAE. Deafness confirmed for 11 children, and 5 children were implanted. Before of implementation of UNHSP, average age of children at time of confirmation of deafness was 30 months, and after implementation UNHSP, average age of confirmation of deafness was 7 months (experimental group). For control group of children, relation was 39 months- 34 months. Before of implementation of UNHSP, at ENT clinic Tuzla were implanted 29 children with average age at time of implantation 64.74 months, and after that were implanted 7 children with average age at time of implantation 31.15 months.

Conclusion: UNHSP, even with very low initial coverage rate leads to reducing average age of confirmation of deafness, all of which can still lead to early interventions.

P1-7-28

First analysis Newborn Hearing Screening Program in Algeria

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Newborn hearing screening program (NHSP) is commonly used worldwide since the ninetieths to promote infant's health. In Tizi-Ouzou, a landlocked country in Algeria, we started a newborn hearing screening in a maternity with high Birthrate level

Aims: The aims of this study are to analyze the first results of one year of NHSP in a high level birthrate maternity and to evaluate hearing impairment rehabilitation.

Materials and method: It is a prospective study to analyze hearing disorder in infant with three stages between June 1st 2011 and May 31, 2012.

Results: The department of Tizi-Ouzou has a total of 1 139 593 inhabitants with 22 284 new born in 2010. There are 35 maternities with different birthrate level. S'bihi maternity has the highest birthrate level of the department with a total of 9416 new born in 2010. The ENT Department in Tizi-Ouzou Hospital endorses the role to evaluate the hearing for all the new born in S'bihi maternity with three stages. The first stage before maternity discharge tests Oto acoustic emission (OAE). The two others stages will take place in the ENT department. The second stage after one month from birth tests OAE. The third one, at 3 months, searches auditory brainstem electric response. Between June, 1 2011 and May 31 2011 we tested 7454 new born for the first stage. The study is still current. 859 newborn were referred to the second stage but only 656 were tested. 25 new born whose failed the 2nd stage were referred to the third stage which gives us 15 infants with deafness. Two toddlers present a profound hearing loss and are fitted with a cochlear implant. Two others present a unilateral hearing impairment and were given advices for their parents to avoid disorders for the precious ear. The remains children present a mild hearing loss and are fitted with conventional hearing aid.

Conclusion: The new born hearing screening program enter in the objectives to promote health. The prevalence is 0.2 % in S'bihi maternity. The NHSP in Algeria is feasible and the perspectives of our study are to use its results to extend this screening to the entire department first, then to all the country.

P1-7-29

Cochlear implant in children with congenital deafness identified by neonatal hearing screening program

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Introduction: The program of universal hearing screening for newborn population aims early diagnosis of deafness and intervention as soon as possible by conventional hearing aids or cochlear implant for severe or profound hearing loss.

Materials and methods: Our study was based on data gathered through the universal screening of deafness in newborns between 2008–2012 and cochlear implant program in Iasi between 2009 to 2013. Diagnosis of hearing loss was made no later than 6 months of age, the recommendation for cochlear implantation being made before the age of 1 year. We analyzed the incidence of profound deafness with cochlear implantation indication in tested children and the results of the implantation using the free field sound perception tested by visual reinforced audiometry and speech development based on speech therapeutic reports.

Results: The study includes a number of 31 331 children (92.96% of total newborns) tested in our universal newborn hearing screening during the analyzed four years. In Iasi were identified 41 children with sensorineural hearing loss, 21 of them with cochlear implantation indication, representing 0,67/1000 neonates. Only 15 came back in our center to be implanted. The first babies with profound deafness from Iasi screening program were implanted in 2010. Despite early diagnostic and early cochlear implant recommendation, only 60% were implanted between 1 and 2 years old, 20% between 2 and 3 and 20% between 3 and 4 years old. That is why the mean age of implantation in deaf children coming from screening program was 2,6 years old. The auditory evaluation shows the achievement of tonal hearing thresholds at 25 dB between 1 and 4 months postimplantation. Development of speech perception and speech production is very individual.

Conclusions: The hearing screening program in Iasi reaches the actual gold standards, being universal and having continuity in the last 5 years. The program is valued by the recovery of auditory-verbal skills in children diagnosed with severe to profound deafness, cochlear implantation being done in most cases at ages between 1 and 2 years. Implantation results encourages the insertion of children in normal school and normal society.

Key words: Neonatal hearing screening, cochlear implant.

P1-7-30

Educational placement of pre-lingulally deaf children who received cochlear implant between 5 to 10 years of age

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The aim of the study was to identify the educational placement of pre-lingually deaf children who received cochlear implantations at an older age. We reviewed the data of 138 children who were implanted between the age of 5 and 10 years under Pakistan cochlear implant program. 60% of the children attended mainstream school. 4% attended special education school for deaf children, whilst 35% were taught at home with private tutors/parents. There were 2 (1.4%) non-users. 94% of the parents were satisfied with the outcomes and felt their expectations met.

Conclusion: Pre-lingually deaf children who received cochlear implantations after the age of 5 years benefit from cochlear implants in terms of their educational placement.

P1-7-31

Cochlear implant in child: Auditory, language abilities and school integration

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Aim: Outcomes evaluation of cochlear implantation in children in relation to the age at implantation.

Material and methods: 75 children implanted unilaterally with Neurelec cochlear implants have been evaluated on the auditory performance, speech rehabilitation, and school integration. They have been enrolled from 2007 to 2010.

Results: The mean implantation age and assessment age were respectively 3.3 and 6.4 years. The elder children were implanted later: on average at 1.85 years old for children less than 4 years old and 4.64 years old for children aged 8 and over. Auditory performances and speech rehabilitation outcomes improved according to the age range. However, children implanted earlier had better results. Overall 80% of the children had integrated a mainstream school system by the age of 8.

Conclusions: Cochlear implantation before language acquisition seems to be a critical point in a good hearing rehabilitation. This cohort demonstrates the importance of early intervention.

P1-7-32

Comparison of speech discrimination and comprehension of cochlear implant users: computer produced speech versus live voice

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The rapid development of technology and the use of Personal Computers into everyday life over the past decades has introduced e-learning in education and speech therapy.

The objective of this study is to reveal the difference in effectiveness between a computer - oriented program and the intervention provided by a speech therapist, with the use of printed images. In accordance, a computer program was utilized displaying four pictures simultaneously on the screen reproducing an acoustic stimulus which matched one of the pictures randomly displayed.

The test was administered to 20 prelingually deaf children, who have undergone cochlear implantation. All children attend preschool or primary school programs. All children had pure tone audiograms in the four basic frequencies better than 35 dBHL. The speech sounds produced by the computer were of a higher frequency in order to evaluate discrimination and comprehension rather than hearing awareness ability. Each child was provided with 10 sets of four pictures in four different groups. Initially, the test was taken on the computer followed by another session when the pupil was provided with the same picture sets in printed form and the speech sounds were produced by the therapist. Test results were compared and revealed limited concentration when the child used the computer software. On the contrary, the results were considerably better when the test was executed by the speech therapist due to the ability of the therapist to choose the correct moment to provide the stimuli when the child was most concentrated and alert.

P1-7-33

Performance differences between recorded and live voice speech audiometry in implanted children

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Aim: To compare patient performance in two different kinds of speech audiometric measures.

Material and methods: Thirty five (35) children, successfully implanted with multichannel devices were tested. Two different kinds of speech audiometric tests were carried out, without lip reading. A sentence recognition test and a word detection test of 25 two-syllable words, in the Greek language. Speech stimuli were provided by a CD player through speakers in a silent audio room at 65 dB and then by the live voice of a speech therapist.

Results: Average sentence recognition score was 83% using the CD and 92% with the live voice. Average word recognition score was 87% with the recording and 95 % with the live voice.

Conclusions: Speech audiometry scores were higher using live voice. The patients can be better stimulated with the live voice, than with a digital recording, as they can interact better with the speech therapist.

P1-7-34

Correlation analysis of LittlEars©-questionnaire and A§E© in cochlear implanted children

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Introduction: Valid audiologic testing for very small infants is very important for diagnostic evaluation of Cochlea Implantation. The LittlEars©-Questionnaire subjectively observes the hearing development in infants, the A§E© (auditory speech sound evaluation) is an objective, audiologic/ linguistic test. It was investigated whether both tests regularly used provide supplemental information on hearing development after Cochlear Implantation and whether there is a positive correlation of results.

Material and methods: In 58 unilateral/bilateral implanted patients (age: 12 to 65 months) Schmid Giovannini-Test, Pollack Test, “Mainzer” Speech Comprehension Test, LittlEars© Questionnaire and A§E©-Test were performed pre- and postoperatively and correlation analysis was performed.

Results: Results of A§E©-Test, the LittlEars©-Questionnaire and the other correlated positively. Especially at a hearing age between 18 and 36 months the A§E©-Test provides valid results in phoneme-detection and phoneme-discrimination. The effects of bilateral implantation, cognitive deficits and bilingual education could also be highlighted by the evaluated tests.

Conclusions: Parents subjective evaluation correlates positive with objective measurement tools like the A§E©-Test. Together, both tests provide a valuable addition for evaluation of hearing and language development for our very small patients.

P1-7-35

Happiness in Iranian cochlear implanted adolescents

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Objective: Hearing impairment other than medical issues can have an impact on adolescents' quality of life and can lead to their isolation and depression .This study attempted to obtain information about one of mental health components, happiness. We studied the happiness status of the Iranian Cochlear Implanted adolescents.

Method: We used a descriptive-comparative method. All of the cochlear implanted students (girls and boys) in all the high schools of Tehran in year 2012-2013 were our statistical community. Sixty nine cochlear implanted girls and boys were selected by randomly stratified sampling. We used the Oxford happiness questionnaire as our tool.

Results: Using analysis T, our findings showed that happiness scores were different in boys and girls Cochlear Implanted adolescences. The boy´s happiness score was higher than girl´s happiness scores, but not significantly important. Happiness scores of both boys and girls were under mean Happiness scores (40-42).

Conclusion: Based on the research findings, happiness score of cochlear implanted adolescents were lower than average scores of The Oxford Happiness Questionnaire (40-42) and also the girls have scores lower than boys. Appropriaste programs should be done to improve happiness status of hearing impaired adolescents.

Keywords: Cochlear Implant, happiness, hearing impaired, adolescents.

P1-7-36

Restoration of hearing with cochlear implant in asymmetric and unilateral deafness in children

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Introduction: A marked improvement of listening skills is known for more than a decade from bilateral cochlear implantation ago.

In an attempt to restore, at least partially binaural hearing in individuals with "unilateral sensorineural hearing loss called "single sided deafned " in Saxon language, we started to implant highly selected patients .

Material and methods: These are children with unilateral deafness and a contralateral ear with useful hearing, complaining of loss of binaural hearing abilities. Impairment understand / discriminate speech in noisy environments. Loss of sound source localization skills.

Results: At the time of this presentation, seven patients are implanted, the seventh was introduced a few weeks ago .

Conclusion: Our experience and Inclusion - Exclusion Criteria based on understanding , Elocution and Hearing, for emerging candidates in this limited and restricted group of patients is presented.

- Is not possible to generalize that is an indication for all individuals children with unilateral deafness.
- There is NO sufficient or optimal or specific literature on the subject . Not enough experience. There´s some about SSD and adults with tinnitus. Is just beginning in children.
- Recommended first choice if the patient meets the inclusion criteria. Bone Anchored Hearing Aid may be the second option.
- The hardest thing: meet the protocol inclusion / exclusion.
- Some children do not qualify because of malformation or aplasia of the cochlear nerve.
- More cases and experience is necessary.
- Not all of them make the decision to be implanted.

P1-7-37

Clinical study of MED-EL new speech processor (RONDO) for child

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Introduction: In Japan, they that have hearing loss (especially from new born) have been not social acceptance. .As Heredity thought without a basic theory still remains, Disabled children`s parents and family may receive the discrimination which is completely groundless. Therefore they catch up in the earliest possible stage and entry mainstreaming. And it is also important to make it be the same cosmetic as like normal children. In this time our team had been studying effect of RONDO compare with OPAS.

Subjective: 5 children (8 ears) who have An average percentage of correct answers is 80% or more in Japanese monosyllabic test (60dBHL) and SNR testing score over 50%(±5 S=60dBSPL N=55dBSPL Speech noise)

Method: Compare with OPUS and RONDO using maximum score monosyllabic test and SNR test (+20 +10 +5).

Result: For all patients, the difference of results was not seen in both testing results.

P1-7-38

An examination of the relationship between tone perception and tone production on Mandarin-speaking children with cochlear implants

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Objective: In addition to speech sound disorders, Mandarin-speaking CI recipients may also encounter greater challenges in perceiving and producing Mandarin tones. It is believed that the failure of perceiving changes in fundamental frequency may result in the failure on lexical tone production. The study is aimed to examine the relationship between tone perception and tone production on Mandarin-speaking children with cochlear implant.

Method: Two experiments were carried out in this study. In Experiment I, 10 cochlear implanted patients and 3 normal hearing children were involved. All the participants accepted a lexical tone recognition test. Ten sets of Mandarin four tones were produced by three males and three females. The recordings were converted into individual audio files, and then edited into a testing file on the SuperLab 4.5. The stimuli were randomly played by the SuperLab 4.5. In addition, all the participants also received a recording of the ten sets of Mandarin four tones. In Experiment II, for evaluating CI users' speech intelligibility, all the participant's tone production in Experiment I was judged by a panel of 3 listeners. Intelligibility scores were calculated as the average of the 3 listeners' responses. The perception and production tasks in both experiments were conducted in the soundproof rooms.

Results: The average correctness of tone perception was 54.96% for CI users, and 93.47% for NH children. The average intelligibility score was 71.4% for CI users, and 100% for NH children. It showed that tone perception and intelligibility scores were highly correlated. The CI users with higher correctness in tone perception will perform better on their speech intelligibility. The speech intelligibility of the CI users with 65% correctness in tone perception in this study was almost like the normal-hearing.

Conclusion: The abilities of tone perception and tone production in CI users are quite identical. The ability of their tone perception can be a good predictor to their speech intelligibility, and vice versa. These results can serve as indices for clinical applications when long-term advancements in spoken-language development are considered for CI recipients.

P1-8 Surgical issues: Revision/re-implantation, malformation & robotic surgery

P1-8-1

Morphological aspect of the transattical approach for cochlear implantation

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Cochlear implantation is an effective procedure for restoring hearing capacity to individuals with severe-to-profound hearing impairment. Since the development of cochlear implantation in the 1960s, both the surgical technique and the implant design have been modified to reduce complication and allow better functional results.

The classical technique for placing cochlear implant (CI) involves mastoidectomy and posterior tympanotomy. However, only few alternatives to this classic approach have been described in the literature. The suprameatal approach was developed by Kronenberger et al. in 1999. This method is a simple and safe surgical procedure that does not endanger the facial nerve and the chorda tympani.

The purpose of the present paper is to report the results of our study of anatomical variation and relations of the middle ear on the large collection of the temporal bones. Attention was paid to the structures and landmarks which are important for CI.

In the mastoid region we examined and precisely defined: the type of pneumatization, the position of the sigmoid sinus, the course of the mastoid segment of the facial nerve and the facial recess. We noted great variability in the course of the facial nerve through its mastoid segment. The nerve bifurcation distal to the second genu was found in two cases. Dehiscence in the bony covering of the facial nerve were observed adjacent to the facial recess. Variations in the location of the chorda tympani nerve were also described.

In the area of the attic we described the morphological variations of the medial and lateral compartment and their communication with the other middle ear spaces. The compartment of the attic varies in shape and dimensions, depending upon the position of the auditory ossicles (the body of the incus and the head of the malleus) in relation to the attic walls, the degree of prominence of lateral semicircular canal and the direction of the course of the tympanic segment of the facial canal. Knowledge of the morphological relations and variations is important for classical and alternative surgical method for cochlear implantation.

P1-8-2

Round window electrode insertion in the inner ear pathology

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A number of authors suggest that round window (RW) electrode array insertion decreases inner ear trauma and promotes hearing preservation. However, inner ear pathology can interfere with this approach. The surgeon usually faces on with cochlea abnormalities and ossified scala tympany. The number of patients with malformations and labyrinthitis ossificans constantly increases. We believe that the RW approach is the best choice for these cases despite the lack of benefit from hearing preservation.

Since the complete shift at our institute in mid-2008 from cochleostomy to the RW surgical approach, more than 2000 cochlear implantations (CI) have been performed on pediatric and adult patients. Cochlear malformations were found in 118 children. Labyrinthitis ossificans of basal turn was found in 77 cases with different length of obliteration from ossified window to 5-6 mm ossification of descending part of basal turn. Ossification of the whole first turn or more than one turn was excluded from the study. According to L. Sennaroglu, the malformations of cochlea encountered and chosen for CI (71) included 4 common cavities, 5 incomplete partitions type I (IP I, cystic cochlea) and 20 IPs type II (Mondini deformity).

In three cases of common cavity and two IP I cases, the round window membrane was not identified and the electrode was inserted via cochleostomy. In all Mondini cases, the RW niche was present, but in two cases cochleostomy was performed due to mucosa thickening as a result of otitis media with effusion, and in two cases - due to facial nerve position.

In every case of ossification the drilling started from the round window niche. The length of ossification was 0.5 - 1 mm in 24 cases, 1 - 4 mm - in 36 patients, more than 4 mm - in 17 cases. The ossified RW and scala timpany lumen had different color in each case in every case, looking whiter then labyrinthine capsule.

RW electrode insertion was achieved in 89.04 % of cochlear malformation cases. The full insertion of standard electrodes has been achieved in all included ossification cases, although it was not a “pure RW insertion”.

Thus RW insertion is promising in malformed ears and RW may serve as an important landmark to facilitate CI in cases of labyrinthitis ossificans.

P1-8-3

Cochlear implant surgery through natural orifices: The endomeatal approach (EMA)

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Introduction: A surgical approach using the external auditory canal and the round window as a natural access pathway for cochlear implant positioning, the endomeatal approach, is described. This approach avoids performing an antromastoidectomy, the subsequent posterior tympanotomy and the promontorial cochleostomy. The endomeatal approach also allows an optimal insertion plane for electrode array atraumatic insertion through the round window.

Material and methods: The technique was developed and practiced in fresh temporal bones and then it was applied in patients. This surgery has an endomeatal first stage, which begins with a stapedectomy-like tympanomeatal flap. This flap allows an easy access to scala tympani via round window niche. The internal part of a groove is drilled on the posterior wall of the EAC. The groove is parallel to the EAC axis and starts in its inner border. Once the endomeatal stage is completed, a standard retroauricular approach is performed, in order to make the receptor-stimulator well and to complete the groove externally, until it connects the middle ear with the external mastoid surface. A flat second well is drilled in front of the first one to lodge the remaining electrode lead. In small children this well is deepened. The electrode array is introduced in the scala tympani through the RW and located into the groove. The electrode is covered and fixed inside the groove with bone paté. The extra length of the electrode lead is located in the second well and the receptor-stimulator is fixed in its well. The ground electrode is placed under the periosteum, the retroauricular incision is sutured, the tympanomeatal flap is restored and a dressing is placed into the EAC.

Results: Surgical time was significantly shorter than in standard approach. Electrode insertion was easy. A multicenter study was conducted over 200 cases compared EMA to others techniques was realized and index of complications were similar and functional results adequate.

Conclusions: The goal of this approach is to avoid antromastoidectomy and posterior tympanotomy, which are replaced by the EAC groove. It is simpler and safer, eliminating the risk of facial nerve injury. It also allows a better access to the round window, with a less traumatic electrode insertion, suitable for “soft surgery” performing. It may advantageously replace the classical transmastoideal approach.

Learning outcome: Soft surgery concept must include the all temporal bone and not only the cochlea itself.

P1-8-4

Cochlear implantation through the round window: optimizing the surgical procedure

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Objectives: Spreading indications of cochlear implantation, such as bilateral cases, makes it mandatory to lower as much as possible the morbidity of the surgical procedure. The round window insertion allows for direct implantation in the scala tympani. The question is how optimizing the quality of insertion through the round window with the lower morbidity.

Patients and methods: This retrospective analysis includes all cases implanted with a cochlear implant Digisonic SP (Neurelec) since 2004. We checked the operative charts and the depth of insertion. Surgical technique, complications (facial palsy, infection, alteration of taste) were collected as well as the type of electrode array. For comparisons, contingency tables were used and a CHI-square test was performed. A p-value < 0.05 was considered significant.

Results: 126 cases of patients with non-malformed cochleas were implanted through the round window. The mean age was 53.8+/-16.2 for adults and 3.5+/-2.6 for children (24 cases). The mean follow-up was 33+/-22 months. All cases were implanted through a transmastoid approach, with identification of the round window niche through a posterior tympanotomy. A few cases required a combined transmeatal- transmastoid approach (8 cases). The straight electrode array had either a square or a soft pointed tip (n=84). Full insertion was achieved in 79 out of 84 cases with a soft tip vs 18 out of 42 square tips (Chi square= 41.41, DOF=1, $p< 0.0001$). Two cases were stuck at the round window niche by a prominent crista fensetrae (no possibility of deeper insertion nor withdrawal). In all cases the chorda tympany was preserved. In one case a misrouting to the vestibule required a revision surgery. No facial palsy, no infection, no cases of extrusion occurred.

Conclusion: Cochlear implantation through the round window with a soft-tip Digisonic SP can lead to a 94% rate of full insertion. Drilling out of a prominent crista fenestrae is recommended. A combined transmeatal - transmastoid approach can be used in order to clearly identify the round window and to preserve the chorda tympani in case of narrow facial recess.

P1-8-5

Long term results of an alternative technique for cochlear implantation: the transattical approach

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Introduction: The mastoidectomy and posterior tympanotomy approach (MPTA) is considered to be the elective surgical technique for most cases of cochlear implantation (CI). However, under certain circumstances, MPTA can be a difficult and risky approach, for example, in cases of malformations, a narrow facial recess, or an anterior sigmoid sinus. Several alternative approaches have been described; all of them offer advantages and drawbacks compared with the MPTA. However, these techniques are not very popular among surgeons and some of them require specific training or material, which limits their feasibility. The transattical approach (TA) is based on a mastoidectomy and a cochleostomy made through a transmeatal tympanotomy. The electrode is driven from the mastoid to the middle ear through the attic, avoiding the opening of the facial recess. This way, some of the drawbacks and contraindications of the MPTA are overcome with an easy and direct technique. The objective of the present study is to determine the value of the TA in CI surgery

Methods: Retrospective chart review study. The inclusion criteria for the study group were to have undergone a CI in our Department using TA as the primary technique, and comply with a minimum 1 year recorded follow-up. For the control group, we included the cases operated using the MPTA within the same period of time (2001-2006). We analyzed the TA technique and compared both groups looking for differences between them in surgical time, auditory results, complications and electrode integrity.

Results: After selection criteria, the TA group was composed of 74 ears operated in 71 patients (47 adults, 24 children). For the control group we included 59 cases operated using the MPTA (33 adults, 26 children). The etiology of the deafness in both groups was similar. The surgical time was significantly shorter in the TA group. No significant differences were found between groups considering the postoperative complication rates. However, some of the complications found in the TA could be related to the approach and further discussed. The auditory results for adults and children were similar in both groups, though the children in the TA performed slightly better at long term. Regarding the electrode integrity, no differences at damage rates were found between techniques. However, some of the most basal contacts in the TA provided no auditory sensations to the patient

Discussion: MPTA usually allows for a direct insertion of the electrode array in the cochlea. However, in some cases this insertion may be difficult or risky even in the most experienced hands, and an alternative approach should be chosen. TA achieves good long-term functional results and complication rates similar to those described for other approaches. We compare this technique benefits and drawbacks with other alternative approaches and discuss its indications and limitations

Conclusion: The TA is a safe approach for CI, useful when the MPTA cannot be used

P1-8-6

The modified transcanal approach revisited: technique and results

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Cochlear implantation is becoming a routine procedure all over the world. With increasing centers and surgeons a relatively simple and reproducible technique must be developed. Any technique must be easily taught, must be safe and with comparable results to standard techniques. Many modifications were devised for two main reasons: simplify the approach and counter different anatomical situations. This presentation aims at presenting our variation of the transcanal approach outlining the technique and results. It is a direct relatively straight forward approach with a more physiological access to the round window. It is less surgically demanding than the classical approach with superior exposure. It is more versatile especially in difficult situations. Our results including difficulties and complications are outlined

P1-8-7

The trans-attic trans-canal approach for cochlear implantation, a safer and effective technique

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The standard described technique of cochlear implantation is through a posterior tympanotomy and facial recess approach. This “classic approach” is not without hazards and difficulties, asides danger of injury to the facial nerve, sometimes aberrations in the course of the facial nerve or anomalies of the cochlea or the round window may make this approach challenging. Various alternatives have been described to overcome these difficulties, including the transcanal and the suprameatal approaches, but these are not without complications and limitations.

We describe our experience with a modification of the approach gaining the benefit of many approaches, using what we call the “trans-attic trans-canal” approach. 131 cases of cochlear implants were performed using the Pulsar and Sonata (MED-EL, Austria) implant in 117 cases and the Hi-Res 90K (Advanced Bionics, USA) implants in 14 cases, over a period of 22 months, with a minimum of 4 months follow-up period after surgery, and up to 2 years. The results show that we had one single case of facial paresis that resolved after 2 weeks due to a dehiscent facial nerve. Audiologic and phoniatric results were comparable to the surgeries performed by the classic approach.

In conclusion, the trans-attic - trans-canal is a safer and less time consuming approach that harvests the benefits of avoiding electrode exposure in the canal, and avoids possible trauma to the facial nerve, with equal final outcomes.

P1-8-8

Concept for an ideal process of cochlear implantation

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Technical improvements in middle ear and cochlear implants have increased the use in patients with severe to profound hearing loss. Even in patients with unilateral hearing loss, implantation rate is more and more growing. However, implants are still very expensive and subtle cost calculation in hospitals is important. When we started our implantation program in 2009, financing was relatively unclear. Due to that implantation criteria had to be defined because the number of inquiries of patients was soaring. In this presentation, we will review our concept in the candidacy of cochlear and middle ear implantation. The focus will be on the interdisciplinary approach in patient selection and pre-therapeutic consultation of a senior surgeon, a speech therapist, and, in selected cases, a clinical psychologist. The paper will focus on selection criteria, standard operating procedures, and quality management at our department.

P1-8-9

Using a sub-periosteal pocket: Do we need to drill an implant bed for the Flex 28 Cochlear Implant?

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Background: Traditionally both implant bed drilling and suturing to calvarial bone was felt to be necessary to secure the Cochlear Implant in both adult and paediatric populations. Risks of drilling an implant bed include cerebrospinal fluid leak, dural injury and intracranial complications[1]. In view of this, the senior author utilised the implant dimensions of the Flex-28 and evolved our routine fixation surgical technique to mitigate a need for drilling an implant bed for the receiver-stimulator.

Technique modification: A tight sub-periosteal pocket is created to securely fit the implant without a drilled bed for the implant itself. This pocket is closed with two absorbable sutures (2:0 vicryl) to prevent the anterior displacement of the implant.

Design: Retrospective case note review of patients that received MED-EL Flex 28 Cochlear Implant from November 2011 to November 2012.

Results: 81 Flex-28 Cochlear Implants were inserted using this technique modification in 19 children and 41 adults. Patients were assessed with a minimum of 12 months post-operative follow up. We have experienced no intracranial complications and no episodes of device migration or implant extrusions. This modification was introduced with perceived advantages in minimizing the risk of intracranial complications without compromising the security of implant placement. It has shown the additional benefit of resulting in a shorter overall operative time.

Reference:

[1]Dodson, K.M., Maiberger, P.G., Sismanis, A. Intracranial complications of cochlear implantation. *Otol Neurotol.* 2007 Jun;28(4):459-62.

P1-8-10

Covering the mastoid cavity with a “Bone Cap” in cochlear implantation

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Objective: Cochlear implantation is the most effective management of severe-to-profound sensorineural hearing loss. Traditionally, the procedure starts with a postauricular incision, followed by mastoidectomy. Once the electrode is inserted and the cable is recoiled within the mastoidectomy trough, many surgeons place a piece of Gelfoam to secure the cable in the mastoid cavity. However, this method does not reduce the risk of lead injury during wound closure. Postoperatively, the method also causes some bony defect with scalp indentation in appearance. Therefore, we aim to preserve the integrity of temporal cortex and to protect the electrode in the mastoid cavity by using a “bone cap” to cover the mastoid cavity. We found that this bone cap not only can protect the cable, but also may play an important role in the revised surgery.

Methods: From April 01, 2009 to January 31, 2014, all patients underwent cochlear implantations in our department with a 2.5cm postauricular incision. Instead of drilling off the cortex of the mastoid, we used osteotome and hammer to carve a bone cap 2cm in length and 1cm in width and save it in a saline-soaked gauze. After the electrode insertion had been completed, the bone cap was placed back. Then the muscle and skin flap were sutured layer by layer.

Results: All but two bone caps were successfully harvested with subsequent replacement on the mastoid cavity after the insertion of the electrode. The two failed cases with broken temporal cortical bones include a 10-month-old boy with thin skull bone, and a patient with brittle bone cap secondary to radiotherapy for nasopharyngeal carcinoma. Postoperative vertigo and vomiting were noted in a young patient who had large vestibular aqueduct syndrome (LVAS). In those recipients who underwent re-implantation, we found that the fibrosis in mastoid cavity caused by first operation was significantly less. This makes it easier to explant the device.

Conclusion: During cochlear implantation, covering the mastoid cavity with a bone cap can keep the integrity of anatomic structure, protect the electrode, and make re-implantation safer. However, this method might not be good for those patients who are less than one year old, after radiotherapy, or with LVAS.

P1-8-11

A surgical survey on the usability and applicability of the HiFocus Mid Scala electrode

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Introduction: The mechanical specification of an electrode as: length, diameter, stiffness and modiolar design is reported to be a contributing factor potentially causing intracochlear damage and associated degradation in performance. However, also the differences in the surgical technique including the choice of the cochlea entrance, the speed and angle of insertion may be associated with the trauma. A particular surgical technique appears important in achieving an atraumatic insertion. Soft surgery techniques are designed to maximize preservation of residual hearing: one method is to avoid the drilling of a cochleostomy by inserting the electrode array into the cochlea via the round window membrane. Round window insertions however are not always straightforward as the angle of insertion is not ideal due to anatomical factors and this approach may not be suitable for all recipients. How flexible are the designs of modern electrode concepts and their insertion tools for fulfilling these individual surgical approaches and preferences?

Objectives: The objective of this survey is to assess how the new HiFocus Mid Scala electrode and insertion tools are used across cochlear implant recipients of differing ages and anatomical characteristics. The data may help understanding how flexible the electrode and insertion tools are for on spot deviations of the preferred surgical technique based on anatomical pre requisites.

Methods: The survey is being conducted in multiple implant centres in Europe, North America and Asia. Two questionnaires are used, one to collect data on centres and surgeons profile and preferred insertion technique and one to collect data for individual surgeries.

Results and conclusion: Data set from eight centres, thirteen surgeons and twenty one surgeries were collected so far. All surgeons who participated do have moderate (5-10 years), to long term (more than 10 years) surgical experience with the CI. For the twenty one surgeries only two deviations of the preferred surgical technique based on anatomical limitations were reported. Further results and new data will be presented.

P1-8-12

New cochlear implant philosophy- fully implantable device

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Introduction: The primary goal of cochlear implantation is more or less achieved-hearing restoration and social inclusion. The pitfalls remain: bulky outer unit fragile to movement, moist and shock and at the end aesthetically unacceptable. The aim of this presentation is to show possible solutions under current technological conditions.

Methods: We are going to present a model and practical solutions of new implant design. All calculations are estimations and not proven on experimental model

Results: Theoretically new design estimated adapted anatomical and surgical approach with easier electrode placement minimal invasive surgery approach less possible complications and greatest patient satisfaction.

Conclusion: New implant design enables easier surgical procedure with minimal invasive approach. It fulfills all patient´s demands and expectations.

P1-8-13

Simultaneous endolymphatic sac drainage and cochlear implantation in patients with Meniere's disease

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Introduction: In late-stage Meniere's disease patients often suffer from severe vestibular dysfunction along with profound sensorineural hearing loss. In these cases two treatment goals should be observed: alleviation of vertigo spells as well as increase of auditory function and restoration of binaural auditory input.

Methods: 4 subjects with Meniere's disease and profound hearing loss underwent simultaneous endolymphatic sac drainage and cochlear implantation in 2010 - 2013. In all cases, Meniere's disease was refractory to medical treatment; none of the subjects had undergone any surgical treatment.

The surgical technique was as follows: 1) Taking into consideration Donaldson's line and perpendicular drown through the middle of external auditory canal to the anterior surface of sigmoid sinus posterior fossa dura was exposed on the crossing of these two lines and endolymphatic duct as well as endolymphatic sac were visualized. 2) Lumen of the sac was opened widely. 3) In order to prevent its occlusion, two fossulae were formed anteriorly to the endolymphatic sac area, parietal folium of the dura was folded forward and fixed in the fossulae with two bone fragments. 4) 0.1 ml of dexamethasone was instilled into the opened lumen of the sac towards the endolymphatic duct. 5) A posterior tympanotomy was performed and a standard electrode was fully-inserted via the round window.

Results: The postoperative follow-up period ranged from 6 months to 3 years. During the primary examination, 2 subjects experienced horizontal spontaneous nystagmus without gaze fixation. Spontaneous nystagmus was not elicited in either early or long-term postoperative period. Average absolute asymmetry of subcortical optokinetic nystagmus decreased by 19 and 26 in early and long-term postoperative periods, respectively. Average absolute asymmetry of cortical optokinetic nystagmus decreased by 9 and 13 in the same time spans. The composite equilibrium score increased on average by 8 and 19 in early and long-term postoperative period, respectively. Based on complex vestibulometric investigation, signs of vestibular function compensation were revealed in all subjects. According to a specially developed questionnaire, all patients reported improvement in their post-operative quality of life and either an absence (3 subjects) or significant decrease (1 subject) in the frequency and intensity of vertigo spells. Our subjects' audiological performance correlated with that of CI users with profound sensorineural hearing loss who had not suffered from Meniere's disease.

Learning outcome: Simultaneous endolymphatic sac drainage and cochlear implantation could be a viable option for patients with late-stage Meniere's disease and profound hearing loss. This technique dramatically alleviates vertigo spells and increases audiological performance.

P1-8-14

Management of CSF gusher in cochlear implantation

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Introduction: The incidence of cerebrospinal fluid (CSF) gusher in cochlear implantation is reported between 1 to 5% in large series. Failure to create a watertight seal around the cochlear implant array would create a risk for further CSF leakage and produce a potential hazard for meningitis. Various techniques have been reported to seal a CSF leak around a cochlear implant array. The purpose of this study is to share our experience of CSF gusher in cochlear implantation and to introduce our management technique.

Methods: Demographic, radiological and surgical results of patients with CSF gusher in 621 consecutive cochlear implant recipients including children and adults as well as our management technique were evaluated and a review of the literature has been included.

Results: Twenty two (3.5%) cases had CSF gusher. Two patients (9.09%) were post-lingually deafened adults and the rest (90.91%) were children with congenital deafness. Nineteen patients (86%) had various types of inner ear malformation. Three patients (14%) had no predictive preoperative imaging and history for CSF gusher. In all patients, CSF gushers were controlled with our technique of packing the electrode entrance site with no additional measures. The presenter will describe his technique in detail.

Conclusion: Surgeons should always be ready to manage this event even in unpredictable cases. Management of CSF gusher can be mainly performed during the initial surgery by precise technique of tight packing of the electrode entrance site and further nonsurgical or surgical measures are rarely required.

Learning outcome: Management of CSF gusher in cochlear implantation is mainly based on initial surgical technique and surgeons should always be ready to deal with it.

P1-8-15

Evaluation of internal receiver migration in cochlear implantation using subperiosteal pocket technique

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Objective: Stabilization of the internal receiver stimulator (IRS) is crucial for data transmission between the headpiece and the IRS in cochlear implantation. In the standard technique of cochlear implantation, the internal receiver-stimulator (IRS) is embedded into a socket drilled on the calvarial bone in order to prevent migration. Sutures have also been used for this purpose. Improper stabilization of the IRS may lead to migration and extrusion from the skin. In the subperiosteal technique, IRS is fixed under the subperiosteal plane, and drilling is redundant. Therefore, operation time can be reduced up to 30% with this technique and there is no risk of intracranial complication. The aim of the study to evaluate migration of the IRS in cochlear implantation using subperiosteal pocket technique.

Materials and methods: This is a prospective clinical study. Between December 2012 and January 2014, 32 pediatric patients (age between 12 months and 8 years (96 months), mean±SD 27.8± 19.5 months) who underwent cochlear implantation included the study. All the implantations were performed by two experienced surgeons (YG, KSO) using subperiosteal pocket technique. At the planning phase of the study, the application of cranial x-ray scanning for the evaluation of migration was considered. However, this plan was discontinued due to concerns about children being unduly exposed to x-ray radiation. Therefore, a migration was evaluated by the measurements between external receiver and reference points that were lateral cantus, tragus and mastoid tip. We measured all the distances during surgery and at 6th months of postoperative period. We accepted as implant migration if difference between intraoperative and postoperative values in 2 or 3 different measurements was more than 1cm. Intraoperative and postoperative values were compared by statistical analysis.

Results: Thirty-two pediatric patients were included in the study. Of these patients, 17 were female and 15 male. There was no major or minor complication during or after the surgery. Intraoperative mean implant- lateral cantus distance±SD was 13±1.3 in cm, mean implant- tragus ditance±SD was 8.5±0.9 in cm and mean implant-mastoid tip distance was 8.4±1.1 in cm. At the 6th month of postoperative period, mean implant- lateral cantus distance±SD was 13,3±0.5 in cm, mean implant- tragus ditance±SD was 8.6±0.5 in cm and mean implant-mastoid tip distance was 9±0.6 in cm. There were no statistically significant differences between intraoperative and postoperative measurements. We observed posterior implant migration of 1.5 cm in 2 cases, but they have used the implants without any problem. There was no anterior implant migration.

Conclusion: Some authors claim that implant migration is an important drawback in subperiosteal pocket technique. Although we have observed minimal migration in two patients (6%) in our study, no troublesome complications were found in these patients.

P1-8-16

Surgical challenges during electrode insertion in cochlear implants

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Introduction: Treatment of patients with profound hearing loss can be conducted using cochlear Implant. Due to anatomical variability and congenital malformations in the inner ear, sometimes insertion of CI electrode may present problems.

Aim: Our aim was to assess the effects of application of different surgical techniques in implantation (cochleostomy, round window) affecting postoperative results.

Material and method: Our method of choice in treatment of severe hearing impairments in presented cases was cochlear Implantation. We have used various cochlear implants types, with various electrodes. We selected implants and electrodes appropriately to the type of hearing loss and the type of defects the inner ear anatomy. Our material consists of patients with various inner ear malformations (incomplete partition, Mondini syndrome, common cavity, LVAS), often accompanied by intraoperative gusher.

Results: The results of the surgical procedure are shown in computed tomography imaging studies. Authors discuss the results of audiological after implantation and complications.

Conclusions: Assessment of the effects of different surgical techniques application in cochlear implants in congenital inner ear malformations indicated that the best result of implantations gives the round window technique of electrode insertion. Audiological results are good, but not as good as in patients with normal anatomy.

P1-8-17

Cochlear implantation in the obliterated cochlea

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Intro: To overcome the greatest challenge for cochlear implant surgeons, which is to find a lumen in an obliterated cochlea

Methods: The process starts first by identification of an obliterated cochlea by careful meticulous examination of imaging (CT scan and MRI) of the cochlea. A completely ossified obliterated cochlea must be identified as this is a contraindication for surgery; but partially obliterated cochleae by fibrous tissue or ossification are still possible to implant.

Results: Series of cochlear ossification 78 patients, 16 had bilateral complete ossification and were deemed inoperable; the better ear was selected in the rest, 32 the cochlear lumen was reached by deeper (more than the usual drilling), 14 by drilling anterior to the normal location but posterior to the Jacobson´s nerve, 16 required middle turn insertion.

Discussion: Surgery must be carried out as soon as possible after imaging has been evaluated. Various surgical approaches for cochleostomy in order to reach a lumen in the partially ossified cochlea for a successful insertion of an optimum number of electrodes are required.

Conclusion: Although a brainstem implant is an option in cochlear obliteration; trying to implant the cochlea itself in such a situation is still possible and has lesser morbidity.

Learning outcome: overcoming the difficulty of finding a lumen in ossified cochlea

P1-8-18

Cochlear implant in cochlear ossification. Surgical options

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Objective: To describe the experience of the Otoaudiologic Investigations Center (CIOA) and Cesar Milstein Hospital Group in the management of patients with cochlear ossification drawing a clinical-therapeutic classification to assist in the decision making and describe the different surgical techniques.

Study design: update and review of cases.

Setting: Adult and pediatric tertiary referral center for cochlear implantation.

Interventions: Diagnostic and therapeutic observations were performed.

Conclusions: Despite the presence of cochlear ossification, regardless of the degree, a specialized center with an experienced surgical team may have different therapeutic possibilities.

These depend on the precise diagnosis of the type, location and extent of obstruction.

It is very useful the classification of each case for the therapeutic choose and evaluate the results.

The earlier the diagnosis the greater the range of possibilities. Obviously with more impact on functional outcome.

The different possibilities must balance the need of make a cochlea approach to place as many critical active electrodes as possible with the risk and aggressiveness of each technique.

It is very important consensus with the family about the technique, the possibility of changes by the found intraoperative and expected functional outcomes after implantation.

The best situation would be, in each case, beginning with the least risky approach and the most likely to benefit hearing.

In our group the correct interpretation of diagnostic images, the judicious choice of technique and experience in different approaches has made possible to meet that goal without complications and with good functional outcome.

P1-8-19

Approach to the second turn of cochlea in cases of cochlear ossification

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Introduction: Cochlear ossification primarily occurs in the scala tympani of the basal turn of the cochlea. While performing cochlear implantation (CI) in cases with more than 5 mm basal turn ossification, approach to second turn tends to be the most problematic for the surgeon. Such ossification interferes with full electrode insertion and, therefore, hinders optimal postoperative audiological performance. A number of options for dealing with cochlear ossification have been described. Some authors propose performing a second cochleostomy to insert a split-electrode. In this study we propose an approach, which was developed from a temporal bone middle and inner ear structures syntopy study, to the second cochlea turn that enables the highest possible spiral ganglion cell and modiolus preservation.

Methods: In the present study, 11 deaf patients with more than 5 mm basal turn ossification, according to temporal bone CT, underwent CI. The follow-up period varied from 6 months to 1 year.

Results: The surgical approach was as follows: 1) we performed an extended mastoidectomy with exposure of sigmoid sinus, dura mater and sinodural angle. 2) Extended posterior tympanotomy was carried out up to the facial nerve canal wall. 2) We removed the incus and bony bridge, making it possible to open the basal turn up to its passage into the second turn. 3) The first cochleostomy was created in the typical place. 4) We removed the anterior crus of stapes and anterior 2/3 of the footplate and preserved intact the posterior stapes crus and tendon of stapedial muscle. 4) Using the processus cochleaformis as a landmark, the second cochleostomy was performed 1 mm inward to the anterior margin of the oval window niche on the line proceeding from the processus pyramidalis parallel to the stapes crura. Full electrode insertion was confirmed via postoperative CT scan.

P1-8-20

Cochlear implantation in patients with ossified cochlea: surgical techniques and outcomes

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Introduction: Labyrinthine ossification can considerably complicate cochlear implantation. It occurs surgical problems and the insertion of a conventional multi-channel cochlear implant be difficult or impossible.

Objective: The study aims to evaluate surgical techniques of cochlear implantation in patient's deafness with ossified cochlea and investigate the audiologic outcomes.

Study design: A retrospective case note review of patients with post meningitic deafness and ossified cochlea requiring cochlear implantation has been analyzed.

Patients and methods: We have recorded 170 implant procedures performed at the department of Otolaryngology and head and neck surgery of the University of Algeria between 2007 and 2013. The age of patients were between 18 months and 54 years.

Among of them, 13 cochlea (10 pediatric and 03 adults) patients have an ossified cochlea after bacterial meningitis. All patients were preoperatively investigated with high resolution CT and MRI. Radiological and surgical results were analyzed and audiological outcomes were evaluated using the categories of audiological performance score (CAPS).

Results: Thirteen (13) patients underwent cochlear implantation after meningitis, the age at implantation ranged from 04 years to 23 years.

Eleven (11) patients have a partial ossification and have benefited a cochlear implant:

- In 08 cases, the implants were placed after drill out basal turn of the cochlea. The insertion of the electrodes was complete.
- In 03 cases, the implants were placed with retrograde technique after CWU (02 cases) and CWD (01 case). The insertion of the electrodes was incomplete.

At surgery 02 patients with abnormal radiologic findings have an extensive obliteration which can be considered as an operative surprise. The use of Auditory Brainstem implantation (ABI) through a retro sigmoid approach (in a second stage) might be necessary. In this study, only six (06) patients had categories of auditory performance score (CAPS) of 5 or higher.

Conclusion: Cochlear implantation can be significantly benefit for patients with post meningitic deafness. However, the audiologic outcomes are difficult to predict. Earlier audiological consultation and imaging would have multiple benefits for management and rehabilitation.

Keys words: Cochlear implantation - ossification - imaging considerations - surgical approach - outcomes.

P1-8-21

The long-term outcome of cases with cochlear implantation due to advanced otosclerosis and van der Hoeve syndrome

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Both of advanced cochlear otosclerosis and van der Hoeve syndrome (osteogenesis imperfecta) show similar progressive profound deafness and demineralization of the temporal bone surrounding the cochlear capsule. It is recently reported that the association with COL1A1 in both of two diseases may cause similar demineralization. For those patients, cochlear implantation (CI) is the only promising treatment option. However, such Japanese patients are very rare and only a case study on CI insists of relatively poor speech perception result and complications of facial nerve stimulation, or unstable T/C level.

Here we report a long-term outcome in 12 patients with advanced cochlear otosclerosis and van der Hoeve syndrome. We evaluated the speech performance by using Fukuda VTR before 2003 and using by CI-2004 since 2004. As a result, the mean sentence perception score (91%) of 12 cases was better than that (78%) of CI cases deafened by other causes. Facial nerve stimulation was elicited in only one of 12 cases. Therefore, we concluded that CI can be considered as a treatment option for deaf patients with advanced cochlear otosclerosis and van der Hoeve syndrome.

Furthermore, according to this conclusion, we proposed the strategy flow chart how to select the hearing aid, stapes surgery or CI for Japanese patients with advanced otosclerosis and van der Hoeve syndrome, based on the speech discrimination score, computed tomography classification and the air-bone gap.

P1-8-22

CI surgical technique and post-op auditory benefit for cases with cochlear ossification

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Objective: To research surgical technique for cases with cochlear ossification and to summarize surgical approaches for successful operation.

Method: Basing on result of pre-op temporal bone CT, 79 cases diagnosed with cochlear ossification were classified into following 4 groups: ossification in round window, ossification in basal turn, ossification in 1/2 to 3/4 turn, ossification more than 3/4 turn. 3 surgical approaches were determined for 4 groups because same surgical approach was applied for group 2 and 3.

Results: 79 cochlear ossification cases were confirmed among 3175 CI cases. For further detail, 21 cases were confirmed as group 1, and 41 cases as group 2, 13 cases as group 3 and 4 cases as group 4. Electrode arrays were inserted successfully for all 79 cases. Regarding to surgical approaches, approach 1 was applied for group 1, approach 2 for group 2 and 3, and approach 3 for group 4. After activation, electric-stimulating hearing was obtained for 74 cases via surgical approach 1 and 2. Average hearing threshold with CI in speech frequency was 35dBHL, while score of Mandarin speech recognition test 3 months after activation was achieved as 100% for mono-syllable rime and 91% for mono-syllable onset. 4 cases were conducted with approach 3; Average hearing threshold with CI in speech frequency was 70dBHL, while score of Mandarin speech recognition test 3 months after activation was achieved as 70% for mono-syllable rime and 30% for mono-syllable onset. One of those 4 cases was confirmed as modiolus ossification, score of this case was 50% for mono-syllable rime and 0% for mono-syllable onset.

Conclusion: Key surgical technique for cochlear ossification case was preventing injury to modiolus. Speech test score of case with cochlear ossification within 3/4 turn was equal to average score of all CI cases. Surgical approach for case with whole cochlear ossification was complicated and auditory benefit post-op was not reliable.

Key words: Cochlear Implantation, Surgical approach, Ossification

P1-8-23

Cochlear implants in children with anomalous cochleovestibular anatomy.

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Aim: To report surgical aspects of cochlear implantation and postoperative auditory outcomes in children with abnormal cochleovestibular anatomy.

Setting: Tertiary level hospital

Study design: Retrospective case review

Methodology: 12 patients with inner ear malformations who underwent cochlear implantation using standard transmastoid facial recess approach at a tertiary level hospital were retrospectively reviewed. Their age ranged from 1-11 years. They were classified according to Sennaroglu and Saatci classification as follows: common cavity (n=3), IP type || (mondidnis dysplasia) with large vestibular aqueduct (n=6), hypoplastic cochlear nerve with narrow IAM (n=1), suspicious aplasia of cochlear nerve (n=1), thin nerve and common cavity (n=1). Minimum of 1 year follow up was taken. Outcome measures: CAP || & SIR

Results: Facial nerve was found anomalous in 1 patient. CSF gusher occurred in 5 cases. In all the cases complete electrode insertion was achieved. All candidates showed improved auditory and expressive performance. Patients with narrow IAM leveled poorly as against others.

Conclusion: Cochlear implantation is surgically feasible in patients with inner ear malformation. Children with narrow IAM should be carefully and individually considered

P1-8-24

Cochlea implantation via a superior cochleostomy in incomplete partition type III

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Cochlea implantation in the malformed cochlea is a challenging procedure. Recently, the malformation of the incomplete partition type III has been described in individuals with X-linked deafness.

The morphologic criteria for this malformation contain:

bullous dilatation at the lateral end of the internal auditory canal, enlargement of the labyrinthine segments of the facial nerve- and superiorvestibular nerve canals, absence of the modiolus, and incomplete separation of the basal turn from the inner auditory canal. In case of cochlea implantation via round window these morphologic changes are associated with a high risk of misplacement of the electrode array from the basal turn into the inner auditory canal, endangering the local essential structures.

In the current presentation the handling of a patient with incomplete partition type III is described. The presurgical CT scans showed an incomplete partition type III with an incomplete separation of the basal turn from the inner auditory canal. The electrode insertion was performed via cochleostomy to the site of the scala vestibuli. A profuse cerebrospinal fluid gusher ceased after 20 minutes. The correct position of the MED-EL® medium electrode in the cochlea was intraoperatively monitored with c-arm x-ray unit and postoperativey by cone beam computed tomography showing 11 electrodes within the cochlea. This cochleostomy approach at the promontory site to the scala vestibuli has been shown to be appropriate in case of incomplete partition type III to avoid dislocation of the electrode to the inner auditory canal.

P1-8-25

Mastoid obliteration versus hyperosmolar protocol during cochlear implantation in malformed inner ear with high gusher risk

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Introduction: Objective of this review is to report the surgical aspects of cochlear implantation in malformed cochlea and mostly to determine the appropriate management of gusher during malformed inner ears cochlear implantation. To this purpose we decided to compare mastoid obliteration and a hyperosmolar protocol based on specific drugs in major inner ear malformations with big gusher risk.

Methods: Between 2007 and 2013, we performed 320 cochlear implantations. 43 patients had inner ear malformations and 15 with high gusher risk (we did mastoid obliteration with external auditory canal closure for 6 patients and we applied a special hyperosmolar therapy protocol for 9 patients). The anomalies were classified according to Sennaroglu classification. There were two patients with incomplete partition (IP) type I (cystic cochleovestibular malformation), four cases of IP type II (classical Mondini´s deformity), eight patients with large vestibular aqueduct (LVA) syndrome, and one patient with X-linked deafness IP type III.

Results: Per operative observations were collected for all patients with evaluation of the leakage with a new scale (The degree of leakage ranged from Grade 0: no leakage during cochleostomy, to Grade 4: uncontrollable leakage of liquid under pressure or real gusher). With the hyperosmolar protocol we were able to manage all gusher cases even grade 4, and no necessity to perform mastoid obliteration. We also noticed a diminution of vertigo with the protocol comparing to mastoid obliteration.

Discussion: The most important operative complication to expect in this specific population is the occurrence of a gusher during the cochleostomy and the need to control a persistent leakage after the insertion of the implant. Gusher during cochleostomy is due to the enlargement of the communication between the perilymphatic and subarachnoid spaces, leading to increased intra-cochlear pressure. The development of the medical management protocol was based on the pathophysiological and pharmacological understanding gained from the field of neurosurgery. The treatment was well tolerated in our children.

Conclusion: Hyperosmolar protocol has good tolerance and allows its use in most patients with major inner ear malformation. Vertigo seems to decrease with this hyperosmolar protocol.

Learning outcome: With the hyperosmolar protocol we were able to manage all gusher cases even grade 4, and not anymore necessity to perform mastoid obliteration.

P1-8-26

Outcomes in cochlear implantation in patients with cochlear malformations following minimal invasive transcanal technique

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Introduction: In our experience transcanal surgery technique for cochlear implantation was proved to be minimally invasive and safe method in both children and adults.

Material and methods: The authors present series of 100 implanted patients operated by minimal invasive surgery. In four cases congenital deafness proved to be due to the cochlear malformations. In cases of suspected malformation, preoperative MSCT (multislice CT scan) and MRI were performed in order to get finer details of ear anatomy. Transcanal and modified transcanal technique was used in all patients.

Results: No perioperative or postoperative complications occurred. All of the patients had normal length electrodes. Regarding postoperative auditory performance and speech development or restoration, all of the patients had good results; postoperative audiograms ranged 20-60 dB. Speech intelligibility for open set sentences was achieved one year postoperatively. Three of the cases use verbal communication, and one is using gesture and speech.

Conclusions: We found this technique feasible for cochlear implantation both in children and adults. This technique enables safer access and better angle in performing cochleostomy in cases with normal anatomy as well as cochlear malformations. Also, modified transcanal technique enables physiological angle for insertion, which is extremely important in difficult cases.

P1-8-27

Outcomes of cochlear implantation in Japanese children with malformation of the cochlea and/or cochlear nerve

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Introduction: We consider the severity of cochlear anomalies and the presence of cochlear nerve anomalies (CNAs) to be the most important factors affecting postoperative results. The purpose of this study was to evaluate the outcomes of cochlear implantation (CI) in children with malformation of the cochlea and/or cochlear nerve. The study examined 21 ears in 13 children.

Objectives and Results: Our study involved the review of 27 ears in 17children (eight of whom had undergone bilateral CI) with malformations in the cochlea and/or cochlear nerve. These patients were among 202 implantation cases performed in Nagasaki University Hospital from January 2005 to December 2013. The children were classified according to the Sennaroglu classification system - cochlear aplasia (n= 1, 2 cases), common cavity (n = 1, 2 cases), incomplete partition Type 1 (n = 2, 2 cases), cochlear hypoplasia (n = 3, 5 cases), incomplete partition Type 2 (n = 7, 10 cases) and a normal cochlea with CNAs (n = 3, 6 cases).

We evaluated the patients' outcomes following CI using the Infant-Toddler Meaningful Auditory Integration Scale (IT-MAIS), pure-tone hearing threshold with CI, a Picture Vocabulary Test (PVT) and an articulation test. Following CI, the IT-MAIS average improved as follows: 1 to 13 (cochlear aplasia), 24 to 39 (common cavity), 4 to 22 (incomplete partition Type 1), 7 to 30 (cochlear hypoplasia), 19.5 to 37 (incomplete partition Type 2), 11 to 38 (normal cochlea with CNAs).

Discussions and conclusions: Many previous studies reported no significant differences between the postoperative outcomes of children with cochlear malformations and those without them; however, the outcomes of children with cochlear nerve malformations tend to be remarkably poor. In our study, the speech development of children with CNAs was remarkably slow and poor, but the outcomes of children with cochlear malformations and cochlear nerve malformations scored almost equally on the IT-MAIS. This may be influenced by bilateral CI. The further analysis of more of these cases is needed to evaluate the actual speech abilities of children with CNAs following CI.

P1-8-28

Malformations of the inner ear in profound sensorineural deafness

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Introduction: Sensorineural hearing loss is the most common sensory deficit. Etiologies of deafness in children are different from those of adults. Congenital disease is the most common cause of hearing loss in children. The Purpose of this presentation is to study patients with congenital malformations of inner ear in congenital sensorineural hearing loss who are candidates for cochlear implantation

Materials and methods: This is a retrospective study of 6 years, about 600 profoundly deaf patients which 240 have received a cochlear implant and 120 are waiting All have received a careful clinical and paraclinical examination (PEA, audiometry, CT, MRI ...)

Results: we had 30 cochleovestibular malformations: total aplasia of the cochlea, hypoplasia of the cochlea and vestibule or, Mondini cases, amputation of the semicircular cannels case and enlarged vestibular aqueduct.

Discussion: Profound deafness in children is severe; it prevents the normal language acquisition. The incidence of congenital profound deafness is between 1/800 and 1/1000, approximately 20% are caused by inner ear malformations, enlarged vestibular aqueduct is the most common, radiographically evident abnormality of the inner ear. According to the literature, cochlear malformations are compatible with cochlear implantation except labyrinthine aplasia and agenesis of the cochlear nerve.

Conclusion: The etiology of congenital profound deafness is multifactorial and complex. Congenital inner ear abnormality is a major cause of hearing loss in children. The knowledge of these malformations is necessary to allow correct management of these patients

Keywords: sensorineural deafness, congenital malformations of inner ear

P1-8-29

Cochlear implant in chronic otitis media

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Objective: To describe the experience of the Otoaudiologic Investigations Center (CIOA) and Cesar Milstein Hospital Group in the management of patients with chronic otitis media and cochlear implant developing a clinical-therapeutic guide to assist in the decision making. Study disaing: update and review of cases.

Setting: Adult and pediatric tertiary referral center for cochlear implantation.

Interventions: Diagnostic and therapeutic observations were performed.

Conclusions: Cochlear Implantation in Patients with Chronic Otitis Media is a double challenge. On one hand to obtain a cavity without inflammation, dry, safe and stable in time. On the other hand, adjusting the resulting anatomical condition for the correct positioning and retention of the implant and preventing its possible extrusion. To achieve these goals the surgeon must evaluate different variables such as the type of chronic, simple or cholesteatoma otitis media; the presence of an earlier radical cavity with its size and coverage; the presence of a wet or dry ear, etc. The use of diagnostic imaging techniques such as diffusion MRI are useful. Each case must be evaluated in detail and opt for its resolution in one or two surgical times and the type of technique used. The choice of 2 surgical times arises in the presence of wet ears. Possible surgical techniques used are mentioned: the cartilage tympanoplasties in Simple chronic otitis media, reconstruction and coverage of radical cavities and ear disfunctionalization. Judicious management of clinical and anatomical variables and the domain in the different surgical techniques will ensure the best possible outcome.

P1-9 Difficult patients, atypical or challenging situations

P1-9-1

Learning to listen when you can't sit still; a pre-school child with balance dysfunction

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Objective: Following modifications of auditory verbal therapy, to investigate the changes in attentive behaviors of a pre-school child, bilaterally implanted and identified with balance dysfunction

Study Design: Single case study in an independent Auditory Verbal Practice

Methods: Traditional auditory verbal therapy was modified to include activities that provide a high level of proprioceptive feedback and a physical environment to support vestibular stability. Three 30 minute segments of video were analyzed, pre and post modifications to investigate changes in the child's attentive behaviors; viewed as duration of time spent sitting and length and duration of interactions with parent. Qualitative information about use of modifications in the home environment was obtained from parental feedback in semi-structured interviews.

Results: Following modifications of the physical environment for listening, sitting on the floor with body supported by wall, the child sat more frequently and for longer periods of time. The child interacted more frequently and for longer duration for activities that provided a high level of proprioceptive feedback.

Conclusion: Balance function is not routinely assessed in UK paediatric cochlear implant programs despite research which has shown that, half of paediatric cochlear implant candidates have vestibular deficits, and 51% of implants induce modifications of existing vestibular function Jacot et al (2009). Sensory integration theory Ayres (1961) proposes that children with vestibular deficits may seek additional somatosensory information in particular that from movement or touch; they move to provide information on where their body is in space and feel secure when body area is against a solid surface. Therapists focusing on the development of listening need to recognize this additional sensory need and modify intervention.

P1-9-2

Cochlear implantation in children with cerebral palsy

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The aim of this study is to assess the post-implantation speech perception and intelligibility of speech produced by five profoundly deaf children with cerebral palsy.

Functional outcome was assessed using the Speech Perception Categories and the Speech Intelligibility Rating scale. The follow-up of the series ranged from 12 to 72 months.

At the last follow-up, two children who were placed into speech perception category 1 (detection of a speech signal) preoperatively progressed to category 6 (open-set word recognition with familiar words) postoperatively. Two children moved from preoperative category 2 (pattern perception) to postoperative category 6. One child placed into category 0 (no detection of speech) preoperatively progressed to category 4 (word identification) postoperatively. Before implantation, three children had connected speech unintelligible, and two subjects had connected speech intelligible to a listener who concentrates and lip-reads. At the last follow-up, one child had connected speech unintelligible, two children had connected speech intelligible to a listener who concentrate and lip-reads, one child had connected speech intelligible to a listener who has little experience of a deaf person's speech, and one child had connected speech intelligible to all listeners.

Cochlear implantation allowed these patients to dramatically improve their quality of life, increasing their self-confidence, independence and social integration.

P1-9-3

Cuban cochlear implant program: Eight years of experiences with deaf and deafblind children

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Introduction: Since 2005 was created the "Cuban Cochlear Implant Program" (CCIP), with priority for deaf blind children. It extends the number of specialties of the group, being possible a comprehensive work-care and research for the benefit of children.

Objective: To describe the CICP work with deaf and deaf blind children, with emphasis on clinical and surgical aspects.

Methods: Retrospective study of deaf and deaf blind children who received a Cochlear Implant (CI) between 2005 and 2012 in the framework of the CCIP. From the medical and surgical database was extracted information.

Results: CCIP covering all provinces in Cuban. Ototoxicity was the main cause of deafness. The risk factors pre / peri-natal and Usher Syndrome were as major diseases and causal agents of deaf blindness. Hearing loss was predominantly pre-lingually, was confirmed and characterized by electroaudiometría in all children. All children received unilateral Cochlear Implant, with a mean age at implantation of 7.6 years, but particularly in the year 2012 have greatly lowered the age of implantation within the CCIP. In all cases surgery was without any complications. After rehabilitation, in general, implanted children show improvements in communication through speech, as well as in quality of life, including children who are deaf blind.

Conclusions: The CICP has achieved sustained work in the evaluation and implantation of deaf blind children, successfully after hearing rehabilitation, all a result of a working protocol of our national group of Cochlear Implants.

P1-9-4

Cochlear implantation in children with sickle cell disease

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Introduction: Sickle cell disease (SCD) is associated with an increased incidence of sensorineural hearing loss. Although the hearing loss is usually mild, some patients develop severe-to-profound SNHL, for which cochlear implantation (CI) may be an option.

Methods: This case report describes two children with SCD who developed bilateral profound SNHL and underwent CI.

Results: One patient became profoundly deaf after an acute episode of dizziness. Imaging revealed bilateral labyrinthitis ossificans, necessitating electrode insertion into the scalae vestibule. The second patient was born with unilateral severe SNHL, but developed bilateral profound SNHL following acute vaso-occlusive crisis. She had bilateral scala tympani CI. Both children are making good progress with their implants.

Conclusion: Children with SCD are more likely to develop SNHL compared to the normal population and should have regular audiological assessment. Our cases illustrate the variable manners in which children with SCD may develop SNHL, and the difficulties associated with managing such cases. As CI plays an important role in auditory rehabilitation of these children, clinicians should be aware of the potential development of cochlear fibrosis and ossification and ensure prompt assessment following an acute vaso-occlusive crisis or an unexplained vestibulocochlear event. If the child proceeds with CI surgery, peri-operative input from paediatricians and microbiologists is essential.

P1-9-5

Hearing implant treatment of patients with thalidomide associated middle and inner ear malformations

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Introduction: Thalidomide (Contergan ©, Chemie Grünenthal) is a tranquilizer, mainly prescribed in 1957-1961, that causes heavy malformations of inner organ and extremities in unborn children, depending on the moment of intake. In Germany, there are about 2400 patients suffering from thalidomide- related impairment, about 40% with an affection of the inner and/ or the middle ear. For the first time, a thalidomide case with implantable hearing aid on the one and cochlear implant on the contralateral side is presented and discussed.

Casuistic: We report about a 52 year old female patient with congenital, thalidomide associated bilateral hearing loss. The patient was provided with hearing aids at the age of 4 years. On the right side the patient suffers from a 3rd degree dysplasia of the auricle. When presenting for the first time at the age of 51 due to an insufficient hearing aid with progredient hearing loss on the left side, examination showed a partially developed external auditory canal on the right side and a normal development with intact tympanic membrane on the left side. Audiogram showed a deaf right side and a bone conduction of 40dB at 0,25kHz, decreasing at 70 dB at 2 kHz and 60 dB at 6 kHz on the left side. Freiburger Speech discrimination test showed a hearing loss for numbers on the left side at 90 dB, the monosyllable comprehension was 10% at 110dB. There was a strongly reduced speech reception in free field.

Therapy: After unsuccessful optimizing of the hearing aids, surgical intervention with a vibrant soundbridge implantation on the left side via round window coupler was performed. In the course, the patient was satisfied with hearing and speech understanding, but still felt impaired by the missing stereoacousis. After completion of the screening tests and patient´s profound education on possibly slow gain of speech discrimination due to the long existing deafness, cochlea implant surgery of the right side was performed. 3 months after surgery, the patient reports a highly improved stereoacusis and is able to make phone calls. Audiogram shows a hearing level of 55 dB on the right side and a hearing loss for numbers of 55dB.

Conclusion: The treatment of patients with complex ear malformations is a special challenge for the treating team. Because of very low number of data, in every case an individual solution in dialogue with the patient needs to be found, to achieve the best possible outcome.

P1-9-6

Cochlear Implantation in a girl with left internal auditory canal stenosis and very small strip of nerve: a case report

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To report a 6 year-old girl with right internal auditory canal atresia and left internal auditory canal stenosis with a small strip of cochlear nerve after left cochlear implantation.

Results: The 6-year-old girl was implanted with Medel Sonata Ti-100 on the left side. One year after implantation, The pure tone threshold at 0.25, 0.5, 1, 2, 4 and 8 KHz were 50, 70, 80, 40, 40 and 50 dB respectively. The 6 ling´s sound detection were consistent on /A/,/E/, /S/ and /CH/. The /U/ and /M/ were sometimes correctly detected. She could discriminate the drum and triangle sounds, and also consistently discriminate her name.

Discussion: The small strip of cochlear nerve showed promising results after cochlear implantation. The auditory-verbal rehabilitation must be continuously implement to the patient, together with the assessment of communication after 2 years of cochlear implantation. If there is not enough verbal communication, the auditory brainstem implantation on the right side will be considered.

Conclusion: In the patient who had internal auditory canal stenosis with a small strip of cochlear nerve, the cochlear implantation can demonstrate the sound detection and discrimination.

P1-9-7

Paediatric vestibulo-cochlear malformations and international collaboration for the UK's first bilateral Form19 electrode cochlear implantation

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Introduction: We present a one year old girl in Wales, UK with profound bilateral congenital sensorineural hearing loss. The South Wales Cochlear Implant Programme (Bridgend) arranged MRI and CT scans which revealed asymmetric bilateral severe vestibulo-cochlear dysplasia.

Method: Implant electrode selection advice was sought from MEDEL (Innsbruck, Austria) and Professor Sennaroglu (Ankara, Turkey) for his expertise in paediatric dysplastic cochlear implants. The patient's imaging and hearing data was shared electronically between the 3 national centres with online email discussions around possible electrode selection and operative techniques.

Results: The newly developed commercial MEDEL FORM electrodes (from Prof Sennaroglu's experimental CORK electrode designs) were recommended for more electrodes within the shortened cochleae and tapered electrode shoulder proximally to optimize cochleostomy sealing to contain any perilymph 'gusher' encountered. Bilateral cochlear implant surgery was performed in Wales on September 2013. MEDEL's UK Technical Director attended for peri-operative advice. Intra-operative cochlear measurements led to the FORM19 electrodes being uneventfully implanted bilaterally. Post-operative hearing outcomes have been better than expected.

Conclusion: We have demonstrated the benefits of international collaboration for patients with complex cochlear implant needs when regional expertise is limited. We highlight the collaboration, electrode design features, operative steps and post-surgery hearing development of this child, the first UK recipient of bilateral FORM19 electrode cochlear implants.

P1-9-8

Cochlear implantation in a patient with multiple ear and skull base aomalies

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Hyperphosphatasia is a heterogeneous group of disorders characterized by an increased bone remodeling secondary to increased osteoclastic activity.

We report on a 16 year teenager with congenital hyperphosphatasia with high cognitive abilities who suffers from profound hearing loss, and optic nerve atrophy. Audiologic evaluation revealed no speech understanding with hearing aids. HRCT and MRI demonstrated vertebral osteoporosis, fusion of the axis and atlas, Arnold Chiary malformation type 1, expansion of the calvaria and the skull base including the temporal bones, bilateral multiple anomalies of the vestibular labyrinth with near normal cochlea and wide communication between the cochlea and the internal acoustic canal bilaterally. A prominent aberrant anatomic relation between the external ear canal, the middle ear and the facial nerve also exists bilaterally.

The aim of this case study is to present the surgical challenge and the hearing outcome one year after cochlear implantation.

P1-9-9

A rare case of petrous apex cholesteatoma

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Petrous apex cholesteatomas are extremely rare conditions of temporal bone. This situation is always challenging even for a very experienced otosurgeon. There are not so many cases described in the literature and every described case can help to decade about surgical strategy, approaches and to make a prognosis.

The case: A 30-years old female arrived to our department of Otorhinolaryngology for cochlear implantation, because of both-side deafness since she was 20 years old. Starting from 5 years of age, she got 5 middle ear operations each side because of chronic suppurative otitis media. At the moment she had bilaterally radical cavity, chronic otitis was in a stabile remission, no discharges from ears. MRI scan shows a large petrous apex cholesteatoma on the left side. During the next two month she got facial paresis at the left side. Our patient was operated by translabyrintal approach to the petrous apex, decompression of the facial nerve was made in the level of internal acoustic canal. Obliteration of the postoperation cavity was done using abdominal fat. Immediately improvement of facial nerve function was achieved.

The aim of demonstration: To show a rare case of petrous apex cholesteatoma despite of repeated middle ear surgeries.

P1-9-10

Digisonic(®) SP Binaural cochlear implantation in a patient with left deafness in cholesteatoma and right severe-profound hearing loss

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We present a bilateral cochlear implantation with Digisonic® SP Binaural cochlear implant of a 61-years-old man with left deafness in petrous bone cholesteatoma and right severe-profound sensorineural hearing loss.

We describe the surgical technique for the implantation of Neurelec Digisonic® SP Binaural cochlear implant, a device which allows stimulation of both cochleae within a single receiver; in particular the left subtotal petrosectomy with blind-sac closure of the external auditory canal, closure of Eustachian tube, and abdominal fat obliteration in combination with cochlear bilateral implantation with the construction of a subperiosteal tunnel from one side to the other of the cranial vault. Finally we present the results of successful implant activation in which the Patient, with a long acoustic deprivation, had a 20% score for words recognition in quiet.

Hearing impaired patients with cholesteatoma can be successfully treated for both their middle ear pathology and their hearing loss in a single-step surgery and cochlear implantation can effectively provide hearing rehabilitation. The Neurelec Digisonic® SP Binaural implant may be considered a cost-effective alternative to standard bilateral cochlear implantation in bilateral hearing loss.

P1-9-11

Cochlear Implantation following therapy of acoustic neuroma

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Tumors of the inner ear canal are a rarity. Depending on the size of tumor hearing loss can occur. Sometimes an acoustic neuroma is found during investigation regarding cochlear implantation. Radiotherapy of these tumors represents an increasing alternative treatment instead of surgery. A successful Cochlear Implantation after stereotactic or surgical treatment of an acoustic neuroma is bound to the presence of functional nerve fibers of the N. cochlearis.

3 patients where investigated for Cochlear Implantation after irradiation (n=1) or surgery (n=2) of an acoustic neuroma at the ENT-Hospital Halberstadt between 01/2012 and 08/2013.

A positive promontory testing was seen in 2 patients. One was treated surgically and one by radiotherapy. Positive promontory test means to receive an acoustic signal during electrical stimulation by using a thin needle placed on the promontory.

A second patient after neuroma-surgery showed a negative promontory test. The positive result of the promontory test was the criteria for the Cochlear Implantation. The patient with negative promontory testing did not get an advise for Cochlear Implant-surgery. Both patients implanted with a CI show an improvement of speech perception after 6 and 10 days of rehabilitation.

The outcome in Freiburger number-test achieves 100% in both cases, the monosyllabics were detected correct in 45% (patient after irradiation) and 15% (patient after surgery) at a level of 65dB in quite. Cochlear Implantation is an appropriate method to restore hearing after acoustic neuroma-treatment. A positive promontory testing in such cases is mandatory as well as an intensive information preoperatively regarding possible results below the over-all average in comparison of patients implanted without acoustic neuroma anamnesis.

P1-9-12

Cochlear implant, the best option in patient with neufibromatosis type 2 underwent radiosurgery

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Introduction: Neurofibromatosis Type 2 (NF2) is a neurological disease with dominant autosomal transmission.The presence of bilateral schwannomas of the VIII nerve is a mark of NF2. Progressive sensorineural hearing loss with poor discrimination is the rule. The preservation of hearing associated with the control of tumor growth are the pillars that guide the treatment of NF2 .The auditory rehabilitation range from adaptation of conventional hearing aids to the auditory brainstem implant(ITC). NF2 has traditionally been treated with the ITC implanted during surgery of tumor . However, the auditory results with this technique are limited, many authors raise the best therapeutic option microsurgery with preservation of the cochlear nerve and cochlear implant. Studies have demonstrated an auditory performance even better, functional hearing preserved in cases treated with radiotherapy .This paper describes the case of a patient with bilateral acoustic neurinomas that underwent radiotherapy and cochlear implant.

Case report: GMC, 50 year old, male, with a severa sensorineural hearing loss in the right ear and profound in the left. Presence of expansive process occupying the interior of both internal auditory canals, measuring in the left 2,0 x1, 2x0, 7cm, and right 1,0 x0, 7x0, 7cm. Exam compatible with bilateral acoustic Schwannoma. He underwent radiosurgery . Over the years, there was dissatisfaction with the results of the use of hearing aids. The cochlear implant was indicated in his right ear in Dec / 2012. The choice of side was based in presenting a smaller volume tumor.

Discussion: Radiosurgery has emerged as a first-line option in the treatment of small sporadic vestibular neuromas with the main aim of conserving the functional hearing. In 2013, a Belgian study showed hearing preservation with use of radiosurgery in the treatment of NF2. In that series of 12 patients undergoing radiotherapy 78% had functional hearing until two years after the radiation. However, the hearing deterioration can occur after several years, but once the cochlear nerve was preserved, there is always the possibility of hearing rehabilitation through direct stimulation of spiral ganglion cells via electrodes implanted in the cochlea, because there isn't the damage to nerve cells caused by the tumor and the surgical manipulation. Trotter et al, in 2010, published the results of cochlear implantation in two patients with NF2 who underwent preoperative radiotherapy in the implanted ear, one of them reached 96% for sentences recognition and the other 72%. While systematic review in 2012 showed that 8 patients with NF2 and deafness underwent radiosurgery, 6 achieved discrimination of sentences in open- set with cochlear implant .In the case presently reported the patient with NF2 who underwent radiotherapy and he underwent cochlear implant in his right ear and discrimination of 100% of the sentences in open environment 1 year after implant.

P1-9-13

Simultaneous cochlear implantation and translabyrinthine removal of vestibular schwannoma

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Decision making in patients with a vestibular schwannoma (VS) in the only hearing ear is challenging. Restoration of hearing when they become deaf will depend on the status of the remaining cochlear and the integrity and function of the cochlear nerve. In terms of hearing restoration, cochlear implantation (CI) is the most effective option if the cochlear nerve could be preserved intact and the cochlea could be remain responsive to electrical stimulation. Auditory Brainstem Implants (ABI) would be another option for the patients in which the cochlear nerve could not be spared during VS removal, while the hearing results with an ABI are still far poor than those with a CI. If CI is being considered, it should be performed near the time of the surgery for VS removal, because cochlear fibrosis and/or ossification might occur in a short time after the surgery. When the translabyrinthine approach for VS removal is selected, CI surgery should be done as close as possible to the procedure and optimally. Simultaneous CI and translabyrinthine removal of VS was considered for the patient who suffered from severe sensorineural hearing loss on the side with VS and profound deafness on the contralateral side due to past sudden deafness. The first CI was preceded on the contralateral side, then the second CI was performed one year after. Simultaneous CI and translabyrinthine VS removal is a good option that should be considered when discussing and planning the most appropriate strategy.

P1-9-14

Cochlear implant as an alternative treatment for deafness caused by vestibular schwannomas: a case report

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Objective: to report a case of cochlear implantation as an alternative treatment for profound sensorineural hearing loss caused by vestibular schwannoma.

Design: Case report.

Material and methods: A 49 years old female patient diagnosed with a left profound sensorineural hearing loss due to a vestibular schwannoma who developed a right fluctuating moderated sensorineural hearing loss due to a Meniëre syndrome with fare results with hearing aids. The patient was implanted in the ear affected by the tumor.

Results: A 49 years old woman who had been followed since 2007 because of a vestibular shwannoma on her left ear that was originally diagnosed due to a progressive sensorineural hearing loss. The annually MRI showed no progression in the tumor size. In 2010, she began with tinnitus, fluctuating hearing loss in the right side (other side), and dizziness. With the diagnosed of Meniére syndrome she was treated with betahistine, trimetazidine and corticosteroids with no benefits. The hearing aids had fare results. As an alternative treatment to improve her hearing we perform a cochlear implantation on the left side (the one with the tumor in situ). Nowadays, seven months later, she is doing auditory rehabilitation with acceptable results.

Discussion: There are many pathophysiologic ways in which a tumor of the VIII cranial nerve can compromise a patient´s hearing: loss of hair cells, spiral ganglia degeneration, cochlear invasion or compression of the nerve or the vessels by the tumor. Hearing may be deteriorated after the surgical treatment of a vestibular shwannoma, even though a hearing preservation surgical technique is done. There has been a growing interest in cochlear implant as an alternative option for auditory rehabilitation in patients with vestibular shwannomas with residual cochlear nerve function. One of the important considerations following cochlear implant surgery in these cases is monitoring the tumor growth. Although a number of devices are deemes to be MRI compatible up to 1.5 tesla, there are potential risks. Alternative options are removal of the magnet and the use of magnetless device. Subsequent monitoring of the tumor size, is usually done with CT scans. Rehabilitation of hearing is a great challenge in patients with profound hearing loss in case of presence of vestibular shwannoma. There are only few cases worldwide of using cochlear implant in the presence of vestibular shwannomas. Irumee et al (2013) reported ten years, seven patients with vestibular schwannomas and bilateral profound hearing loss who received a unilateral cochlear implant. The audiologic outcomes were variable.

Conclusion: We think it is possible that patients with a vestibular shwannoma that didn´t grow through the years, may be benefited with a cochlear implant in order to improve their hearing. We reinforce the literature, showing that cochlear implant can work well in the presence of tumor of the VIII cranial nerve.

P1-9-15

Cochlear implantation in a patient with prior medulloblastoma

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Introduction/Method: A case study presentation of a 42 year old male adult with medulloblastoma. The patient experienced a CVA following excision of the posterior fossa tumor and subsequent radiotherapy resulted in reduction in visual field, reduction in balance function, mild speech & language impairment and gradual deteriorating hearing loss. He underwent intensive assessment to determine his suitability for a cochlear implant due to the complex nature of his condition. He presented with audiological results that were inconsistent and outside criteria as well as processing difficulties which contraindicated the benefits of implantation. Exceptional funding was granted despite the nature of his hearing loss and the unpredictability of the outcome and he was implanted with a Nucleus CI 512.

Results: By 6 months post implant, the patient was able to follow conversation 1 to 1 in quiet but still required clear, slow speech to differentiate words and time to process language. He still had difficulty in background noise. Unfortunately at this time he experienced an implant failure. The patient was re-implanted with a Nucleus Freedom Contour implant. The outcomes have been positive. When recently tested he achieved 96% on open set sentences auditory alone and has also shown improvement in his long term memory.

Discussion/Conclusion: This case study demonstrates that patients presenting with residual hearing at assessment concomitant with central co-morbidities require a thorough work up. Patients with excisions of tumours present with other difficulties such as impairment with speech & language and balance problems. These patients will require additional rehabilitation for interpreting the signal through the implant but can achieve good outcomes.

P1-9-16

Cochlear implantation in otosclerosis: audiological concerns

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Introduction: Otosclerosis is an osteodystrophy of the labyrinthine capsule. Otosclerotic involve the enchondral bone of the otic capsule. Patients having profound bilateral sensorineural hearing loss secondary to otosclerosis obtain benefit from cochlear implantation. Post-implantation Facial Nerve (FN) stimulation is one of the most frequent complications of the cochlear implant (CI) procedure.

Objective: The aims of this study are 1) to investigate auditory outcomes in speech perception with CI, 2) to describe audiological complications 3) to determinate incidence of facial nerve (FN) stimulations, 4) to explain modifications in cochlear implant fitting and 5) to compare results with a control group of non-otosclerotic patients.

Study design: Retrospective review

Subjects: The subjects of this study were 30 postlingually deaf adults (35 ears), implanted at the Cochlear Implant Center Prof. Diamante, Buenos Aires, Argentina. The mean age at implantation was 53 years (range 32-85 years). They all received the Nucleus Cochlear Implant System. They were evaluated with the Latin American Protocol (Cochlear Corporation) using vowels, consonants, disyllabic words and sentences in open set.

Results: All subjects improve in speech perception abilities, but scores vary in a wide range. The outcome is lower and the variance is higher when were compare otosclerotic patients with control group of cochlear implant (CI) patients not affected by otosclerosis. FN stimulation was resolved in all cases modifying the CI fitting. Tinnitus was found in some cases. On occasions it was necessary to reduce levels of stimulation, change rate of stimulation and coding strategies or switch off electrodes. The new CI technologies, with the possibility to stimulate with lower intensities make it possible for audiologists to successfully manage these complications**.** Statistical study will be presented.

Conclusions: A wide range of abilities in speech perception were founded. Although on average outcomes may be poorer, CI can provide useful communication capabilities. Cochlear implantation is reasonable, beneficial and adequate in adults with otosclerosis. Specific medical indicators like ossification, surgical complications or partial insertion should be considered in prognosis. Patients with otosclerosis derive significant benefit from CI; however, an increased risk of cochlear ossification with partial insertion and facial nerve stimulation has to be taken in account during preoperative counseling.

P1-9-17

Outcomes of cochlear implantation in patients with far advanced otosclerosis

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Introduction: Cochlear implantation in individuals with far advanced otosclerosis presents both surgical and fitting challenges. The development of cochlear obliteration in some of these patients overtime may lead to an incomplete electrode insertion, the abnormal bone occupying the otic capsule in this disease may lead to an unusual electric current spread resulting in non-auditory stimulation (mainly facial nerve stimulation) and clinician claim that auditory nerve function might become poor in this population, leading to a relatively poor outcome. The aim of the study is to present pre-implantation imaging findings and the surgical challenges related to these findings, fitting issues as well as hearing outcome in individuals with far advanced otosclerosis.

Methods: 10 patients are included in the study. Their mean age at implantation was 57.5 years (range, 42-70y). Six had undergone stapes procedure and one had undergone fenestration over the years prior to implantation. All patients used hearing aids consistently prior to referral for implantation.

Results: Number of electrode inserted was sufficient in all patients. All patients used their cochlear implant consistently. Between pre- and post-implantation, speech-perception tests scores improved significantly in all patients. In one patient speech perception score post first implantation was lower than expected and he was therefore implanted contra-laterally with a better outcome.

Discussion: Most fitting issues can be solved via mapping manipulations. Surgical difficulties are not as significant as expected based on pre-implantation imaging findings, nevertheless, the possibility of cochlear obliteration development calls for an early implantation in patients with far advanced otosclerosis.

Conclusion: Cochlear implantation is an excellent solution for the majority of individuals with severe-profound hearing loss related to far advanced otosclerosis.

P1-9-18

Cochlear implantation in labyrinthitis ossificans

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Labyrinthitis ossificans is a pathologic ossification in the otic capsule due to an inflammatory or destructive process. The main causes are meningitis, trauma and otosclerosis. Cochlear ossification results in sensorineural hearing loss and its presence os associated with technical difficulties and poorer functional results. Advances in surgical techniques and bioengineering provided the development of special electrodes for this condition. The aim of this study is to evaluate the functional results with partial standard and double-array cochlear implantation in ossified cochleas and further the performance using the device, the complication rate and patient´s satisfaction.

A retrospective and transversal analysis of data on the demographic aspects, auditory performances, surgical findings and quality of life was made. A satisfaction questionnaire was implemented and a transorbital radiograph was used to evaluate migration and depth of insertion of the electrode and the position of the internal component. All patients who underwent either partial insertion of a standard electrode array or double-array electrode insertion for their cochlear implantation in a quaternary centre in the last five years were enrolled.

Eight patients (six adults and two children) were included. The cause of labyrinthitis ossificans was bacterial meningitis in six cases, Cogan´s syndrome in one patient and trauma in one patient. The majority of patients were implanted in adulthood and the average duration of deafness was 104.5 months. Displacement of basal electrode was observed in one patient and he went through a new surgical procedure with successfully repositioning. Bacterial meningitis was the most common cause of cochlear ossification in the sample. In adult patients, meningitis acquired in childhood resulted in a longer deafness than children patients had , which may explain poorer auditory results.

Patients with ossified cochleas benefits significantly from double-array and compressed short array cochlear implantation.

P1-9-19

The CHARGE syndrome: about a case and literature review

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Introduction: The CHARGE syndrome is a rare congenital disease with multiple malformations, its incidence is estimated at 1/10 000birth. The acronym CHARGE is used to describe congenital anomalies: Coloboma, Heart defect, Atresia choanae, Retarded growth and development, Genital anomalies and Ear anomalies/deafness. Our aim is to present an update on clinical presentation, genetics and behavioral aspects in the CHARGE syndrome.

Materials and methods: L.A is a 4-year-old girl with CHARGE syndrome. she received a clinical (cardiovascular, ophthalmologic, otologic....) and paraclinical examination (hearing test, CT, MRI....)

Results: She show typical characteristics of CHARGE: coloboma, retarded growth and development, psychomotor retardation, ear anomalies with profound deafness, bilateral cleft lip and palate. The neuroimaging revealed malformation of the inner ear with aplasia of the semicircular canals

Discussion: Most of the CHARGE syndrome cases are sporadic although 17 familial cases have been reported to date The mode of inheritance of CHARGE syndrome is autosomal dominance with variable penetrance. Most often it is a point mutation in the CHD7 gene, located on chromosome 8 (8q12). There are major and minor clinical criteria for the diagnosis Psychiatric disorders have also been described: obsessive compulsive disorder (72% of patients),the motor tics, the autistic syndrome, or combinations of these disorders. There is no specific treatment of CHARGE syndrome, but some defects must be corrected by surgery soon after birth as profound deafness by cochlear implant.

Conclusion: The suspicion of CHARGE syndrome in a child requires a multidisciplinary medical evaluation and regular followed up to provide better care

Key word: CHARGE syndrome, cochleovestibular malformations, semicircular canal malformation deafness

P1-9-20

Cochlear implantation on a patient with usher syndrome (TypeI) by the MYO7A gene variation - a case report

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Usher syndrome is an autosomal-recessive-inheritance disease which is complicated with congenital or progressive bilateral sensorineural hearing loss (SNHL) and retinitis pigmentosa (RP), and some of the causative genes have been already identified. We experienced a case of Usher syndrome diagnosed definitely by detection of the gene variation of MYO7A. There are few clinical reports of the case having this genetic mutation, and in our best knowledge, the case reports about cochlear implantation on patients of this disease are rare. Thus we herewith report our case mainly on clinical pictures.

The case is a 9-year-old boy. He had passed the newborn hearing screening tests on both ears. At 1 year old, his parents noticed that he made no response to any sound or voice, and visited the otologist. He was diagnosed as having bilateral severe SNHL at 1 year and 2 months old. We fitted hearing aids(HAs) on both sides, and started auditory-verbal education at 1 year and 6 months old. However hearing thresholds were 50-60dB, and we evaluated that the effect of HAs was insufficient. We performed cochlear implantation (CI) on his right ear at 2 years and 7 months old. After the operation he had been nursed and educated using implanted cochlea on his right ear and wearing HA on his left ear, but at the age of 6 years old he gave up using HA and had not used it since then. For the purpose of hearing by both ears, we performed CI on his left ear at 6 years and 7 months old. Hearing thresholds has been improved to 25-30dB and word recognition is as good as 96% in 60dBSPL and 100% in 70dBSPL, using bilateral implanted cochleae.

The variation of MYO7A became clear five years after the gene examination at the time of the first CI. He had also nearsightedness and astigmatism, so visual correction has been done with glasses since 5 years old. After we knew the MYO7A gene variation, we requested the ophthalmologist further investigation, and laboratory findings was consistent with RP.

As Usher syndrome causes severe auditory disorder and visual impairment, when the disease reaches an advanced stage, and the patient falls into a remarkable communication disorder. Since our patient had already underwent CIs on both ears, the auditory communication is secured, and he attends elementary school and has good development of speech and academic performance.

P1-9-21

Cochlear implantation in children with Waardenburg Syndrome

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Children with Waardenburg syndrome (WS) derive significant benefit from cochlear implantation (CI). We conducted a retrospective review of the records of 6 children (2.2%; 2 boys and 4 girls) who underwent 275 CIs at our department between 1993 and 2012.

Four children had a familial history of WS and WS Type I phenotype, while one boy and one girl met the criteria for WS Type II. They were all diagnosed as having bilateral profound sensorineural hearing loss at 1-21 months after birth and underwent CI between the ages of 1 year 8 months and 5 years 7 months. Ear examination results and temporal bone high-resolution computed tomography (CT) findings were normal in all patients. During surgery, a patent cochlea was detected in all patients, and the electrodes were implanted with ease into the scala tympani. A retrospective case study was performed to assess speech perception, speech production, general intelligence, and educational setting in 4 children with WS with profound hearing impairment (age, 8-24 years) who underwent CI with Nucleus 22/24. Five and 10 years after implantation, all children articulated Japanese words with an average score of 72%. A profound improvement was demonstrated by the fact the five children could attend kindergarten or mainstream school. Speech perception and speech intelligibility capabilities significantly improved in all patients after receiving the implants.

P1-9-22

Cochlear implantation in children with large vestibular aqueduct syndrome - timing of intervention, implantation strategy and post-implant management

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Introduction: To determine how children with Large Vestibular Aqueduct Syndrome (LVAS) should be managed with regard to cochlear implant assessment and successful post-implantaudiological rehabilitation.

Methods: Children with LVAS were retrospectively identified from a database of all patients referred to the Paediatric Hearing Implant Centre at St Thomas´ Hospital (London, UK), for CI assessment between 1996 and 2011. Potential candidacy was based on the documented hearing loss and lack of benefit from optimally fitted hearing aids.

Results: Of the 246 children assessed for cochlear implantation in our centre over the 15 year period, 20 (8.2%) were identified with LVAS. Five patients did not meet the criteria for implantation. The other 15 received a unilateral cochlear implant, one pre-lingual, 5 peri-lingual and 9 post-lingual (pre-lingual < 18 months of age), peri-lingual 18 months -4 years old, post-lingual >4 years of age).

Discussion: The Speech Perception Cumulative Index (SPCI) was used as the outcome measure. Post-operative audiological performance of the children implanted showed good progress, which was dependent on certain rehabilitative factors. The majority of these implanted children (12/15, 80.0%) used bimodal stimulation, an acoustic hearing aid in the contra-lateral ear in addition to their cochlear implant, careful management of the hearing aid is essential in order to facilitate adaption to the cochlear implant.

Conclusion: The decision to implant is not alwaysstraightforward with this population. In view of the natural history of the progressive hearing loss associated with LVAS, the assessment process, audiological criteria, implantation strategy and audiological rehabilitation may need to be modified from those of non-LVAS children with congenital hearing loss.

Learning outcome: Children with LVAS present as a different population due to the progressive nature of the hearing loss. In our experience older children and teenagers are reluctant to have both ears implanted simultaneously and want to hold onto their acoustic hearing for as long as possible due to their functional hearing presenting better than their pre-lingual equivalent. This should be an important consideration and unilateral or sequential implantation should be considered in these cases.

P1-9-23

Case study of an adult cochlear implant patient with total non-auditory sensation unrelated to the facial nerve from first programming session and its management

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Introduction and Method: An adult with congenital progressive sensorineural hearing loss (unknown aetiology), with consistent hearing aid use was assessed for a cochlear implant. The subject had normal speech and language whose hearing deteriorated to an extent where hearing aids were inadequate for good speech perception.

He was implanted with a MED-EL Sonata cochlear implant on his right side. A full insertion of the implant was achieved with no complications during or after surgery. On his first programming session non-auditory sensation, (NAS) was present across all electrodes unrelated to the facial nerve. This was experienced as a feeling across the head and torso. Telemetry of implant function was normal. He perceived no sound. Programming was tailored to initiate auditory sensation so as to provide access to sound and better speech perception. This process was over several months by providing low levels of stimulation with gradual activation of the electrodes, initially without any hearing.

Results: Patient presents with excellent functional outcomes after long term programming regime and use of processor.

Conclusion/Discussion: This case study demonstrates that patients with total NAS with a cochlear implant can be 'trained' to accept electrical stimulation which can result in normal use and good or excellent outcomes.

P1-9-24

A case of auditory neuropathy spectrum disorder with a normal hearing threshold

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Auditory neuropathy spectrum disorder (ANSD) is a hearing disorder characterized by an absent or severely abnormal ABR, with preservation of OAE and/or cochlear microphonic. For infants with typical sensorineural hearing loss, a hearing aid fitting should proceed in the earliest months of life based on the results of electrophysiologic tests including ABR or ASSR. However, for infants with ANSD, a hearing aid should be fitted after confirming the elevated pure-tone or speech detection thresholds using behavioral tests because electrophysiological methods do not predict auditory detection thresholds for them and patients with ANSD can present with varying degrees of hearing loss from slight to profound.

Hereby, we report a 12-year-old boy with ANSD who has normal hearing sensitivity. His hearing thresholds were 18dBHL for the right ear and 16dBHL for the left ear. However, the speech discrimination scores were 20% for the right ear and 32% for the left ear. This case shows that patients with ANSD can present with a normal hearing threshold and a hearing aid fitting for them should be decided based on the ear-specific pure-tone or speech detection thresholds demonstrated by behavioral audiologic tests.

P1-9-25

Three years after cochlear implantation girl of 25 - case report

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In Montenegro first CI was implanted 15.december 2008.y. in oldest hospital in Montenegro,``Danilo I`` in Cetinje.

At the beginning we implanted two patients:

1. Boy of 11 years who have prelingual defness.

2. Girl of 19 years (on left ear hearing was lost 2 years before implantation, and on the right year was gradual loss of hearing -on that ear was operation of cholesteatoma).

3. Eight months later implanted was 60 years old man who lost his hearing on both ears three years prior to implantation.

Indications which we used:

1. Deafness on both ears for all patients
2. No usage of any hearing aid and complete incomprehensibility speech
3. Healthy middle ear
4. Porosity cochlea proven with CT and MRI
5. Good weighting electrostimulation hearing nerves
6. Positive Logopedi the Rehabilitation after the installation Cochlear implant
7. Valid psychological finding and psychiatrist
8. Regular findings for general anesthesia

Two years later were implanted five more case

- I patient: 3.5 years old girl, pre-lingually defness, wears two hearing aids 1.5 years. Biological threshold of hearing about 80 dB, in the process of speech rehabilitation.
- II old boy nearly six years, pre-lingually defness, wears two hearing aids, in speech rehabilitation. Biological hearing threshold above 70 dB.
- III boy younger than 3 months prior to the biological threshold of hearing about 80 dB.
- IV girls 9 years old, wears two hearing aids, the hearing threshold over 90 dB
- And the fifth patient is a girl of 25 years / patient which is our case report/,who has a hearing impairment of their third year, and the last 5 years have a significant deterioration of hearing and speech. Preoperative PTA was about 80 dB.

Preoperatively she was done ABR, ASSR, OAE, pure-tone audiometry, tympanometry and CT both temporal bones with other preoperative diagnosis. For first three CI who were implanted the surgery approach was mastoidectomia with timpanotomy posterior and for last five CI we used Veria technique. Due to congenital anomaly of the left ear, it was decided to accede to cochlear implantation in her right ear. Since then it has been almost a three years with daily exercising consistently girl started a job, hang out with friends who heard and here´s what she and her mother that she was strong support for the rehabilitation of the road say about everything. Three years after the installation of CI patient have PTA about 25 dB and Free Field Audiometry 75%. Andrea / girl who was operated on / at the last fitting she said: ´I thought I am lost before installation, and I was disappointed when I turned on the implant because I did not understand what we are talking, but now I see that I got a chance in life, how I look forward to the progress and effort that I made to be even better, "I will finished with these words.

P1-9-26

Indications of cochlear implant in NF2: a report of 12 cases

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Objective: Considering hearing preservation or rehabilitation during neurofibromatosis type 2 (NF2), cochlear implant (CI) can be discussed among other treatments (Internal Auditory Canal decompression, Chemotherapy, Auditory Brainstem Implant (ABI)). The aim of this study is to evaluate indications and results of CI in NF2.

Material and methods: Between 1996 and 2013, auditory rehabilitation was performed for 65 patients with NF2 with CI (n=13), or ABI (n=52). Indication of CI, Cochlear (n=5) or MED-EL (n=8) devices, was discussed in case of absence of vestibular schwannoma (VS) growth, even if previous treatment was performed (radiotherapy, previous surgery with cochlear nerve preservation, and /or chemotherapy). Electric stimulation (promontory test under local anaesthesia) was performed in all cases. In 3 cases CI was performed during or after schwannoma surgery with cochlear nerve preservation. The auditory perception was evaluated by testing, with and without lipreading, the disyllabic word recognition (open-set lists), and the speech understanding (usual sentences), on quiet and noise situations.

Results: Age at time of CI was 41.5 years (21-70) The mean follow-up was 33 months (3-117)

Except for 2 patient who had no response with the CI, postoperative testing evidenced clear improvement of the hearing performances: i) disyllabic words: 47% CI alone and 82 % CI with lipreading; ii) sentences: 52% CI alone and 85 % CI with lipreading; iii) Sentences in noise with SNR 10: over 50 % for 5 patients.

In one case, revision surgery was performed due to secondary growth of tumor and decreased CI performance.

No pejorative predictive factor was found for the 2 cases without any response after CI. Previous electric stimulation test was positive and no tumor growth was identified.

One recent case was performed on contralateral side of ABI without any benefit, after 10 years hearing privation and no response during electric stimulation. First results, 3 months after CI activation, demonstrated hearing recognition without lipreading.

Conclusion: These results show a clear benefit of CI in NF2 patients, in selected cases even if previous treatment. Predictive value of previous electric stimulation appears to be limited. Most of the patients can reach general results obtained with CI on other indications than NF2.

P1-9-27

Cochlear implantation versus auditory brainstem implantation in bilateral total deafness after head trauma: personal experience and review of the literature

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Objective: To determine the effectiveness of cochlear Implant (CI) in hearing restoration after temporal bone (TB) fractures and investigate the adequacy of auditory brainstem implant (ABI) indication for TB fractures.

Study Design: Retrospective clinical study; a systematic re- view of the literature in PubMed was also performed to identify all published cases of bilateral TB fractures or bilateral deafness after head trauma treated by means of CI or ABI.

Settings: Quaternary otology and skull base surgery referral center. Patients: Eleven consecutive patients presented with bilateral severe-to-profound sensorineural hearing loss after head trauma. Interventions: CI as primary intervention or following a pre- vious treatment.

Main Outcome Measures: CI performances were evaluated in the auditory-only condition in both closed-set and open-set formats. Temporal bone (TB) fractures occur in 22% of head traumas. The fracture line may involve functionally important structures, including the fallopian canal, the internal auditory canal (IAC) and the anterior and posterior labyrinth. Otic capsule involvement arguably carries a high risk of severe loss of cochlear and vestibular function (1). Bi- lateral TB fractures with otic capsule involvement expose patients to a high risk of bilateral deafness and meningitis. Hearing loss may also follow traumatic head injury with- out evidence of fractures (2). Cochlear implants (CI) have been used as effective means for hearing rehabilitation

Results: Fourteen CI were placed, 11 as primary treatment and 3 after ABI failure. At the last follow-up, all patients gained useful open-set speech perception. In secondary CI, all patients obtained better auditory results with the CI if compared with ABI. CI performance did not decrease with time in any case.

Conclusion: Cochlear implantation after TB fractures has proved to have excellent audiometric results. Initial evaluation of a patient bilaterally deafened by head trauma should be always aimed to rehabilitate hearing by means of cochlear implantation. Risk of meningitis or facial stimulation after cochlear implantation, cochlear ossification, and negative electrophysiologic testing should not be considered determinant factors in favor of ABI placement.

P1-9-28

Single case report: Word recognition after late unilateral cochlea implantation despite negative auditory nerve testing in a patient with acquired deafness due to infantile meningitis

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Background: Cochlea Implantation in acquired deafness is usually based on positive results in auditory nerve testing. Furthermore, onset of deafness early in life is often associated with poor outcome in speech recognition levels after late cochlea implantation.

Material and methods: A 41year old patient suffering from organic brain syndrome and slight mental retardation in consequence of meningitis before the age of one year leaving him deaf on the left ear and profoundly deaf on his right ear was fitted with a cochlear implant (CI) on the left ear. Auditory nerve function was tested prior to implantation using electric *Amplitude-modulation following response (AMFR).* No reproducible responses were found with stimulation currents up to 1,2mA (Milliampere). On express request of the patient and his mother, the left ear was nonetheless fitted with a cochlear implant. Since first fitting, the patient has repeatedly participated in a word-picture matching task while EEG was recorded.

Results: From the first fitting, the patient reported hearing. One year after implantation, measurement of functional gain showed values between 50 and 65dB. The patient is able to discriminate and match sounds. Comprehension of numbers with CI only is 30% at a speech sound level of 80dB. The behavioral results of the word-picture matching task have been steadily improving to 100% correct over all conditions of the task during last measurement.

Discussion: A patient with long term deafness due to infantile meningitis was successfully implanted and fitted with a Cochlear Implant despite negative AMFR measurement. His abilities in sound and word recognition are slowly but steadily improving. The patient is wearing his cochlear implant every day and is content concerning the benefit.

Negative potentials in spite of an intact auditory nerve might result from altered neuronal conduction after brain disease in early childhood. This should be considered when evaluating measurements of either electronic or acoustic auditory evoked potentials.

P1-9-29

The clinical progress of simultaneous bilateral CI after meningitis with an IP-II anomaly

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Children not only with inner ear anomalies, but also with meningitis require the special attention of the implant team. Imaging studies should be visualized carefully and the surgeon should be ready to handle possible complications during surgery. As well as this, surgical intervention after meningitis needs to be prompt.

I would like to present an 8 year old child with bilateral profound hearing loss.(She was implanted at Izmir Bozyaka teaching and research hospital by the author) After meningitis she was diagnosed with profound bilateral sensory neural hearing loss and her candidacy for a cochlear implant was evaluated. A temporal CT of the right side demonstrated a right cochlea and labyrinth within normal limits. However, an IP-II anomaly was observed on the left side. Her CT demonstrated a deficiency of the modiolus and incomplete separation within the cochlea and enlargement of the vestibular aqueduct.

CI surgery on the right side using a standard length MED-EL electrode proceeded normally, however on the left side a gusher was observed after round window insertion of a compressed MED-EL electrode. The electrode array was packed circumferentially with connective tissue, fibrin glue was utilized and the gusher stopped. However, her rinore developed during the postoperative 6th. week and a second bout of meningitis ensued. After medical treatment of her meningitis she was operated on again to find the site of the gusher. A transcanal route was utilized to visualize the middle ear. CSF leakage was visualized between the posterior crus of the stapes and the annular ligament. Temporal fasia, connective tissue and fibrin glue was used to obliterate the leakage site after stapes removal. There was no leakage in the RW area. Leakage stopped after this operation. Unfortunately, the child developed meningitis for the third time 2 months later.

I would like to emphasize the critical clinical progress of such meningitis cases with inner ear anomalies, the process can be dramatic not only for the family, but for the CI team, too. In this group of patients, congenital dehiscences may be present between the posterior crus of the stapes and the annular ligament,- the significance of which may be underestimated. The surgeon should be aware of the possible clinical situations he or she may need to face, should carefully examine the CT and maybe request repeated CT examinations so that situations arising can be dealt with during surgical intervention.

This presentation will include short, surgical video clips.

P1-9-30

Cochlear implantation in a child with brain infarction

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Objective: Criteria for cochlear implantation have been expanded to those with multiple handicaps . To look at the impact of cochlear implant in a child with partial atrophy at left cerebral hemisphere.

Method: Our case report is about of successful cochlear implantation in a four-year-old child, male, with diagnosis of bilateral profound neurosensory hearing loss and congenital brain infarction (temporal, parietal and occipital lobes of left hemisphere were involved). A neuro-imaging assessment (TC, MRI, Somatosensory Evoked Potential map) was performed in order to complete candidacy evaluation.

Results: There were no abnormal surgical findings and no complications were described. After seven months of cochlear implantation the patient has been improving sound localization with increased attention and auditory follow up is successful. There is a high degree of parents satisfaction.

Conclusions: We emphasize the expanding candidacy criteria to provide patients with the opportunity for cochlear implantation, and the importance of a full neuroimaging assessment during clinic evaluation period. Cochlear implantation is a promising procedure for children with additional disabilities in order to improve their quality of life.

P1-9-32

Whole-exome sequencing identifies POU3F4 p.Ala116fs mutation in two brothers with hearing loss

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One of the most common genetic diseases in human is hearing loss (HL). The majority of cases are nonsyndromic (70%) and 1-5% are nonsyndromic X- linked. Most cases are due to mutations in a single gene. Nevertheless, DNA diagnostics for hearing loss are challenging, since it is an extremely heterogeneous trait. Although more than 70 causative genes have been described for the nonsyndromic hearing loss alone, diagnostic application of the scientific progress has lagged behind. Some previous reports have shown that "next-generation DNA sequencing techniques" have the potential to offer a novel testing platform that could test all known genes in a sensitive, specific and cost-efficient manner. In this study, whole exome sequencing (WES) for direct genetic diagnosis in NSHL was used. Sequential filtering of variants obtained from WES, bioinformatic analyses, and Sanger sequencing validation identified premature termination p.Ala116fs mutation in POU3f4 gene as the candidate disease-causing mutation in the family. POU3F4 belongs to a subfamily of transcription factors, which are characterized by 2 conserved deoxyribonucleic acid-binding domains, a 75- amino acid POU-specific domain and a 60-amino acid homeodomain, both helix-turn-helix structural deoxyribonucleic acid-binding motifs. In this study clinical features and genetic analysis of a male child from a Polish family with congenital deafness and POU3F4 p.Ala116fs mutation is described. Usually clinical features of DFNX2 (DFN3) often include a mixed, progressive hearing loss, temporal bone anomalies, and stapes fixation.

P1-9-33

Effects and consequences of Digisonic SP cochlear implant on radiotherapy planning

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Purpose: The aim of this study was to assess dose attenuation by a Digisonic SP cochlear implant (CI) and evaluate its impact on treatment planning.

Materials and methods: The Digisonic CI was irradiated with 6 MV photons. Overall dose attenuation was assessed with MOSFET dosimeters and Gafchromic films. In addition, we evaluated the attenuation of separate CI components. Dose attenuation was also calculated using different radiation treatment planning systems (TPS) software and dose calculation algorithms. The CI was placed on a head phantom. Single beam and multiple beam plans were evaluated for dose attenuation using 2 radiation techniques (Conformal and Stereotactic radiotherapy) and 4 different algorithms (Clarkson, Point Kernel-Superposition, Ray Tracing and Monte Carlo).

Results: MOSFET and Gafchromics film showed maximal 6 to 7.5% radiation dose attenuation, at the center of the CI. Computerized TPS-based dose attenuation by the implant was 4% to 8.1%, using a single ipsilateral field. No clinically meaningful dose attenuation was found in multiple field plans owing to the contribution of various beam paths with only a couple going through the implant using either conventional conformal or stereotactic treatment plans.

Conclusion: Dose attenuation induced by a Digisonic SP CI is about 6%, for single 6 MV photon field. This dose reduction is unlikely to be clinically significant, as single field radiotherapy plans to this anatomic region are uncommon.

P1-9-34

Three cases of cochlear implants placed after radiation induced severe hearing loss

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Objectives: Radiotherapy (RT) for head and neck tumors may damage the auditory pathways if they lie within the radiation field. The state of the auditory pathways plays a significant role in the success of cochlear implantation. The aim of this study was to investigate the hearing outcome of cochlear implantation in irradiated ears.

Methods: Patients who had received cochlear implantation at Tokyo Medical University Hospital and those who had received RT for head and neck tumors were retrospectively evaluated. In addition to a review of case records, Japanese speech perception and discrimination tests were performed and a validated subjective questionnaire was administered.

Results: Three female patients (age 43,67,75years) met the criteria for this study. They were successfully treated with RT for nasopharyngeal carcinoma (NPC). The total radiation dose delivered to the neck was 54-70 Gy. Postoperative extensive clinical tests, including CT and MRI, showed neither primary nor secondary brain tumors. All the patients had profound deafness, and conventional hearing aids had not been useful. They all had received cochlear implantation within 12 to 16 years after RT and showed good hearing outcomes.

Conclusions: This study demonstrated that three patients who became deaf after RT for NPC achieved good hearing outcomes after receiving cochlear implants. Therefore, cochlear implantation could be a viable option for rehabilitating such patients.

P1-9-35

Advanced Bionics® cochlear implants in patients with prelingual hearing loss

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Cochlear implants (CI) have become standard in the treatment of prelingual, postlingual and perilingual deafness and hearing loss in children. Bilateral implants are considered standard for bilaterally affected children. Studies also find that the CI provides better access to speech for most children, and this access results in improved speech perception and production. In earlier times children who did not react to acoustic stimuli and were able neither to understand speech nor to acquire it spontaneously encountered severe discrimination, being dismissed as simple-minded or worse. Different studies broadly agree that one or two of every 1000 newborns have a hearing impairment that on current evidence warrants treatment or observation, i.e., permanent hearing loss with a lowering of the absolute threshold of hearing for speech perception by at least 35 dB. Approximately 50% of severe hearing impairments arising in the inner ear are thought to be hereditary in origin. When new cochlear implant (CI) sound processors are being introduced by the manufacturers, usually the newest generation implants benefit first from the new technology in order to release the full potential of the new hardware. Subsequently, for the Advanced Bionics system the Harmony behind-the-ear processor was only compatible to the newer generation implants, i.e. the CII and HiRes90K, at the time of market release.

Objective: Evaluate the improvement of language oralization and sound perception in patients with prelingual deafness underwent cochlear implant using Advanced Bioncis® device.

Method: Retrospective study of the patients fitted with Advanced Bionics® cochlear implant in our institution between 2011 and 2012. Medical records were analyzed.

Results: Sixteen patients underwent to cochlear implantation using Advanced Bionics® devices. There were 37,5% prelingual and 62,5% postlingual patients with bilateral hearing loss. Mean age at implantaion was 3,6 years (range 2 to 6 years) in the prelingual group. There were no medical history of deafness in families. All prelingual patients used hearing device before the cochlear implant. The hearing levels improved after CI in all patients.

Conclusion: This study evaluated patients with pre-lingual deafness using the Advanced Bionics® cochlear implants demonstrated significant gains in neural stimulation and language development in children.

P1-9-36

Cochlear implantation on a patient with sudden-onset deafness due to otitis media with ANCA-associated vasculitis - a case report

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We sometimes encounter cases that have otitis-media-like symptoms and progressive sensori-neural hearing loss, but have a limited pathological change only in the middle ear without involvements in nose, lung and kidney pathological change. Usually they show positive anti-neutrophil cytoplasmic antibody (ANCA). As either antibiotics or tympanostomy tube insertion are not effective, and correct diagnosis is difficult in early stage, this syndrome is being defined as otitis media with ANCA-associated vasculitis (OMAAV), and the diagnostic criteria has been proposed in Japan now. We experienced a patient who showed bilateral sudden profound deafness by OMAAV. A 35 year-old woman suddenly had severe dizziness and the hearing loss of both sides, and she came our emergency clinic. Myringotomy revealed outflow of the effusion. The pure-tone audiometry showed scale-out bilaterally. There was no response either to ABR or to DPOAE. There was no facial paralysis. CT and MRI did not show cerebrovascular disorder. Various immunologic examinations showed that MPO-ANCA and PR3-ANCA were strongly positive. We diagnosed this case as OMAAV and treated with a steroid and the immunosuppressive drug. But her hearing did not improve at all, We performed CI in the left ear four months after the onset of her deafness. Although CI enabled her hear again, she had a problem. As the electric resistance within the cochlea were getting higher, she temporarily required such a high current as caused facial stimulation in order to acquire a hearing. But now, repetitive fitting fortunately have enabled her to communicate with not only her family but also any persons by her left CI. We recognized that the CI is very useful tool for bilateral deafness caused by OMAAV as well as other causes. To our knowledge, there have been only three cases with ANCA-positive and bilateral deafness, who underwent CI and had a good result. We believe that the knowledge and early diagnosis of this disease are prime important for us clinical otologists so that the patients can regain hearing by early CI before ossification of the cochlea.

P1-10 Rehabilitation for children – speech production, speech perception

P1-10-1

Identification of nasal vowels by French Parisian cochlear-implanted adults

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Intro: Cochlear implant (CI) dramatically improves global speech perception, communication, and quality of life of post-lingual hearing-impaired adults. However, because correct identification of the phonemes is not always completely achieved, numerous studies were performed to identify specific problems in recognition of consonants and vowels (Valimäa et al., 2012). Nasal vowels are absent in English or Finnish and present in less than ¼ of worldwide languages including French with /ɑ̃/, /ɔ̃/, and /ɛ̃/. Nasal vowels are produced with added nasal cavity resonator, which introduced additional formants and antiformants. Acoustic cues of the nasal vowels are not only based on the frequencies of the formants but also on their relative intensity. In normal-hearing population, the listener strategy used to identify the nasal vowels is not completely known. Furthermore, cochlear implanted patients complain to recognize the nasal vowels. The aim of this study was to identify the nasal vowels recognition in CI patients.

Methods: A retrospective study was done on 52 women and 30 men (age = 55±15 years, mean ± SD, [26-81]) presenting post-lingual hearing loss, implanted from 1991 to 2008 in Beaujon hospital (Paris, France) with different CI systems/coding strategies (Speak: 25, ACE: 40, CIS: 12, HiRes90k: 2, MPIS: 3). Tests were performed at the earliest stage of rehabilitation (3±0.9 months [1-4]) and later, after at least one year after implantation (35±26 months [12-120]). Patients were asked to recognize 7 oral and 3 nasal vowels associated to the /p/ consonant pronounced by female speech therapists at direct voice.

Results: At the both stages, nasal vowels were significantly less well perceived than oral vowels ($p < 0.05$): 77%±24.2 vs 36%±37.9 for oral and nasal vowels, respectively, at the earliest stage, and 87%±16.3 vs 57%±38.4 at the latest stage. In case of error on nasal vowel, CI patients identified not another nasal one but an oral vowel in 94% of the cases.

Discussion: In French, nasal vowels are more difficult to perceive than oral vowels by CI-users and this difficulty remains even late after implantation. Contrary to the non-implanted hearing-impaired patients, who confused nasal vowels between them (Adam & Lefevre, 2006), CI users mainly gave oral vowels as responses when nasal vowel is presented, missing the specific feature allowing them to categorize the vowel as nasal.

Conclusion: Further studies would try to explain which acoustics cues are missing to CI-users to identify the nasal feature. Studies of nasal vowels perception could provide a new light on the phonetic perception of cochlear implant users. It should be very interesting to verify this difficulty in nasal vowel recognition in Meridional/Canadian French, Polish/Hindi or Portuguese speakers.

P1-10-2

Analysis of Rehabilitation results of children after cochlear implantation

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Objective: Assessment of rehabilitation effectiveness of children with sensoneural auditary inefficiency of IV degree and hearing loss after cochlear implantation (CI).

Methods: 65 children aged between 10 months and 13 years with sensoneural auditary inefficiency of IV degree and hearing loss after CI. CI systems Cochlear (Nucleus Freedom and Nucleus CP 810) were used. Children had undergone complex audiological and neurological examination before CI.

Results: There was bilateral lesion in all cases; asymmetric in 73 % cases. CI was performed at age 1 year - in 9 patients, 1 - 2 years - 21, 2 - 3 years - 17, 3 - 5 years - 9, older than 5 years - 9. In 46 cases monoaural (MA) CI, 19 - biaural (BA). Rehabilitation results were assessed in patients within 3 and then following 6 and 12 months after CI. After connection of speaking processor moving reaction was observed at distances of 1-2 meters in all patients with single-step BA CI and in 81% after MA regardless of age.

In 3 months after MA CI regardless of age phoneme readability of speaking loudness and single words at distance of 6 meters appeared. After BA CI good speech understanding at distances of 6 meters in situation of limited choice and improvement of sound localization were observed in the age group of up to 2 years in 2 months, in the age group of elder children in 1.5 months and in 3 months of speaking processors use.

Six months after MA CI legibility of whisper and speech (WS) occurred (according to age) at distances of 6 m in situation of limited choice. After BA CI these results were in the age group of up to 2 years in 4 months, in the age group of elder children in 5 months and; in 6 months all patients of this group showed legibility of WS according to age) at distances of 6 m in situation of limited choice. After BA CI 19 patients (100%) 1 year later showed good understanding of WS at distances of 6 m in situation of unlimited choice and extending phrase (according to age). Conduction of tonal threshold audiometry (at free sound field) showed that hearing thresholds corresponded to hearing loss of I degree. After MA CI good understanding of WS at distances of 6 m in situation of unlimited choice occurred only in 31 patients out of 46. Insufficient skills formations rates in 7 of 11 children were due to concomitant pathology. Conduction of tonal threshold audiometry (at free sound field) showed that hearing thresholds corresponded to hearing loss of I degree in 36 patients.

Conclusions: Rehabilitation of children after CI enables to get compliance of speech and hearing development of children with their age what lead to complete patients' adaptation in speech environment and improvement of quality of life of children and their families. According to results of our observations it should be noted, that these parameters are got significantly earlier after BA implantation.

P1-10-3

Speech intelligibility in sentences after reading and dictation training in children with prelingually hearing disabilities who use cochlear implants

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Objective: This study verified whether strengthening the network of equivalence relations between dictated sentences, printed sentences, and action figures in children with cochlear implants would affect the speech intelligibility sentences in reading and pictures naming tasks. During the pre-test, the children pronounced better when reading sentences (AVG=87,55% accuracy) than when they named the action pictures (AVG=31,62% accuraty).

Materials and methods: The sessions were conducted via notebook computer containing PROLER® software, which managed sound (amplified by attached speakers) and images. Three sets of stimuli were compused witch detected sentences, human actions pictures e printed sentences, which were organized by the syntactic structure subject-verb-object according to Brazilian Portuguese Language; sentences were overlapped by the object. Five children with prelingually hearing disabilities who use unilateral cochlear implant, 8-11 years, with **6,6 years of cochlear implant use (in average) and were services users of Audiological Research Center/HRAC-USP-Bauru, were recruited for the study.**

Participants were assessed within the middle intelligence, the categories of language and hearing had high scores, but estimated age by PPVT was less than chronological age for all the participants.

The teaching consisted in to construct sentences by selecting words in the sequence subject-verb-object, according to the dictated sentences. **Auditory recognition** was trained **by tasks of selecting pictures** according to the same **dictated sentences**. Post-tests assessed the comprehension of the relation between pictures and construction of sentences, since they were paired to the same dictated sentences; in addition, the naming of action pictures and the reading of three taught sentences and an additional six sentences, derived from a recombination of component words of the taught sentences.

Results: All children achieved 100% precision in the tasks of teaching and test comprehension of dictated sentences. They also improved speech intelligibility with a higher correlation between naming pictures of actions (96.65% accuracy, in average) and the reading of sentences (in average, 95.11% accuracy), with trained stimuli and sentences derived from a recombination of components (mean = 74.98%). This performance was maintained and evaluated at one month follow-up.

Conclusion: The program was able to accelerate the processes of auditory discrimination and their relations to speech production, lowering the disadvantages in vocalization in these children.

P1-10-4

Language development and speech intelligibility of Egyptian children using cochlear implant

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Introduction: Children with profound sensorineural hearing loss (SNHL) experience delay in learning to understand the speech of others and to produce intelligible speech. This delay is rooted in a lack of refined access to the spectral and temporal cues of the acoustic-phonologic components of speech. When traditional amplification devices (hearing aids) are unable to restore access to the full range of phonemic components of speech, a cochlear implant is a widely used treatment option for those children.

Methods: Thirty Egyptian children aged from 4 to 6 years with bilateral severe to profound and profound SNHL. They were fitted by bilateral behind ear hearing aids and had regular language therapy for one year with poor response, and then they were implanted &enrolled in rehabilitation with CROP team for another one year. Lack of benefit from appropriately fit hearing aids is determined by the lack of progress in the development of simple auditory skills& by poor language development.

Battery included:

1. Modified preschool language scale (El Sady et al., 2010) is used for language assessment.
2. Speech intelligibility assessment is measured by the Arabic Speech Intelligibility Test for Children (Bassiouny et al., 2011). Language test before using hearing aids is retrieved from the children medical profiles. Other assessments were done twice

1st before implantation& the 2nd assessment was done after 1 year of regular rehabilitation with cochlear implant. Language development after rehabilitation with hearing aids is compared with language development after one year of rehabilitation with cochlear implant.

Result: The receptive language with cochlear implant is higher (28.3 ± 4.7) than with hearing aids(17.3 ±0.8), this difference was statistically significant. The expressive language with cochlear implant is higher (32.5±7.2) than with hearing aids (22.5±1.1), this difference was statistically significant. The total language development with cochlear implant was higher (60.8±11.6) than with hearing aids (39.9 ±1.4), it was statistical significant difference. Frontal phonemes are developed with a significant difference compared to the back phonemes Speech intelligibility is improved dramatically by using cochlear implant.

Discussion: This study shows children who get little benefit from hearing aids had benefit from using cochlear implant. Other studies indicate greater vocabulary improvement in children enrolled in total communication programs after cochlear implant.

Conclusion: Cochlear implantation is a safe and reliable technique. The fact that many profoundly hearing-impaired children using cochlear implant can develop functional levels of speech perception and production, attain age-appropriate oral Language, develop competency level in a language other than their primary language,

Learning outcome: Continuation of language therapy together with proper mapping accordingly is a must to enroll these children in main stream school.

P1-10-5

The pediatric postoperative outcomes of the cochlear implant systems

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Cochlear implants (CI) have considerably improved quality of life in children with bilateral profound hearing loss, by offering them significantly greater access to sound, which has promoted an increase in communication abilities. Some of those children develop oral language and speech production skills. CI outcome in children with profound deafness is highly variable. The purpose of this study is to present the postoperative auditory performance, the speech intelligibility scores and the integration into mainstream school system of children implanted with CI.

Between May 5th, 2007 and April 29th, 2013, 44 patients with a bilateral profound deafness have been implanted unilaterally with a NUCLEUS™ FREEDOM™ system (Cochlear Corp. Australia) and included to a retrospective cohort study. A postoperative evaluation of the auditory performance (CAP, APCEI) and the speech intelligibility (SIR, IT-MAIS) was assessed. The integration to into mainstream school system was followed.

44 children were included in the analysis, 23 males and 19 females. The mean age at implantation was 4±1.6 years old (yo) (2 yo - 10 yo). The duration of the follow-up (FU) was from 9 months to 6 years (Y). 98% of children were prelingually deaf. The cohort was divided into two groups. Group 1 (G1) (n=9) with less than 2Y after the CI implantation and group 2 (G2) (n=23) with more than 2Y after the implantation.

The auditory performance (APCEI, CAP) of G1 was scored as follow: APCEI: 10, CAP: 4 (3-5) whereas the G2: APCEI: 18, CAP 5 (4-6). Moreover, the speech intelligibility (SIR, IT-MAIS) of G1 was scored as follow: SIR: 1 (0-3), IT-MAIS < 2 while the G2: SIR: 3 (2-4) and IT-MAIS between 3 and 4 for all questions. Likewise, All children of G2 are integrated into school system whose 78% into mainstream school.

The results showed the ability of children of G1 of discrimination of sounds (CAP: 4) and their primary ability to discriminate words (APCEI: 10) with an absence of speech intelligibility (SIR: 1). Immediately after 2Y after implantation, The CAP scores were gradually increased, all the children understood phrases (CAP: 5) with very good speech intelligibility (SIR: 3) and IT-MAIS between 3 and 4 for all questions. 2Y after CI, and despite the lack of motivation of the parents (67%), all children were able to integrate the school system whose 78% into mainstream school system.

These data suggest that implanting children with CI allows the best opportunity for them to acquire communication skills. A rigorous FU of speech and language therapy is critical to acquire the best auditory performance and speech intelligibility. Thanks to a strict speech therapy FU of at least 2Y, the cochlear implanted patient is able to integrate a school system.

All children with congenital deafness who underwent CI before age of 6Y appeared to benefit from the implant. However, the data add the evidence of the importance of a strict long term speech and language therapy FU.

P1-10-6

Study to examine the feasibility of using radio aids (FM systems) in an aqueous environment, specifically school based swimming lessons with Cochlear Corporation processors

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Intro: The recent introduction of the Aqua Accessory for use with recent Cochlear© processors has made the use of radio aids in the swimming pool feasible. Thus children might not only make use of their hearing in watery environments but also benefit from a greatly improved signal-to-noise ratio in school based swimming lessons.

Methods: The study considered children having school based swimming lessons, who were users of Cochlear Corporation processors, and who were accompanied by teachers or assistants trained in the use of radio hearing systems. The radio receivers had to be ear level types that would physically fit into the Aqua Accessory. Questionnaires were used to evaluate the effectiveness of the Aqua Accessory with the processor and radio receiver.

Results: Children demonstrated improved access to instruction, increased confidence, increased enjoyment of the sessions, and greater engagement with other children.

Discussion: It has been well documented for decades that deaf children need greatly improved signal to noise ratio for satisfactory learning, yet the noisiest conceivable environment of the swimming pool is the most challenging to overcome. This study showed the considerable benefits for a number of children having swimming lessons. The study also highlighted the need to make adjustments to equipment and counsel the children about noise they had not previously experienced. Waterproofing is a relatively recent phenomenon in hearing instruments. This study might lead to other more detailed studies which in turn could encourage other manufactures to look more closely at making devices more water resistant.

Conclusion: Radio aids can, with some processors be used to great effect in this very important learning situation, reducing risk, reducing stress (for child and teacher), increasing enjoyment and engagement.

P1-10-7

Distant results of children hearing and speech development assessment after cochlear implantation

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Aim: Results assessment of hearing, speech and social children's development after cochlear implantation (CI) after 5-7 years period.

Methods: Operations have been performed at the ORL-clinic of Dnepropetrovsk Medical Academy since 2006. 73 children, who had implantation five years ago, were assessed. The MedEl implants were implanted (49 implants Combi40+, 24 implants Pulsar and Sonata). The “Russian set of tasks” (by I.Koroleva, 2008) of international methodology “Evaluation of auditory responses to speech” (EARS) was used. Social and family conditions were also estimated.

Results: Children implanted at the age before 36 months have significantly better speech perception results than older children. Patients need constant training with parents and teachers and attending preschool educational establishments. In 3 years after operation children parsed 20-29 words per minute, after 6 years - 32-37 words per minute. Thus, only within 4-5 years after operation, auditory perception of spoken words starts to progress visibly. Among 58 children at school age, 43 ones (74,1%) study at general school, 11 children attend musical schools (violin, piano, flute), dance classes. Tempo+ speech processor was replaced by Opus2 for 12 children. And we have got great results: the quality of speech has improved in 1-2 months. The CI patients, aged 11-17, had more problems, as well as 2 children after meningitis.

Conclusions: CI Results are connected with children age, attending preschool educational establishments, active parents' participation, and the signal-coding strategy. Only within 4-5 years after operation, auditory perception of spoken words starts to progress visibly. There are also additional factors: pre-implant residual hearing, number of electrodes and electrical dynamic ranges used, psychosocial problems, which may influence on some implanted children results.

P1-10-8

The Sibiu speech understanding test

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Introduction: It is the first and, so far, the only test developed in Romania to evaluate speech understanding in 2 - 6 year old CI users

Materials: The Sibiu Speech Understanding Test is available on CD (female and male voice) and it consists of 2 lists of 10 monosyllabic words each, 2 lists of 10 disyllabic words each (in total 40 words), plus 1 list of 50 monosyllabic and disyllabic words (the first 40 words plus 10 new disyllabic words).

Also, every word list contains images corresponding to each word: if the child is not yet able to speak properly, he can show the image and the evaluator can be sure the child understood correctly or not the word he heard.

To assess the difficulty of the lists, 60 normal hearing subjects with the same age were tested for validation.

For the purpose of evaluating speech understanding in noise, noise with a speech shaped spectrum was recorded along with the spoken lists for the female voice.

Result: Test results of more than 200 children, all MED-EL CI users show high scores of performance. This test can be used by either the rehabilitation specialist but also the parents of implanted children (3 videos).

Conclusion: The test is an important tool for the evaluation of the performance of pediatric CI users with the focus on 'speech understanding in everyday life”

P1-10-9

Language development in deaf children two years after cochlea implantation - results in the German language development test battery for two year old children (SETK-2)

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Intro: The aim of early cochlea implantation is a normal speech development. It depends on different factors at what age children achieve an age appropriate speech development. Literature indicates that in the first years after implantation hearing age is equivalent to the speech development. Therefore it is concluded that implantation before the second birthday is recommend in bilateral deaf children (1, 4).

Methods: Test measurement with the SETK-2 (3) took place 2 years after cochlea implantation. The SETK-2 consists of 2 tests for receptive language (words / sentences) and 2 tests for expressive language (words/ sentences) (3). Data of 60 children were analyzed (33= male, 27= female) with hearing age 24 months (Min: 10, Max: 28). Age of the children lay between 28 and 80 months (Median: 45,5 months). 50 % of the cohort were implanted before their second birthday and in total 81,7 % were implanted before their third birthday. At the time of the test measurement 48,3 % of the children were implanted bilaterally. For analysis nonparametric tests and descriptive statistics with the SPSS Version 21 were used.

Results: Most of the children showed hearing age appropriate results in the test. The median of the normal curve equivalent in the four subtests were: 61 (comprehension: words), 54 (comprehension: sentences), 49 (production: words) and 46 (production: sentences). Some children's results were below their hearing age (word comprehension: 13,3 %; comprehension of sentences: 14,3 %; word production: 28,3 %; production of sentences 33,3,%). 6,7 % of the cohort demonstrate results above the average (compared to their hearing age) in all 4 subtests. In a subgroup of children who grow up monolingual (German) (n=38) 11,1 % showed results above the average in all 4 subtests. In this subgroup less children showed results below average (word comprehension: 2,8 %; comprehension of sentences: 8,8 %; word production: 13,9 %; production of sentences 21,2,%)

Discussion: In this cohort most children demonstrate a hearing age appropriate speech development 2 years after cochlea implantation. We could find a significant correlation between all subtests and the age at the first mapping of the CI. That an early cochlea implantation leads more often to an age appropriate language is showed in different studies (2).

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P1-10-10

The retrospective analysis of the cochlear implantation effectiveness depending on the age of intervention

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Background: It's well-known that the cochlear implantation is the only possible effective method for the rehabilitation of deaf children for restoring their hearing and speech. Implementation of universal newborn screening contributed to early diagnosing of hearing loss, which provides opportunity for earlier intervention where necessary. Speech development in kids starts from birth and ends around 6 years old. Patients with congenital deafness benefit more from early cochlear implantation- earlier intervention means early and good speech development.

Aim: The aim of our study was to analyze the results of implantation related to children's age at the time of intervention.

Materials and methods: The retrospective study of the results of 39 children implanted in period of 2004-2012 at “Erebuni” MC, Armenia with Nucleus cochlear implant systems (”Cochlear”). Patients have been divided into 3groups according to the age of patients: patients from 1 to 2,5 years old (y/o), patients from 2,5 to 4 y/o and more than 4 y/o at the time of surgery. The results of implantation were estimated only by auditory questionnaire (Little Ears) one year after the surgery.

Results: 1 year after first fitting of implant group of 13 children implanted at the age of 1-2.5 y/o had “higher than average” results. In this group 2 patients had “lower than average” results. These results were most likely contributed by additional disabilities in those children. In the group of patients implanted at the age of 2.5-4 y/o 3 patients had “average” results and 10 patients had “higher than average” results. And finally, in a group of children implanted in the age higher than 4 y/o 1 child had “lower than average” result, 9 had “average” results and 3 had “higher than average” results. During the estimating of the age factorsignificance, 2 patients with additional disabilities implanted at the age from 1-2.5y/o age were excluded from this study, as they were obviously affecting average results of this group. In the age group of 1-2.5 y/o during the surgery the average result as per questionnaire was 29,77±2,86 points from maximal possible 35,in the age group of 2.5-4 y/o during the surgery the average result was 26,77±3,14 and in the group ofimplanted patients in the age of higher than 4 y/o the average result was 24,31±4,33. The statistical analysis showed the significant difference in case of comparing results of patients from the age group of 1-2.5 y/o at the time of surgery with the results of patient's from in the age groups of 2.5-4 y/o and higher than 4 y/o at the time of cochlear implantation ($p < 0,05$).

Conclusion: The results of our study showed that one year after cochlear implantation the best results were obtained in the group of patients implanted at the age of 1-2.5 y/o.

P1-10-11

Preschool television programs: analysis using SmartSound IQ data logging

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Introduction: As professionals working with children, we often advise parents to reduce the amount of time the television is on and spend more time involving their children in the carer's daily routines. However, the reality for many parents is that television allows the child to be occupied while the parent undertakes essential tasks and may also be an enjoyable shared experience at other times. A recent BARB analysis suggests that children watch TV for an average of 17 hours per week. The SmartSound IQ data logging function of a Nucleus® CP900 sound processor now gives the potential to analyze how the sound from television programs is processed.

Method: We combined data collected through viewing figures and a parental survey to select the top five programs watched by children under 5 years old. These programs were analyzed using the SmartSound IQ data logging function of a Nucleus® CP900 sound processor in order to assess proportions classified as speech, noise, speech in noise, music or quiet. A real time analysis of the same episode was undertaken by speech and language therapists to provide a comparison.

Results and conclusions: Results and conclusions of the project will be presented. Implications for how processor data logging is interpreted and consequent counseling for parents and families will be discussed.

Learning outcome: The data presented will help clinicians gain a better understanding of the data logging function on SmartSound IQ, to guide interpretation and counseling.

P1-10-12

Long term outcomes in cochlear implanted children

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Objectives: The present study investigated long-term auditory skill development in 113 deaf children who used their implants form 1 until 6,9 years. The aim was to describe the multidisciplinary team approach of the pediatric cochlear implant program of the Annaba University Hospital in East Algeria to evaluate the communication outcomes of the Arabic-speaking children implanted unilaterally with regard to the audiological performance, communication outcomes, educational achievement and implant device safety.

Study design: Retrospective study.

Setting: Annaba University hospital in Algeria.

Patients: 113 cochlear implanted children were tested. Surgery occurred between 30 March 2007 and 4 August 2013. At the time of study enrollment, cochlear implant use ranged from 1 year to 6 years and 9 months.

Main outcome measures: In order to investigate the relationship between long-term CI use and perception outcomes, analytic and descriptive statistics for the speech, auditory performance was calculated for the entire sample and then for three subgroups based on duration of use: 1-2 years, 3-4 years, and 5-6 years. Perceptive abilities were evaluated using audiometric testing and questionnaires including APCEI-scales and IT-MAIS. We also studied school attendance and implant device performance. One way-ANOVAs were used to test for differences between the three duration of CI use subgroups.

Results: A significant difference and improvement ($p < .001$) between each component through de the duration of CI use. The APCEI-scales results indicate that children are active and they have an obvious need to wear the implant all day. Also, children develop a good comprehension of oral message meaning over the duration of use. The IT-MAIS results demonstrate significant evolution ($p < .001$) by the duration of use that children vocalize frequently when using their cochlear implants and respond frequently to speech and environmental sounds in everyday situations. The results of auditory assessment protocols (APCEI-scale and IT-MAIS) were compatible with the results of the objective assessment in tonal audiometry. Furthermore, the cochlear implant allowed the children to access to mainstream educational environments.

Conclusion: Cochlear implants provide deaf children the opportunity to develop oral functional communications skills. This long-term study on 113 children with 1 to 6 years of cochlear implant use reveals that cochlear implantation is safe in the long term, and provides functional levels of speech perception and speech intelligibility for profoundly deaf children and has given them access to useful hearing in their daily lives.

P1-10-13

Auditory performance and speech intelligibility of Mandarin-speaking children implanted before age 5

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Objective: (1) To report the auditory performance and speech intelligibility of 84 Mandarin-speaking prelingually deaf children after using cochlear implants (CIs) for one, two, three, four, and five years to understand how many years of implant use were needed for them to reach a plateau-level performance; (2) to investigate the relation between subjective rating scales and objective measurements (i.e., speech perception tests); and (3) to understand the effect of age at implantation on auditory and speech development.

Methods: Eighty-four children with CIs participated in this study. Their auditory performance and speech intelligibility were rated using the Categorical Auditory Performance (CAP) and the Speech Intelligibility Rating (SIR) scales, respectively. The evaluations were made before implantation and six months, one, two, three, four, and five years after implantation. At the fifth year after implantation, monosyllabic-word, easy-sentence, and difficult-sentence perception tests were administered.

Results: The median CAP score reached a plateau at category 6 after three years of implant use. The median SIR arrived at the highest level after five years of use. With five years of CI experiences, 86% of the subjects understood conversation without lip-reading, and 58% were fully intelligible to all listeners. The three speech perception tests had a moderate-to-strong correlation with the CAP and SIR scores. The children implanted before the age of three years had significantly better CAP and monosyllabic word perception test scores.

Conclusions: Five years of follow-up are needed for assessing the post-implantation development of communication ability of prelingually deafened children. It is recommended that hearing-impaired children receive cochlear implantation at a younger age to acquire better auditory ability for developing language skills. Constant postoperative aural-verbal rehabilitation and speech and language therapy are most likely required for the patients to reach the highest level on the CAP and SIR scales.

P1-10-14

Children with cochlear implants and cerebral palsy- selection, rehabilitation, outcomes

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Cerebral palsy (CP) is a complex clinical entity which, apart from various degree of motor impairment, could be associated with intellectual and cognitive deficit, other disabling medical conditions and hearing loss. Cochlear implant (CI) should be considered for CP children with profound hearing loss and sometimes for those with lesser degree of hearing impairment and auditory neuropathy spectrum disorder (ANSD), if no benefit from hearing aids could be obtained.

Consideration of cochlear implantation as a possible solution in CP children with hearing impairment depends on general health of a child and severity of motor, intellectual and cognitive deficit. Cochlear implantation in a child with cerebral palsy should be carefully scheduled in accordance with developmental features and general health. If a child is in poor health condition CI surgery is out of question. Decision to consider cochlear implantation as a possible solution for each child with CP and hearing loss should be made by an experienced multidisciplinary team, based on individual needs and capacity. Future perspectives and possible outcomes should be presented to the parents in details to develop realistic expectations and motivation for the procedure.

Although cochlear implantation could improve auditory performance in CP child, there is no guarantee that the child will develop oral speech and language in spite of intensive postoperative rehabilitation. Obstacles in speech development following cochlear implantation in children with cerebral palsy could be caused by intellectual, cognitive or motor problems especially in oral-pharyngeal musculature. Combination of different rehabilitative techniques is necessary to meet complex needs of cochlear implanted children with cerebral palsy in order to achieve the best possible individual outcome.

The authors will present two completely different outcomes of cochlear implantation in children with cerebral palsy.

P1-10-15

Performance of children with additional disabilities after cochlear implantation

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Introduction: Cochlear implantation for children with profound hearing loss and additional disabilities (mental retardation, autism) was controversial in the earliest period of implantation

There is no consensus on cochlear implant candidacy for children with multiple handicaps.

Objective: The purpose of this study was to investigate the performance of children with multiple handicaps after implantation and to explore their progress.

Methods: Six implanted children were included four with mental retardation and two with autism spectrum disorder who have cochlear implants.

Progress in speech perception, speech intelligibility and speech language have been measured using the ladder APCEI and language. We retrospectively examined outcomes of performance and explored between this progress and the degree of their attaint after implantation.

Results: The progress in audition, speech, and language in children with mental retardation has been shown consistent improvement after implantation. However, the children's with autism have middle results. Although language development of children with mental retardation was better and they could communicate verbally 3 years after implantation. For the children's with autism their language development was slow

Conclusion: Children with multiple handicaps (mental retardation, autism) show demonstrable benefit from cochlear implantation and the postoperative performance was tempered by the degree of their handicaps.

Key words: Cochlear implantation, children, mental retardation, autism, performance

P1-10-16

CI children with complex needs and new rehabilitation material supporting this population

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Many studies confirm that during the last two decades the population of children with complex needs has grown. In particular, a greatly increased number of very premature babies are now surviving through advanced medical care where this is available. However, up to 40% of very early born babies have significant and permanent disabilities. These frequently include difficulties in the areas of hearing, vision, kidney function and respiration. Society can now offer much to premature babies. Significant changes have taken place, and continue to take place, in the tools and technology to support them. One example is the Cochlear Implant (CI): this can benefit children who are profoundly deaf, including those with complex additional needs.

In the last years the inclusion criteria for cochlear implantation have been widened. The consensus is growing that additional disabilities are no longer a contraindication. Therefore more deaf children with complex needs receive cochlear implants.

Cochlear implants can bring benefits across a range of areas, including listening, the development of communication, psychosocial skills, and pre-academic and academic function. However, there are differences in the type of benefits cochlear implantation will bring to children who are deaf with complex additional needs and to those whose primary need is caused by deafness alone. The lecture will go through different system of outcomes monitoring, strategies in rehabilitation, different benefits complex needs children can have from a Cochlear Implant and will introduce the new material from MED-EL supporting the rehabilitation of CI users with complex needs called WE CAN!

P1-10-17

Requests of cochlear implantation (CI) in multihandicaped children

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The implantation requests of parents with highly hearing-impaired children with additional physical and mental disabilities increases.

Although it is not expected in general that hearing impaired children with additional cognitive limitations may find language acquisition automatically by a CI, but a positive use of auditory impressions can be seen in most cases. These are mostly very individual and affect the development of motor skills as well acoustic orientation in the environment. This is of enormous importance not only for the patients themselves, but also for their social contact persons.

On the basis of three case studies of multiply disabled children (deaf-blind, charge association, multiple disabilities after CMV infection), the benefit of both one- and two-sided CI-supply in each individual case is described. For the interdisciplinary rehabilitation team, these patients often represents a significant extra effort, both in advance of the cochlear implantation, as well as in lifelong CI-aftercare. The positive development of these children can only be realized in close cooperation of experts in various fields, with parents and with a multidimensional conveying and therapeutic approach.

The above mentioned challenge of rehabilitation care is entirely possible in an outpatient aftercare program which is also more flexible to handle. This is also because the outpatient follow-up appointments can be kept very closely to respond quick and intensive to possible changes.

To that extent, the cost-benefit debate has to be initiated. However, since in our center the progress of these patients are seen as hugely positive, it is an obligation to enter into this debate. To ensure adequate supply also financially, and with regard to the inclusion thoughts it is desirable that the reimburstment systems consider this overhead to be useful.

P1-10-18

Outcomes of cochlear implantation in deaf children with associated disabilities

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Cochlear implantation of deaf children with associated disabilities is a challenging problem and evaluation of results is often impossible using standard test associated with speech perception and intelligibility. Cerebral palsy, global developmental delay and autistic spectrum disorder are not contraindication for cochlear implantation today. The aim of this study was to estimate the benefit from this procedure in the group of children with associated mental delay.

In our department between 2008 and 2013 32 cochlear implantations were performed, 5 of them for children with at least one associated disability: cerebral palsy (n=3), Down syndrome (n=1), autistic spectrum disorder (n=2).

To evaluate results of cochlear implantation we used Children Glasgow Benefit Inventory scale. Parent of implanted children compared the quality of their children life before and after surgery. For each question possible answers were much better (+2), little better (+1), no change (0), little worse (-1) and much worse(-2).

All patients received Neurelec cochlear implants with Digi SP processors. The age at implantation was minimum 2, maximum 9 years old (mean 4,6). The time from surgery was minimum 27 months, maximum 64 months (mean 50,4). The overall scores ranged from 0 to 23, mean 13. All but one patients had positive answers for questions about overall life, happiness, things he/she does during the day, behavior, development, self - consciousness, the ability to spend time with friends, contacts with other members of the family and other people. It seems to be very important that also all but one stated that cochlear implantation had positively affected the children's ability to concentrate on a task and learning. Nobody observed negative changes after surgery. It is well known that hearing impairment may be devastating for cognitive, emotional and social development especially when it is present at birth. When it is associated with any mental delay or disability together they may form a vicious circle which may be stopped by cochlear implantation. The results of our study reveal that most of patients have benefit from surgery and it is also effective in the rehabilitation of other additional handicaps.

The evaluation of results is very difficult in this group of patients because of poor speech perception but it seems that there is no doubt that children with mental delay have improvement of quality of life and also benefits in daily life after cochlear implantation.

P1-10-19

Cochlear implant in children: Auditory, language abilities and school integration

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Introduction: Bilateral implantation and electrical stimulation modalities are parameters that may influence the auditory performances, it is crucial to improve in deaf children outcomes and to optimize technical aspects of cochlear implants.

Objective: To assess the subjects' auditory performance implanted in their childhood using different Neurelec CI generations.

Material and methods: Monocentric retrospective clinical trial enrolled 80 subjects implanted uni- or bilaterally with different Neurelec CI generations. Comparative study was use to compare performance between uni and bilateral implantation and Digisonic Convex and Digisonic SP cochlear implants. Patients have been evaluated at once visit with an open-set-speech recognition adapted to the age in quiet (65dB SPL) and noise (65dB SPL and SNR +10 dB SPL), PTA (Pure tone Audiometry), CAP (Categories of Auditory Perception), SIR (Speech intelligibility Rate) and school insertion were also assess.

Results: The mean implantation and assessment age were respectively 4.4 and 11.1 years. Children who underwent a bilateral surgery were implanted at 5.2 years old. A significant difference was observed in speech intelligibility between uni and bilateral implantation in quiet (60% vs. 79%, p< 1‰) and noise (42% vs. 62%, p< 1‰), no difference was noted in PTA, but a clear improvement was noted after each implantation with a mean range from 31 to 30 dB HL and 33 to 34 dB HL respectively for bilateral and unilateral subjects in 500 Hz to 4000 Hz frequencies. CAP and SIR mean scores obtained by unilateral and bilateral implanted subjects were different (p< 0.05). Children implanted with Digisonic SP, compared to Digisonic CX, showed a better performance in quiet (74% vs. 51%) and in noise (56% vs. 34%), but no difference was identify in PTA, CAP and SIR. Auditory performances outcomes improved significantly after implantation and were similar whatever the CI generation. In term of schooling, 15.8% were in regular schools, 31.6% in a specialized educational institution and 52.6% both. 50 % and 34.5% of teenagers were in higher or secondary education, and a youth was trained in a specialized educational institution.

Conclusions: Performances in bilateral subjects were significantly better than unilateral subjects on speech intelligibility in quiet and noise. Bilateral implantation in children demonstrates a better speech and language development trough SIR and CAP scores. Implantation before language acquisition is critical point in hearing rehabilitation, but technical progress in cochlear implants contributes significantly. This cohort demonstrates the importance of bilateral implantation in children and the positive effect of new technology on speech intelligibility.

P1-10-20

The fundamental frequency of voice in candidates for cochlear implantation depending on their age

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Introduction: The fundamental frequency (Fo) of voice is one of the most important parameters that characterise the individuality of the speaker. The value of this parameter changes as the individual develops and grows

Aim: To define the value of fundamental frequency (Fo) of voices of children with normal hearing and profound hearing loss in various age groups, and to assess the age-related changes of Fo.

Material and method: The material consisted of 165 children aged between 6 months and 12 years, including 79 (48%) children with profound sensorineural hearing loss that was present since birth and 86 (52%) children with normal hearing who made up the control group. The children were divided into four age groups:6 months- 1 year old; 2- 3 years old; 4-6 years old; 7-12 years old. Each of these groups had its own control group.

All subjects' voices were recorded on a digital tape-recorder under generally accepted studio conditions. Every subject pronounced the vowel “A” with prolonged phonation. Recordings were done with a condenser microphone located 10 cm away from the mouth of the speaker. Subsequently, recordings underwent acoustic analysis, performed with a digital spectrograph (KAY), and the Fo value was measured. Analysis was focused on a selected part of the isolated vowel “A”. In the case of infants and toddlers, in whom it was impossible to elicit phonation of the vowel “A”, analysis was performed on sonographically selected segments of crying sounds, which were equivalent to the “A” vowel. The measured values of vocal Fo were analyzed statistically within groups.

Results: The findings showed that the differences of fundamental frequency values between over one year old children with and without hearing impairment are statistically significant. The largest differences in Fo values were found in children between the age of 1 and 3.

Conclusions: At ages over 12 months, Fo values of hearing and deaf children show significant differences. With development and growth, vocal frequencies of both hearing and deaf children undergo progressive lowering. The largest Fo value differences between hearing and deaf subjects were found in the toddler group (aged 1-3 years). The most marked Fo lowering in hearing children takes place between ages 1 and 3. This process is delayed in deaf children and starts after the age of 3.

P1-10-21

Intonation of speakers with cochlear implant

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This study aims at analyzing the intonation of patients with a cochlear implant and comparing it to normal hearing speakers. This is done because the intonation of CI patients might be different to that of normal hearing speakers because the cochlear implant does not allow a good perception of the fundamental frequency, which is the cue for perceiving intonation. In this investigation the CI patients are divided into two groups depending on whether they are prelingually or postlingually deaf speakers. Each group was compared with an age and sex matched control group with normal hearing speakers. The target of this study are simple yes-no questions which are expected to have a rising contour of the fundamental frequency. Those utterances of CI patients were first analyzed regarding the variability of the intonation contours in comparison with normal hearing speakers. Secondly, they were measured for the rise of the fundamental frequency and compared again for CI patients and normal hearing speakers.

The results showed that CI patients varied to a great degree with respect to the fundamental frequency contour. Only 57 % of the utterances were produced with the expected rising intonation contour whereas the normal hearing speakers produced this contour at a percentage of 98 %. Furthermore, prelingually deaf CI patients had a greater variability in the intonation contour in comparison to the normal hearing control group as well as to postlingually deaf CI patients.

Looking at the measurements for the rise of the fundamental frequencies there are no clear differences between CI patients and the normal hearing control group. Comparing prelingually deaf CI patients with their matching control speakers shows also that there are no major differences in the rise of the fundamental frequency. Looking at utterances produced by postlingually deaf speakers with CI reveals that they have a greater rise in the fundamental frequency than the normal hearing speakers.

The main differences between the groups regarding the variability of the produced intonation contours are interpreted in terms of the role of auditory feedback during speech acquisition taking into account that the fundamental frequency is not perceived very well by CI patients, influencing the production of an appropriate intonation contour. The difference in the rise of the fundamental frequency comparing postlingually deaf CI patients and normal hearing speakers is interpreted as an exaggerated rise due to the memory of postlingually deaf CI patients as to how the appropriate intonation of a yes-no question sounds.

P1-10-22

Acoustic analysis of vowel production during the first year after cochlear implantation

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After cochlear implantation auditory feedback is partially restored. Therefore this study aims to investigate the development of vowel production during the first year following cochlear implantation. The German vowel system with its numerous vowels and their dispersion in the vowel space provides a versatile opportunity to get a precise overview of the articulation of vowels by cochlear implant patients. Three postlingually deafened male cochlear implant patients were recorded reading German sentences before and 1 month, 3 months, 6 months and 12 months after activating the speech processor. Measurements were made of the fundamental frequency (F0), the first and the second formant frequencies (F1 & F2), relative vowel durations of seven German vowels /a:, e:, i:, o:, u:, ɵ:, ɣ:/ and of the vowel spaces.

The results showed increased F1 values for all speakers one year after activation of the speech processor compared to the first recording. Therefore, the vowels are more open. The F2 values also increased for every speaker, except for the high, front vowels /i:/ and /e:/. There is no such clear tendency for the F0 and duration measurements: For two of the speakers the F0 values decreased from the first measurement before activating the speech processor to one year after. For the third speaker F0 increased. It is the same for the relative vowel durations: The relative durations increased for two of the three speakers, for the third one it is the opposite tendency. Against our expectations during the first year of cochlear implant experience, the produced vowel spaces are all getting smaller for all of the three speakers.

These results suggest that the positive effect of regained auditory feedback after cochlear implantation on the vowel production of cochlear implant speakers needs longer than one year to be measurable.

P1-10-23

Speech perception in adult patients, users of Digisonic® SP cochlear implant with Saphyr processor

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Introduction: In Brazil, Cochlear Implant surgeries have been covered by the Public Health System (SUS), since 1993. National studies have investigated the results of speech perception in adult users, by comparing different models and makes of devices. This investigation is important, so as to aid in the suitable indication for different cases submitted to surgery.

Goals: To analyze the results of long-term speech perception of adult patients, users of cochlear implants with the Digisonic® SP system and Saphyr speech processor.

Material and methods: The study was developed at the Cochlear Implant Section/Audiological Research Center (CPA) at the Craniofacial Anomalies Rehabilitation Hospital with the University of São Paulo at Bauru (HRAC/ USP-Bauru). The results of the records of 4 adult patients users of unilateral cochlear implant with the Digisonic® SP device and Neurelec Saphyr speech processor were assessed in four distinct moments (pre-surgical moment, com CI at electrodes activation, at 3 and 6 months of device use) of the audiometry in free field and closed an open-set speech perception (Bevilacqua, 1996 ;Lacerda, 1976;Oliveira, 1992).

Results: Case 1 achieved better results in open settings for the recognition of monosyllables and sentences when compared to other cases because it is a post-lingual hearing loss. Subsequent clinical cases showed a pre lingual hearing loss, in which the long-time hearing deprivation significantly reduces the chance of winning speech recognition after surgery.

Conclusion: Despite the variability in all the cases analyzed, the results suggest improvement in the auditory skills and in the speech perception tests following 6 months of effective use of the Digisonic® SP device and Saphyr speech processor. The patients presented excellent results in closed-set speech recognition and began open-set speech recognition, besides reporting improvement in their quality of life following CI surgery.

P1-10-24

Analysis acoustic in children voice user cochlear implants

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Objective: The purpose of the study is to perform a computer acoustic analysis in a group of users with pediatric cochlear implant and without the device.

Patients: This study involved 30 patients aged 4 to 18 years cochlear implant users with a minimum of 2 years at the time of testing.

Measures: Patients were tested under two conditions. With and without the cochlear implant to carry out the study program analysis and synthesis of voice use praat.

The acoustic analysis was performed using the vowels (a / o / i), an encouraging and comfortable for child phonation. The microphone was placed to 15 cm once the digitized signal was calculated:

- Jitter (frequency variation cycle to cycle)
- Shimmer (amplitude variation cycle to cycle)
- -Noise to harmonic ratio (NHR)
- Fo: Fundamental frequency

Results: The voice in the hearing impaired qualities child have been using computerized methods described, showing associated with differential characteristics sensory deficit. Inadequate auditory feedback is likely to affect the loudness level overall, rhythmic organization, and melodic variation in speech resulting in reduced and even intelligibity overall quality of the utterances although the might have increased effort articulatory . Find differences with lows f0 rise of the results of children with and without implant cochlear. However, was noticed an improvement in the measurements of jitter (p = 0.005) and zimmer (p = 0.020) boise and to harmonic ratio (p = 0.012)

Conclusion: The determination of jitter, shimmer, f0 to harmonic noise ratio and were a good indicator of early and improved control in young children phonation with and without the device. This analysis will open futures studies of relevant points to consider in fittings and rehabilitative aspects concerning the qualities of the voice in patients cochlear implant.

P1-11 Auditory neuropathy

P1-11-1

Etiological and rehabilitation dilemmas in late on set auditory neuro pathy spectrum disorder

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Auditory neuropathy Spectrum disorder is a hearing disorder in which sound enters the inner ear normally but the transmission of sound from the inner ear to brain is impaired. It's a new diagnosis that has challenged professionals to identify the exact etiology of the disorder .The diagnosis of infant and childhood auditory neuro pathy is relatively common compared to the late onset ANSD. The objective of the study was to compare the etiologies and performance of amplification devices in late onset ANSD. 20 patients were identified with similar audio logical profile, including present OAEs and cochlear micro phonics and absent ABR with degree of moderate to severe sensory neural hearing loss. The method involves total of 20 patients diagnosed having late onset ANSD identified above 12 yrs between 2001 to 2004 in our hospital. We prepared a proforma for taking detailed history of these 20 patients and also give a trial of different types of amplification devices including cochlear implantation in four of the patients. The result shows that the etiology of late onset identified auditory ANSD does not follow the common etiologies that are observed in infant and child hood with similar audio logical profile. There is no significant benefit in using amplification devices in these patients except those patients who underwent the cochlear Implantation who showed variable results.

Keyword: auditory neuropathy, etiology, amplification devices, late onset, infant and child hood ANSD,

P1-11-2

Evaluation of the results of cochlear implant among prematures and fullterms with perinatal or postnatal hypoxia

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Objective: Preoperative evaluation of the type of deafness before cochlear implant for all deaf children with severe bilateral sensorineural hearing loss with history of perinatal hypoxia in order to assess the mechanism of deafness among prematures and full term with a history of perinatal hypoxia.

Study Design: A longitudinal study of all pediatric cochlear implant patients referred to Sydney Cochlear Implant Centre who had history of perinatal or postnatal hypoxia or asphyxia. Electrophysiological data were collected retrospectively and prospectively and analyzed. Some oto-acoustic emissions (OAE) data was collected during the neonatal period prior to referral for cochlear implant.

All subjects were tested using round window electrocochleography (RWEcochG), auditory brainstem responses (ABR), and implant-evoked electric auditory brainstem responses (EABR). The tested group consisted of 57 profoundly deaf child who experienced hypoxia or asphyxia in their perinatal period is further divided into two subgroups, prematures (their gestatic age is below 31w) and fullterms (born after 31weeks of gestation).

Cochlear implantation was done for all studied cases and evaluation of the results was done using electric ABR and numerical interpretation was done in the monopolar, bipolar mode and compared to the behavioral responses

Institution: Alexandria School of medicine Alexandria Egypt

Keywords: Auditory neuropathy, otoacoustic emissions, round window electrocochleography, electric auditory brainstem potentials.

P1-11-3

Assessment of speech perception and language in children with Auditory Neuropathy Spectrum Disorder users of cochlear implant

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The cochlear implant is indicated for habilitation and rehabilitation of patients with Auditory Neuropathy Spectrum Disorder (ANSD). The characteristics inherent to this type of hearing impairment may determine additional difficulties for developing more complex listening skills, such as the perception of speech sounds in noise. Thus, the aim of this study was to investigate the speech perception and language in children with ANSD users of cochlear implant. The study has been carried out at the Audiological Reserch Center, Hospital for Rehabilitation of Craniofacial Anomalies*, University of São Paulo, campus Bauru, Brazil*. The HINT / BRAZIL (Hearing in Noise Test - Brazilian Portuguese version), proposed by Nilsson et al. (1994) and adapted to Portuguese by BEVILACQUA et al. (2008) was used to perform the speech perception in noise test. In addition, were carried out the Meaningful Auditory Integration Scale (MAIS) or the Infant-Toddler Meaningful Auditory Integration Scale (IT-MAIS) and Meaningful Use of Speech Scale (MUSS). The sample consisted of 26 children, being 14 children with ANSD users of cochlear implant (experimental group) and 12 children with sensorineural hearing loss users of cochlear implant (control group). The results showed no statistically significant performance between groups in relation to speech perception in noise test. The evolution of auditory and language skills was similar for both groups. Thus, children with ANSD can benefit from cochlear implants.

P1-11-4

Clinical picture of patients with auditory neuropathy

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Objectives: To describe the clinical picture of the patients with the key clinical feature of hearing loss for pure tones and reduction in speech discrimination out of proportion to the pure tone loss, having some of the criteria of auditory neuropathy (i.e. normal otoacoustic emissions, OAE, and abnormal auditory brainstem evoked potentials, ABR) and lacking others (e.g. present auditory reflexes).

Methods: During 1997 - 2013, in a retrospective study, patients' records were reviewed and the results of OAE and ABR and pure tone audiometry (PTA) were tabulated as well as speech discrimination scores (SDS), measured in all patients using a standardized list of 25 monosyllabic Farsi words at MCL in quiet.

Results: Both ears of 50 patients (32 males and 18 males) comprised the study population. Mean age at the onset was 15.2±3.5. Hearing thresholds were measured at 250 to 8000 Hz at octave intervals. SDS had a mean±SD of 29.2±30.7. A strong significant correlation was noted between SDS and hearing threshold. Six samples (33%) had auditory reflexes. All of the patients were suffering from different degrees of tinnitus. Four patients were able to hear music, without understanding the words of the singer, although the SDS in all of them was no more than 10.

Conclusions: Reviewing the medical records revealed deterioration of hearing and speech discrimination over time. Although in most of the cases the hearing loss had been more apparent in the lower frequencies, a stronger correlation was found between SDS and hearing threshold at higher frequencies. These patients may not benefit from hearing aids, as the outer hair cells are functional and amplification doesn't seem to help; though, it was tried for all.

P1-11-5

The auditory characteristics of children with narrow Inner Auditory Canal (IAC)

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Objective: To report the auditory characteristics in children with narrow inner auditory canal. To assess whether the narrow inner auditory canal is associated with auditory neuropathy spectrum disorder (ANSD).

Materials and methods: A total of 11 children (1.2-5.8 yrs) with narrow inner auditory canal (4 unilateral, 7 bilateral) participated in this study. We measured middle ear impedance, brainstem auditory evoked potentials (BAEP), distortion-product otoacoustic emission (DPOAE), behavioral threshold and cochlear microphonic (CM). 10 children who have no congenital malformation in inner and middle ear with profound sensorineural hearing loss were as controls, age-matched.

Result: There was no significant difference between the subjects with narrow IAC and the comparison group in most of audiological examinations. As the behavioral thresholds using warble-tone audiometry shown, all the subjects in the two groups suffered from profound hearing loss. In the BAEP tests, Wave V was not confirmed in the two groups. All the children had an “A” type of tympanogram, with compliance peaked near zero decapascals. And there was no response in the reflex. In addition, none of the subjects had positive DPOAEs in majority of the test frequencies (from 500HZ to 8000HZ). However, there was a significant difference (P=0.000001) between the two groups in CM. For the subjects with narrow IAC, 83.3% of ears were confirmed normal CM, while there were none of ear confirmed normal CM for the comparison group. According to the criteria of ANSD (presence of OAEs and/or CM; absent or altered BAEPs), ANSD were seen in most of the children with narrow IAC.

Conclusion: The children with narrow IAC have a much higher prevalence of ANSD.

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P1-11-6

The influence of agc settings for speech recognition in eight cochlear implanted patients with auditory neuropathy

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Objectives: Auditory neuropathy affects the synchronous activity of the auditory nerve, but not the cochlear amplification function. The aim of this study is to find out how modifying the compression and AGC system's characteristics of the speech processors of the cochlear implanted patients that suffers of auditory neuropathy, is influencing the speech understanding in and noisy environments. Patients with neuropathy that are wearing hearing aids have better results at speech audiometry for linear amplification or minimal compression settings. We know that some children benefit more from a cochlear implant than from hearing aids. We can have a clue on how certain settings of the fitting parameters can improve the speech understanding.

Methods: We tested a number of 8 patients wearers of MEDEL cochlear implants and diagnosed prior to implantation with auditory neuropathy. They are completing a series of speech understanding tests with different configurations of settings of the compression and AGC parameters. They were tested both in silent soundproof rooms and in noisy listening situations.

Results: The results were analyzed to see if there is any statistical significant relation between the configuration of the AGC system and compression settings and speech understanding for patients with auditory neuropathy.

Conclusions: In CI users with auditory neuropathy, the speech understanding tends to be better in certain configurations of settings of the compression ratio of AGC system.

P1-11-7

Our experience of paediatric cochlear implantation in auditory neuropathy spectrum disorder

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Introduction: Auditory neuropathy (AN) was first reported by Starr et al in 1996. In a study from Berlin et al. (2010), it was demonstrated that 85% of the patients diagnosed with auditory neuropathy spectrum disorder (ANSD) had developed improved speech comprehension and language acquisition with a cochlear implant (CI). We would like to present eleven ANSD patients who underwent cochlear implantation at Birmingham Children's Hospital, UK.

Aim: To report the outcomes of cochlear implantation in paediatric ANSD patients

Methods: We retrospectively reviewed eleven patients with ANSD who were referred as candidates for cochlear implantation. Categories of auditory performance (CAP), speech intelligibility rating (SIR) and communications earplug (CEP) scores were measured. All patients underwent vigorous cochlear assessment and counseling. Pre-operative investigations included MRI and CT scans, and audiology and speech and language assessments.

Results: Average age of patients who underwent a cochlear implantation was 3.5 years (range 1.5-4 years). Three patients had bilateral simultaneous implantation, seven sequential and one unilateral as declined a simultaneous implantation. Six children were born premature and one of these had ototoxic drugs. Past medical history included congenital CMV, cerebral palsy, jaundice and several blood transfusions. Sound field test pre implantation was moderate to profound in four patients, severe to profound in three and profound in three. Sound field post cochlear implantation was 15-30dB in two patients, 25-30 in two, 35-40 in three, 35-45 in two and one has not been tested. CAP scores were measured in 8 patients with scores of 7 in one patient, 6 in three patients, 5 in three patients and 4 in one. Therefore were at the very least able to discriminate some words without lip reading to being able to understand a conversation without lip reading. SIR scores were also measured in 8 patients with a score of 2 in three patients, 3 in two patients, 4 in one and 5 in two patient which varied from unintelligible speech to intelligible to all listeners. CEP score was measured in 8 patients with a score of 6 in two patients, 4 in two, 3 in two and and 1 in two patients. Only two children attended a school for the deaf.

Discussion: Results have been variable in the literature and remains a controversial topic. Cochlear implantation has benefited the children in this study.

Conclusion: To our knowledge, cochlear implantation in children with ANSD has shown promising results and this is reflected in a number of outcomes such as by the improvement in sound field tests

Learning outcome: Detailed assessment is paramount and should not be delayed. Auditory neuropathy patients can benefit from a cochlear implantation.

P1-11-8

The pmn/pmn mouse, an animal model for auditory neuropathy?

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Auditory neuropathy (AN) is characterized by absent or abnormal auditory brainstem response (ABR), while otoacoustic emissions (OAE) and/or cochlear microphonics (CM) are present. These findings indicate that the hair cell function is normal, but the lesion is at the level of the hair cells synapse to the afferent nerve fibres or the auditory nerve itself. Individuals with AN can have various degrees of pure tone hearing loss and generally have disproportionately poor speech understanding. In contrast to individuals with non-AN hearing loss, hearing aids may provide little help in speech understanding in most individuals with AN. Cochlear implantation has been shown to enhance speech understanding in most cases of AN.

A detailed and profound knowledge about cochlear organization and function can be the basis for future therapeutic strategies for AN. One approach to investigate AN is the use of animal models, like the progressive motor neuronopathy (pmn/pmn) mouse. This mouse line has been originally described as a model for a fast developing motoneuron disorder and is characterized by a progressive axonal degeneration of peripheral nerves. The genetic defect is the homozygous mutation of the TBCE gene, which leads to a dysfunctional co-factor of the tubulin-dimerization. This results in a disturbance of the microtubule assembly, which negatively influences the axonal function. In addition animals develop a profound hearing loss.

In order to reveal the origin of this hearing deficiency, affected animals were investigated by electrophysiological experiments including DPOAE and frequency-specific ABR. Additionally histological examinations of the cochlear structures and the auditory nerve including confocal microscopy and transmission electron microscopy were performed.

Electrophysiological measurements displayed elevated thresholds in ABR measurements in pmn/pmn mice starting postnatal week 3. In addition DPOAE thresholds were elevated. Histological investigations revealed a degeneration of microtubules in normally myelinated auditory nerve fibres, accompanied by a secondary loss of outer hair cells. The TBCE protein was specifically stained in cochlear outer hair cells and inner pillar cells.

These results imply that the pmn/pmn mouse represents a neuronal and cochlear type of hearing loss due to tubulin dysfunction. Despite the loss of outer hair cells it may be used as a new animal model for auditory neuropathy. Especially since it is known, that in AN patients a secondary dysfunction of outer hair cells develops. Due to the fast developing pathology in the pmn/pmn mouse, the model might be particularly useful for the testing of potential pharmaceutical strategies for future therapies of AN.

P1-11-9

Relationship between patients with clinical auditory neuropathy spectrum disorder and mutations in GJB2 gene

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Intro: The auditory neuropathy or auditory dyssynchrony is a condition in which there is involvement of the auditory nerve fibers in nerve conduction with dyssynchrony.

Objective: To analyze the pattern of clinical relationship between patients with clinical auditory neuropathy spectrum disorder and *GJB2* gene.

Study Design: Retrospective analysis.

Setting: Tertiary referral center.

Patients: Clinical information and genetic evaluation (*GJB2*) of 45 patients with *AUDITORY NEUROPATHY SPECTRUM DISORDER* were analyzed.

Intervention: Diagnostic.

Main Outcome Measures: Included in the study, 45 patients with bilateral hearing loss and clinical diagnosis of ANSD. The genetic evaluated are described below.

Conclusions: The diagnosis of auditory neuropathy should be considered in patients with bilateral hearing loss initiated through adolescence. GJB2 gene could be related to ANSD.

P1-11-10

Cochlear implantation versus hearing amplification in patients with auditory neuropathy spectrum disorder

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Objective: Patients with auditory neuropathy spectrum disorder (ANSD) exhibit altered neural synchrony in response to auditory stimuli. Cochlear implantation (CI) is thought to improve neural synchrony in response to auditory stimuli and improve speech perception relative to conventional hearing amplification (HA).

Study Design: Retrospective review.

Setting: Tertiary otologic practice.

Subjects and methods: Subjects included patients with ANSD treated at Vanderbilt University from 1999 to 2011. Sixteen patients underwent CI, and 10 received binaural HAs. Pretreatment performance was assessed through speech reception thresholds and parent questionnaire (Infant-Toddler Meaningful Auditory Integration Scale [IT-MAIS]). Post treatment outcomes were assessed using IT-MAIS and closed-/open-set speech perception scores.

Results: Two HA users underwent neuromaturation and were excluded from further analysis. For the remaining patients, median duration of device use was 48 months. All CI patients had a prior binaural HA trial with failure of auditory skills development. Median available pretreatment IT-MAIS score was 13 and 30 for CI and HA groups, respectively (rank sum test, P = .32). Posttreatment, 6 of 16 CI patients and 4 of 8 HA patients achieved open-set speech perception scores ≥ 60%. No differences between groups were found in posttreatment IT-MAIS scores (rank sum test, P = .11) or the percentage of patients achieving the above levels of open-set speech perception (Fisher exact test, P = .67).

Conclusions: A wide range of speech perception outcomes are observed in ANSD patients. In our ANSD population, patients who exhibited failure of auditory skills development with HAs were able to achieve comparable overall speech perception outcomes after CI relative to those who continued to make appropriate auditory progress with HAs alone

P1-12 ABI

P1-12-1

Temporal coding of neuroprosthetics in the central auditory system: Comparison of optogenetic, electrical and acoustic stimulation of the cochlear nucleus

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Introduction: Hearing outcomes vary widely across users of auditory implants. One possible explanation for this variability may be limited spatial selectivity due to the spread of electrical current. One approach to improve outcomes is to increase the number of electrode channels on an implant array, but 'cross-talk' and side effects may be limiting factors. Alternatively, a neuroprosthesis based on optogenetics may be able to increase spatial resolution by increasing the number of potential channels and reducing current spread. The most widely used opsin in neuroscience is channelrhodopsin-2 (ChR2) and despite its potential to increase spatial resolution, ChR2 may not possess the temporal kinetic properties necessary to encode auditory information. In this study, we investigate the temporal resolution of an exciting new opsin called Chronos in the auditory brainstem and compare its temporal properties to that of ChR2-, electric- or acoustic-based stimulation.

Methods: A left suboccipital craniotomy was performed in CBA/CaJ mice, and an adeno-associated viral vector (AAV) with ChR2 or Chronos was injected into the ipsilateral CN. After a 4-6 week survival period, the left CN and right inferior colliculus (IC) were exposed. Multi-unit recordings from the central nucleus of the IC were measured in response to acoustic, electric or optogenetic stimulation (via a blue-light laser fiber of 473nm wavelength placed on the surface of the CN). For electric stimulation of the CN, we used customized rodent electrodes designed at École Polytechnique Fédérale de Lausanne (EPFL). At the conclusion of the experiment, animals were perfused and the brainstems were harvested. Post-experiment histology was analyzed to localize opsin expression in neural tissue. Raster plots based on data were generated.

Results: The synchronization index (SI), peaked at ~0.7 below 50 Hz and was < 0.2 above 100Hz in ChR2 mice. In contrast, the peak SI in Chronos mice was similar for frequencies < 50 Hz, but SIs $\geq$ 0.5 were maintained at higher stimulation rates compared to ChR2. SI of ChR2 and Chronos were lower compared to electrical and acoustic stimulation controls. Both ChR2 and Chronos cases demonstrated clear stepwise activation thresholds. Post-experiment histology revealed transfection of the cochlear nucleus.

Conclusion: Chronos has a higher synchronization index compared to ChR2 at increasing levels of stimulation at the level of the cochlear nucleus. Our results demonstrate the need to consider temporal properties of opsins when used in the auditory system as the relay of speech signals depends on high rates of stimulation. These studies may demonstrate that Chronos is the ideal “auditory opsin” for light-based manipulation of auditory pathways and basis for a new neuronal stimulation paradigm based on optogenetics.

Funding: MED-EL, Bertarelli Fondation, New England Otoloaryngological Society, and the NIDCD.

P1-12-2

Auditory Brainstem Implants: Indications and contraindications

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Auditory Brainstem implants (ABI) are the standard hearing rehabilitation method for Neurofibromatosis type-2 (NF-2) patients in which the cochlear nerve is absent. However their results do not reach those of cochlear implantation. For this reason, when the cochlear nerve is preserved, hearing rehabilitation should be always attempted first with a cochlear implant (CI).

Other indications of ABI include situations in which it is not possible to place a CI, such as totally ossified cochlea, major malformations and aplasia of the cochlea and cochlear nerves. Recently, the number of non NF-2 indications for ABI in the literature is increasing. However, there are situations in which an ABI is not the device of choice. In cases such as bilateral temporal bone fractures, bilateral common cavity, complete cochlear ossification, advanced otosclerosis and uncontrollable middle ear and mastoid disease, CI should be attempted first. Of course, an absolute contraindication for ABI is when there is patency of the cochlea and integrity of the cochlear nerve. The objective of this study was to analyze and discuss the indications for ABI. Retrospective chart review and systematic review were conducted at Quaternary referral skull base center and referring centers.

The traditional indication for ABI is adults NF-2 patients. In non-NF-2 cases, ABI should be restricted to those patients who have no other rehabilitation options. Patency of the cochlea and evidence of an intact cochlear nerve should be examined with imaging and electrophysiologic testing. Sometimes a CI trial should be planned prior to proceeding with ABI. We have shown that in many cases a CI is still possible and CI provided better results than ABI. In vestibular schwannoma in the only hearing ear, cochlear otosclerosis, temporal bone fractures, (presumed) bilateral traumatic cochlear nerve disruption, auto-immune inner ear disease and auditory neuropathy primarily CI are indicated. Traumatic bilateral cochlear nerve disruption is exceptionally unlikely. In cochlear nerve aplasia, testing should be performed prior to meeting indications for ABI. In malformations, ABI is indicated only in severe cochlear hypoplasia or cochlear aplasia.

P1-12-3

Auditory and non-auditory responses in ABI children

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Objective: Objective of the study was to analyze type of responses (auditory versus non-auditory) to electric stimulation in children users of Auditory Brainstem Implant (ABI) systems.

Material and methods: The behavioral assessment was performed in 6 children (aged 2 to 16 years) users of MED-EL ABI system. The charge level was gradually increased on each electrode with standard fitting software.

Results: The mean number of electrodes with the responses qualified as: auditory and non-auditory were 11 and 3 respectively. Stimulation 11 out of 12 electrodes did not produce any responses in one child.

Conclusions: Responses qualified as auditory prevailed in all but one children.

P1-12-4

Results after sequential bilateral auditory brainstem implantation

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Introduction: Patients with neurofibromatosis type 2 (NF2) considered for auditory brainstem implantation usually have bilateral vestibular schwannoma, which often results in deafness. Most of these patients receive one auditory implant system (ABI) and obtain various levels of functional benefit although not achieving significant open set speech recognition. Four out of five our NF2 patients with ABIs have open-set speech recognition with their one device alone. One patients received bilateral ABIs sequentially.

Methods: In 2006, after surgical removal of the tumor on the right side, 27-year-old man with NF2 was implanted with C40+ ABI system, manufactured by MED-EL, Innsbruck, Austria. The vestibular schwannoma on the left side was removed and the second C40+ was implanted on March 28, 2008. Perceptual and speech comprehension performance was assessed by free-field audiometric testing, Sound Effects Recognition Test (SERT), the monosyllabic word test and a visual analog scale (VAS). All tests were administered under 3 conditions: sound on right side only, sound on left side only, and bilateral sound stimulation.

Results: The free-field audiograms showed the same sensitivity to sounds for both sides. The SERT score for the right side and bilateral condition was 100%, and that for the left side was 80%. Bilaterally, the word recognition scores were equal to the score of the right side (70% and 50% in quiet and in noise respectively). Lack of open-set speech recognition in response to electric stimulation of the left ABI alone was most probably due to the side effects problem. Subjective sound-quality assessment rankings were 6 points, 1 point, and 9 points for the right side, left side, and bilaterally, respectively.

Conclusions: The benefit from bilateral stimulation was proved on VAS. Results of the current study demonstrated that bilateral electrical stimulation from ABIs provide at least the same or better sound perception benefit as that provided by unilateral stimulation.

P1-12-5

Auditory Brainstem Implant in four children with cochlear nerve aplasia

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Objective: The aim of the present study was to assess the possibility of hearing habilitation in four children with aplasia of cochlear nerve by stimulation of the Cochlear Nuclei using and Auditory Brainstem Implant (ABI).

Introduction: Children with profound hearing loss can be habilitated with a Cochlear Implant (CI). A condition for successful auditory stimulation is a developed cochlea and the presence of an adequate number of cochlear nerve fibres. Absence of cochlea or cochlear nerve contraindicates a CI.A similar condition, absence of the cochlear nerve, is observed in patients with Neurofibromatosis type 2 (NF2) after surgical removal of the tumor. A possible auditory rehabilitation in these cases is the insertion of an ABI. Previous studies have considered only patients with NF-2 older than 12 years old possible candidates to receive an ABI but a similar approach has been used in children with congenital cohlear nerve aplasia.

Material and methods: It is a retrospective case review. Four children with cochlear nerve aplasia (2-10 years of age) underwent retro sigmoid approach for placement of the ABI into the lateral recess. The correct positioning of the electrodes was monitored through the Electrical Auditory Brainstem Responses. These patients had radiological contraindications to CI surgery because the MRI revealed bilateral cochlear nerve aplasia, with absence of cochlea in cases 1, 3 and 4, and in case 2 bilateral cochlear malformation and nerve aplasia. The audiological outcomes were evaluated using the CID Speech Perception Categories (Geers, 1994) through the Latin American Protocol for Cochlear Implants (Cochlear Corp.), Free Field with ABI, it-MAIS and MAIS scales.

Results: No surgical or postoperative complications were observed after 72 months of ABI use in the first and second patient, 60 months in the third patient and 36 months in the fourth one. Free Field was around 25-40 dB (frequencies from 250 Hz to 4000Hz). Auditory sensations were produced in all patients with the activation of 13 electrodes in the first child, 12 electrodes in the second, 16 electrodes in the third and 15 electrodes in the fourth child. Patients have achieved speech detection and environmental sound awareness. They are showing auditory improvement in the speech perception through specific tests and Scales. All patients use the ABI in a permanent way.

Conclusion: This study suggests that ABI in children with cochlear nerve aplasia is feasible, with variable results. Speech recognition in open set is possible. Age at implant, (after the sensitive periods) and the presence of other handicaps produce poorer results.

Key Words: Auditory brainstem implant, aplasia of the cochlear nerve, speech perception

P1-12-6

Case study - paediatric ABI fitting

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Auditory Brainstem Implantation is a possible treatment for cases where the auditory nerve has been irreversibly damaged through a tumor or through surgical tumor removal. It can also be a solution for non-tumor cases, e.g., aplastic auditory nerves and/or aplastic cochlea in children.

A case study will be presented of a 2 year old non-tumor child who was implanted with a MED-EL Mi1000 Concerto Auditory Brainstem Implant in May 2013. Discussion will include clinical governance, difficulties in paediatric programming of an ABI, and audiological and rehabilitative results at 12 months post activation.

P1-12-7

Routes towards closing the auditory implant feedback loop

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Intro: Auditory processing involves several nuclei using feedforward and feedback connections [1]. The first are well-understood, but the feedback connections remain elusive aside from the general functionalities. Whilst CI patients receive effective hearing-restoration today, the cognitive load for speech comprehension is still high, especially in noisy environments.

Methods: Using the efferent system in order to improve this lies close at hand [2, 3], however neurotopological, technical and signal processing hurdles exist. First, none of the regions feature a clearly topologically distinction of efferent from afferent fibers, making them difficult to access without the confounding effect on the feedback circuits. Second, the efferent signals need to be transmitted towards the signal processor, which is beyond current technology. Third, measures for feedback suppression must be adopted. Strategies [4] known for phone conversations [5,6] may help, but need to be augmented for variable temporal loops addressing signaling delays of even 100 msec or more.

Results: At the neurophysiological level, recent advances in HDNI technology enable long-term evaluation of the brainstem auditory nuclei in unanesthetized animals with high spatial selectivity. Models have been adopted for particular changes in the gain and latency of the feedback loops among these nuclei. Autocorrelation analyses show first sets of feedback mechanisms on a computational signaling level.

Conclusion: Evoked responses in multiple heterogeneous neuronal populations provide temporally-synchronized data whose timing of activation can be used for identifying efference autocorrelates.

Discussion and learning outcome: Under the view of these findings, a route towards further development of efferent signals in CI systems is presented comprising a review on the dedicated sites for derivation with less ascending inference, signal transmission considerations and functional elements for distributed adaptive feedback suppression.

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P1-12-8

Auditory brainstem implants in children: indication criteria and results

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Originally used to restore the hearing in neurofibromatosis type 2 patients, an auditory brainstem implant (ABI) is an increasingly widespread method even for patients with a completely ossified cochlea, nerve aplasia or cochlea dysplasia, in which case a cochlear implant will not provide sufficient support.

In order to cope with the age-related development of the auditory cortex, early implantation of deaf children is recommended. Since 2006 nine children have been supplied with an ABI in our clinic. Six of these children came from abroad, and didn't participate in regular follow-ups. In these cases, the long-term outcome is difficult to predict. One child will have its first fitting in early spring time of this year; the remaining children have been wearing their devices for two and four years respectively and are showing good progress.

Test battery for our ABI children comprises the questionnaires LittlEARS, MAIS, MUSS, and FRAKIS, the sound and speech recognition tests mFast and MSVK, leading to the CAP classification.

Preliminary results of this study show that in eight children with ABI, a CAP score between 2 and 4 had been achieved.

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P1-12-9

Optogenetically-driven auditory brainstem responses (oABR) in a model of an optical auditory brainstem implant

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Introduction: Contemporary auditory neuroprosthetics are limited by electrical current spread that leads to channel cross talk and limited numbers of effective auditory channels. Optogenetics, in contrast, affords the theoretical ability to stimulate discrete neuronal populations with focused beams of light. One useful assay that has enabled us to gain insight to light driven responses is the optically evoked auditory brainstem response (oABR). Similar to the auditory ABR, the oABR is a far field averaged recording of many stimulus-evoked responses and reflects the synchronized activation of discrete auditory centers. Herein, we investigate oABR responses and discuss its importance in the emerging field of optogenetics in the auditory system.

Methods: We performed viral mediated gene transfer of two opsins, channelrhodopsin-2 (ChR2, n=7 mice) or Chronos (n=4 mice), to the CN of 4-6 week old CBA/CaJ mice using a craniotomy approach. After 3-5 week incubation, a 400μm diameter optical fiber was placed on the surface of the CN. oABRs generated with pulsed blue-light laser light (λ=473 nm) were recorded simultaneously with multi-unit activity in the inferior colliculus (IC). Post-experiment fluorescence immunohistochemistry was performed to determine the pattern of opsin expression in CN neurons.

Results: oABRs were variable across animals. In cases where high rates of stimulus driven spikes were observed in the IC, the oABR consistently showed a clear two-peak response with amplitudes ranging from 0-5 μV baseline to peak and latencies of ~0.2 ms and 4 ms respectively. In some of these cases, however, a longer latency waveform with magnitudes reaching 16 μV peak-peak were present. When the stimulus driven spikes rates were low but still significantly above spontaneous rate, oABR waveforms were not observed. Histological examination of sectioned neural tissue revealed Chronos and ChR2 expression in the CN and limited expression in surrounding brainstem areas.

Conclusion: In contrast to the auditory ABR, there is significant variability of the oABR response. Ongoing efforts to understand oABR variability includes analysis of injection site, infection efficiency, correlation between oABR magnitude/latency and spike activity in the IC, and laser placement. The oABR is an effective measure of light sensitivity in the cochlear nucleus and is an important tool for evaluation of optogenetics in the auditory system.

P1-12-10

Speech perception with auditory brainstem implants in neurofibromatosis type II patients

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Background: In neurofibromatosis type II (NF2), patients likely suffer from lesions at the acoustic nerve due to tumor growth or surgical resection of the tumor. In such cases, sometimes auditory brainstem implantation (ABI) can be a successful treatment.

Methods: 32 patients were implanted with MED-EL ABI and enrolled in a speech perception study. Individual electrodes were evaluated for non-auditory side effects at fiirst activation. Such electrodes were deactivated. Speech and sound recognition performance was determined using the SERT resp. MTP and HSM sentence tests. Subjective benefits were determined by questionnaire.

Results: SERT and MTP outcomes under auditory-only conditions improved significantly within the first year. Open set sentence recognition improved from 5% to 34% within 12 months. The number of active electrodes had no significant effect on performance. All questionnaire respondents where "adequately to very" satisfied with their ABI.

Conclusion: ABI is an effective treatment option in NF2 patients with the potential to provide open set speech recognition.

P1-12-11

Audiological outcomes in a patient implanted with a cochlear and a brainstem implant

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Objective: This study reports on a patient suffering from neurofibromatosis type II who received a brainstem implant (ABI) contralateral to a regular cochlear implant (CI). We illustrate the patient functioning with the two different devices and describe the audiological results. Supplementary, we report the frequency and loudness mismatch between the two implants and how these change over time.

Study design and setting: retrospective case review in a quaternary referral centre.

Patient: NF2 patient with post-lingual profound hearing loss implanted with CI at the age of 26 and implanted with ABI at the age of 30.

Results: The results with the CI only show a pure tone average (PTA) of 30 dBHL, a CVC word recognition score of 94% and a speech-in-noise SNR of -6 dB. At 70 dBHL the phoneme discrimination is 82%. With the ABI the PTA is 28 dBHL. Open set speech understanding score with ABI alone is 30%. Speech in noise tests show clear advantage of the combined ABI and CI condition comparing to the CI alone condition. The pitch perception with ABI is lower than with CI especially at the mid to high frequencies (differences up to half of an octave); there exists also a loudness mismatch of 25 dB between the CI and ABI, but these mismatches tend to decrease over time.

Conclusions:

1. Combination CI/ABI gives better results than the CI alone.
2. There exists a frequency and loudness mismatch between the ABI and CI, but is has a tendency to decrease in time.

Key words: Neurofibromatosis type II, cochlear implant, brainstem implant, deafness, hearing loss, hearing revalidation.

P1-12-12

Hearing restoration in vestibular schwannoma caused deafness: Report of two cases

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Objective: To explore audiologic outcome of auditory brain stem implantation (ABI) and cochlear implantation (CI) in NF2 patients and patients with vestibular schwannoma (VS) in the only hearing ear.

Patients and methods: Study includes retrospective analysis of 2 cases. One is totally deaf patient due to NF2, and the other one is totally deaf due to VS development in only hearing ear. Tumor was removed by retrosigmoid approach in NF2 patient and ABI was performed simultaneously. For the VS in only hearing ear case, tumor was removed by translabyrintine approach and CI was performed simultaneously.

Results: ABI patient showed quite well outcome during the 15 months of follow-up. She has 25 dB hearing threshold at speaking frequencies. She developed open set speech discrimination with 87.5% word discrimination score, 70% sentence discrimination score. She uses device daily manner, she can use telephone. For CI patient, outcome is not perfect but satisfactory. She couldn't develop open set speech discrimination during the 18 months of follow-up. She has 67% the disyllabic words recognition score (close set). She is daily user of device. CI improves quite well lip reading.

Conclusion: ABI and CI are the two options to restore hearing in VS caused deafness. We advocate giving every effort to preserve cochlear nerve during the VS resection and place CI simultaneously. However if it is not possible to preserve cochlear nerve during surgery, ABI is also a good alternative for hearing restoration.

Key words: auditory brain stem implantation, cochlear implantation, NF2, vestibular schwannoma, only hearing ear, deafness.

Original work was under reviewing process to be published in a journal.

P1-13 Bone conduction devices

P1-13-1

Modified skin insicion in new Baha Atract implant

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Objective: Percutaneous bone anchored hearing aids (Baha®) are accepted as gold standard therapy of conductive type hearing loss. Main disadvantage of the percutaneous abutment are skin problems including local infections, skin overgrowth, wound dehiscence and implant loss. By transcutaneous Baha® implants these complications could be avoided. The new transcutaneous Baha® of Cochlear Company, Baha® Attract system, has been released on market. Reverse C skin incision is advised for implanting this new system. Lesser occipital nerve and posterior auricular nerve innervate the skin in retroauricular area. But advised skin incision for new Baha® system may have a risk of damage of branches of these nerves. Additionally auricular reconstructions of patients with auricular dysplasia become very hard because of this incision type. In this preliminary study wound healing and sensory innervation of postauricular skin were evaluated in between reverse 'c' incision and 'clockwise ninety degree rotated 'c' incision.

Material and methods: Twelve patients implanted in Turkey with Cochlear™ Baha® Attract System included the study. Experienced surgeons from two centers, Istanbul University and Kocaeli University, performed all the surgeries. Quality of life, numbness on the implant site and wound healing were evaluated.

Results: The overall mean age was 27.6 years with a range with 5 to 65 years. Of these patients, 7 had ninety degree clockwise rotated 'c' skin incision, 4 had retroauricular advised reversed 'c' skin incision . In reversed 'c' skin incision numbness was found but in the latter incision there was no numbness on the implant side. There were no complications in both groups about wound healing. Patients satisfaction were same in both groups.

Conclusion: Temporalis muscle fascia can be identified easily by superior skin incision and skin numbness could be avoided over the implant. This incision may be preferable in patients with auricular dysplasia whose also auricular reconstruction is planned. But more comparative study is needed for evaluation of these different type of incisions.

P1-13-2

Investigating the skin-abutment interface of the Cochlear Baha DermaLock - evidence of integration?

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Introduction: Recently a new bone anchored hearing systems abutment, the Cochlear™ Baha® DermaLock™, featuring a Hydroxyapatite (HA) coating was introduced. It was hypothesized that this should enable integration with the adjacent skin when used in combination with soft tissue preservation surgery. The resulting sealed skin-abutment interface should prevent bacterial colonization and reduce peri-implant dermatitis. So far only evidence from animal research or research in related fields was available to support the primary theory. Here we investigate, in vivo, if skin integration is possible in patients using the commercially available percutaneous HA-coated DermaLock abutment.

Methods: An abutment (respectively titanium and HA-coated) together with the surrounding skin was surgically retrieved from two patients who had a medical indication for this procedure. The abutments and surrounding tissue were directly fixated and processed for analysis. Histological sections of the skin were investigated using light microscopy and Transmission Electron Microscopy (TEM). The abutment was qualitatively analyzed using Scanning Electron Microscopy (SEM).

Results: The titanium abutment only had an estimated partial (< 30%) and thin layer of attached biological material (< 30 µm thick) which seemed to be constituted of a combination of proteins, sebum, biofilm, immune cells and unorganized skin cells. The HA-coating was fully covered (>90%) by a pronounced thick (> 60 µm) layer of skin which seemed to be organized and composed out of different interconnected structural layers.

Conclusion: In vivo evidence supporting the claim that the Cochlear Baha DermaLock can establish skin integration is presented. This research will be extended to further explore the constitution of skin integration. An ongoing Randomized Controlled Trial should indicate if skin integration also results in favorable clinical outcomes.

P1-13-3

Imaging after Bonebridge implantation

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Introduction: The Bonebridge is a quite new bone conduction hearing aid. One advantage is the transcutaneous transmission of signals which minimizes the risk of infections. Disadvantages are the bigger size and the more invasive kind of surgery. In comparison the alternative of the active middle ear implants it the approval for MRI up to 1.5 Tesla. Nevertheless, the influence of the implant on a postoperative imaging is unclear.

Methods: Two fresh cadaveric human heads were implanted with a Bonebridge System in the mastoidal approach. Afterwards, different kinds of imaging (computed tomography, cone beam computed tomography, 1.5 and 3.0 Tesla MRI) was performed. Especially in postoperative MRT-scanning different sequences and new metal artefact reduction sequences (MARS) were performed. Images were analyzed regarding the artefacts and possibilities of visualizing inner- and middle ear structures as well as structures of the brain.

Results: Despite the existence of the implant an excellent visualization of the middle and inner ear structures was possible by CBCT and CT (fig 1).

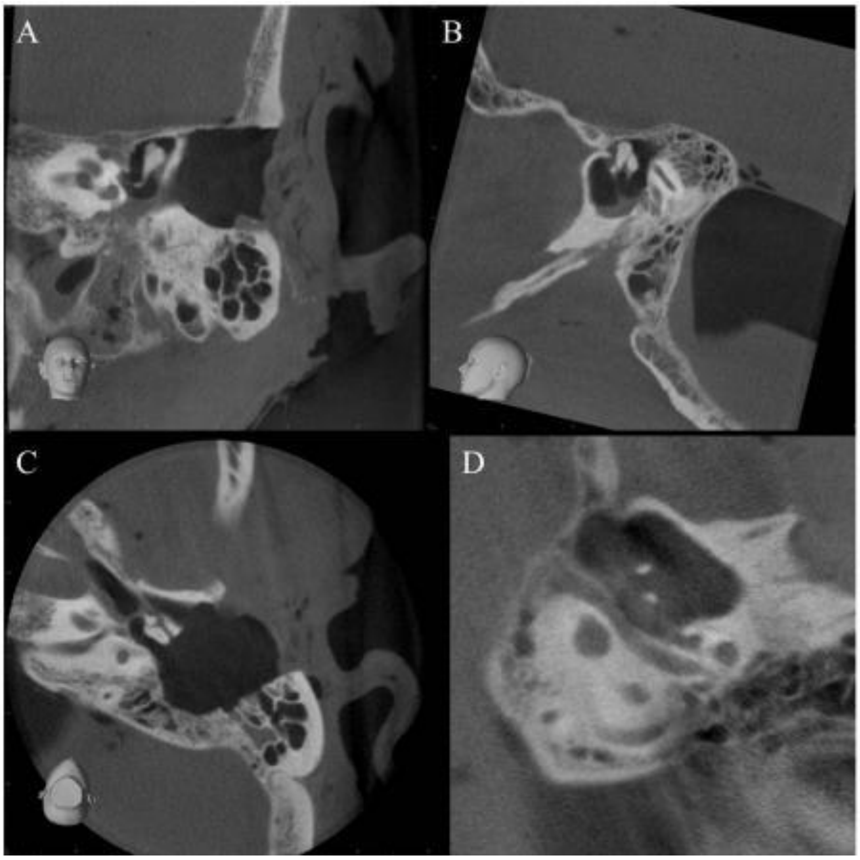

Figure 1

Cone beam computed tomography of the ear after implantation of the Bonebridge on the ipsilateral side. The visualization of the important structures:
A – skull base, incu-malleolar joint
B – horizontal semicircular canal, skull base
C – cochlea, mastoid, middle ear
D – horizontal part of facial nerve) is still possible.
Furthermore, visualization of internal auditory canal is no problem.

[figure 1]

Even the inner ear canal could be evaluated. In 3.0 T MRI the artefacts were huge, so now evaluation of head was possible at all. At 1.5 T MRI a head shadow effect could be seen for at least half of the head. Interestingly, significant differences could be seen in dependence of the sequence and the orientation of admission. The new MARS sequences showed a further improvement of the imaging quality. So an evaluation of contralateral ear (with inner ear canal) was possible (fig 2).

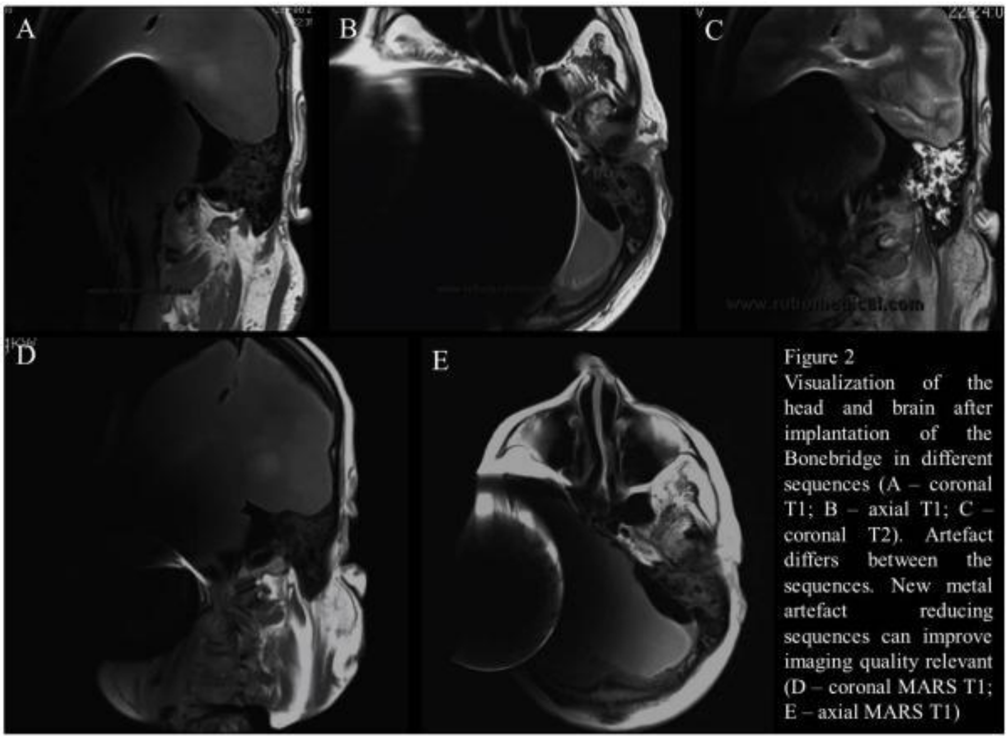

Figure 2 Visualization of the head and brain after implantation of the Bonebridge in different sequences (A – coronal T1; B – axial T1; C – coronal T2). Artefact differs between the sequences. New metal artefact reducing sequences can improve imaging quality relevant (D – coronal MARS T1; E – axial MARS T1)

[figure 2]

Conclusion: No relevant limitations exist in imaging of the middle and inner ear after implantation of the Bonebridge using CT or CBCT. Regarding MRI, as expected relevant artefacts could be detected. Further research has to focus on different sequences and orientation of primary admission and potential of metal artefact reducing sequences to improve the imaging of brain and contralateral ear after implantation.

P1-13-4

localization skills in single side deafness patients with bone conduction hearing devices

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Introduction: Single Side Deafness (SSD) is defined as a permanent sensorineural hearing loss of any degree in one ear with normal hearing in the other ear. Binaural hearing is essential for auditory localization, defined as the ability to determine the source of a sound in the horizontal plane (azimuth).BAHA was approved by FDA since 2002 for the rehabilitation of patients with SSD. Another kind of bone conduction devices for the management of SSD patients are BCHA (Bone Contact Hearing Aid), they are in contact with the bone without osseointegration and surgery, among these is CONTACTMINI (BHM-TECH Grafenschachen 242)

Materials and methods: 8 patients BAHA users for SSD management were included, they were patients with sensorineural hearing loss severe to profound in the affected ear and with normal hearing in the contralateral ear.MethodsLocalization tests were performed in a sound-treated room, dimensions were 10 x 10 feet, with 5 speakers to 4 feet away from the patient, and located at 0 º, 45 º, 135 º, 225 º, and 315 º azimuth In a simulated sound field through Software MySound®, localization tests were performed with both bone conduction hearing devices both silence and noise using random stimuli by the 5 speakers. In silence, each patient received randomly phonetically balanced verbal stimuli of human voice recorded in professional studio, at 55 dB, with a duration of 3 seconds on each speaker, three times by each speaker, by a total 15 stimuli. The same test was performed with background noise of 65 dB in the 5 speakers simultaneously and each correct response was recorded to express it as a percentage of localization.

Results: Patients with SSD have great difficulty localizing sounds from the front and from the affected side in silence, and the evaluated hearing devices don't improve this disability, also, in background noise, patients with SSD have a have a total disability to locate both the front and from the affected side, furthermore, the localization skills from the healthy ear decreases and the evaluated hearing devices don't improve this disability,.

Discussion and conclusions: Patients with SSD lose the benefits of binaural hearing, among them the ability to location of the sound source, neither BAHA and CONTACMINI improve the localization skills.

P1-13-5

A new transcutaneous transmission path for Baha® users: Comparison with the test bands and the percutaneous abutments

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Introduction: Current conventional Baha systems transmit sound through a percutaneous implant directly to the skull. The effectiveness of this approach has been shown repeatedly. Recently, a new transcutaneous system named Baha Attract has been proposed. In this system, vibrations are transmitted from the external sound processor through the intact skin to an internal magnet attached to a standard Baha fixture. The aim of this study was to investigate the effect of this new transmission path on hearing and speech understanding.

Methods: Baha attract transmission paths were simulated in 16 adult, experienced Baha users by attaching a magnet on the existing abutment. Artificial skin (thickness 5.6 mm) was inserted between this magnet and the sound processor magnet. All subjects were tested in 4 different conditions: (1) With a Baha BP110 Power attached directly to their implant (2) with the same processor and a test band, (3) with simulated Baha attract transmission path with a magnet resulting in a force of 1 N, and (4) with a simulated Baha attract transmission and a force of 2 N. In each condition, the following data was collected: bone conduction thresholds measured through the sound processor, aided sound field thresholds, speech understanding in quiet at 65 dB, and speech understanding in noise.

Results: Bone conduction thresholds measured through the sound processor were similar for all conditions for frequencies up to 500 Hz. Above 500 Hz, they were lowest for direct attachment at the abutment. Compared to the other 3 conditions, the difference increased from 4 dB at 1000 Hz to over 16 dB at 6000 Hz. Aided sound field threshold were similar for all for conditions up to 3000 Hz. They were significantly better in condition (1) by more than 9.5 dB above 3000 Hz. There was no significant difference between conditions (2), (3), and (4). Speech understanding in quiet was best in condition (1) (86 % correct on average) and poorest with the test band (condition 2; 69 %). The Baha attract transmission paths ranged between these values (74%). Similarly, speech understanding in noise was best in condition (1) (SNR of 10.2 dB), intermediate with the simulated Baha attract modes (10.5 dB), and poorest in condition (2) (12.0 dB). There was no significant difference between the two magnet strengths in any test.

Discussion: Transcutaneous sound transmission attenuates sound at frequencies above approximately 1000 Hz. This attenuation can be partially compensated by the sound processor.

Conclusion: The simulated transmission path of the Baha Attract system shows higher high frequency attenuation than the direct percutaneous path. Nevertheless, speech understanding in quiet and in noise are even slightly better than with a Baha using a test band.

Learning outcome: The Baha Attract system is expected to attenuate higher frequencies sounds, but speech understanding should be equal or better than through a test band.

P1-13-6

Linear incision with no soft tissue reduction BAHA insertion: preliminary results

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Purpose: To describe the experience and outcome of linear incision for BAHA implantation without soft tissue reduction over a year.

Methods: Retrospective review of patients who underwent Baha insertion with linear incision technique with no soft tissue reduction in two hospitals in Manchester from August 2012 to August 2013.

Results: 57 patients were implanted with a Baha with a one stage linear incision without soft tissue reduction technique over a period of 12 months in Manchester Royal Infirmary and Salford Royal Hospital. Intraoperative complications were an excessive bleeding (1%), exposed dura (1%) and need of minor tissue reduction(1%). Average surgical time 12min. Successful postoperative outcome was achieved in 78% of the patients, therefore postoperative care and follow up visits were reduced to a 1 week and 3 months after. Postoperative complications were classified as minor (requiring conservative or local treatment) and major (needing surgical intervention). Minor complications were presented in 21% of the studied population (12 patients), 19% skin inflammation/infection, 1% skin overgrowth and 1% pain. Pain and loss of scalp sensation are minimal. Five patients required a revision surgery, a posttraumatic fixture loss was excluded because it does not depend on the surgical technique, therefore 7% presented major complications (4 patients). Failure of osseointegration represented a 5% (one due to fixture loss probably related to a small incision and soft tissue overgrowth) and skin overgrowth a 1%. Skin necrosis was not observed in any patient.

Conclusions: One stage linear incision with no soft tissue reduction technique for Baha insertion is an effective surgical technique which involves a low surgical time and less postoperative care. Few major complications were present.

P1-13-7

Bone anchored hearing device implantation: The evolution of a surgery in a neurotology practice

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Objective: Over the course of 9 years, the primary author has employed 3 surgical techniques for bone anchored hearing device (BAHD) implantation. The first employed a dermatome with soft tissue reduction, the second a skin flap with soft tissue reduction, and the third a linear incision without soft tissue reduction. This study reviewed the effects of each surgical technique on postoperative wound healing, delayed skin outcomes and surgical time.

Study Design: Retrospective chart review.

Setting: Tertiary referral neurotology practice.

Methods: All patients who underwent BAHD implantation by a single surgeon were identified. Note was taken of age, gender, surgical indication, surgical technique employed, device implanted, postoperative skin outcomes, delayed skin outcomes, surgical time, and OR time. Delayed skin outcomes were classified according to the Holgers scale. Patients were grouped by technique employed: Group 1=dermatome, Group 2=skin flap, Group 3=linear incision without soft tissue reduction.

Results: One hundred and fifty nine patients were identified who underwent 161 procedures for BAHD implantation. Thirty six patients comprised Group 1, 101 comprised Group 2, and 24 comprised Group 3. When assessing postoperative skin outcomes, 6 (16.6%) patients in Group 1, 9 (8.9%) in Group 2, and no patients in Group 3 had abnormal implant site healing, a statistically significant difference ($p=0.024$). Delayed skin reactions were seen in 3 (8.3%) in Group 1, 7 (6.9%) in Group 2, and no patients in Group 3, which was also statistically significant ($p=0.007$). Implant loss was seen in 2 (5.6%) in Group 1, 3 (3%) in Group 2, and in no patients in Group 3. Observed mean surgical time also differed with Group 1 necessitating 57.7 ± 11.9 minutes, Group 2 requiring 41.3 ± 11.3 minutes, and Group 3 taking 18.6 ± 6.0 minutes ($p< 0.001$).

Conclusions: BAHD implantation employing a linear incision without soft tissue reduction resulted in the least eventful surgical site healing and reduced incidence of delayed skin reactions with the shortest surgical time. By contrast, the dermatome technique produced the worst skin outcomes while necessitating the greatest amount of surgical time.

P1-13-8

Evaluation of the effectiveness and efficiency of the Cochlear BAHA Attract system

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Introduction: The new Cochlear Attract BAHA system is a transcutaneous device that uses a bone conduction as a way of stimulation of cochlea. In this system, as opposed to commonly used BAHA Connect device, there is no direct contact of the implanted part and external processor. The implant and the magnet are placed completely under the skin, and the processor joined to the external magnet held directly at the internal part of the device. With such an arrangement it is possible to limit the number of possible complications, primarily related to the infections in area of the implant. On the other hand, the type of signal transmission to implant may lead to a loss of power and signal quality, which might influence the subjective and objective benefits.

Aim: To assess the objective and subjective benefits of new Cochlear BAHA Attract system in patients with conductive and mixed hearing loss.

Material and methods: Material includes 8 patients, 3 males and 5 females, mean age=31, with mixed or conductive hearing loss in the implanted ear, implanted unilaterally in the Institute of Physiology and Pathology of Hearing in 2013. For the evaluation of objective benefits Polish monosyllabic word tests, the SRT measurements and free field audiometry have been used. Subjective benefit was assessed using APHAB questionnaire and own survey designed especially for this study.

Results and conclusions: The results confirm the effectiveness of treatment of the conductive and mixed hearing loss using Cochlear Baha Attract system. This new device gives the ability to improve the quality of life, as well as is accepted and tolerated by the patients in their daily lives. The Cochlear Baha Attract system could be an alternative choice to other implantable device available on the market for treatment of certain types of hearing loss.

P1-13-9

An active bone conduction implant in patients with single-sided deafness

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Introduction: Bone anchored hearing aids are one option in treatment of patients with single-sided deafness. The Bonebridge of MED-EL is the first active bone conduction implant with transcutaneous transmission across the intact, closed skin. We show the results of our retrospective study using the Bonebridge in patients with single-sided deafness.

Objective: Ten patients suffering from single-sided deafness were implanted with a Bonebridge in our ENT department between Aug. 2011 and Dec. 2012. Four females and six males with a mean age of 45 years and an age range of 21-70 years with hearing on the contra-lateral side not worse than 20 dB HL in the bone conduction (BC) at 0.5, 1, 2, 3 and 4 kHz. All sound field measurements were performed with the contra-lateral ear plugged and muffled under unaided and aided thresholds. The subjective benefit was assessed with the APHAB.

Results: Within this group of patients we achieved good audiological results with a high level of patient satisfaction. In the Freiburg monosyllable test at 65 dB the patients improved from 18% in unaided condition to 90% in aided condition with the Bonebridge.

Conclusion: The Bonebridge is an audiologically equivalent alternative to CROS hearing aids and percutaneous devices in the management of patients with single-sided deafness.

P1-13-10

Indication criteria and outcomes with the transcutaneous bone conduction implant Bonebridge

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Objective: The Aim of this study was to evaluate functional hearing gain, speech understanding, as well as preoperative bone conduction thresholds with the bone conduction implant Bonebridge.

Study Design: This was a retrospective study at a tertiary referral center

Methods: 24 consecutive Bonebridge patients were identified. 9 patients suffered from combined hearing loss (HL), 12 from atresia of the external auditory canal and 3 from single sided deafness (SSD). One patient was lost to follow up. 23 patients were therefore analyzed.

Results: The overall average functional hearing gain (FHG) of all patients (n=23) was 28.8 dB (± 16.1 standard deviation SD). Monosyllabic word scores at 65dB SPL in quiet increased statistically significantly from 4.6 (± 7.4 SD) percentage points to 53.7 (± 23.0 SD) percentage points. Evaluation of preoperative bone conduction thresholds revealed three patients with thresholds higher than 45 dB HL in the high frequencies starting at 2kHz. These three patients had a very limited benefit of their bone conduction implants.

Conclusion: The bone conduction implant Bonebridge provides satisfactory results concerning functional gain and speech perception if preoperative bone conduction lies within 45 dB HL.

P1-13-11

Speech comprehension in background noise in SSD patients using Baha after a vestibular schwannoma surgery

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Intro: Since September 2010, 13 patients after a retrosigmoid approach to the vestibular schwannoma (VS) with a consequent single-sided deafness (SSD) have been implanted with the Baha (bone anchored hearing aid).

Methods: Patients underwent testing of speech comprehension without Baha, 6 weeks and one year after the Baha setting. Score of understanding of sentences in the noise background was calculated in three different situations:

1. SnhNssd - signal from the normal hearing side, noise from the deaf side,
2. S0N0 - signal and noise from the front,
3. SssdNnh - signal from the deaf side, noise from the normal hearing side.

Tests were conducted in a sound-treated room with 3 loudspeakers situated in the angle + 45^{o}, 0^{o} and - 45^{o} in the 0.75m distance from the subject´s head.

Results: We have found no differences in S*0*N*0* situations in 65dB:65dB test configuration. For the S0N0 65dB:70dB configuration there is an improvement with Baha after 6 weeks and 1 year, but the difference is not statistically significant. The opposite situation is in S*ssd*N*nh* condition where patients reached statistically significant improvement for both 65dB:65dB and 65dB:70sB configurations, after 6 weeks and also after 1 year (p=0.037; resp. 0.0014).

Conclusion: We consider the Baha implant should be an integral part of the care for patients with SSD after vestibular schwannoma surgery. Our data proved statistically significant improvement of a speech comprehension in a background noise.

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P1-13-12

Early experience with BAHA Attract - active atranscutaeneous solutions

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Introduction: It has been observed that much of the soft tissue related problems in bone anchored hearing solutions are related to the percutaneous nature of the coupling of the device to the anchorage. The skin around the abutment also requires lifelong aftercare. Hence tissue preservation and non-skin penetration (transcutaneous) is the direction of travel for bone anchored devices. We have used the BAHA Attract system from September 2013 in selected patients.

Methods: This is a prospective longitudinal study of 10 consecutive cases of BAHA Attract surgery between September 2013 and February 2014. Data was collected perioperatively and postoperatively (at 1 week, 4 weeks and 3 months [in some]). The perioperative data included information on incision, surgical technique, skin thickness, fixture, bone polishing and surgical time. The post-operative data included soft tissue status, pain and numbness.

Results: 10 patients received the new implant. Average age was 43years (range 21 - 60). 6 were female and 4 were male. The commonest indication was conductive deafness (8) and single sided sensorineural loss (2). Two cases were performed under local anesthesia only. Average surgical time was 40minutes. All had the 4mm fixture. Average skin thickness was 6.2mm in the midpoint but varied by 1mm at the anterior and posterior rim of the flap. The incision in all cases was "C" shaped with the open limbs facing inferiorly. There was minimal nursing care required post operatively as the wound healed neatly by 1 week no hair loss and minimal numbness. No complications were reported. All reported some local numbness but none reported any pain, swelling or skin tenderness. Majority were loaded with the processes in 6 weeks and the magnet strengths varied from 2 to 4.

Conclusion: The initial experience with the non-skin penetrating BAHA Attract is positive with negligible post-operative care and no complications or patient morbidity. The results are aesthetically pleasing and has high patient satisfaction due to absence of skin penetrating abutment, no bald patch and no aftercare. Longer term results would be needed.

P1-13-13

Placement considerations for the MED-EL Bonebridge

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Intro: The Bonebridge (BB; MED-EL Corporation, Innsbruck, Austria) is a new, transcutaneous bone-conducting hearing implant (BCI) of particular interest to those with an intolerance or inability to wear conventional hearing aids and an aversion to percutaneous bone-conducting alternatives.

Where possible it is intended that the BB should be placed as close to the cochlear as possible and preferably that it should be accommodated within the mastoid region of the temporal bone, secured to the cortex with two screws. While CT scanning allows pre-operative planning, traditional mastoid placement is not always possible. Many BB candidates have had previous mastoid surgery such as mastoidectomy with or without subsequent obliteration. Some mastoids are hypoplastic, poorly aerated or simply too small to accommodate the device. In these cases an alternative position for the device must be found while insuring that the ultimate position of the external processor is optimal. Alternative placements have been described. The so-called retrosigmoid placement has evolved to deal with a prominent sinus. Skull-base experience warns us that a truly retrosigmoid position involves considerable disturbance of pericranial tissues and muscle and in addition places the device quite far from the ear. Equally siting the device more superiorly over the middle fossa, one is likely to find thinner bone and one must certainly be prepared to encounter dura.

Methods: Here we describe our experiences with our first cohort of 6 patients receiving 7 BB´s (one bilateral). With proximity to the cochlea in mind, and provided a solid thickness of healthy cortical bone was present, we aimed to place the device as close to a traditional mastoid position as possible. The presence of structures necessarily exposed in our drilling to fully accommodate the device was recorded either photographically or in a diagram. Sigmoid sinus, middle and posterior fossa dura and emissary veins were all encountered in our series.

Results: Our approach to dealing with these structures in order to mitigate the risk of damage is outlined. Secure placement of a device was possible in each case with no undue trauma to exposed structures . In most of our cases the device was rested against exposed dura and / or sigmoid sinus. There have been no immediate or intermediate complications arising from the placements, such as local pain or headaches. Longer term follow up is planned.

Conclusion / Discussion: There is considerable latitude as to where the BB can be accommodated behind the ear. Through careful exposure of the dura and / or sigmoid sinus, the device may still assume a respectable position, close to the cochlea. No ill effects have been seen to date from this approach or from having the device rest up against these structures. Device performance has been excellent.

Learning outcome: Absence of a capacious or well-aerated mastoid is not a contraindication to BB surgery.

P1-13-14

Acoustic and wireless hearing in bone-anchored hearing

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Intro: In patients with mixed or conductive hearing loss that have contraindications for using conventional hearing aids amplified sound may be delivered through bone-anchored hearing devices. Bone-anchored hearing devices have developed rapidly during the past few years. However, users of bone-anchored hearing devices still encounter problems when communicating in everyday situations, in challenging listening conditions, and when communicating with landline telephones and mobile telephones. In this study the acoustic and wireless performance of the Ponto Plus sound processor of Oticon Medical will be evaluated relative to its predecessor the Ponto Pro.

Methods: Nineteen patients with bilateral conductive or mixed hearing loss and ample experience with a digital bone-anchored hearing device participated in the experiments. Sixteen patients were fitted unilaterally. After a trial period of at least 4 weeks for either device the efficacy of wireless and acoustic communication was evaluated with Oticon Medical Ponto Plus and Ponto Pro sound processors when using (mobile and/or landline) telephone and TV. The evaluation involved speech perception in noise (SPIN) measures, APHAB and SSQ questionnaires and proprietary questionnaires for rating speech intelligibility, sound quality, listening effort, and communication abilities.

Results: At equivalent levels for wireless and acoustic input speech scores were essentially equal. In bone-anchored hearing.

Discussion: The effect of direct, unamplified sound is generally small as direct sound will be attenuated by the conductive component of the hearing loss, the 'air-bone gap'. By setting substantially (*e.g.*, +6 or +9 dB) more gain to the wireless input relative to the acoustic input wireless connections to telephone and TV should offer superior sound quality with little interference from ambient noise. The validity of this concept was corroborated by the real-life experiences of fifteen patients showing a strong preference for Ponto Plus with the wireless option over Ponto Pro.

Conclusion: Wireless connectivity has shown to be a valuable feature in bone-anchored hearing for communicating over the telephone and watching TV.

Learning outcome: insight into the efficacy of wireless connectivity in bone-anchored hearing

P1-13-15

Fitting of the MED-EL Bonebridge system

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Introduction: In 2012 MED-EL introduced new Bonebridge device designed for patients with mixed or conductive hearing loss and also for single sided deafness. Fitting rules, implemented in the device's software and recommended by the producer, such as DSL (Desired Sensation Level), do not always produce the expected, optimal effects. This is due to the particular method of fixing the device in the body - coupling of the transducer with the bone - and the method of stimulating the auditory system through the bone. This often compels specialist to use the individual approach to the fitting process and has the significant influence on final results and patient's satisfaction.

Aim: The aim of this study is to present the fitting procedure of this device and selected case studies demonstrating the adjustment of the device's fitting to patient's subjective feelings.

Material and methods: Material includes 10 patients, 8 males and 2 females, mean age=32, SD=8,08, with mixed or conductive hearing loss in the implanted ear, implanted unilaterally in the Institute of Physiology and Pathology of Hearing between December 2012 and May 2013. For the evaluation of benefits Polish monosyllabic word tests and free field audiometry have been used. Assessment of the applied fitting principle is based on functional gain and amplification curves differences between those determined using the DLS principle and those preferred by the patients during the fitting.

Results and conclusions: In the study group we noted higher amplification tolerance than indicated by the DSL principle implemented in producer's software. Patients with conductive hearing loss preferred linear amplification. Varied effectiveness of transducer-skull coupling indicates the necessity of the individual fitting of the electro-mechano-acoustic parameters of the device. These parameters are not possible to be established based only on the pure-tone audiometry with conventional transducers. In some patients we observed feedback problems and problems in achieving the desired amplification despite having implemented the anti-feedback algorithm. In all studied patients the fitting of the implants, after application of the specific corrections, has been deemed satisfactory.

P1-13-16

Bone-anchored hearing implant loading at three weeks: Stability, survival and tolerability after three years

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Objectives: To evaluate the clinical results of a three week loading period for percutaneous titanium bone-anchored hearing implants. Implant survival, stability changes, skin reactions and subjective benefit assessment are evaluated three years after implantation.

Design: An open, prospective clinical trial was set up, in which 30 adult patients were included. Implantation with a Cochlear Baha BI300 implant was followed by visits at 10 days, 3, 6, and 12 weeks, 6 months, and 1, 2, and 3 years. The sound processor was fitted three weeks after surgery. During all follow-up visits implant stability quotient (ISQ) values and Holgers' classification for skin reactions were recorded. Additionally, subjective benefit was evaluated with the Glasgow Benefit Inventory (GBI).

Results: One implant was lost before loading. Another two patients did not complete three year follow-up: one patient died within 2 years of inclusion and another was lost to follow-up. ISQ values showed a dip 10 days post-surgery and hereafter increased to stabile values above baseline. Observed skin reactions were generally mild and no additional adverse events were recorded. The GBI demonstrated a subjective benefit at three years.

Conclusions: The current study indicates that loading of a bone-anchored hearing implant with a sound processor at three weeks is safe in adult patients with good bone quality. Reducing loading time will offer possibilities of early hearing rehabilitation.

P1-13-17

Improving speech in noise hearing performance of users of a bone conduction hearing system using a wireless remote microphone

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Intro: The key need of hearing impaired individuals is improved speech understanding in challenging listening situations. While, directional microphones provide significant benefits, a new potential solution is to use wireless transmission technology to transmit the talker's signal directly to the bone conduction sound processor. A new generation of DSP technology available in the latest bone anchored hearing solutions which incorporates the 2.4GHz ISM transmission technology to transmit the signal from remote microphone.

Methods: The study involved both a technical and clinical evaluation of the performance of an external microphone. For the technical measurements we measured the exact signal-to-noise ratio (SNR) in three rooms; (a) lecture theatre (RT=0.25s), (b) cafeteria (RT=1.8s) and (c) sound isolated room (RT=0.5s). In each room we examined the effects of distance, reverberation and improvement in SNR over the no mini-mic configuration.

For clinical measurements, patients (N=10) with a bone conduction hearing system participated in this investigation. Each patient wore a Baha 4 sound processor paired to a 2.4GHz wireless microphone ("mini-mic") worn by the talker. Testing took place in an isolated sound booth with two loudspeakers. The Swedish version of the HINT test was used to determine the 50% level of speech recognition in noise. Speech was presented from the front loudspeaker (0) with noise from the rear loudspeaker (180). Three test situations were conducted: (1) omni-directional microphone, (2) automatic directional microphone, and (3) a wireless microphone was placed 15cm in front of the front loudspeaker. The testing was completed in two set-ups, (a) sound processor microphone + mini-mic, or (b) mini-mic only.

Results and discussion: In both the technical and the clinical tests, the wireless configuration demonstrated the largest benefit in hearing performance in noise. For technical measurements, we demonstrated that the use of a mini-mic was able to overcome some of the challenges provided by increased distance, and reverberation time. Importantly, in each of the three scenarios there was a significant increase in the recorded SNR. For the situation of sound processor microphone and mini-mic combined a significant mean improvement of 3.08dB was observed (p< .0001). For the mini-mic only situation a significant mean improvement of 7.5dB was observed (p< .0001). Additionally, subjective reports using a visual analogue scale (VAS) indicated that all the participants found it easier to listen to the test material using the wireless accessory than with the conventional sound processor level microphone in this test situation.

Conclusion: Results of the study conclude that sound processor incorporating wireless technology improve speech recognition in noise compared with conventional bone conduction sound processor. The clinical situations and implications of this new technology will be discussed.

P1-13-18

A national registry for bone anchored hearing implants

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Introduction: In the UK, there was little information on users of bone anchored hearing implants. Information on their numbers and characteristics is necessary for patients, professionals and funders to make decisions.

Methods: An invitation to clinics across the UK led to a working group to develop a National Registry of users, collecting anonymous information. Limited data was initially collected to encourage full participation and completeness, and ethical advice was obtained. The National Registry is a small, focused database, collecting information including numbers, ages, hearing loss, aetiologies, indications, timings from surgery to placement and long-term usage rates. It provides group data, accessible to all via the website, and provides clinics with their individual data for their own use.

Results: To date, information has been collected on over 2,400 patients by 10 large participating centres; up to date data will be presented on age at implantation, level and type of hearing loss, typical times to fitting and usage rates. It will provide evidence on typical indications and on the numbers of those being fitted in the group who have unilateral losses.

Discussion: In an era of evidence based health-care services which are increasingly financially challenged the need for the continuing and sustained collection of such data, which is readily understood by patients, families, professionals and non-specialists alike is increasingly vital. Clinicians are using the database to provide up to date information on the practice and take up of bone anchored hearing systems and their use both nationally and in their individual centres.

Conclusion: The National Registry is the first attempt to address this issue and is now providing an opportunity for the first time to obtain a picture of the development of bone anchored hearing implant practice in the UK.

Learning outcome: The presentation will provide the opportunity for attendees to understand the value of such a database and its use and the current status of bone anchored hearing implant use in the UK.

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P1-13-19

Evaluation of the MedEl bonebridge in single-sided deafness using a multisource noise field

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Single-sided deafness (SSD) negatively affects speech perception, especially in difficult listening situations. Also directional hearing, which is based on interaural time- and level-differences, is severely impaired in patients suffering from SSD. Therapeutic options for SSD include CROS hearing aids, the implantation of a BAHA, cochlear implantation and the fully implantable bone-conduction hearing aid Bonebridge. The aim of this study was to examine the performance of SSD patients who had been implanted with a Bonebridge in a multisource noise field (Rader et al., 2013).

Speech perception with and without the Bonebridge was determined in a setup with sound sources from different spatial positions and using an adaptive speech recognition test (Oldenburg Sentence Test, OLSA). In the first experiment, patients with severe to profound hearing loss in one ear and normal hearing in the other ear, were tested in different loudspeaker configurations, and with different background noise signals (Oldenburg-Noise, Fastl-Noise). As the main outcome parameter, speech-reception thresholds (SRT) were calculated.

In the second experiment, the lateralization of test-signals was analyzed. Broadband signals were presented at the same time with different signal levels on both channels of ear-enclosing headphones. Using a visual analog scale (VAS) the setting causing centralization of the hearing impression was determined, and it was evaluated if the lateralization depends on level differences.

In addition, the Bern Benefit in Single-Sided Deafness (BBSS) questionnaire, evaluating the subjective benefit of the implantees, was completed by the participating patients.

P1-13-20

Baha attract versus Baha Dermalock system: Multicenter comperative clinical study

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Objective: To compare the clinical and audiological outcomes as well as patient satisfaction of Bone-Anchored Hearing Aid surgery with percutaneous BA 400 dermalock and transcutaneous BAHA attract systems.

Study Design: This is a multicenter, retrospective clinical study to evaluate BAHA without skin thinning and BAHA attract systems.

Methods: The patients who underwent Baha connect and Baha attract surgery were analyzed for hearing results, surgical complications and specifications for both systems. The mean operation time, speech reception thresholds and bone conduction thresholds with and without aided conditions were evaluated. Patient satisfactions were also determined for both groups by Glasgow inventory questionnaire.

Results: The surgical indication was chronic otitis media for both groups. Mean follow up time was 12 months for dermalock and 6 months for the BAHA attract. The mean of free field hearing thresholds, the mean of free field speech recognizing thresholds and the results of the speech recognition in free field test showed a significant improvement with the Baha.

Conclusion: Bone anchored hearing devices are considered when use of a conventional air conduction hearing aid is not possible or effective. Both transcutaneous and percutaneous BAHA surgeries are effective in rehabilitation of conductive hearing loss. Even though transcutaneous attract system is cosmetically more acceptable, the percutaneous dermalock system is still necessary for the patients whose hearing loss is worse than 30 desiBell

P1-13-21

A minimally invasive technique for the implantation of Baha attract system

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Bone anchored hearing aids are known as an effective surgical option for hearing rehabilitation for many years. Up to now, lots of surgical techniques have been described for this surgery. However, technological modifications about this issue still necessitates renewals of the surgical techniques. With this report, we aimed to describe a new minimally invasive surgical technique for Cochlear^{TM} Baha^{R} Attract System which is a new non-skin penetrating device that uses magnet retention instead of an abutment to connect the Baha sound processor with the BI300 implant. The technique has two consecutive incisions. One of them is 2 cm length and superior to the position of the magnet and the other one, is 5 mm length and positioned onto the center of the magnet. We believe that; with this technique, the risks of conventional technique such as, flap necrosis, numbness, hematoma will be lesser.

P1-13-22

Baseline of effectiveness, quality of life and soft tissue complications with Baha

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Aim: The aim of this investigation was to establish a baseline of performance for patients who receive a Baha bone conduction hearing system to treat one of the following rypes of hearing loss: conductive hearing loss; mixed hearing loss; or single-sided deafness. The secondary aim was to establish the incidence of soft tissue complications experienced and determine the correlation to performance, patient characteristics or implant device. A multi-centre approach was pursued, therefore a tertiary outcome was to determine the influence of cultural or centre related differences in effectiveness/quality of life outcomes existed.

Methodology: A multi-centre, randomised survey of existing Baha implantee outcomes was undertaken. Effectiveness and effect on quality of life of Baha were evaluated using the Glasgow Benefit Inventory (GBI) questionnaire- adult or paediatric version as appropriate. This was accompanied by a general purpose demographic information questionnaire. The soft tissue complications meanwhile were evaluated using the Holgers Index scale and a four grade tissue overgrowth scale. The GBI questionnaires were translated into Slovene and Greek for native language subject responses for Slovenia and Cyprus, respectively. The existing English language questionnaires were used for Malta.

Results: A total of 73 adult responses and seven paediatric responses were returned (Nicosia:36adult/7 paediatric; Maribor: 31adult; Msida: 6 adult). The Baha treatment impacted positively on the lives of 67 subjects and negatively on the lives of 6 subjects. The majority of subjects and negatively affected were only slightly so, and suspected contributing factors could typically be identified. Ten instances of soft tissue complications. More completely described results will be presented, which includes the other analyses performed.

Conclusions: Treating conductive or mixed hearing loss, or single-sided deafness with Baha was found to be effective with a positive impact on the quality of life for a large majority of patients. Furthermore, the results of this retrospective study provide a baseline for further work and/or newer treatment types.

P1-13-23

Initial results with the bone bridge active bone conduction device

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Objective: This study was undertaken to determine the efficacy of the first five patients in our clinic implanted with the bone for their mixed or conductive hearing loss.

Design: Speech in quiet and in noise will be compared to preoperative results so that each subject serves as his or her own control in a single test protocol. Quality of life questionnaires have also been administered and include the APHAB (Abbreviated Profile of Hearing Aid Benefit) and the TRQ (Tinnitus Reaction Questionnaire).

Study sample: 5 patients implanted monaurally with the Bone Bridge in the poorer hearing ear.

Results: To date, our first 2 patients have demonstrated significant improvements with their speech in quiet and speech in noise results. Their pre-vs post-operative performance in quiet with speech presented at 65dBSPL improved when averaged from 48% to 93.5%. Speech in noise measures were also improved by 3dBSNR in one patient and by 0.5dBSNR in the other. For one of the subjects with significant tinnitus pre-operatively, scores on the TRQ (Tinnitus Reaction Questionnaire) diminished from 29 to 4.APHAB results demonstrated significant benefits on three of the four subscales of the APHAB. The complete results from our first 5 patients will be discussed in detail.

Conclusions: Results from our initial cohort of patients implanted with the Bone Bridge are promising with patients demonstrating improvements on speech perception in quiet and in noise. To date, there have been no complications associated with device implantation or rehabilitation. Improvements have also been observed on quality of life questionnaires.

P1-13-24

Bonebridge - performance and localisation results with a new bone conduction implant

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In 2012 the Bonebridge system (MED-EL Innsbruck, Austria) was introduced to the market. The device represents a semi-implantable active bone conduction implant with transcutaneous signal transduction. We examined possible negative effects on localisation and directional hearing caused by the direct connection of the implant to the bone, which could lead to simultaneous signal conduction to the contralateral ear. We also present surgically and audiologically challenging cases.

We report on 13 patients that have been treated with the Bonebridge system in our clinic. Speech perception in quiet and noise by means of the Freiburg monosyllable word test and the Oldenburg sentence test in noise were obtained. In addition directional hearing tests were performed in the coronal plane (± 60°) with a custom made speaker array with a resolution of 1.5°–5°, arranged in an anechoic chamber.

All patients accept and benefit from the implanted system. No infections or surgically adverse effects occurred in our patients. Indication mainly consisted of middle ear pathology related to previous surgery not sufficiently improved by previous surgical intervention (e.g. cholesteatoma). Mean test results showed a speech reception threshold of -4.6 dB SNR following implantation. In contrast, a significant improvement in accuracy of directional hearing was not observed.

Thus, the Bonebridge implant does improve speech perception, especially in noise, while a negative effect on directional sound localization accuracy was not observed so far.

P1-13-25

Bilateral Bonebridge implantation in a case of congenital conductive hearing loss. Lessons from the first North American case

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Intro: Here we present a case of a 35 year old female with Klippel-Feil syndrome and bilateral conductive hearing loss who was simultaneously implanted with bilateral Bonebridge implants.

Methods: SM is a 35 year old female with Klippel-Feil syndrome. She had a history of chronic middle ear disease, manifesting as atelectatic tympanic membranes bilaterally and a left sided pars tensa perforation, treated in the past with cartilage tympanoplasty. Due to her congenitally abnormal ossicular chain and abnormal middle ear anatomy, ossiculoplasty was not attempted at this time. Postoperatively, she had stable ears but a maximal bilateral conductive hearing loss, as well as an intolerance to conventional amplification and an aversion to a percutaneous bone anchored hearing implant, which made rehabilitating her hearing difficult.

Postop testing included Air and Bone Conduction Pure Tone Audiometry (AC/BC PTA), speech discrimination, and headband assessment using PontoPro Power (Oticon Medical AB, Askim, Sweden) and Baha BP110 (Cochlear Bone Anchored Solutions AG, Mölnlycke, Sweden) pBCI processors. Her 4-frequency Pure Tone Average (PTA_4; 0.5, 1, 2 & 4kHz) was: right ear AC/BC, 68.75/20dB; left ear AC/BC, 75/17.5dB (Figures 1 and 2). Speech discrimination was 100% with a Speech Reception Threshold (SRT) of 70dB in both ears. Following thorough preoperative counseling and informed consent, she was listed for bilateral Bonebridge implantation. Preoperative Computed Tomography (CT) scans were available from prior to her previous surgery. In November 2013, BB implantation was performed under general anaesthesia.

Results: Both implants were activated simultaneously 4 weeks after surgery, and were programmed to a comfortable level for the patient. Aided soundfield PTA_4 was 28.75dB for the right ear and 32.5dB for the left ear (Figures 6 and 7). Mean functional gain in PTA_4 for the two ears was 41.25dB. The patient completed a validate questionnaire for hearing aids, the Glasgow Hearing Aid Benefit Profile (GHABP), following surgery. She also completed the Glasgow Benefit Inventory (GBI).

Discussion: This is the first described case of a bilateral BB implantation in North America, and it demonstrates that the device is effective for treatment of congenital conductive hearing loss, providing excellent closure of the air-bone gap, especially in the high frequencies.

Conclusion: We report a case of a woman with a challenging bilateral congenital conductive hearing loss due to Klippel-Feil syndrome. Bilateral BB implants provided good hearing improvement, even at 4kHz and above, with effective closure of the ABG at 4kHz.

Learning outcome: Bilateral BB seems to be equal or better that unilateral implantation in terms of hearing gain across the speech frequencies, but in this patient, it did not improve quality of life measures more than unilateral BB or bilateral pBCI.

P1-13-26

Bone anchored hearing implants installed with soft tissue preservation techniques - A systematic literature review

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Historically, skin thinning has been part of the recommended surgical procedure for installing bone anchored hearing implants (BAHI). It has been considered important to achieve a thin, hairless area around the abutment to avoid skin reactions. Recently, a number of studies have reported outcomes with a tissue preservation technique, where no or a limited amount of subcutaneous tissue is removed around the implant.

We performed a systematic literature review to evaluate the outcomes of this relatively new practice. Eight studies met the inclusion criteria, all published in 2011 or later. The total number of implants installed with tissue preservation surgery in the studies was 150 (control groups with other techniques excluded). The average follow-up times for the studies varied between 12 months and five years. The precise surgical technique differs between the studies, but generally the surgery falls into two main groups. Implants from different vendors are included in the results. From an implant system perspective, the most important aspect is that abutments with sufficient length are available. All published results are related to abutments with a titanium surface. The general conclusion is that in terms of skin reactions, a practice with tissue preservation is at least as good as the previous skin thinning practices. Importantly, no new types of complications were reported in any study. Several studies report less numbness around the implant as a patient benefit of tissue preservation, as well as a cosmetically better outcome.

In conclusion, this systematic review supports the practice of soft tissue preservation for placement of percutanoeus bone anchored systems.

P1-13-27

A wide bone anchored hearing implant: 6 months data from a prospective multi-center study

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Recently, wider diameter (4.5 mm) bone anchored hearing implants have been introduced. The wider implants ensure a higher initial stability, ultimately aimed at further reducing implant loss rates and improve predictability of the treatment. The objective of this study was to investigate the wide Ponto implant from Oticon Medical, with focus on initial stability, stability development over time, implant loss and skin reactions.

The study is a prospective multi-centre study, including three tertiary referral centres in the UK. The study was designed as a case series study, with thirty adult patients included. The surgical technique varied across centres, and included both soft tissue preservation and skin thinning using the dermatome. Implant stability was measured at surgery and at all follow-up visits (10 days, 6-12 weeks, 6 months and 12 month after surgery) using resonance frequency analysis (ISQ values). At all follow-up visits, skin status and skin height was assessed and skin reactions classified according to the Holgers' scale.

The preliminary results showed good initial stability, a stable ISQ development over time, and few adverse skin reactions. Six month follow-up data on stability and soft tissue outcomes will be presented.

P1-13-28

Clinical evaluation of results of using new Baha® abutment covered by hydroxyapatite and new surgical technique without soft tissue reduction

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The aim of this study is the evaluation of results of using new Baha abutment covered by hydroxyapatite (Baha® BA400, Cochlear Ltd.) and new surgical technique without soft tissue reduction.

Material and methods: The results of treatment of 9 adult patients were compared with results of 178 patients implanted earlier by standard technique with soft tissue reduction.

Results: In analyzed group we find: slight shortening of time of surgery, similar results of implant stability (RFA) before sound processor connection, very good cosmetic results in 6 patients, some soft tissue overhanging in 2 and retraction pocket formation and inflammation (Holgers 2) in 1, no numbness and pain in operated area in all operated.

Conclusions: New Baha abutment covered by hydroxyapatite (Baha® BA400) enables safely use new surgical technique without soft tissue reduction. In authors' opinion the most important benefit from this technique is limited bleeding during operation, reduction of using of coagulation and less risk of lesion of nerves and numbness or pain after operation. The esthetic results and healing process confirm the advantage of technique without soft tissue reduction over standard technique.

P1-13-29

Transcutaneous bone conduction implant (Bonebridge®) - first results in speech perception and directional hearing

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Introduction: The Bonebridge (BB, MED-EL) is an active bone conduction implant (BCI) that is primarily indicated in patients with conductive and combined hearing loss. It transmitted sound directly to the inner ear on both sides.

Objectives: To obtain clinical data from our first cases implanted with a new transcutaneous BCI.

Methods: We report our first three cases of Bonebridge® implantation. Two subjects received an implant caused by meningeoma - or vestibular schwannoma resection. Another case underwent implantation by dysplasia of outer and middle ear with atresia of outer ear channel.

Speech perception in quiet is tested with the Freiburger monosyllable test at a level of 65 dB SPL preoperatively in unaided and aided condition. Audiometric thresholds (air conduction, bone conduction and sound field) were assessed preoperatively and postoperatively. Directional hearing is examined in a spatial sound laboratory that provides the hard-/ and software environment for fine-grained control of spatial auditory scenes. An arbitrary number of sound sources can be distributed and mixed so that a realistic spatialized sonic scene with clearly recognizable sound localization can be produced in the lab setting. In result, the system allows to simulate sonic environments as they appear in everyday life of listeners

Results: Speech perception in quiet is improves in all subjects. We observed no complication (wound healing) after Bonebridge® implantation. The surgical procedure was shown only same minor problems. Our directional hearing test results will be discussed in detail.

P1-13-30

Sound localization in patients supplied with the Bonebridge

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Intro: The Bonebridge is a new bone conduction implant stimulating the auditory system with an implanted vibrator via bone conduction. Although successful hearing and speech intelligibility is already verified in multicenter studies, no published results exist about sound localization with this new system.

Methods: Four female subjects were implanted at the Innsbruck Medical University (June 2011 to September 2011) in one ear using the Bonebridge Implant. Sound localization was tested in an anechoic chamber using 12 loudspeakers arranged in a circle of 2 m diameter with a resolution of 30 degrees. After a test trial subjects had to localize 120 presentations of broadband noise (45 dB and 75 dB SPL) delivered from different directions. The test was conducted in two hearing conditions: with and without the Audioprocessor turned on in omnidirectional microphone mode. All conditions, levels, and directions were randomized. Each subject was tested at three different sessions: 6 months, 1 year and 2 years after surgery.

Results: Depending on the degree of hearing loss of the contralateral ear, the duration of hearing impairment and the duration of implant use the results in this small sample are quite scattered. At the present status of investigation the localization ability of sounds from different direction is found to be equal or slightly improved when using the implant. The localization accuracy improves over time, especially within the first year of implant use.

Conclusions: Due to the small number of subjects tested and the broad variety of individual hearing pathologies, a statistical evaluation of results is not yet applicable. More measurements are planned in the future. First results show that localization ability is not worse when using the implant. Over time an improvement of localization accuracy is already observed.

P1-13-31

Safety and performance of the Bonebridge™ Bone Conduction Implant System in children and adolescents

Baumgartner W.[1], *Böheim K.*[2], *Hamzavi J.*[1], *Keck T.*[3], *Mendiola J.*[4], *Potzinger P.*[3], *Schlögel M.*[2], *Sprinzl G.*[2,5], *Wolf-Magele A.*[2,5], *Bock G.*[4]

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Introduction: The Bonebridge (Vibrant MED-EL, Innsbruck, Austria) is a semi-implantable, transcutaneous bone conduction hearing implant system developed for the treatment of patients suffering from conductive, mixed or profound unilateral (single sided deafness) hearing loss. It was CE marked for adult patients in 2012 and increased the treatment options for patients not able to benefit from already established non-invasive, or surgical interventions for various reasons. Since then, evidence accrued for the Bonebridge (BB) to be a safe and beneficial device, accompanied by high user device satisfaction. In order to provide this treatment possibility to younger patients as well, a clinical investigation to prove safety and performance of the Bonebridge implantation and use, was conducted in a cohort of children and adolescents.

Materials and methods: This prospective, multicenter study evaluated medical and audiological outcomes of 12 German speaking patients (age 5-17 years) implanted with the BB at 4 Austrian clinics. Patients with conductive or mixed hearing losses with bone conduction thresholds better than 45 dB HL in the frequencies 0.5-4 kHz were included. Surgical reports, adverse event documentation and bone conduction threshold stability measures pre-, and post-operatively (pre-op, post-op) allowed to evaluate device-, procedure-, and usage-related safety. Performance testing included comparison of pre-op and BB aided post-op free field thresholds (0.5-8 kHz), word recognition scores (WRS) at 65 dB SPL in quiet (Freiburger Monosyllables or Göttinger Kindersprachtest) and speech reception thresholds (SRT) for 50% word understanding in sentences in quiet (Oldenburger Satztest, OLSA or Oldenburger Kindersatztest, OLKISA). The Hearing Device Satisfaction Scale (HDSS) questionnaire served as instrument to evaluate the patients subjective satisfaction with the BB. Results were analyzed after a follow-up period of 3 months post-op.

Results: The analysis included 8 male and 4 female patients, aged 5-17 years old (mean 11 years), presenting with conductive hearing loss and the following etiologies: atresia auris (n=7), microtia (n=2), anotia (n=1), chronic otitis media (n=1), ear canal stenosis (n=1). Safety parameter analysis determined unchanged pre-op versus post-op bone conduction thresholds, as well as an absence of serious device-, procedure-, or usage-related adverse events. Significant improvements were detect for BB aided free-field thresholds at 3 months post-op of 23-33 dB HL (mean 29 dB HL) as well as for the two speech tests, when compared to the pre-op unaided condition: the WRS significantly improved from 14.5% to 82.1% and the SRT improved from 72.7 dB SPL to 45.2 dB SPL with the BB. Patients used the BB on average for 10.5 hours per day and reported to be very satisfied with the device (mean overall device satisfaction of 88%).

Summary and conclusion: In summary, the Bonebridge provides good aided benefit in terms of word recognition scores, speech reception thresholds, and aided soundfield thresholds with a low complication and a high subjective device satisfaction. It demonstrates, that this active bone conduction implant is a valuable treatment option to help adult patients, adolescents and children older than 5 years, suffering from mixed and conductive hearing losses.

P1-13-32

Effectiveness and Impact on quality of life of Baha in Russian speaking patients

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Aim: To date very little information has been available in regard to the effectiveness of treating hearing loss with Baha and its impact on quality of life in Russian speaking countries. Mainly this has been due to a lack of suitable evaluation tools being available in Russian. The absence of this information is of course problematic in regard to appropriately counseling candidates, but it also prevents analysis of the effectiveness of treatment option(s) in the future. The aim of this study therefore was to establish such a baseline in Russian speaking countries - Russia, Belarus and Ukraine - for both adult and paediatric Baha patients, consisting of general demographic information, effectiveness of treatment and impact on quality of life.

Material and methods: A general purpose demographic information questionnaire and both the adult and paediatric versions of the Glasgow Benefit Inventory were translated into Russian. The translation process consisted of forward and then backward translations from/to English to ensure validity. These questionnaires were then administered to patients in three centres on a random basis.

Results: 23 adult patients were selected at random, with their demographic information collected and the translated adult version of the Glasgow Benefit Inventory completed. There were: 12 male patients, average age 40.4 (SD 19.3) years, and 11 female patients, average age 47.2 (SD 18.4) years. The adult patients on average had been implanted for 2.4 (SD 1.1) years and used their Baha sound processors for 11.9 (SD 5.6) hours on average per day. The average mean total score of the Glasgow Benefit Inventory was 27.4 (SD 24.6).
Meanwhile 24 paediatric patients were selected at random, with their demographic information collected and the translated paediatric version of the Glasgow Benefit Inventory completed by the patients' parents/care-givers. There were: 14 male patients, average age 10.8 (SD 3.9) years, and 10 female patients, average age 11.6 (SD 4.6) years. The paediatric patients on average had been implanted for 2.7 (SD 1.7) years and used their Baha sound processors for 13.4 (SD 2.6) hours on average per day. The average mean total score of the Glasgow Benefit Inventory was 53.2 (SD 17.6). A significant positive correlation was identified between the total score and the number of hours per day of Baha use, $r(22) = 0.42$, $p = 0.043$. A full overview of the demographic information, the Glasgow Benefit Inventory sub-scores and the analyses conducted will be presented.

Conclusions: The treatment of hearing loss caused by atresia of the external auditory canal, chronic otitis media or Treacher Collins syndrome with Baha was found to be successful. This study has achieved its goal of establishing a baseline of effectiveness and impact on quality of life for patients suffering these diseases/syndromes in Russian speaking countries.

P1-13-33

Long term-safety and effectiveness of the Bonebridge™ Bone Conduction Implant System in adults

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Introduction: The Bonebridge (Vibrant MED-EL, Innsbruck, Austria) is a semi-implantable, transcutaneous bone conduction hearing implant system developed for the treatment of patients suffering from conductive, mixed or profound unilateral (single sided deafness) hearing loss. It was CE certified for adult patients in 2012 and for children older than 5 years in 03/2014, and increased the treatment options for patients not able to benefit from already established non-invasive, or surgical interventions for various reasons. Since then, evidence accrued for the Bonebridge (BB) to be a safe and beneficial device, accompanied by high user device satisfaction. The here presented preliminary data derive from a study conducted to investigate long-term safety and effectiveness of the BB.

Materials and methods: This prospective multicenter (7 middle European clinics) study evaluates long-term safety and effectiveness of the BB in a patient group of German speaking adults (>18 years) affected by a conductive or mixed hearing loss and bone conduction thresholds better than 45 dB HL in the frequencies 0.5-3 kHz. Surgical reports, adverse event documentation and bone conduction (BC) threshold stability measures pre-, and post-operatively (pre-op, post-op) allow evaluation of device-, procedure-, and usage-related safety. Performance testing includes comparison of pre-op and BB aided post-op free field (FF) thresholds (0.5-8 kHz), word recognition scores (WRS) at 65 dB SPL in quiet (Freiburger Monosyllables) and speech reception thresholds (SRT) for 50% word understanding in sentences in quiet (Oldenburger Satztest, OLSA). The Hearing Device Satisfaction Scale (HDSS) questionnaire serves as an instrument to evaluate the patients subjective satisfaction with the BB.

Results: The analysis includes 9 male and 20 female patients with a mean age of 47 years (range 19-74 years) implanted with the BB, presenting with either a conductive- (n=12) or mixed hearing loss (n=17) and nine distinct etiologies of which three, Atresia Auris (n=6), Chronic Otitis Media (n=5), Cholesteatoma (n=10) are most prominently represented. We find, that mean bone conduction thresholds are stable over time (1-24 month post-op), suggesting that the residual hearing is not affected by the procedure and usage of the BB. In terms of performance, we detect a significant improvement for FF thresholds (mean functional gain of 27 dB HL), WRS (+ 56.3 %) and SRT (-19 dB SPL) in the BB aided condition. The mean HDSS of 79%, available for 26 patients, reflects a high device satisfaction and completes the afore mentioned positive results. As there is no significant difference detectable between short-, and long-term observation for BC thresholds, FF results and speech test outcomes, this preliminary results underline the assumed long-term safety and effectiveness of the Bonebridge implant.

Summary and conclusion: In summary, the Bonebridge provides stable benefit in terms of word recognition scores, speech reception thresholds, and aided free field thresholds, in concert with a negligible risk for the residual hearing. These outcomes, accompanied by the high subjective device satisfaction, demonstrates that this active bone conduction implant is a valuable treatment option to help patients suffering from mixed and conductive hearing losses.

P1-13-34

Safety and performance of the Bonebridge™ Bone Conduction Implant System in children and adolescents

Baumgartner W.[1], Bock G.[2], Böheim K.[3], Etschmaier K.[2], Hamzavi J.[1], Keck T.[4], Potzinger P.[4], Schlögel M.[3], Sprinzl G.[3,5], Wolf-Magele A.[3,5]

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Introduction: The Bonebridge™ (Vibrant MED-EL, Innsbruck, Austria) is a semi-implantable, transcutaneous bone conduction hearing implant system developed for the treatment of patients suffering from conductive, mixed or profound unilateral (single sided deafness) hearing loss. It was CE marked for adult patients in 2012 and increased the treatment options for patients unable to benefit from already established non-invasive, or surgical interventions for various reasons. Since then, evidence accrued for the Bonebridge (BB) to be a safe and beneficial device, accompanied by high user device satisfaction. In order to provide this treatment possibility to younger patients as well, a clinical investigation to prove safety and performance of the BB implantation and use, was conducted in a cohort of children and adolescents. The BB for children aged 5 years and older was CE certified in March 2014.

Materials and methods: This prospective, multicenter study evaluated medical and audiological outcomes of 12 German speaking patients (age 5-17 years) implanted with the BB at 4 Austrian clinics. Patients with conductive or mixed hearing losses with bone conduction thresholds better than 45 dB HL in the frequencies 0.5-4 kHz were included. Surgical reports, adverse event documentation and bone conduction threshold stability measures pre-, and post-operatively (pre-op, post-op) allowed to evaluate device-, procedure-, and usage-related safety. Performance testing included comparison of pre-op and BB aided post-op free field thresholds (0.5-8 kHz), word recognition scores (WRS) at 65 dB SPL in quiet (Freiburger Monosyllables or Göttinger Kindersprachtest) and speech reception thresholds (SRT) for 50% word understanding in sentences in quiet (Oldenburger Satztest, OLSA or Oldenburger Kindersatztest, OLKISA). The Hearing Device Satisfaction Scale (HDSS) questionnaire served as instrument to evaluate the patients subjective satisfaction with the BB. Results were analyzed after a follow-up period of 3 month post-op.

Results: The analysis included 8 male and 4 female patients, aged 5-17 years (mean 11 years), presenting with conductive hearing loss and the following etiologies: atresia auris (n=7), microtia (n=2), anotia (n=1), chronic otitis media (n=1) and ear canal stenosis (n=1). Safety parameter analysis determined unchanged pre-op versus post-op bone conduction thresholds, as well as an absence of serious device-, procedure-, or usage-related adverse events. Significant improvements were detect for BB aided free-field thresholds at 3 month post-op of 23-33 dB HL (mean 29 dB HL) as well as for the two speech tests, when compared to the pre-op unaided condition: the WRS significantly improved from 14.5% to 82.1% and the SRT improved from 72.7 dB SPL to 45.2 dB SPL with the BB. Patients used the BB on average for 10.5 hours per day and reported to be very satisfied with the device (mean overall device satisfaction of 88%).

Summary and conclusion: In summary, the Bonebridge provides good aided benefit in terms of word recognition scores, speech reception thresholds, and aided soundfield thresholds with a low complication rate and a high subjective device satisfaction. It demonstrates, that this active bone conduction implant is a valuable treatment option to help adult patients, adolescents and children older than 5 years, suffering from mixed and conductive hearing losses.

P1-13-35

Sound localization with a bone conduction hearing implant in patients with a unilateral air-bone gap: Analogue vs. digital sound processors

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Intro: Sound localization in the horizontal plane is mainly based on interaural level differences (ILDs) in the high frequencies (> 3 kHz) and interaural time differences (ITDs) in the low frequencies (< 1.5 kHz). These cues are highly distorted in patients with a unilateral hearing loss. Several studies have shown that bone conduction hearing implants (BCI) can improve the localization abilities of this group of patients. However, the latest generations of digital BCI sound processors have a processing delay of 3 milliseconds while ITDs are in the order of microseconds. This might possibly affect the localization abilities of a patient in the aided condition. The current study aims to verify which cues (ILDs and/or ITDs) can be used by patients with a unilateral air-bone-gap wearing a BCI. Moreover, we want to find out if the time delay, related to digital sound processing, has an effect on a patient´s performance.

Methods: Testing was done in 11 patients with a unilateral air-bone gap and normal hearing in the contralateral ear. All patients were implanted with a BCI at least one year prior to the test moment. Sound localization skills were tested using 9 loudspeakers located in a frontal semicircle at a distance of 0.8 m from the listener's head. Stimulus coordinates ranged from -90° to +90° in azimuth at intervals of 22.5°. Three different localization stimuli were used: broadband noise (BB; 0.5 - 20 kHz), low-pass noise (LP; 0.5 - 1.5 kHz) and high-pass noise (HP; 3 - 20 kHz). Performance was assessed for the unaided condition as well as for the aided condition with both an analogue and a digital BCI sound processor.

Results: All data were recently collected. Data analysis will be done in the next few months and the results of the current study will be presented at CI2014.

P1-13-36

Preoperative headband assessment for the Medel Bonebridge in conductive hearing loss: Is it helpful or misleading?

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Intro: The Medel Bonebridge was launched in 2012 and is relatively new to market. As there are few guidelines for preoperative assessment with this device, many centres have followed a similar protocol to that employed when testing traditional percutaneous bone-conducting implants (BCIs) using a traditional device on a headband. Such trials are well established but have limitations with loss in transmission due to soft tissue damping - more marked at higher frequencies, and affecting both pure tone and speech audiometry. Preliminary data from our Bonebridge cohort show impressive closure of the air-bone gap particularly at high frequencies and we suspect that headband trials with traditional BCI´s might significantly underplay the Bonebridge´s true potential. Here we compare preoperative assessment using a BCI processor on a headband with postoperative device performance in a group of patients with conductive hearing loss (CHL) implanted with the Bonebridge and another group with fully osseointegrated percutaneous BCIs

Methods: This case-control study compares audiometric data from preoperative headband assessments in 6 patients undergoing Bonebridge implantation (cases prospective) with 20 patients already implanted with a percutaneous BCI (controls – retrospective Data analysis: frequency-specific comparison (0.5, 1, 2, 3 & 4kHz) of the following scenarios: postoperative soundfield for implanted Bonebridge *vs.* percutaneous BCI, preoperative BC PTA assessment (traditional bone conductor/headband in soundfield) *vs.* postoperative soundfield for Bonebridge, preoperative BC PTA assessment (traditional bone conductor/ headband in soundfield) *vs.* postoperative soundfield for percutaneous BCI, preoperative BC speech discrimination (headband) *vs.* postoperative aided speech discrimination (Bonebridge/ percutaneous BCI)

Results: We show a discrepancy in the post-operative Bonebridge performance and that predicted by a preoperative trial of headband using a traditional BCI. Our results have particular relevance in the apparent under-estimation of the high frequency performance which is possible with the Medel Bonebridge.

Discussion: A full discussion of our findings and the implications for the reliability of pre-operative headband testing using one of the established BCI's will be presented.

Conclusion: If preoperative headband trials fail to simulate true device performance it is possible that erroneous conclusions might be drawn from such trials which might mislead a patient's decision making. It is possible that individuals who could benefit from Bonebridge technology might decline the opportunity to pursue such a device based on an inaccurate headband trial which in essence might undersell the Bonebridge's true performance.

Learning outcome: Care is advised when drawing conclusions from pre-operative headband trials using established BCI's for the Medel Bonebridge.

P1-13-37

Baha in various acquired and congenital ear malformations in children

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Introduction: Treatment and rehabilitation of children with conductive and mixed hearing loss in cases of congenital ear malformations (bilateral microtia with external auditory canal atresia), after chronic otitis media, or in single sided deafness (SSD) can be conducted applying Bone Anchored Hearing Aids (BAHA).

Aim: Our aim was to assess the results of application of BAHA in children and to compare hearing obtained with typical bone conduction hearing aids (head-band hearing aid, bone conduction glasses, or cross system in SSD) to hearing in BAHA system.

Material and methods: Our method of choice in treatment of hearing impairments in presented cases of various defects of the ear was attachment of titanium fixture to the temporal bone, and removal of subcutaneous tissue around attachment (with or without dermatome). The procedure was performed as a one stage in older children or two-stage in younger children. After implantation the titanium screw was not used for about 3-4 months, to provide good healing and proper osseointegration. Then a hearing aid was selected. Audiological examinations were performed 1 and 6 months after hearing aid fitting. Our material consists of 108 patients in the age form 3 y.o. to 18 y.o.

Results: Audiological results are good and sustainable. Thresholds measured in the free field audiometry wearing BAHA hearing aids are on average 8,8 dB lower in comparison to previously used hearing aids. Our patients emphasize that the new hearing aids provide better sound quality, speech understanding, are comfortable and are more aesthetic comparing to typical bone conduction hearing aids.

Conclusions: Application of BAHA in children with various hearing loss in ear malformations is good from audiological perspective as well as with regard to safety and everyday comfort of a user.

P2-1 Medical issues

P2-1-1

Cochlear duct length variation and 31.5mm electrodes: Is there a contradiction?

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Modern concepts of “Soft Surgery” cochlea implantation consider anatomical variations in the cochlear duct length (CDL). A variety of formulas are suggested to predict the CDL. Considering this variation of CDL a full insertion of 31.5mm electrodes should be impossible in a number of cases.

A retrospective analysis was performed in 132 consecutive patients receiving MED-EL cochlea implants (CI) with 31.5mm Standard and FLEXsoft electrodes. Electrode impedances and postoperative radiographs for electrode placement control were reviewed for inactive basal electrodes or incorrect placement. Additionally, preoperative high resolution computed tomography imaging was used for CDL calculation. Preservation of residual hearing was reviewed in a subgroup of 36 patients. Radiological calculated CDL varied between 24.2 and 39.4mm depending on the formula used. The average insertion angle was 624° - approx. 1¾ turns. No basal electrodes were deactivated or had high impedances in any of the patients. Three patients underwent revision surgery due to electrode kinking. Eventually, a full insertion was radiologically proofed in all patients.

The use and full insertion of 31.5mm electrodes is no contradiction to the variation of cochlear duct length. Preservation of residual hearing was achieved in 60% in a subgroup of patients. The currently used formulas for CDL approximation appear not to meet the complex geometric anatomy of the human cochlea. This may be critical if used for calculations in frequency specific hearing preservation surgery.

P2-1-2

Intracochlear pressure changes related to different insertional speeds of cochlear implant electrodes

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Introduction: The preservation of residual hearing, prevention of vertigo and tinnitus are beside an optimal audiological outcome the aims of a modern cochlear implant treatment. Beside new electrode designs other factors are of growing interest which might influence or determine an atraumatic insertion of a cochlea implant electrode. One factor is the speed of insertion. But the knowledge about it is still limited. The aim of the present study was to observe the intracochlear pressure changes related to different insertional speeds in a cochlear model.

Material and methods: All insertions were performed with an Advanced Bionics IJ electrode and an insertional tool at a model. The different defined insertional speeds (1mm/sec., 0.5 mm/ sec., 0.1 mm/ sec.) were performed with a linear actor. The evaluation of the pressure changes was performed with an micro sensor.

Results: We observed a correlation between the different insertional speeds and the increase of intracochlear pressure.

Discussion: The atraumatic insertion of cochlea implant electrodes is crucial for the preservation of residual hearing. In our model experiments, we were able to observe for the first time a relationship between insertional speed and intracochlear pressure changes.

P2-1-3

The assessment of the influence of the surgical technique on HiFocus Mid-Scala electrode insertion depth in children

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Introduction: Several CI electrode types are available to fulfill anatomical variations and surgeons' individual preference. While short electrode arrays as typically used in patients partial deafness will have a shallower insertion, the full hearing restoration may be compromised if the loss of residual hearing progresses over time. On the other hand a deep insertions were reported to increase the level of trauma. The choice of the cochleostomy location was also reported to influence the electrode insertion depth. However, there is today no clear consensus on the insertion depth and it appears to be a subject to inter-centre and surgeon variability. The HiFocus Mid Scala electrode was designed to achieve a stable and consistent insertion depth by the mid modiolar design making it less susceptible to variations in individual cochlea geometries.

Purpose: The primary aim of this study is to investigate the influence of individual cochlea geometries on the insertion depth of the HiFocus Mid-Scala electrode for pediatric patients with severe-to-profound hearing loss. The results will be compared with those obtained for the HiFocus 1j electrode.

Methods: In this prospective study a minimum of 12 postlingually deafened children (older than 1 year) and adults without any anatomical abnormalities will be implanted with the Hires90k Advantage implant and the HiFocus 1j or the HiFocus Mid-Scala electrode. Tonal audiometry will be performed for each subject just after switch-on and at 1, 3 and 6 months after to assess the patients performance evolution in time. Vocal audiometry will also be performed at 6 months after activation and will be compared to the pre-operative figures. Plane radiographies in Stenver's view are systematically taken for each patient after surgery and will be used to estimate the angular insertion depth. The estimation of the modiolus diameter derived from the pre-operative CT images. Correlations between the diameter of the modiolus, the angular insertion depth will be estimated.

Results: 8 patients have already been implanted with the Hires90k Advantage implant for this clinical study, including a bilateral HiFocus Mid-Scala subject. The insertion was systematically performed through the round window. Three new subjects are already programmed for the coming weeks. The tonal audiometry done after switch-on already shows a good level of hearing preservation compared to pre-implantation. The placement analysis of the electrode arrays will be performed at once when the recruitment for the study will be over.

Conclusions: The initial results of the study show already a positive effect of the HiFocus Mid-Scala electrode in preserving residual hearing shortly after the surgery. Data collection is ongoing and further results will be presented and discussed.

P2-1-4

Concept into round window approach for cochlear implantation: A procedure not just an opening

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The insertion of the electrode into the scala tympani through the round window has been used by many surgeons early in the history of cochlear implantation, and is resurging again as the standard technique. The surgical approach for cochlear implant through the round window has many advantages over a classical cochleostomy. It is relatively easy and the electrode can be placed close to the tonotopically organized auditory nerve fibres in the spiral lamina.

However, many difficulties may arise during round window exposure or electrode insertion. Difficulties might arise in the proper exposure, visualization and illumination. Round window orientation can be very variable between different patients and its proper identification is crucial for a safe surgery. The anteroinferior overhang of the niche and the crista fenestra might hinder the proper electrode insertion or result in a kink. Finally the orientation of the round window gives an idea about how the cochlea turns for complete electrode insertion.

Challenging scenarios in each step can be overcome by considering the access to the round window a stepped procedure. We present our concept and procedure followed in cases of round window insertion, to realize a smooth atraumatic full insertion of the electrode. We present the technique step by step, identifying different landmarks, and exposing the challenges encountered and how to overcome them for proper surgical approach.

P2-1-5

Device fixation in cochlear implant: outcomes of bone well technique

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Introduction: Cochlear implantation is a worldwide procedure that provides hearing rehabilitation and improves speech perception. One of the described complications is the device migration, which can result of failure of receiver-stimulator (R/S) fixation. With the increase of operative experience and refinement of the procedure, plenty techniques of R/S fixation was described in the literature, such as suture fixation, temporalis pocket, drilling a bony seat or well. However, the ideal technique to avoid complications still remains a point of debate.

Objective: To compare general complications and device migration for a group undergoing fixation of R/S using a bone well with a group undergoing cochlear implantation without this fixation technique (subperiosteal pocket).

Methods: It was performed a retrospective case review in the department of otorhinolaryngology, head and neck surgery of a tertiary referral center. Clinical sample included all patients with severe-to-profound or profound hearing loss who underwent cochlear implant surgery between October 2008 and April 2013 using devices from the same manufacturer. These patients were divided into two groups: one with the bone well fixation technique, other without device fixation. It was applied clinical forms to all patients and analyses device migration with XR exam.

Results: Thirty-two patients were included, with ages ranging from 5 to 70 years. Follow-up period ranged from 5 to 60 months. The patients, divided into two groups (pocket and bone well), were analyzed through major and minor complications. No intraoperative, wound or intracranial complications have been observed in either groups.

Discussion: The fixation of cochlear implant device is a discussed topic in literature, with a wide variety of techniques described. Most series have low rate of complications, on par with our results. In our review, there were no statistically significant difference between both groups regarding overall complications and device migration.

Conclusion: Both techniques, using a subperiostal pocket and a bone well, showed low rates of complications in our study, with few differences between the groups.

P2-1-6

Practical observations on cochlear implant surgery

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Objective: To describe practical surgical orientations in performing classical and alternative techniques for cochlear implant surgery in order to standardize the approach . This practical orientation is needed for CI surgery to remain safe and effective while minimizing complications.

Methods: Surgical encounters during a standardized approach for cochlear implantation at Ain Shams University and MOH cochlear implant programs since 1993. The standardized technique was modified and tailored according to the anatomical finding and the device used.

Results: The transmastoid facial recess approach is the commonly utilized technique. Alternative techniques are only resorted to when there are anatomical constraints precluding the use of the standard one. Practical orientation for the classical and alternative techniques including all the steps of surgery are to be illustrated.

Familiarization of the basic technique and its modification according to the surgical findings and the device used are crucial to any otologist performing cochlear implant surgery.

P2-1-8

Cochlear implantation for postmeningitic deaf patients: Nagasaki experiences

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Introduction: It is well known that sensorineural hearing loss (SNHL) caused by acute bacterial meningitis is generally severe, and cochlear implantation (CI) surgery for those patients is sometimes difficult because of frequent incidence of cochlear fibrosis or ossification. We retrospectively reviewed postmeningitic CI cases those we have experienced for these 15 years.

Patients and methods: Subjects were 8 postmeningitic patients (9 ears), who underwent CI surgery in the period from April, 1998 till December, 2013, at Nagasaki University Hospital, Nagasaki, Japan, with their age ranging from 11 months to 66 years with an average of 32.3, including 4 children. We analyzed their pathogenic bacteria, CT and MRI findings, surgical findings, cochlear implant device used, number of the electrode inserted and their audiological outcome.

Result: The causative bacteria were *Streptococcus pneumoniae* in 3 patients, *Haemophilus influenzae* in 2 patients, *α-Streptococcus* in one patient, and was unknown in the remaining 2 patients. Cochlear ossification was suspected in 4 ears on the CT, and cochlear fibrosis or ossification were suspected also in 7 ears on the MRI. Intraoperative findings confirmed cochlear fibrosis in one patient and cochlear ossification in 5 patients. Among 5 ears in which cochlear ossification was confirmed during surgery it was preoperatively suspected in 3 ears (60%) on the CT and 4 ears (80%) on the MRI. In addition, we could not preoperatively suspect cochlear fibrosis in one ear in which we confirmed it during surgery, but fibrosis was preoperatively suspected by the MRI in this case. Full electrode insertion was achieved in 7 ears (77.8%) during surgery. Implants used were Cochlear N24 (Straight electrode in 2 patients and Contour Advance electrode in one patient), Cochlear N22 in 4 patients, MED-EL combi40+ in one patient, Advanced Bionics Clarion in one patient. Although all patients seemed to have benefits from CI, we found considerable variation in audiological outcome among our patients; 2 patients with long duration of postmeningitic deafness (14 and 53 years) and one patient with complications (cerebral infarction one month after CI) showed poor audiological outcomes.

Conclusion: MRI seems more advantageous for the diagnosis of postmeningitic change of the cochlea such as fibrosis and/or ossification. Necessity of CI in the early stage after meningitis was reconfirmed. As the possibility of progression of neural damage is pointed out even long after CI in postmeningitic case, long-term follow-up of those patients seemed necessary.

P2-1-9

Is cochlear implantation possible after acoustic tumor surgery?

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The answer is yes, provided that the cochlea remains patent, and the cochlear nerve is intact. This statement is discussed in light of the histolopathologicak findings in ten temporal bones of patients who underwent acoustic tumor removal by the translabyrinthine approach(8), and middle fossa (2) approaches which were available at the House Ear Institute, Los Angeles. Recommendations for the choice between CI and ABI are given accordingly.

P2-1-10

Cochlear re-implantation using the same or different manufacturer´s device

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Objective: To evaluate the speech perception performance outcomes and to assess electrode array functional integrity of cochlear re-implantation (CRI) using a cochlear implant device of the same manufacturer compared to CRI using a different manufacturer´s device.

Method: The medical records of 25 CI recipients, 23 children and two adults who underwent CRI were retrospectively reviewed. Age at first implantation was 12 months to 8 years for the children, and 20-25 years for the adults. Fifteen CI recipients received implants of the same manufacturer, and 10 received devices of a different manufacturer. The three cochlear implants manufacturers: Advanced Bionics, Cochlear and MedEl were represented in the present series. Records were analyzed for device failure/malfunction type, surgical findings, number of electrode channels inserted, post-operative complications, and best aided pre and post CRI speech perception outcomes by monosyllabic and bi-syllabic word tests in quiet.

Results: The reasons for re-implantation were device failure/malfunction in 23 patients and medical reasons (i.e. pain) in 2 others. Full insertion of the electrode array was accomplished in all re-implanted patients, with mild difficulties in the insertion of the electrode array in one patient. No surgical or medical complications were evident the present series. Speech perception results indicated comparable performance in 10 patients, better performance in 9 patients and poorer performance in 4 patients. In two children comparison was not possible due to their young age at first implantation.

Conclusion: There is a high rate of success in CRI with preservation or improvement of preoperative performance in the majority of patients. Regardless of using the same or different manufacturer´s device, CRI surgery is well tolerated and most patients can expect successful outcomes.

P2-1-11

Ambulatory surgery in pediatric cochlear implantation.

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Introduction: Ambulatory surgery (AS) is developing in France due to changes in resources allocation in our Health Care System, because medical technologies allow that, and because population acceptance is increasing. Cochlear Implantation (CI) is well documented in literature for complications rates in adults and in children. CI is possible as an ambulatory surgery in selected cases.

Objective: To describe our population of ambulatory surgery in pediatric cochlear implantation. To describe the selection criteria considering rules and recommendations in the French health care system. To describe complications and/or conditions that precluded any discharge of the patient the day of the surgery. To report feeling of parents about AS.

Design: Retrospective study on charts in a University hospital and tertiary referral center for CI in adults and children.

Population: 45 children were implanted in our Institution between October the Ist, 2012 (date of starting of an institutional AS program for CI surgery in children) and April the 3rd, 2013.

Methods: Charts were retrospectively reviewed reporting number of ASs and non ASs, and in this cases the cause(s) of the number of days of stay at hospital. In France, a day after a phone call by a nurse is mandatory to keep contact with family, to ask if any problem occurred, to counsel family and give recommendations if needed. These phone call are reported in charts, and were analyzed.

Results: According to French official recommendations, 22 children were planned for AS (49%). We will report these criteria. Age ranged from 2 to 15.5 years (mean : 5.4 months). In 2 cases surgery was performed for explantation due to device breakdown and implantation again in the same procedure. In 3 cases deafness was associated with deformation. Mean duration for surgery from skin to skin was 2 hours and 10 minutes. Children could be discharged the day of CI surgery in 82% of cases. The main cause for keeping children at hospital were major vomitings. For patients discharged the day of AS, no complaint was reported during the interview during the day after phone call by the nurse. On patient was admitted again for scalp hematoma and pain, but no second surgery was necessary.

Conclusions: France is changing medical habits moving to AS. AS is possible in CI surgery even in children. Learned Societies recommendation, and Health System Authorities rules should to be followed. Families must be counseled before surgery. Patient tracking during stay at hospital has to be strictly organized following dedicated protocols, including prevention of pain and vomitings. Back home trip and counsels for stay at home must be explained and documented in a written way to parents. A day after phone call is mandatory to prevent unknown and latent complication at home. Despite this very strict protocol, some patients must stay at hospital, vomitings beeing the first cause of swith from AS programmation.

P2-1-12

Intra-operative standard facial nerve monitoring for CI surgery

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Introduction: All efforts should be done to prevent facial nerve injury in cochlear implant and that's the reason why Facial Nerve Monitoring (FNM) is becoming routine used intra-operatively. The literature demonstrates that this technology is widely used though with large diversity in the timing and the amount of electrical current. The aims of this study is to share our experience on using standard FNM in CI surgery.

Methods: Different amount of stimulation current (Medtronic NIM®) in different stage of operation was performed. We initially set 2.0mA to locate the possible tract of nerve. Then, 1.0 mA was used when compact bone is encountered to identify possible aberrant nerve. And when facial recess is nearly drilled out, we skeletonized the FN with 0.5mA stimulating current.

Results/Discussion: Since 2010, in more than 250 cases of CI, we have found this standard FNM did prevent nerve injury. Only one patient with bizarre anatomy had temporary facial weakness with fully recovery few months later. Besides, by using this methods, some facial nerve abnormalities were also noted among patients who had been regard as "normal structure" pre-operatively.

Conclusion: Using standard FNM was safe and timesaving in CI surgery, most importantly, it largely decreased the chance of nerve injury.

P2-1-13

Employment of cochlear implant in skull base surgery

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Introduction: The cochlear implant is the normal solution for severe and profound hearing loss. Skull base surgery procedure often required the sacrifice hearing function. An interesting and innovative application field for cochlear implants is to restore hearing function after this skull base surgery procedure. The objective of this study is to describe our indications and the employment of cochlear implant in that kind of surgery procedure (and show our experience in this field, presenting same cases treated in our hospital).

P2-1-14

Dependence of functional results of stapedoplasty from the size of perforation of the footplate

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Hearing loss treatment in patients with the timpanal and mixed forms of otosclerosis is surgical. In favor of carrying out surgical treatment the fact of bigger progressing of a sensoneural component of hearing loss in not operated ears in comparison with the operated testifies. Nowadays the amount of obliterative forms of otosclerosis with the mixed nature of hearing loss has increased (from 22,7 to 31,2%), forcing to seek for more effective methods of surgical rehabilitation.

Objective: Assessment of change of thresholds of bone conduction in dependence on the size of footplate perforation in patients with otosclerosis.

Examination and treatment of 100 patients with timpanalny (at 29%) and mixed (at 71%) forms of otosclerosis was carried out. The patient of the 1st group (50 people) executed a piston technique of stapedoplasty with a laser assistance (diameter of perforation - 0,6-0,8 mm) and use of a titanium piston implant with a diameter of 0,4-0,6 mm and 4,25 mm long. The patient of the 2nd group (50 people) - a technique a laser-assisted stapedoplasty(diameter of perforation - 1,5 mm) and use an auto cartilage of auriculus (1,0×3,5 mm) as a prosthesis of the stapes, which was placed on a vein graft. The tonal audiometry was carried out by the same audiologist on the 10-12 day postop and in 1, 3, 6 months and 1 year. As a result of research in 1 group only in 3, 6 and 12 months gradual improvement of hearing on bone conduction in the range of 2 kHz in limits of 5-10 dB, whereas in 2 - in 10-12 days and 1 month improvement of hearing in the colloquial range of frequencies, and in 3, 6 and 12 months - on all range of frequencies in limits of 10-20 dB was noted that is caused by reduction of intralabyrinth hypertension, and also restoration of transmission of sound vibrations in case of broad opening of the vistibulum was observed.

Thus, the obtained data testify to improvement of thresholds of bone conduction with increase of the size of footplate perforation in patients with otosclerosis that can influence functional efficiency of stapedoplasty, including the simultaneous application of Vibrant Soundbridge.

P2-2 Middle ear implants

P2-2-1

Patients candidates for middle ear implant system: Psychosocial aspects

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Introduction: The Hospital for Rehabilitation of Craniofacial Anomalies (HRAC) from the University of São Paulo (USP) is a national reference in the treatment of craniofacial malformations as well as in hearing restoration through electronic devices for the deaf. The Audiological Research Center (CPA) of the HRAC/USP has more than 1,100 implanted patients, keeping excellent physical structure and interdisciplinary team in this field. Since 2011, HRAC has adopted the *Vibrant Soundbridge* Middle Ear Implant System, an implantable middle ear hearing prosthesis as an alternative in the rehabilitation of people who cannot use conventional hearing devices or who cannot benefit from them. In Brazil, *Vibrant Soundbridge* was regulated by the National Health Surveillance Agency (ANVISA), under Resolution No.1285 of May, 2010, nevertheless rare surgeries have been performed and all in patients with normal middle ear. This study aims at assessing the psychosocial profile of patients presented with ear malformation, candidates for *Vibrant Soundbridge surgery*.

Methodology: A documentary and census survey was performed**,** by analyzing the data of the psychological and social interview, according to the protocol used at CPA (HRAC/USP), from seven medical records of the patients submitted to surgery. The aspects analyzed were: age, gender, marital status, education, occupation, socioeconomic status, sociability, affection, family dynamics, view of disability and expectations as to the surgery.

Results: The patients are in the age range 14-22 yrs, being 4 females and 3 males, all single. Most of them graduated from high school, their socioeconomic status is low and only one is an university students and works. Most patients report satisfactory sociability, have family support and present a realistic view as to their hearing impairment. However, some patients show predominant negative feelings in relation to themselves and depressed mood states. All presented realistic expectations and motivation for the surgery.

Conclusion: This study showed the psychosocial profile of patients presented with ear malformation, candidates for the *Vibrant Soundbridge surgery,* identified possible risks and psychosocial barriers and aided in the referral of cases, which reflects in their integral treatment, in a humanized work conception.

P2-2-2

Intraoperative objective measures in vibratory implants

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Introduction: Intra-operative measurements are common in cochlea implantation to determine the functionality of the device. Here the measurement of electrode impedances and electrical evoked acoustic reflexes are standard procedures. In middle-ear and bone-conduction implants intra - operative testing of devices and transmission is less common. Exploiting and developing new mechanical, acoustical and electrophysiological intra-operative tests provides better insights into the effectiveness of different stimulation strategies with middle ear implants (MEI) and to decide on the best configuration in patients during surgery.

Methods: Intra-operative LDV and acoustic measurements in the external auditory canal (EAC) were established and used to assess mechanical reference data of various implants and applications. Laser Vibrometer measurements were performed intra-operatively at sites that possibly reflect the input to the inner ear e. g. stapes footplate, round window or ossicles including all commonly implanted devices. So far, intra-operative LDV and acoustic measurements of acoustic reverse functions in the external auditory canal (EAC) in single sided deafness patients during implantation were established.

Results: A first analysis of 10 patients implanted with the Bonebridge bone conducting device yields lower correlation of vibration of the skull with ipsi- and contra-lateral outer ear canal sound pressure (Fig1) than expected. LDV measurements (Fig.2) were clearly discernible from the background noise (grey lines in Fig.2) generally present in operation theatres.

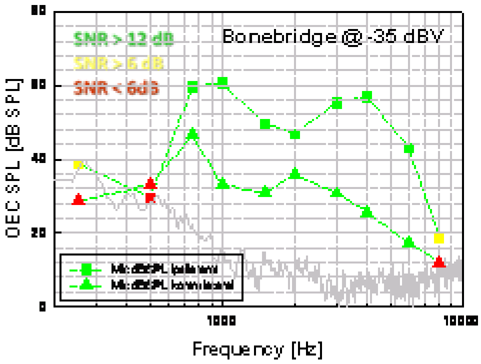

Fig.1:intra-op acoustic measures in the range 100 Hz to 10kHz.

[acoustic measurements in the EAC]

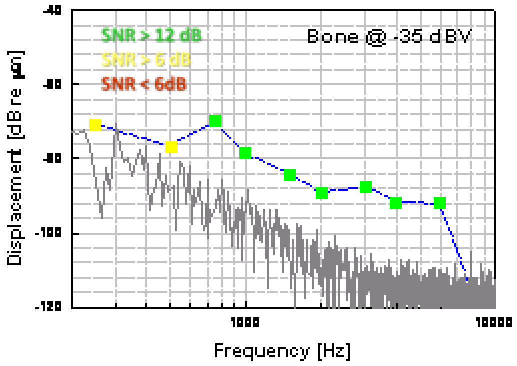

Fig.2: intra-op LDV measures according to frequency

[Laser Vibrometer measurements]

Discussion: To verify this result and to improve the method, the technical possibility, to stimulate devices in already implanted patients was evaluated to establish a diagnostic tool for clinical routine.

Conclusion: Intra-operative LDV of skull vibration and acoustic measurements of acoustic reverse functions in the external auditory canal (EAC) in single sided deafness patients with the Bonebridge were weakly correlated.

Learning outcome: This first data set serves as an example of possible application of interest and can be extended to new devices and applications.

P2-2-3

Direct round window stimulation with the Vibrant Soundbridge (MED-EL): 5-year experience using technique without fascia

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Background/ Purpose: An objective of this study is to present the 5-years of surgical experience and the extended results of hearing preservation (based on 3 years follow-up study) with the Vibrant Soundbridge® with the FMT placed directly against round window membrane with fascia only used as covering tissue to stabilize FMT in place.

Methods: A retrospective survey of surgical and audiological data was conducted to evaluate performance and stability of hearing; audiometric measurements were performed in fixed time intervals. Material included 21 patients, aged 19 - 62 yrs. (mean 48,4 y.o.), with mixed or conductive, bilateral or unilateral hearing loss. Surgical intervention involved the monaural implantation of MED-EL VSB. Placement of FMT was directly against the round window membrane without interposed fascia, but with covering material. Surgeries had been performed between 2006 and 2009. Results had been assessed using pure tone audiometry thresholds.

Results: In 5 years of experience with that technique, no significant complications or device extrusion were observed except for two revision surgeries due to necessity of FMT reposition. In the 3-year follow up of the study group we observed stable hearing in the implanted ear.

Conclusion: We conclude that the direct round window stimulation is an alternative for patients with hearing impairment caused by chronic otitis media and/or lack of the ossicles, especially after modified radical mastoidectomy. It allows achieving good results in selected group of patients, although further observation on a larger population is needed to confirm the long-term validity and effectiveness of this method.

P2-2-4

Techniques to improve the efficiency of a middle ear implant: Effects of coupling method on intracochlear pressure

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Intro: Active middle ear implants (AMEIs) effectively treat moderate to severe sensorineural, mixed, or conductive hearing loss by vibrating the ossicular chain with an electric actuator. Previous work in our laboratory has shown that the effectiveness of an AMEI at producing motion in the stapes depends jointly on the coupling mechanism and the exact placement of the actuator along the ossicular chain (Deveze et al. 2013). Here, we extend those results by measuring intracochlear pressure concurrently with stapes motion during AMEI input.

Methods: The AMEI was coupled to the ossicular chain using the following methods: 1) placing the tip of the transducer in contact with the incus body (baseline), 2) with áWengen clips crimped to the transducer and attached to the incus long process (ILP), and 3) after chain disarticulation, a bell-shaped prosthesis crimped onto the transducer and placed in contact with the head of the stapes. Performance of the AMEI in each condition was assessed by measuring the pressure in scala vestibuli (P_{SV}) and scala tympani (P_{ST}), using fiber-optic pressure sensors, concurrently with stapes velocity (v_a) via a single-axis laser-doppler vibrometer, and comparing computed maximum equivalent ear canal sound pressure levels (L_{Emax}).

Results: Consistent with our previous report, coupling to the ILP or stapes produced similar or substantially improved stapes velocity relative to the baseline coupling condition; however, intracochlear pressure did not always show a comparable increase in performance with alternative coupling methods.

Discussion: Alternative locations for ossicular coupling may increase stapes velocity; however, this increase is not necessarily converted entirely into higher intracochlear pressures, suggesting that linear stapes velocity alone cannot explain energy transfer into the cochlea. Despite the differences, L_{Emax} was relatively high with all coupling methods, suggesting that patients may gain substantial benefit regardless of coupling technique.

Conclusion: Intracochlear pressure as well as stapes velocity varies with different coupling methods of the AMEI to the ossicular chain. Further research assessing clinical outcomes is necessary to elucidate the qualitative benefits of various coupling techniques.

Learning outcome: At the conclusion of this activity, participants will be able to appreciate the benefits of optimized AMEI ossicular coupling.

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P2-2-5

Considerations of coupling modalities of the vibrant soundbridge to the round window

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Introduction: The backward stimulation of the cochlea using the floating mass transducer (FMT) of the vibrant soundbridge (VSB) (MED-EL, Innsbruck, Austria) is a treating option for patients with conductive and mixed hearing loss. Yet there is vivid debate on the most efficient technique of coupling the FMT to the round window and a demand for a more standardized procedure for the most efficient stimulation of the cochlea.

Methods: We performed a human temporal-bone study to evaluate the efficiency of sound transmission of the VSB with the FMT placed against the round window. The inner ear was stimulated via the VSB with a frequency sweep from 50 Hz to 20 kHz at 300 mV. Stapedial footplate vibrations were recorded with LASER- Doppler-Vibrometry and the volume velocities calculated. Coupling of the FMT was facilitated with and without interposed cartilage and connected to the Round Window Coupler (RWC) (MedEl, Innsbruck, Austria). The various coupling conditions were applied either to the unaltered round window niche or to the fully exposed round window membrane. Furthermore, the effects on sound transmission of FMT loads pushing it towards the round window membrane were evaluated.

Results: In the unaltered round window niche transmission efficiency could be raised significantly by interposing cartilage between the FMT and the round window membrane compared to the FMT placed solely or in conjunction with the RWC. Coupling of the FMT to the fully exposed round window resulted in similarly increased volume velocities of the stapes footplate with either interposed cartilage, attached to the RWC or by direct placement. Increasing pretension of the round window membrane diminished overall transmission efficiency. Additionally, higher pretension reduced transmission of the low frequencies while enhancing the high frequency range.

Discussion: A definite contact to the round window membrane of the FMT is essential for effective backward stimulation of the cochlea. Interposed cartilage in the unaltered round window niche can accomplish effective sound transmission while reducing the amount of drilling. In contrast, placing the FMT solely and with the RWC against the unaltered round window niche significantly decreases energy transmission. For the fully exposed round window membrane interposed cartilage and the RWC revealed no adverse acoustic effects. No matter the applied coupling technique the pretension of the round window membrane displays considerable alterations of the transmission efficiency in vitro.

Conclusion: Definite coupling of the FMT to the round window membrane is crucial for optimal energy transfer to the inner ear. Neither autologous cartilage nor the RWC display adverse audiologic effects. Pretension of the round window membrane through the applied load to the FMT should be taken into consideration towards a more standardized coupling procedure.

P2-2-6

The method of middle ear implantation in patients with chronic suppurative otitis media

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Difficulties in standard method of middle ear implantation usage in patients with chronic suppurative otitis media occur because of pronounced destruction presence in postoperative cavity, the lack of anatomical landmarks - as a result - and high probability of facial nerve canal and dura mater damage during the operation. The development of safe access to tympanum with a reliable sanitation of middle ear cavities in order to perform middle ear implantation was **the objective** of the study.

Materials and methods: 5 patients with chronic bilateral suppurative epitympanoantral otitis media treated at the National Centre of Otorhinolaryngology in 2010-2013 were included into the study. The following criteria of selection into the study group were highlighted: mixed hearing loss with pronounced neurosensory component (with bone conduction thresholds in the area of low and high frequencies at 35-55 dB and up to 75 dB, consequently). All of the selected patients were operated using the developed method: front tympanotomy was performed after antromastoidotomy with pathological tissues removal from the antrum and entrance to antrum extension. Access to tympanic cavity is provided, lateral wall of attic removed and tympanum revision with pathological tissues removal made. Floating cylinder is introduced into tympanum through the entrance of antrum from the side of mastoid cavity and fixed on the stapes with titanium clips from the side of external auditory meatus. Tympanic membrane is formed with auricular cartilage, meatotympanal flip put on its place and swabbing of external auditory meatus performed. The operation ends with fiber-wise stitches on the wound behind the ear.

Results: No symptoms of facial nerve paresis, nasal liquorrhea or meningeal irritation were observed in operated patients in the early and late postoperative periods.

Speech intelligibility increased on average from 32.6% to 88.0% after audio processor connection according to speech audiometry in the free sound field in all the operated patients.

Conclusion: Minimization off: acial nerve damage risk (no standard posterior tympanotomy is performed), reliable sanitation of middle ear cavities and secure FMT fixation on stapes head (it is extremely difficult to fix FMT on stapes head through posterior tympanotomy) are the main advantages of the developed method.

P2-2-7

Implantable hearing system for congenital anomalies of the ear

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Intro: The Audiologic Research Centre of the Hospital for Rehabilitation of Craniofacial Anomalies of the University of São Paulo (HRAC/USP) is a national reference for treatment of craniofacial malformations as well as hearing restoration through electronic devices, having conducted more than 1,000 cochlear implant surgeries. In this context, the HRAC provides those patients who have external and middle ear malformations - congenital or acquired - with surgically implanted hearing devices to restore hearing to this population.

Methods: This study was conducted at HRAC/USP and approved by the Ethics Committee, with objective to determine the audiologic benefits of the Vibrant Soundbridge (VSB) in patients with congenital aural atresia. Ten patients with bilateral congenital aural atresia underwent surgical insertion of the VSB middle-ear prosthesis. The patients were selected according to the following inclusion criteria: (a) between the ages of 12 and 65 years; (b) with conductive or mixed hearing loss; (c) bone conduction thresholds within the range recommended by the company; (e) familiar with hearing aids or unable to wear or benefit from conventional hearing aids for medical reasons; (f) speech understanding at least 50% or better at 65 dB SPL for word lists with amplification; (g) emotional and psychological stability; and (h) realistic expectations. Patients underwent tympanomastoidectomy unilateral with wide opening of the attic and removal of atrophic bone and exposition of the supply-structure of the stapes. The FMT was coupled to a specific titanium prosthesis (Clip-coupler) and fitted in the movable stapes. The evaluation process proposed in this study was comprised of free-field audiometry and the following speech perception tests: monosyllable word recognition and Hearing in Noise Test (HINT).

Results: The mean of the free-field audiometry thresholds was 58.33 dB HL in the preoperative without hearing aids and 28.33 dB HL in the postoperative using VSB, equivalent to a functional gain of 30 dB HL. The mean of monosyllable recognition was less than 40% in the preoperative condition without hearing aids and more than 80% in the postoperative using VSB. The mean of threshold recognition in HINT exceeded 70 dB HL with S/N ratio greater than 5 dB HL in the preoperative condition without hearing aids and below 50 dB HL with S/N ratio less than 1 dB HL in the postoperative using VSB.

Discussion: The results obtained in the patients' evaluation showed improvement in scores using the VSB compared to a condition without amplification.

Conclusion: The study shows that the VSB is safe and effective for patients with aural atresia, providing a satisfactory functional gain in sound perception and speech recognition, thereby contributing to improved communication for these patients.

Learning outcome: The importance of effective rehabilitation in these patients enables integration in society, through a surgical procedure that has been shown to be safe.

P2-2-8

Validation of the new aMEI-score for selecting malformed middle ears scheduled for active middle ear implants

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Introduction: Active middle ear implants (aMEI) are being increasingly used for hearing restoration in congenital aural atresia. The existing gradings used for CT findings do not meet the requirements for these implants. The recently developed *active middle ear implant score* (aMEI-score) for aural atresia describes the extent of the malformation and predicts the difficulty of the implantation. In a second multicenter study the score was validated and the predictive value towards the hearing outcome was investigated.

Methods: 78 malformed ears, implanted with an active middle ear implant were retrospectively analyzed. The aMEI-score was calculated by screening the HRCTs. The middle ears were classified on a 16-point scale (16-13-easy, 12-9 moderate, 8-5 difficult, 4-0 high risk). The surgeons subjectively classified their implantations and the results were correlated with the calculated score. For assessing the audiological outcome, the patients were grouped according to their aMEI-score.

Results: The strength of agreement between the calculated score and the performed implantations was good. The comparison of the new aMEI-score with the Jahrsdoerfer score showed that only the aMEI-score allows a differentiated assessment regarding an implantation of an active middle ear implant. The audiological outcome does not predominantly rely on the severity of the malformation, once the implant is successfully implanted.

Conclusion: The *Active Middle Ear Implant Score for Aural Atresia (aMEI-score)* allows more precise risk stratification and decision making regarding the implantation. Active middle ear implants allow a safe and reliable hearing restoration in aural atresia.

P2-2-9

Results of conductive and mixed hearing loss treatment with vibroplasty couplers at the stapes head and footplate

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Introduction: In certain cases of conductive and mixed hearing loss conventional surgical techniques may be unsatisfactory and ineffective. Achieving the desired outcomes often requires the use of active middle ear prostheses such as the MED-EL Vibrant Soundbridge. The small size of the transducer allows its location on almost any chosen structure of the middle ear which takes a part in the transmission of sound vibrations to the cochlea. The FMT (floating mass transducer) can also be attached to the stapes or its remnants if mobility of this bone is preserved. Such use of this device can be treated as a solution for selected surgical and audiological problems.

Aim: The aim of this study is to present the results of Vibrant Soundbridge system with the FMT placed on the stapes head and footplate in mixed and conductive hearing loss.

Material and methods: There were 28 patients, aged 12 to 73 yrs. (mean age- 57), including 17 women and 11 men, with conductive or mixed hearing loss in the ear chosen for implantation. Surgeries were performed between 2010 and 2013. The patients were all assessed preoperatively and postoperatively to obtain hearing thresholds for both AC and BC at standard frequencies, and they were tested in free field conditions with pure tone audiometry and Polish monosyllabic speech tests. Additionally, the functional gain was calculated.

Results: The results of the study confirm the safety of the applied surgical techniques and the postoperative effectiveness of the MED-EL Vibrant Soundbridge device within hearing preservation (100% of cases). Significant improvement of speech recognition in most patients was also observed. Compared to the preoperative results (without prostheses), a decrease of postoperative pure tone thresholds (with VSB) in the free field conditions was observed as well. Treatment of mixed and conductive hearing loss using MED-EL Vibrant Soundbridge with FMT located on the stapes or its remnants is an alternative for commonly used methods of treatment in these types of cases.

P2-2-10

New coupling method for a DACI to the inner ear

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Intro: Direct acoustic cochlear stimulation has been developed for subjects with severe-to-profound mixed hearing loss. A new acoustic hearing implant, named Direct acoustic cochlear implant (DACI), couples to the perilymph at the level of the oval window. In this experimental study the feasibility of coupling the device to a surgically more accessible inner ear site was investigated.

Methods: A temporal bone study on 5 fresh frozen cadaver heads was set-up with the Codacs (Cochlear) implant coupled to the lateral semicircular canal (LSC), thereby creating a third window. The performance of the device stimulating this third window was compared to the standard set-up, using a Laser-Doppler Vibrometry set-up. Stapes fixation was mimicked with dental acrylique application at the stapes footplate.

Results: New surgical and coupling techniques were developed and will be presented. Best performance is obtained when canal is opened and covered with fascia. At 1000mV, the DACI actuator connected to the lateral canal after canalotomy outperforms the device at its standard location. Estimated maximum performance of the DACI at the LSC is about 130 dB SPL equivalent.

Conclusion: the best performance is achieved when the LSC is opened and covered with fibrous tissue. Stapes fixation does not impede the DACI performance at the LSC. It is shown that LSC stimulation with a DACI provides at least equal output as the standard application.

P2-2-11

Fixation of the FMT at the short incus process - A new application method of the VSB®

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The main purpose of the development of the Vibrant Sound Bridge® (VSB) in 1996 was the treatment of sensorineural hearing loss by coupling the FMT to the long process of the incus. During following years the indication for the VSB was broadened to combined or conductive hearing losses in cases of defects of the ossicular chain by coupling the FMT to the round window, stapes suprastructure, stapes footplate or omto a “third window”. Nevertheless in cases of an intact ossicular chain the placement of the FMT to the ossicles remains the preferred method. In cases of exceptional narrow posterior tympanotomy and missing of possible transmeatal approach to the middle ear the fixation of the FMT at the long process of the incus can be of considerable difficulty.

In above mentioned case of VSB surgery with an intact ossicular chain and hindered adequate exposition of the long process of the incus we performed the fixation of the FMT at the short process in 8 cases. The surgical method as well the audiological results will be demonstrated. In all cases we got an essential improvement of the hearing comparable to results of patients with fixation of the FMT at the long process of the incus.

The placement of the FMT at the short process of the incus is a feasible method in VSB surgery in cases of an intact ossicular chain and particular anatomical difficulties. In cases of potential difficulties of the fixation caused by the distinctive form of the short process the additional use of bone cement can be helpful

P2-2-12

Middle ear implant VS Hybrid Cochlear Implant for high frequency SNHL

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Profound SNHL responds well to a standard Cochlear Implant with rewarding results. However, if the individual has residual hearing in the low frequencies there is a reasonable chance that the pure tones will be lost. Hybrid Cochlear Implants have been suggested as a solution for this problem. Unfortunately, there continues to be a loss of the low frequency pure tones in a large number of these patients.

One solution would be to use a middle ear implant instead of a hybrid CI. The Maxum middle ear implant has the advantage of being a minimally invasive surgical procedure that can be performed under local anesthesia. A small magnet is attached to the stapes through a transcanal approach. After three weeks an integrated processor coil (IPC) is inserted into the external auditory canal. The IPC has an electromagnet driver. By driving the stapes directly it is possible to obtain as much as 60 dB of functional gain in the high frequencies without distortion, acoustic feedback, or the sensation of occlusion.

For these reasons the author believes a Maxum should be considered in these patients before a Hybrid Cochlear Implant. If the SNHL progresses, then a CI can still be performed at a later date. This sequence of events delays the invasion of the cochlea and in some cases prevents the need for a CI altogether.

P2-2-13

Results with the new Cochlear CODACS system

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Background: Profound mixed hearing losses are still a great challenge in modern audiology and otosurgery. Available treatment does not provide expected results in many cases. Both surgical (inc. stapedotomy, middle ear implants, bone conduction implants), and non-invasive (conventional hearing aids) approaches are inefficient or even impossible to apply in many cases. A new partially implantable middle ear prosthesis - Cochlear CODACS - may be in the future a prospective alternative for the current solutions.

Aim: The aim of the study is to present audiological results of the patients with profound mixed hearing loss using a Cochlear CODACS system.

Material: Material consists of 5 patients (aged between 43 and 71 y.o.; mean age 51 y.o.) implanted unilaterally with a Cochlear CODACS device, in 2012, in the World Hearing Center, Kajetany/ Poland. The surgeries were conducted as a part of a multicenter clinical study sponsored by the Cochlear company.

Methods: Audiological assessment was based on impedance audiometry and pure tone audiometry (in headphones and in free field). The Polish monosyllabic speech tests in noise and in quiet conditions, and the adaptive sentence test were also applied.

Results and Conclusions: Hearing and functional structures of the ear were preserved in a 100% of cases. While 4 out of 5 cases of patients with CODACS devices showed an improvement of speech recognition scores. In noise SRT (speech reception threshold) defined as the SNR (signal-to-noise ratio) was lower in comparison to preoperative results in conventional hearing aids. The authors also observed lower postoperative pure tone audiometric thresholds in free field conditions with Cochlear CODACS devices, than with hearing aids worn before surgery. Obtained results allow us to state that the new implantable Cochlear CODACS system may be an alternative for other treatment methods applied in cases of profound mixed hearing loss.

P2-2-14

The use of Vibrant Soundbridge with couplers in patients with conductive and mixed hearing loss

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Introduction: The Vibrant Soundbridge is a middle ear implant, that can be used to stimulate the stapes footplate with or without stapes remnants and also round window membrane in patients with hearing impairment due to the chronic otitis media and/or lack of the ossicles, especially after modified radical operations with mixed and conductive hearing loss.

Aim: The objective of the study was to show the surgical technique used in patients with hearing loss after multiple previous operations to whom we used Vibrant Soundbridge with couplers as a method of hearing improvement.

Material and methods: Material included adult patients with chronic inflammation of the middle ear and mixed or conductive hearing loss, after multiple previous operations including radical modified operations with destruction of the elements of the middle ear - tympanic membrane or/and ossicles. Age was 19 - 62 yrs. Most of those patients had previous radical modified operations. In these patients Vibrant Soundbridge with couplers was used as the method of hearing improvement. Surgical approach included FMT with RW coupler placement onto the round window, and FMT with OW coupler on the stapes footplate. We discussed the surgical technique and limitations of use of Vibrant Soundbridge in patients with chronic otitis.

Results and conclusions: Stimulation of the inner ear through round window or stapes footplate using FMR with couplers is an alternative and good method of treatment in selected group of patients with hearing impairment and mild to severe destruction of the middle ear elements. It requires good surgical technique. In follow up, no significant complications or device extrusion were observed.

P2-2-16

Technical and research investigations in the development of a novel magnetic attraction bone conduction hearing system

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Intro: For the development of a new magnetic transcutaneous bone conduction hearing system, a number of key technical questions were addressed through feasibility research. These involve (a) efficient transcutaneous sound transmission, (b) determining the optimum retention force, and (c) estimating performance expectations between transcutaneous and percutaneous systems.

Methods: Laser Doppler Vibrometry (LDV) was used to estimate sound transmission to the promontory in a series of cadaver experiments. Estimation of the optimum force and pressure for the retention/transmission of the system was determined through a series of experiments. To estimate the hearing performance, a unique test setup attaching a soft tissue model to the abutment of existing percutaneous patients (N=10) enabled comparison of unaided, percutaneous and transcutaneous transmission.

Results and discussion: The results of the LDV investigation confirmed the transmission advantage of using a single osseointegrated implant was a 5-15dB frequency dependent increase in transmission efficiency compared to a system that used multiple non osseointegrated screws. Further testing indicated that while transmission efficiency was greater than with a softband, that due to skin attenuation, some transmission loss should be expected when comparing with the percutaneous abutment system. The softband measures highlighted the important relationship between force, pressure and magnet area to ensure good sound transmission, secure retention and to avoid soft tissue complications when measured at 1.5-2N. The comparison of the system with existing Baha patients determined that compensating for skin attenuation through available increased gain of the sound processor could provide audibility and hearing performance results similar to the percutaneous abutment.

Conclusion: The development of a novel transcutaneous bone conduction hearing system required a number of fundamental technological innovations and scientific investigations. These investigations focused on the interrelationship of sound transmission, contact force and required skin pressure. Ensuring that you have sufficient force for retention, good soundtransmission and that the peak contact pressure against the soft tissue remains below 0.6 N/cm2 is key to the development of a clinical useful system. The result is a system that provides an alternative to the percutaneous bone conduction hearing systems.

P2-2-17

Stability testing after osseointegration with a wide implant, performing surgery without skin thinning: A 1 year follow up

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Objective: To evaluate 10 cases of osseointegration using a wider fixture (4,5mm)with Resonance Frequency Analysis.

Patients: 10 adults were operated on consecutively with the non-skin thinning implantation of bone-anchored hearing devices.

Intervention: Eligible adults for bone-anchored hearing device implantation were operated and followed for a total of 1 year. All patients were operated according to the tissue preserving technique without skin-thinning using a 4 mm long and 4,5 mm wide fixture (Oticon Medical) with abutments varying in length from 9-12 mm. Resonance frequency analysis was tested after completed surgery, after 1 week, after 3, 6 and 12 months. Stability values (ISQ) were measured with values ranging from 0 - 100(representing a range of low to high stability respectively).

Main Outcome Measure and Results: All adults concluded the study. Mean age was 54 and there was 7 females and 3 males. No one lost their abutment during the test period. Stability varied in the first test after surgery from ISQ 38 to 61, to ISQ 51 to 62 after 1 year. One patient changed the abutment from 12 to 9 mm during the 1 year test period.

Conclusion: The technique for osseointegration using a wide fixture implant and the non-skin thinning surgical performance shows after 1 one year to be a safe procedure with good stability and no losses.

P2-2-18

Comparison of the audiologic results obtained with the Bone Anchored Hearing Aid attached to the testband and to the abutment. A prospective study

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Objectives: Quantify the audiometric differences between the preoperative test with the Bone Anchored Hearing Aid attached to the testband and the final postoperative result with the device positioned at the implanted abutment.

Patients and methods: A **prospective** study was carried out in a tertiary otological referral centre. 14 adults (27-74 years) were included in the study. Inclusion criteria were bilateral air-bone gaps bigger than 40 dB and more than 4 months of device experience.

Audiometric free-field thresholds and speech audiometry scores have been evaluated for the two situations: device attached to the testband and device attached to the abutment.

Results: For frequencies 256 to 4096 Hz significant differences in the range of 5 to 20 dB were found between the device coupled with the abutment and the preoperative testing with the device positioned at the headband. These differences were also reflected in the speech audiometry with differences in speech threshold of 10 dB approximately.

Conclusion: We have found significant differences in the Audiometry and speech understanding thresholds between the preoperative test conditions and the final postoperative result. We considered that these results should be taken into account in the preoperative counseling process of these patients.

P2-2-19

Individual computer assisted 3D planning for surgical placement of the Bonebridge bone conduction hearing device

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Introduction: The study aimed on evaluating the benefit of a preoperative three-dimensional (3D) planning tool for surgically placing the bone conduction floating mass transducer (BC-FMT) of the Bonebridge (BB) bone conduction implant.

Method: A preoperative planning tool was developed which allowed to freely adjust the Bonebridge implant in an individual 3D model of the skull for checking the possibility of completely fitting the BCI-FMT into a bony bed and finding an optimal implant position. The Bonebridge was implanted with mastoid or retrosigmoid placement after individual preoperative planning and “virtual surgery” in adult and pediatric patients with conductive or mixed hearing loss due to chronic ear disease, malformation, or single sided deafness. The main outcome measures were feasibility of the preoperative 3D planning process, transfer into the intraoperative situation and audiological results after BB implantation.

Results: Individual preoperative planning was considered beneficial especially in cases of small mastoid bone volume, e.g. due to previous canal wall down mastoidectomies, and in the case with malformation. The audiological results were similar to those reported in the few cases or small case series on Bonebridge implantation published so far and to those from studies with the Baha implant.

Discussion and conclusions: For optimal placement of the BC-FMT of the BB, preoperative 3D planning is recommended especially in primarily small, poorly pneumatized mastoids, hypoplastic mastoids in malformations, reduced bone volume after canal wall down mastoidectomy or small mastoids in children. Efforts should be made towards reducing segmentation and surgical planning time by means of automatization.

P2-2-20

A prospective comparison between the new wide and conventional Ponto implants: 6-months data in first 20 patients with tissue reduction and preliminary results on numbness in tissue preservation technique

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Introduction: This report provides a comparison between the new Ponto 4.5-mm wide implant in comparison to the 3.75-mm conventional Ponto implant.

Methods: In this randomized, prospective clinical trial, the first cluster of 20 adult patients was randomly assigned to the wide (test) implant and conventional (control) implant in a 2:1 (test:control) ratio. ISQ-values were measured at implant surgery as a baseline, and at 1, 2, 3, 4, 6, and 12 weeks, and 6 months post-surgery. Skin reactions according to Holgers' grading scale were monitored during follow-up. All implants were loaded at 3 weeks after implant surgery. Subjective benefit was measured using the APHAB, GHSI, and GBI questionnaires.

Results: No implants were lost during the 6-months follow-up time. One patient (control implant) required soft tissue revision surgery. Mean absolute ISQ values for the test implant were higher than for the control implant. Both implants showed a safe ISQ tendency over time. Skin reactions were comparably low, with only 1 adverse skin reaction (Holgers grade 2, test implant). Both test and control implants provided subjective benefit for the patients.

Discussion: Results of in total 60 patients with 6 month data need to be awaited. Part of these serve as control group for 25 patients with the Oticon wide implant operated with the tissue preservation technique. Preliminary results on numbness will be presented.

Learning outcome: The current short-term data suggest that both test and control implant are a secure treatment option for patients requiring BAHI.

P2-2-21

Comparing different brands of bone anchored hearing systems - A review of the literature

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Since 2009, two brands of percutaneous bone anchored hearing systems are available. The aim of this study was to compare the audiological outcomes of the two systems by means of a systematic literature review.

We performed a systematic review of studies where sound processors of the two brands have been directly compared (within-subject test designs). Ten studies in total met the inclusion criteria. An overview of these studies will be given. The quality of the study design varied, as well as the generation of sound processors compared. When further restricting the data to only comparing the latest generation sound processors from both manufacturers and studies adhering to a balanced cross-over design, seven studies with a total of 84 patients remained. We will report results from laboratory-based speech tests as well as self-reported benefit based on standardized questionnaires. A general finding of the studies was that for the latest generation sound processors, there is a weak or no correspondence between results on speech tests in the laboratory and self-reported results. For the studies where patient preference/choice of sound processor was reported at the end of the study (N=57) the Ponto Pro family of sound processors was rated significantly higher by the users than the BP100/BP100 family of sound processors.

P2-2-22

Bone anchored hearing aid with hydroxyapatite abutment efficient in preventing necrosis of cutaneous flaps

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Intro: Currently the state of the art in BAHA surgery is represented by BAHA DermaLock abutment with hydroxyapatite. Good soft tissue attachment and limited pocket formation are desirable in order to obtain a barrier and effective peripheral immunological defence against microorganisms to maintain a healthy implant site long-term. Around 2000 patients received this type of hearing aid worldwide and all research teams reported excellent results. We introduced this new technology through the National Hearing Aid Implant Program at Coltea Clinical Hospital in Bucharest. Although we have a limited budget we considered that switching to this type of implant will prove cost efficient on the long term.

Methods: We present a series of 4 patients that received BAHA DermaLock with hydroxyapatite abutment. All patients were adults due to the specificity of our hospital and they had a mixed hearing loss due to bilateral chronic otitis. One case had not gained sufficient benefit from open ear devices. Given the fact that we operated on adults we performed only BAHA fast surgery procedures. Patients were fitted with BAHA processors six weeks after the surgical implantation.

Results: The surgical success of a BAHA implant depends upon percutaneous implant which must be surrounded by thin, hairless and immobile skin in order not to cause an adverse soft tissue reaction at the interface between skin and screw, thereby remaining stable over a long period of time. Hydroxyapatite has been shown to provide a tight adherence with the surrounding soft tissues. In all our 4 cases did not suffer from complications such as skin flap necrosis with healing by second intention, infection of the flap, skin growth over the abutment, failure of osseo-integration and implant extrusion.

Discussion: Baha procedures with abutment is a facile technique with a short learning curve even for less experienced surgeons.

Conclusions: We have successfully performed the first 4 BAHA procedures with DermaLock and hydroxyapatite abutment in Romania. Hydroxyapatite-coated DermaLock associated a soft tissue preservation technique and provides a superior treatment with good clinical outcomes and significantly improved cosmetics for the BAHA patients.

Learning outcome: The benefits of Baha DermaLock prove that even the most difficult cases can be solved with cost efficiency.

P2-2-23

Pilot data of the bacterial flora on the percutaneous bone anchored hearing system abutment

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Introduction: A disadvantage of the skin-protruding bone anchored hearing system is its relatively high rate (up to 40%) of peri-implant dermatitis. The constitution of peri-implant dermatitis is still unclear. A gain in knowledge is necessary in order to devise new treatment options. One potential major contributing factor could be that bacteria colonize the skin-abutment interface and subsequently give rise to infections. It has been established that bacteria can exploit strategies such as biofilm formation to resist treatment. This could explain the sometimes persistent or recurrent peri-implant dermatitis which does not react well to treatment. Little is known about the role of bacteria on the abutment, both in an inflamed or non-inflamed condition. In theory, bacteria could even be beneficial. Previously, research was mostly confined to conventional cultures which lacked the sensitivity to investigate (an)aerobic bacteria or their complex composition. Pilot data, which has been gathered by using techniques in molecular microbiology to overcome these limitations, is presented.

Methods: A novel 16S-23S rDNA interspace (IS)-region-based profiling method (IS-pro) is used to identify and quantify bacterial species which could inhabit the abutment, its direct surroundings and contralateral retro-auricular skin. It is performed using swabs of patients and their abutments with and without signs of inflammation as assessed by using the Holgers index. Biofilm formation on retrieved abutments is investigated using Scanning Electron Microscopy (SEM).

Results: Evidence for a distinct bacterial flora including seemingly misplaced species which have opportunistic pathogenic properties is found on and directly around an abutment. Moreover, on most abutments signs of biofilm formation are present.

Conclusion: The presented pilot data indicate that bacteria and their ability to form biofilm should be further investigated by using the proposed methods in a larger group of patients.

P2-2-24

New bone conduction hearing technologies in children: Experience, application & outcomes

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Introduction: To address concerns regarding implant failure, skin infection and cosmetic acceptance in children, new implantable bone conduction (BC) technologies have been sequentially introduced. We report our experience in children using the percutaneous Cochlear™ Baha® BI300 and BA400 and the transcutaneous Baha® ATTRACT implants.

Methods: We collect data prospectively on all children undergoing implantable BC implants. Bone conduction implant stability can be objectively measured using resonance-frequency analysis (RFA) to generate Implant Stability Quotients (ISQs). We aimed to assess implant stability in children undergoing 1-stage surgery using RFA measurements and investigate the possible implications for earlier loading following surgery. Our experience with the ATTRACT transcutaneous device as part of the Controlled Market Release (3+ cases) will also be reviewed.

Results: 9 children underwent 10 BI300 implants with a mean age of 9 years 4 months. 7 children (M:F 3:4) have received the BA400 percutaneous device without soft tissue reduction, with a mean age of 7 years 11 months. Using RFA the mean ISQ at surgery for BI300 implants was 60 and the corresponding unadjusted value for BA400 implants was 50. Incision modifications may be necessary when using the ATTRACT transcutaneous device in children with microtia, or following mastoid surgery.

Discussion: The continuing evolution of implantable BC devices offers greater options for children with CHL or SSD. Greater implant stability has been demonstrated using the BI300 and BA400 implants, which would subsequently enable early Baha loading. The BA400 has provided additional improved cosmesis. The ATTRACT system potentially offers further improvement in cosmesis and skin inflammation and is likely to have greater acceptance in children with microtia and canal atresia and those who would have previously declined Baha.

Conclusion: Bone conduction hearing aids remain an important option for rehabilitating certain hearing losses in children. Advances in technology and implant design mean that the uptake of implantable BC hearing aids in children will increase.

Percutaneous hearing aids will remain an important option in younger children, due to concerns about soft tissue thickness, until active transcutaneous implants become established.

Learning outcome:

1. Percutaneous implant stability in children can be measured prospectively using RFA to generate ISQ measurements.
2. Increased stability of percutaneous Baha (BIA300, BA400) implants support earlier loading at 4-6 weeks in selected children.
3. Transcutaneous implants are likely to lead to greater acceptability and fewer skin problems than percutaneous implants, resulting in increased applications and uptake in children.

P2-2-25

Application of MED-EL Bonebridge in adult patients with congenital and acquired hearing loss - first experiences

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Introduction: MED-EL Bonebridge is a new active, bone conduction implant that can be used in adult patients with a hearing loss of various origin - congenital and acquired. It allows sound transmission directly to the inner ear without middle and external ears involved.

Aim: The objective of the study was to present first experiences and discuss the surgical technique used in patients with hearing loss to which Bonebridge implant was used as a hearing improving system.

Material and methods: The material included 6 patients operated in 2012/2013. Internal part, The Bone Conduction Implant was positioned under the skin of adult patients with congenital and also acquired deformations. The time of the operation did not exceeded 1,5 hour. No major complications were observed during the operation as well as in the follow up period.

Results and conclusions: First experience is encouraging. Surgery must be preluded by meticulous CT scan assessment in order to be sure that the internal part could be implanted in proper way. In author's opinion this solution is very promising.

P2-2-26

MRI artifacts caused by hearing implants: Assessment of the internal auditory canal in cochlear implant users

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There is an increasing number of hearing implant users that have to undergo brain MRI scans for various reasons. While there is little concern with CT scans, MRI scanning may be problematic in different ways. Inevitable artifacts caused by the magnetic and metallic parts of the implants often prevent assessment of the internal auditory canal and other regions of interest.

In this study we aimed to determine factors that influence the visibility and assessment of the internal auditory canal in brain MRI scans of hearing implant users. For various, potentially life threatening reasons 5 patients using cochlear implants (Cochlear and Advanced Bionics) have undergone brain MRI scans in our hospital using a 1.5 T MRI scanner. Artifacts caused by the implants were analyzed quantitatively and with respect to the assessment of the internal auditory canal. The cochlear implant magnet position was estimated by the calculation of nasion- external auditory canal angle and distance to the external auditory canal.

A direct correlation between the position of the receiver-stimulator with its holding magnet and the visibility of the structures of the internal auditory canal could be found. Even without specific MRI artifact reduction software visualization of the internal auditory canal is possible. This might be of special interest in implanted patients with a history of vestibular schwannoma or neurofibromatosis (Typ II).

P2-2-27

Verbal benefit of cochlear implant in congenitally deaf children

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Intro: The objective of the present study was to evaluate the benefit of speech and language development in deaf children with cochlear implant.

Methods: Cochlear implanted children included in this study were evaluated before and three years after activation of the speech processor by means of pure tone audiometry and speech recognition at 65dB A, in quiet. Appropriate speech materials for children between 5 - 10 years in Romanian language were used. Evaluation included as well LPP (Listening Progress Profile), MTP (Monosylabic-Trochee-Polisylabic) tests and monosylabic words closed set.

Results: 62 children participated in this study, age range between 2 and 6 years.

Children implanted at 3 years of age obtained 90% speech recognition score at 65dB A in quiet, while children implanted between 5 and 6 years of age obtained just 60% speech recognition score in the same condition. Regarding LPP and MTP tests, the majority of children reached 100% scores after 12 month of rehabilitation. For monosylabic words closed set, progress exist in every child.

Discussion: Just 4 children out of 24 with hearing aids before CI obtained scores different from 0% in this battery test before cochlear implantation. If we considered communication mode in implanted children 3 years post activation, 45% are using auditory mode alone, 28% visual and auditory together, 14% visual communication mode and 13% auditory, visual and gestual mode.

Conclusion: All children with CI for at least 2 years are integrated in mainstream schools and kindergartens with results similar of their hearing-age pairs.

Learning outcome: Speech and language benefit in cochlear implanted children is significant and it depends on age of implantation.

P2-2-28

Safety and effectiveness of the Vibrant Soundbridge® when implanted in children and adolescents: An analysis of patient data collected six months post-implantation

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Intro: The Vibrant Soundbridge® (VSB) (Vibrant MED-EL, Innsbruck, Austria) is intended to treat patients diagnosed with a mild-to-severe sensorineural, conductive, or mixed hearing impairment. The VSB has been approved (CE mark) to be used to treat patients 5 years of age and older. This study is designed to collect long-term safety and effectiveness data in subjects between the ages of 5 and 17 years old up to 36 month post-operatively. Presented data are derived from an interim analysis completed 6 months post-operatively.

Methods: This is a prospective, single-subject repeated measures study in which each subject serves as his/her own control. A total of 28 subjects between the ages of 5 and 17 years who were treated with a VSB in 5 clinics located in Germany, Austria, and Italy were included. Pure tone audiometry (bone conduction and air conduction) and free-field warble tones measures were taken pre-operatively and at 3- and 6- months post-operative intervals. Word recognition score (WRS) in quiet was assessed using the Freiburger Monosyllable test or the Göttinger Kindersprachtest with a signal presentation of 65 dB SPL. Speech Reception Threshold (SRT 50) for 50% words correct was assessed using the Oldenburger Satztest (OLSA) or the Oldenburger Kindersatztest (OLKISA). The signal-to-noise ratio was also assessed using the OLSA or the OLKISA with the background noise level being presented at 65 dB SPL.

Results: Included were a total of 17 males and 11 females with a mean age of 10.6 years old. Twenty seven of the subjects were diagnosed with a conductive hearing loss and one was diagnosed with a mixed hearing loss. Findings revealed no significant decrease in bone conduction measures taken pre-operatively and 6 months post-operatively, indicating that inner ear function remained unaffected by the treatment. No device related adverse events were reported. Analysis of warble-tone and speech audiometric data collected during the same time period resulted in favorable outcomes when comparing unaided conditions to VSB aided conditions. Improvements in functional gain ranging between 24 dB HL and 35 dB HL (mean = 30 dB HL) for individual frequencies were noted when comparing test results for unaided and aided warble tones presented in the free field. Word recognition scores in quiet increased from 17% (pre-operative) to 93% words correct when aided with a VSB. Results for the speech reception threshold for 50% word understanding in quiet decreased from 63 dB SPL to 40 dB SPL. Likewise, the signal-to-noise ratio decreased from +1.9 S/N dB to -4.1 S/N dB when noise was presented at 65 dB SPL.

Discussion: The findings of this interim analysis indicates that the VSB is a safe and effective treatment when used with children and adolescents who have been diagnosed with a conductive or mixed hearing loss. Word recognition, speech reception thresholds, and signal-to-noise ratio findings indicate significant benefit for individuals when comparing unaided vs. VSB aided testing results.

Conclusion: The Vibrant Soundbridge is safe and effective for use in children and adolescents 5 to 17 years of age for up to 6 months of device use.

Learning outcome: Attendees of this presentation will be informed on the latest safety and effectiveness data available from the ongoing Vibrant Soundbridge in children and adolescents study.

P2-3 Fitting

P2-3-1

Telefitting of cochlear implant patients in National Network of Teleaudiology

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Purpose: The process of diagnosis, rehabilitation and post-intervention care over patients with hearing disabilities, often equipped with different kinds of hearing prostheses, usually requires an experienced, multidisciplinary team to undertake repeated sessions with the patient in the clinic. For the majority of patients it entails long travels from their home, associated with high cost, time, and travel weariness. To reduce patients' burdens and allow specialist from the field to benefit from the experience of the World Hearing Center's team, the National Network of Teleaudiology was established. The Network, consisting of the World Hearing Center, 19 cooperating policlinics in Poland and one abroad, equipped with state-of-the-art hardware and software for teleconference and remote access to distant machines, allows using different telemedical solutions in daily clinical practice. The aim of this paper is to present the use of National Network of Teleaudiology for cochlear implant recipients, mainly by the means of a telefitting method.

Material and method: The telefitting method allows experienced specialist from the World Hearing Center to use Internet connection to fit cochlear implants for patients in cooperating policlinics. The study groups consisted of 208 patients, 114 children (mean age 7.4 years) and 94 adults (mean age 34,5), remotely fitted according to the telefitting procedure introduced in the National Network of Teleaudiology. The patients, or patient's parents, assessed quality and time effectiveness of teleconsultation via questionnaires. Travel time and cost savings were also computed.

Results and conclusions: Patients, or patients' parents, were satisfied with the course and results of telefitting. The Nationwide Network of Teleaudiology has proved to be a reliable platform for telefitting, improving quality of service for the patients and providing substantial time and money savings. With proper models of postoperative care telemedicine can be a method to cope with growing number of patients in the future, but still allowing for the need of expert's knowledge.

P2-3-2

Remote mapping for cochlear implant recipients - Development and validation of a remote cochlear implant telehealth service: Objective and subjective outcomes

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Background: Distance, mobility and availability of time are challenges for people with a cochlear implant to accessing mapping and rehabilitation services. Telehealth technologies offer opportunities to change the way services are delivered to address some of these challenges.

Methods: A web-based system was developed to incorporate video, voice, text and user feedback. MED-EL cochlear implant recipients participated in two programming sessions, one by conventional means and one remotely. A facilitator assisted the recipient during remote sessions. After mapping, fitting was confirmed by open sentences and the Ling six sound test. The preferred map was recorded, as were maximum comfort levels (MCLs). Participants were surveyed regarding technical aspects and satisfaction with the session.

Results: Eleven recipients were tested (average age 67.8 +/- 6.2 years) with an average of 2.7 (+/- 1.9) years' experience with an implant. MCLs were not statistically different between sessions. All patients scored perfect on the Ling test and ten answered all six open-sentence questions, compared to eight and nine people respectively for conventional mapping. Six participants reported no preference between the maps, two preferred the map from the conventional method, and three preferred the map from the remote session. Time for remote mapping was five minutes longer. The most common technical issue raised was video and voice dis-synchrony. Ten participants indicated that they would be willing to use a remote mapping service in the future, and all indicated that they would recommend it for others.

Conclusions: The remote mapping system developed is a reliable method of mapping, with an untrained facilitator playing an important support role, and has excellent recipient acceptance.

P2-3-3

Profile of patients in telecare on patients after cochlear implantation in Opole Center of Hearing and Speech Medincus

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The aim of the study was assessment of patients profile which sit in teleaudiology service after cochlear implantation. The Center of Hearing and Speech Medincus in Opole was opened 4 years ago and in that time 32 patients are under care. Average age is 34,41. Frequency of visits is 2,26 per year. Younger patients are more often likely to attend in telerehabilitation programs. Telefitting is accomplished with Polytec platform. Connection is with World Hearing Center at Kajetany. There is similar number of patients with Cochlear and Medel Speech processors and some Advanced Bionics patients. Full audiological and ENT assessment could be accomplished. Service of speech therapists, psychologists, physiotherapists. Patients from other regions are willing to come for visit as well also implanted in another centers. 91 % patients are satisfied with teleaudiology care, but they are convinced that it is good for visit after hook up.

P2-3-4

Efficacy of remote intraoperative monitoring in cochlear implant surgeries

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Objectives: Intraoperative testing of cochlear implant devices, establishment of electrical threshold for acoustic reflex, and recording neural responses to electrical stimulation have traditionally required the presence of a cochlear implant audiologist in the operating room. The goal of this study was to determine the feasibility of remote testing to improve time efficiency and reduce cost.

Study Design: Prospective.

Methods: A standard PC with Team Viewer software and either Cochlear Corporation or Advanced Bionics Corporation mapping software was configured to perform remote testing.

Results: With the availability of the laptop and internet access, there were no geographic restrictions regarding the site ofremote testing. Remote testing was time efficient, requiring 20 minutes of audiologist´s time compared with 90 minutes when the audiologist had to travel to the operating room.

Conclusion: Remote testing of the cochlear implant device and patient´s response to electrical stimulation is technically feasible. It is timesaving, practical, and cost efficient.

P2-3-5

Possibilities of use of telemedical tools for patients after cochlear implantation including partial deafness treatment in Silesia, Poland

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Telemedical tools are more and more accessible for patients. Silesian Center of Hearing and Speech Medincus is member of National Teleaudiology Network in Poland which is based on exert telefitting model. The aim of the study was to evaluate advantages and disadvantages of the telemedical solution used by the therapists and patients after cochlear implantation. The group consisted of 143 patients who attended consultations in our local center. 88% percent of the patients had also another consultations like speech therapy or physician. There was 95% satisfaction level among patients with post-lingual deafness and after cochlear implantation. 85% positive feedback from pre-lingual deaf patients. As major advantage patients (and their parents) mentioned less cost for transportation and time saving. Other advantages included nice atmosphere of the session and less fatigue during the telefitting (remote fitting) procedure. From experts who accomplish the telefitting there is one big disadvantage. It doesn't save their time. Generally, it is very good procedure and every year we observe around 50% increase of patients' interest in telemedical solutions.

P2-3-6

National Teleaudiology Network - post operative care in teriteriary Center of Hearing and Speech Medincus in Olsztyn, Poland

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The aim of the study was to obtain evaluation of patients with telemedical procedures after cochlear implantation. Center of Hearing Medincus in Olsztyn took care on 102 patients during 2013. Patients which attended for regular consultation and rehabilitation consisted 70 % of the group. In the group which was not regular (less than one during 3 months) attended majority of patients were experienced with CI system and users or longer than 2 years. We prefer cross-control check during examination within for example psychoacoustic tests.8 patients attended more than 2 times per month and all of them had another diseases. 81 % patents who attended during first two years after hook up are postlingually deaf. Patients with prelingual deafness during initial period of rehabilitation prefer to be referred to the World Hearing Center in Kajetany for rehabilitation. During last year we observed higher interest from patient side for telemedicine.

P2-3-7

National telemedicine network - effectiveness in patients from Pomeranian region

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Recently we can observe the increase of exertion Telemedical tools in audiology. Pomeranian Center of Hearing and Speech Medincus is member of National Teleaudiology Network based on exert telefitting model. The aim of the study was to gauge advantages and disadvantages of telemedical solution used by patients after cochlear implantation. The group consisted of 102 patients who attended for consultations in 2012 and 2013. 91% percent of the have been carried out also with another consultations like speech therapy or physician.. There was 92% satisfaction level in patients with post lingual deafness and cochlear implantation. 86% satisfactory answers from pre lingual deaf patients. As major advantage patients (or parents) mentioned mainly less cost for transportation. Lack of finance for post-surgical rehabilitation service ins one of the main reason why patients do not attend for consultations. Rehabilitation service is financed from national reimbursement but long distance travel (how was earlier in case of Warsaw) made patients not possible to go regularly

P2-3-8

Clinical experience with the Cochlear™ CR220 Intraoperative remote assistant

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Introduction: The introduction of Neural Response Telemetry (NRT) nearly 15 years ago has aided clinicians in fitting cochlear implant recipients. The first generation of NRT was time consuming but was reduced with the introduction of Automatic Neural Response Telemetry (AutoNRT®). The practice of running NRT requires a clinician and a computer to be present during the procedure. In recent years, this process has changed at some institutions with use of video links between the clinic and the surgery. This practice has helped reduce clinician transfer time to and from the surgery. Cochlear has recently introduced the CR220 Intraoperative Remote Assistant, a wireless remote that performs AutoNRT®. We expect the use of this new product to reduce clinical time further.

Objectives: To review our intraoperative testing protocol with the use of the CR220. This study describes the methodologies and applications with the introduction of the CR220.

Study Design: We have used a specific protocol for intraoperative testing during and after implantation. This includes Electrode Impedances and Automatic Neural Response Telemetry (AutoNRT®).

Methods: Our methodologies use Custom Sound® Suite 4.0 and the CR220. We describe the details of our protocol used on all of the patients who received a Cochlear™ device at Oxford Auditory Implant Programme in Oxford, UK.

Results: To date we have tested a small number of patients but will have assessed 10 patients by the conference date. These results will be presented.

Conclusions: We currently do not have enough data for complete analysis. However, preliminary data shows the reduction of clinical staff time needed to perform NRT and the measurements are comparable to previous practices. Final conclusions will be presented.

P2-3-9

Fast Psychophysical Tuning Curves (fPTCs) of the cochlea in normal hearing subjects

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Intro: Fast PTC test is a fast computer based method that aims to assess the frequency selectivity of the cochlea and detect dead regions. It can quickly identify tip frequency and Q10 of psychophysical tuning curves derived by using a band of noise that changes in centre frequency and a Békésy method to adjust the masker level required for threshold of the noise. We applied this method in normal hearing subjects in the presence of TEN noise at 3 signal levels. The sharpness of the PTCs (Q10) and the typical shift of tips of the PTCs for 16 normal hearing subjects, when the tip frequency is estimated for the average of a forward and reverse sweep were obtained. The results were used to determine the mean, standard deviation and 95% confidence interval of the shifts in normal hearing subjects.

Objective: The purpose of this experiment was to estimate the typical shift of tips of the PTCs for normal hearing subjects. The results were used to determine the mean, standard deviation and 95% confidence interval of the shifts. The sharpness of the PTCs change with signal level under conditions where off frequency listening is restricted, using a background noise was also assessed. This was done to allow a comparison with the results of hearing impaired subjects tested at the same level (but without background noise).

Study Design: Sixteen adults of both sexes (8 males and 8 females) were randomly selected to establish normative data for the fast PTC test. They were selected with age ranging from 18-45 years. All subjects had normal middle ear function as indicated by tympanometry and acoustic reflex measurement and hearing threshold equal to or better than 20 dB at octave frequencies in the frequency range (250 Hz- 8000 Hz) *(as defined by ANSI S3.6-2004)*.

Key words: tip frequency, Q10, fast psychophysical tuning curves

P2-3-10

FOX for Nucleus

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Intro: Outcome driven and computer assisted CI fitting by means of FOX has been shown to work with Advanced Bionics´ processors. FOX is an intelligent agent to assist in the programming of CI processors. The concept of FOX is to modify maps on the basis of specific outcome measures, achieved using heuristic logic and based on a set of deterministic “rules”. Targets are defined in terms of measurable pyschoacoustic results. Speech audiometry in quiet and noise is equally good or better when compared to conventional manual fitting. This presentation reports on the use of FOX for Nucleus devices.

[FOX for CustomSound]

Methods: A new set of rules has been developed to adapt the FOX artificial intelligence engine to Nucleus speech processors. The new rule set, known as Eargroup´s EG1303 advice is based on a model of the processor´s behavior as a function of the MAP settings. It has followed a one year case wise evaluation and learning curve. The new rule set has been applied to both new and existing CI recipients.

Results: FOX has been made compatible with Cochlear´s CustomSound software. The measured outcome will be reported and consists of free field audiometry, A§E spectral discrimination, A§E loudness scaling, and speech audiometry. An analysis will be made of the strengths and weaknesses of FOX for Nucleus.

Conclusion: FOX for Nucleus sets a next step into the implementation of artificial intelligence into the field of CI fitting. It is anticipated that FOX will continue to improve and that it will soon become available for multicenter evaluation.

Learning outcome: to get acquainted with computer assisted, outcome driven fitting and to be aware of the fact that FOX is becoming available for Nucleus devices.

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P2-3-11

Comparison of fast and slow methods for measuring focused stimulation thresholds in cochlear implant patients

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Intro: The exploration of using focused stimulation in clinical sound processing strategies is under investigation. Focused thresholds are highly variable from channel-to-channel; therefore a precise measure of threshold that can be measured relatively quickly is needed.

Methods: Postlingually deafened adult cochlear-implant users participated. Stimulation was made using the quadrupolar configuration, consisting of four adjacent electrodes. The active current was delivered to the two center electrodes, with a fraction, alpha, directed to the more basal site and the remainder to the apical site. A fraction, sigma, of the return current was delivered evenly to the outer two (flanking) electrodes with the remainder flowing through a distant ground electrode. Analogous to an upward acoustic frequency sweep, the alpha value was increased from 0 to 1 in small steps for the most apical set of active electrodes; this process was repeated for the next, more basal, set of electrodes until all available electrode sets were tested (2 to 15) in a single sweep. Listeners were also tested with downward sweeps. Listeners pressed a button when the signal was audible, causing the current level to decrease, and released the button when the signal became inaudible, causing the current to increase. Stimuli were 200-ms trains of biphasic pulses, 97 us per phase, at a rate of ~1000 pulses per second, repeated at 300-500 ms intervals. Sigma was fixed at 0.9 or 1.0, alpha step size at 0.1, and level step size at 1 dB. For comparison, thresholds were also obtained with a standard, adaptive two-interval forced choice procedure, both for quadrupolar and partial-tripolar configurations.

Results: Thresholds were closely matched for the channel sweep and forced choice adaptive methods when assessed at the central (alpha=1) steering conditions. The sweep method took approximately 12 minutes (with a 500-ms stimulus interval) to complete two runs of forward and backward sweep directions. In comparison, the two-interval forced choice procedure took an average of 94 minutes for all 14 channels. It was also observed that thresholds measured with the partial tripolar configuration tended to be marginally higher than with quadrupolar, consistent with a slight reduction in spatial focusing with the wider four-electrode arrangement.

Discussion: The sweep methods for measuring focused thresholds are fast and reliable and well suited for clinical use. Additionally, the focused thresholds could be used for tailoring speech processors to target healthy populations of neurons.

Conclusion: This study presents a new, fast method for estimating thresholds across the cochlear implant array for focused stimulation. The measurements are similar to those obtained with a more standard psychophysical procedure.

Learning outcome: Attendees will learn about comparisons between new and traditional methods for measuring thresholds when using focused stimulation.

P2-3-12

Setting targets for CI fitting and reaching them with FOX assisted procedures

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Intro: This paper aims to demonstrate the feasibility of defining a substantial set of psychoacoustic outcome measures with preset targets and to adopt a systematic methodology for reaching these targets in a large group of subjects, by more than one clinical centre

Methods: A retrospective multicenter study was conducted in 255 AB Hires90k users fitted with the assistance of FOX. 66 psychoacoustical outcomes were recorded several times: Free field audiometry (6 measures) and speech audiometry (4), A§E spectral discrimination (20) and loudness growth (36). The initial results were reduced to 22 summary variables and compared with the latest results.

Results: The state of the fitting process could be well monitored by means of the measured variables. The use of the FOX computer assisted CI-programming significantly improved the proportion of the 22 variables on target. When recipients used the automated MAPs provided at switch-on, more than half (57%) of the 22 targets were already achieved before any further optimization took place. Once the FOX system was applied there was a significant 24% ($p < 0.001$) increase in the number of targets achieved.

Conclusion: This study demonstrates that it is feasible to set targets and to report on the effectiveness of a fitting strategy in terms of these targets. FOX provides an effective tool for achieving a systematic approach to programming, allowing for better optimization of recipients´ MAPs. The setting of well-defined outcome targets, allowed a range of different centres to successfully apply a systematic methodology to monitoring the quality of the programming provided.

P2-3-13

Free field frequency resolution abilities of cochlear implant users

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Poor spectral resolution is thought to be one of the factors that limit the ability of cochlear-implant (CI) users to understand speech, particularly in noisy conditions.

CI transmission of frequency information relies on the place pitch mechanism to a large extent. Spectral peak extracting algorithms (e.g. SPEAK and ACE) select the number of filters containing the strongest output and only apply stimuli to the associated electrodes. The electrodes stimulate neural populations at discrete positions along the length of the cochlea. The limit of this "spatial resolution" may be due to a number of factors, such as the spread of current produced by each electrode causing unintended neural populations to be stimulated, and uneven neural survival patterns along the sensory epithelia, which are likely to vary between individual subjects.

Some Authors found significant correlations between spectral ripple resolution and speech reception threshold (SRT), consistent with the idea that spectral resolution is particularly important for understanding speech in noise. The present study investigated frequency discrimination abilities of cochlear implant users when presented with pure tone stimuli through their own processors in free field conditions. The aim of the present study was two-fold. Firstly, we investigated what the frequency discrimination ability of cochlear implant users would be in free field and, secondly, which relationship may be found between the spectral discrimination ability and speech perception in noise for CI users.

A group of post-lingually deafened adults implanted with the Nucleus 24 array participated in the study. All subjects had more than three months´ experience with the implant system. Subjects all used ACE strategy as their normal speech processing strategy, with either the Freedom, or CP810/CP910 speech processor, in a monopolar stimulation mode. In order to assess the CI users´ frequency discrimination abilities in free field conditions, pure tone stimuli were adopted. The reference frequencies were 1KHz and 2KHz. The subjects were requested to compare the reference tone to a second one presented at varying frequency until different pitch sensation could be detected. In order to evaluate speech understanding, the speech reception thresholds (SRTs) were determined using disyllabic Italian words and competitive babble noise. The test was performed in adaptive way in order to assess the SNR where SRT was reached. The correlation between spectral discrimination and speech reception thresholds were estimated. The poster will display the obtained results.

P2-3-14

Effects of stimulation rate on speech perception by cochlear implant users

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Introduction: In cochlear implant (CI) patients, temporal processing is often poorest at low listening levels, making perception difficult for low-amplitude temporal cues that are important for consonant recognition and/or speech perception in noise. It remains unclear how speech processor parameters such as stimulation rate may affect temporal processing, especially at low listening levels.

Method: The present study investigated the effects of these parameters on Speech Discrimination Score (SDS) by 14 CI users. Standard Close set Spondee words list were measured as functions of stimulation rate & pulse width of stimulation. This study performed for 14 CI users that had poor Speech Discrimination Score.

Results: Results show that for 11 patients of cases the speech discrimination score was poorer in high rate of stimulation than lower one & in lesser pulse width than wider one. SDS was better with the lower stimulation rate & wider pulse width, especially for quiet-to-medium listening levels.

Conclusion: These results suggest that, although high stimulation rates may better encode temporal information and widen the electrode dynamic range, CI patients may not be able to access these enhanced temporal cues, especially at the lower portions of the dynamic range. This parameter is so important factor for fine tuning of CI mapping especially in users with complain of Speech perception problems.

P2-3-15

Effect of the frequency allocation table in the speech processor upgrade

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Introduction: Over the years, new frequency allocation tables (FAT) were developed for cochlear implant users to focus on the stimulation frequency range for speech sounds. Some patients may have good results with new tables suggested by the company, but it is possible that others do not adapt and degrade the performance of speech perception.

Objective: To identify the effect of the frequency allocation table of the Freedom® speech processor (´new´) to the patients implanted with Nucleus 22®.

Methods: This study included patients implanted with Nucleus 22® who effectively used the implant with no previous experience with the new technology. Seventeen patients met the inclusion criteria, ranging in age from 15 to 82 years and deployed for over 8 years. To identify the effect of the FAT, two maps were created. The converted maps used the same table that the Spectra® processor (´old´), except the limit of high frequency with 7938Hz. And the upgraded map used a new table ranged from 188Hz to 7938Hz. After the programming of the two new maps, the perception of vowels and monosyllabic words were performed at 60dBSPL in live voice because the processor was connected to the computer at a randomized order of presentation of the converted and updated maps. Each patient also defined his/her preference using a visual analogue scale (VAS). The audiometric thresholds were tested with both maps.

Results: All audiometric thresholds, both individually and on average, except for 8000 Hz, were better with new speech processor compared to the old processor. Regarding the choice of FAT, 64.7% of patients (n=11) preferred and performed better with the converted map. The new processor has a limit of FAT, so only three patients were able to maintain exactly the same FAT with better performance in vowels and monosyllables tests with the converted map. Eight patients maintained the lower frequency limit at 120Hz, but the high frequency limit of 8658Hz was changed to 7938Hz. In these cases, we observed better performance on monosyllable test (n = 6) and worse threshold at 8000Hz (n = 7). Six patients preferred the upgraded map. Three of them chose the upgraded map by the VAS, despite better speech perception with the converted map. On the other hand, three patients performed better in monosyllables when the high frequency was increased, and only one patient who got the same score in speech recognition for both FATs tests, had a decrease in the higher frequency limit. We observed that the statistical significant differences in the speech recognition were reflected in the preference in the majority of the patients (82%).

Conclusions: Most of the patients maintained the original frequency table with lower frequency limit.

P2-3-16

Optimization of Fine Structure Processing (FSP) and high-definition Continuous Interleaved Sampling (CIS): Influence on speech perception

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Intro: In the US, there are currently two signal coding strategies which are offered by the MED-EL system: Fine Structure Processing (FSP) and High-Definition Continuous Interleaved Sampling (HDCIS). Traditionally, cochlear implants have provided the envelope or loudness contour of a signal and disregard the fine structure. The aim of FSP is to provide both fine structure and amplitude information. Studies comparing FSP to HDCIS performance, using an intersubject study design in experienced listeners, have reported mixed results. Arnoldner and colleagues (2007) reported that speech perception scores improved in noise using FSP and subjects preferred FSP to HDCIS; however, Magnusson (2011) found no statistical difference in speech scores or patient preference between the two strategies. Currently, it is unclear whether a specific strategy is optimal to listening experience at initial activation of the external speech processor. This study makes a comparison of subjects listening exclusively with one strategy after initial activation. The purpose of this study was to compare speech perception outcomes during the first six months of listening experience with FSP versus HDCIS.

Methods: Adult subjects implanted with a MED-EL standard, medium, or Flex28 internal array, were randomly assigned to either the HDCIS or FSP signal coding strategy. The mapping procedure included loudness balancing, as well as evaluation of stimulation rate, maplaw, sensitivity, and threshold and comfort levels. The audiologist completing speech perception testing was blinded to the specific signal coding strategy. Speech perception testing was completed at the one, three and six-month post-initial activation intervals. Recorded materials were presented in sound field at 60 dB SPL. The test battery included: CNC words in quiet, HINT sentences in quiet and noise (SNR+10), AzBio sentences in quiet and noise (SNR+10, +5) and BKB-SIN.

Results: Preliminary findings suggest no difference in speech perception abilities when tested in quiet. A trend for better performance on the BKB-SIN test with FSP has been observed. Investigators are continuing to collect data to assess this trend and record patient preference beyond the study endpoint.

Discussion: Preliminary results suggest improved speech perception in a fluctuating masker with exclusive use of FSP strategy within the first 6 months of listening experience.

Conclusion: Cochlear implant patients may experience an improvement in challenging background noise when listening experience is initiated with FSP as compared to the HDCIS coding strategy.

Learning outcome: Learner will be able to: 1) identify differences between the FSP and HDCIS coding strategies; 2) describe initial outcomes during the first 6 months of listening experience.

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P2-3-17

Electrode discrimination in late implanted prelingually deafened cochlear implant users

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Intro: Although speech recognition in quiet is very good in a large group of cochlear implant users, most late implanted prelingually deafened patients are still struggling. Due to the long period of auditory deprivation the auditory structures have gone through severe developmental changes and colonization by other sensory modalities. We hypothesize that with current speech processing strategies the signal provided by the cochlear implant is too complex for the compromised auditory system. In order to improve the usability of the CI-signal we want it to contain only relevant perceptual cues. Our focus lies on the spectral cues: if patients are not able to discriminate between two adjacent electrodes, the spectral information inherent to stimulation on a particular site is lost. Therefore our goal is to identify, for a number of prelingually deafened patients, which sites along the array show worse electrode discrimination performance.

Methods: Electrode discrimination difference limens were determined for six prelingually deafened, adult CI users and for each electrode of the array. First, a pairwise loudness balancing with the neighboring electrode was performed, starting with the most central electrode of the array. For each pair, two runs of a 1-up 1-down adaptive procedure were conducted. In the second phase, electrode discrimination testing was done using a 2-down-1-up 3-interval oddity adaptive procedure. To exclude any remaining loudness cues that would still be present after loudness balancing, roving of the stimulus level was applied.

Results: Electrode discrimination difference limens across all subjects and all electrodes ranged from 0.5 (perfect discrimination) to 7.125. Mean difference limens ranged from 1.17 to 3.88. In 5 out of 6 subjects, limens were worse for the reference electrodes located in the basal region of the array. A significant negative correlation ($r = -0.95$, $p = .006$) was found between the mean electrode discrimination limens and the scores on an open set word test.

Discussion: Absolute difference limens are in the order of those found in the few other studies with prelingually deafened subjects and worse than those of postlingually deafened CI users found in the literature. The correlation with speech understanding as well as the worse discrimination skills in the basal region have not been found consistently in this patient group, although the latter has been found in other studies with postlingually deafened CI users.

Learning outcome: In a next phase of the research, the discrimination limens will be used to selectively deactivate a number of electrodes in order to make all spectral channels perceptually distinguishable. We hypothesize that this will have a positive effect on speech understanding.

Conclusions: The variability in discrimination performance across electrodes, worse performance for basal electrodes and correlation with speech recognition is promising for the outcomes with the proposed novel fitting strategy.

P2-3-18

Hear now and always: Nucleus 6 for nucleus 24 implant recipients

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Aim: The Nucleus 6 sound processor provides performance enhancing input processing functionality via SmartSound IQ, including an industry first scene classifier. Benefits of the system have been shown for newly implanted recipients and the latest implant technology. This study aimed to evaluate the speech performance and acceptance of the new Nucleus 6 system in a group of adult recipients with Nucleus 24 implants, upgrading from their existing sound processor.

Material and methods: Single subject, repeated measures design evaluating speech performance in quiet and in noise, and subjective feedback using questionnaires.

Results: While speech performance in noise was equivalent for multi-talker babble noise, performance in speech weighted noise (SWN) with the Nucleus 6 SP was significantly better than the subjects' own processor in SWN. Recipients reported a high level of satisfaction with the new technology.

Conclusions: Subjects were successfully upgraded to the Nucleus 6 system and received performance benefits over that obtained with their own processor.

P2-3-19

Early experiences with the Rondo speech processor

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Introduction: The Rondo speech processor for cochlear implants is a single unit, off the ear device that integrates the control unit, battery pack and coil. A study was designed to assess the ease of use, comfort and overall satisfaction of the processor as well as compare speech perception outcomes with the behind the ear Opus speech processor.

Method: Experienced cochlear implant users who were already using an Opus speech processor were invited to participate in a month long trial with the Rondo processor. They were given a questionnaire about the Rondo to complete prior to the follow up appointment. The patients undertook an auditory alone speech discrimination test in quiet and noise using both the Opus and Rondo processors.

Results: For both paired t-test (parametric), and Wilcoxon signed ranks (non-parametric) there was no statistically significant difference in speech perception between the Opus and Rondo in quiet and noise conditions. The results of the user feedback questionnaire will be summarized.

Conclusion: The results of the trial with the Rondo processor have indicated some benefits for patients. Consequently we have now introduced the device as a choice for adult patients.

P2-3-20

Naida CI Q 70- parental and user experiences

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Introduction: The Naida CI is the latest speech processor launched by Advanced Bionics. This study evaluates the parental and user experiences following a processor upgrade to the Naida CI.

Method: A closed set questionnaire was used to obtain parental and user experiences. The questionnaire was mailed to families after their processors were upgraded either unilaterally or bilaterally. All patients were previously using the Harmony processors.

Conclusion: This study describes the patient experiences from the St Thomas´ Hearing Implant Centre.

P2-3-21

Four cases of cochlear implant in children with internal auditory canal stenosis

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Cochlear implants (CI) are the most common treatment used for people with severe bilateral hearing impairment, and patients with cochlear implants can hear and speak. However, a poor response has been observed in some cases and internal auditory canal stenosis (IACS) is one of the causes of the causes for this poor response.

The aim of this study was to evaluate four congenital CI cases with IACS experienced at our department. There was no auditory brainstem response, and computed tomography of the inner ear showed very narrow bilateral internal auditory canals. Magnetic resonance imaging also revealed a narrow internal auditory canal and a non-delineated cochlear nerve branch. They were implanted between 1 year 8 months and 3 years. A retrospective case study was performed to assess speech perception, speech production, general intelligence, and the educational setting of four profoundly hearing-impaired children with IACS, None of the patients had malformation of the cochlea and were implanted using Nucleus 22/24.

During the early stages, a significant reaction was not observed when maps were created using maximum stimulation, and all cases had poor hearing ability. Post implantation, the follow-up period ranged from 8 months to 10 years. However, 2 patients with short follow-up periods (eight months and one year follow-ups) showed a poor reaction with CI, while the remaining two cases experienced a gradual reaction, which was observed after several years. We hypothesized that the auditory nerve was activated gradually by continuous stimulation, which resulted in the perception of sound. Speech perception and speech intelligibility capabilities improved considerably in three patients after receiving the implants.

P2-3-22

A comparison of cochlear implant speech processor switch on times. Patient views and complications

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Cochlear Implant speech processor switch on appointments are traditionally booked for 4 weeks post CI surgery. We consider it unnecessary to wait 4 weeks with small incision modern cochlear implant surgery. We have changed our switch on appointments to 2 weeks and 1 week post-surgery.

We looked at patient views and contra-indications to doing earlier switch-ons.

We selected 30 patients who were implanted between April 2013 and January 2014 and split them into 3 groups, those who had their switch on at 4 weeks, 2 weeks and 1 week post-surgery. They were split into groups of 10 consecutive implants. We gave adult patients and parents of children a questionnaire at or soon after their switch-on asking for their views and experiences. We kept a record of any complications or problems at switch-on. The results are still be collected and we will present the results in April, together with a discussion and future recommendations. Preliminary results looking at a 2 week switch on are positive, indicating that patients and parents were happy that they had a shorter switch on than the standard 4 weeks. There were no reports of discomfort although dried blood and steri-strips at switch on were observed.

P2-4 Objective measures

P2-4-1

Optimization of registry of electrically induced stapedial reflex in patients with cochlear implants

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Since cochlear implants are most often used in young children, starting from the age of 7 months, therefore use of objective methods of configuration of speech process parameters attains certain significance. From among the known objective methods of determination of level of maximum comfortable loudness, the most adequate is the registration of electrically elicited stapedius reflex thresholds (ESRT). However, as evident in practice, configuration of speech process as per ranges of stapedial reflexes does not always provide fine results.

The objective of the current paper is the optimization of methods of registering ESRT to enhance the effectiveness of configuration of parameters of speech process in patients with cochlear implants.

The registration of ESRT was conducted with standard impedansometr in mode of registration of test of disintegration of acoustic reflex in 60 experiences users of cochlear implants, who have experience permanently using it for no less than 6 months.

The adequacy of configuration was evaluated on the basis of subjective pedagogic evaluation of hearing, threshold audiometry in free audio field and determination of intelligibility of speech as per standard balanced speech tables of Russian.

As shown by our research, the most stable registry of ESRT is achieved with stimulus length of more than 200ms, with period of administration no less than one second. The maximum correlation of thresholds of stapedial reflex with subjective level of maximum comfortable loudness (k=0.79) is noted when administering stimulus with increased stimulating current (from sub-threshold level to threshold level) than in case of decrease (k=0.64). In case of the phenomenon of rapid increase in loudness (as per ESRT registry data) correction is significantly increased (k=0.94).

Data for intra-operational registry of ESRT and data, obtained during the post-opt period, differ from subjective level of maximum comfortable loudness on average by 76±49% and 44±39% respectively, and the maximum difference is attained for basal electrodes, which significantly limits the use of intra-operational reflexes for configuration of parameters of speech process.

The verification of the method of registration of ESRT proposed by us showed that the configuration of speech process as per the given method provides for comfortable perception of all sounds within the speech range with hearing threshold in free hearing field of 25±5dB, not causing at the same time, any subjective discomfort due to loud sounds of intensity 90-120dB. Perception of speech is provided for at a distance of 6-20m and whisper at a distance of 5-6m.

The evaluation of effectiveness of configuration of parameters of speech process using standard balanced speech tables for Russian showed that maximum intelligibility of speech is achieved when speech process is configured as per the ESRT data.

P2-4-2

Prediction of psychophysical measures of cochlear implant maps from the electrically-evoked stapedial reflex thresholds

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Introduction: Cochlear implantation (CI) has become the standard therapeutic measure for congenital hearing loss. After the implantation, programming the speech processor is highly dependent on psychophysical measures that constitute variable levels of loudness sensation created by the electrical stimulation of the implant. Namely, those measures are the threshold (T) and the comfortable (C) levels. Obtaining such measures from a child or an infant who had no previous auditory experience is usually difficult.

Aim: The aim of this study was to predict these psychophysical measures from the easily obtained and objective measure of the electrically evoked stapedial muscle reflex thresholds (ESRT).

Methods: Twenty six CI users of Medel implant were selected. Six patients were excluded due to absent reflexes and only 20 were included. The age of the patients ranged from 14 to 51 years. While putting his/her own headset each patient determined the psychophysical measures of threshold (T) and loud levels but not uncomfortable (C) were obtained. Using the impedance meter probe in the contra-lateral ear, the stapedial reflex thresholds (ESRT) were obtained to electric pulses generated by the programming software and delivered through the implant to elicit the reflex. A change in admittance of 0.05 cc was taken as threshold of the stapedial reflex. The ESRT was correlated with C & T levels.

Results:

Table (1): Correlation co-efficient between the ESRT and the C & T levels in the 12 electrodes.

E#	C		T	
	r	P	r	P
1	0.899*	<0.001	0.001	0.997
2	0.904*	<0.001	0.343	0.139
3	0.871*	<0.001	-0.079	0.742
4	0.885*	<0.001	-0.107	0.654
5	0.960•	<0.001	0.609	0.609
6	0.977•	<0.001	0.816	0.816
7	0.873•	<0.001	-0.142	0.562
8	0.881•	<0.001	0.697	0.697
9	0.885•	<0.001	0.267	0.267
10	0.862•	<0.001	0.609*	0.009
11	0.795•	<0.001	0.594	0.594
12	0.815•	<0.001	-0.334	0.331

[Table 1]

The table shows that there were highly significant correlation between the ESRT levels and the C levels at all the 12 electrodes of the implant, while there was no significant correlation between the ESRT and the T levels.

Table (2): Prediction equations for the (C) levels from the ESRT, at the 12 electrodes. Resulting values are in charge units (qu).

Electrode Number	Proposed equation
1	0.87*ESRT + 4.76
2	0.80*ESRT + 6.10
3	0.91*ESRT + 3.43
4	0.90*ESRT + 3.77
5	0.86*ESRT + 5.07
6	0.83*ESRT + 5.47
7	0.91*ESRT + 3.47
8	0.84*ESRT + 5.58
9	0.92*ESRT + 3.04
10	0.94*ESRT + 2.55
11	0.48*ESRT + 19.63
12	0.86*ESRT +5.22

[Table 2]

Comment & conclusion: Table (2) shows that (C) levels can easily be derived from the objectively measured ESRT. Since most of the available CI soft-wares recommend locking the (T) values to a certain proportion of the (C) value, the derived (C) values can be used to obtain the (T) levels, and henceforth the full CI programming map can be constructed in uncooperative children & infants.

P2-4-3

The value of electrically evoked stapedius reflex in determining the dynamic area of a cochlear implant

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Introduction: Determination of the dynamic area of a cochlear implant is one of the most important programming procedures. Obtaining reliable measures is difficult in some patients, such as infants, children with prelingual hearing loss or patients with inconsistent responses. The use of objective measures, such as electrically evoked stapedius reflex thresholds, can contribute to defining the dynamic field, since they provide specific values that serve as the basis for initiating the electrode mapping process.

Objective: The main objective of the present study was to assess the relationship between the electrically evoked stapedius reflex threshold and maximum comfort level for stimulating electrodes (C-level) inpostoperative cochlear implant users.

Methodology: We assessed 24 adult patients submitted to cochlear implant surgery (*Cochlear* brand) who consistently defined maximum comfort levels for stimulating electrodes postoperatively, between May and June 2013.This is a cross-sectional analytical observational case series study. Two volunteers presented with bilateral cochlear implant and the test was conducted individually in both ears, resulting in the study of 26 ears.

Results: The results demonstrate that all the electrodes selected for the study exhibited higher mean reflex threshold values than their mean C-level counterparts. However, there was no significant difference between reflex threshold and C-level values for electrodes 1, 6, 11 and 16, which allowed objective data provided by electrically evoked reflex thresholds to be used as parameter in determining C-level values. Based on these data, it was possible to stipulate a correction factor ranging between 6 and 25.6 electrical units, depending on the electrode to be programmed.

Conclusion: The use of electrically evoked stapedius reflex thresholds helps the team in charge of programming and mapping cochlear implants determine maximum comfort levels for stimulating electrodes, making the process faster and safer, even for infants, small children or individuals with multiple disorders.

P2-4-4

The relationship between electrical stapedius reflex thresholds and behaviorally most comfortable levels in experienced cochlear implant users

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Programming the cochlear implant's speech processor with subjective methods in young, uncooperative children is difficult. Since young children cannot provide adequate feedback to the clinician, objective methods which do not require patient's response were often used. Electrical Stapedius Reflex Test (ESR) is one of the most common procedures used.

The goal of this study was to investigate the relationship between electricalstapedius reflex thresholds and behaviorally most comfortable levels in experienced cochlear implant patients. The patients implanted with two brands of cochlear implants were compared in terms of ESR thresholds vs MCL/C levels and speech tests results were also compared between the two groups.

46 cochlear implanted patients who had at least 1 year of cochlear implant experience were included in the study. 28 patients were implanted with Nucleus, 18 patients with MED-EL devices. Moderate correlations were obtained between ESR thresholds and C levels in Nucleus users; higher correlations were obtained for MED-EL patients. ESR thresholds were present at higher levels than MCL/C levels in both Nucleus and MED-EL users. No significant difference was obtained between the two groups in terms of speech tests. In conclusion; ESR test can be very informative for programming young and uncooperative patients.

P2-4-5

Auditory nerve recovery function in cochlear implant surgery under local anesthesia and sedation - comparison with general anesthesia

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Introduction: The Custom Sound EP software connected to the Cochlear Implant Contour Advanced Freedom, can realize the measurement of Neural Function Recovery in Cochlear Implant Surgery. There are studies showing changes in neural function recovery in intraoperative and postoperative of CI surgery (GoffiGomez, et al., 2010). It has already been proven by us the ability to perform cochlear implant surgery performed under local anesthesia and sedation (Hamerschmidt et al., 2011).

Objective: To evaluate whether changes in values of To, A and Tau in Neural Function Recovery in surgery for intra cochlear implant under local anesthesia and sedation.

Methods: A prospective study in two groups "A" and "B", "A" 15 patients who underwent CI surgery under local anesthesia and sedation and group "B" 15 patients under general anesthesia. The measurement of the recovery function was made accessing Advanced NRT the software on three electrodes and a basal, one medial and one apical. We used the Wilcoxon test to analyze the results.

Results: No significant difference was observed in the values of To, A and Tau and of neural recovery function in the group undergoing surgery with local anesthesia and sedation, when compared to general anesthesia.

Conclusion: The type of anesthesia, either local or general, does not affect the values of nerve recovery function.

Learning outcome: The anesthesia depends on the choice of the surgeon, and neural telemetry is not affected by the drugs or by the type of anesthesia, either local or general.

P2-4-6

Electrically evoked compound action potential (ECAP) in cochlear implant children; Is there significant changes in auditory nerve response in first year of cochlear implant use?

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In children with cochlear implant (CI), the recording of the electrically evoked compound action potential (ECAP) of the auditory nerve represents an option to assess changes in auditory nerve responses and the interaction between the electrode bundle and the neural tissue over time (Liege et al., 2009). Few studies have been done on how the timing of the recordings affects the ECAP threshold levels.

For the purpose of predicting thresholds and adjustment of the patients' programs over time, we need to understand the changes of ECAP thresholds overtime and to assess the validity of intra-operatively acquired neural response telemetry (NRT) data for setting the speech processor. In this work changes in ECAP thresholds in children during the first year of cochlear implant use will be studied. ECAP thresholds were recorded from children implanted with the Nucleus Freedom or Nucleus 5 devices using the Auto NRT test protocol. ECAP thresholds were obtained at the time of surgery, at initial stimulation, and 3, 6 and 12 months post-stimulation. Five electrodes located at basal, middle, and apical positions in the cochlea were tested at each time interval and thresholds were analyzed and compared.

P2-4-7

Electrocochleography to auditory stimuli in cochlear implant subjects: An overview

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Intro: To date there has been little knowledge of the functional state of the cochlea prior to implantation. Audiograms or other behavioral measures in response to sound can indicate the state of functionally intact connections from hair cells to auditory nerve fibers that lead to the brain. Objective measures of nerve responses also record only the parts of the system that are fully connected. Electrocochleography (ECoG) from the round window and within the cochlea can measure the intact system with better sensitivity than more remote recording locations. It can also record responses from hair cells not connected to auditory nerve fibers. The hypothesis is that better sensitivity combined with additional information will make ECoG a useful diagnostic tool to help estimate the range of likely speech outcomes with the implant.

Methods: Extracochlear responses to sounds were recorded at the round window of cochlear implant subjects, both adults (n=75) and children (n=78). The sounds were tones presented through insert earphones at a high level (>90 dB SPL) across frequencies (250 Hz to 4 kHz). A level series was taken at one frequency (usually 500 Hz) to determine threshold.

Results: Nearly all (>95%) cochlear implant subjects have responses to tones significantly above noise levels for one or more frequencies. The range of response magnitudes to the same sound pressure vary by nearly 60 dB, from ~0.1 µV to 100 µV. The frequencies that contribute are typically 1000 Hz and below, with the response to 250 and 500 Hz predominating within this range. The distributions of response magnitude, frequency response, and thresholds are highly similar between children and adults. There is relatively high predictability between response magnitude and speech score outcomes in our sample (n=22 children and 29 adults). For children, the ECoG magnitude accounts for ~30% of the variance, and for adults about 45% of the variance can be accounted for by this single number, which requires about 10-15 minutes of recording time per case.

Discussion: The response to sound is an easily obtainable and useful measure of cochlear function prior to implantation. It is the first measure of cochlear health that shows a high degree of correlation with subsequent outcomes. It could also be a baseline measure used to monitor cochlear status during the implantation.

Conclusion: ECoG measurements provide a detailed and sensitive measure of cochlear function that can provide clinically useful information.

Learning outcome: At the end of the talk listeners should know the value of ECoG measurements for determining cochlear health prior to implantation.

P2-4-8

Effects of electrode positioning on e-CAP thresholds measurements

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Introduction: The study firstly aimed to identify factors that may predict the threshold level of electrically evoked compound action potentials (e-CAP) after cochlear implantation. Considering that e-CAP thresholds have been shown to correlate with thresholds of psychophysical perception of sounds, they may reflect the auditory sensitivity level of residual neurons after cochlear implantation. To assess this, the relationship between neural response telemetry (NRT) thresholds and auditory neuron frequency was modeled.

Materials: Retrospective chart review in a tertiary referral center. Included in the study were 536 electrodes from 31 subjects implanted between 2006 and 2012 with Nucleus CI24 (straight or perimodiolar array) or CI422 (slim straight array). For each electrode, the values for auto-NRT and impedance at least 6 months after implantation were recorded. Cone beam CT imaging was performed to determine for each electrode the depth of insertion, the scalar location (scala tympani or scala vestibuli), and the distance between the electrode and the modiolus. The depth of insertion was converted into the theoretical frequency of the closest auditory neurons. Statistical analyses were performed using uni- and multivariate mixed models to determine whether the position, impedance, or distance to the modiolus of the electrodes, type of electrode array, etiology of hearing loss, age at implantation, or age and duration of profound deafness, may be factors able to predict NRT thresholds. Finally, NRT was modeled as a function of auditory neuron frequency using a piecewise polynomial regression mixed model with cubic basis.

Results: Depth of insertion varied amongst subjects and its transformation into auditory neuron frequency was required to predict NRT. We demonstrated the unsuitability of considering NRT as a function of electrode number and by multivariate analysis showed that NRT depends on scalar positioning and the impedance squared of the electrodes (b= 8.5 (SEM=1.97), b= -0.11 (SEM=0.02) respectively, $p< 0.001$ for each). The impact of other variables tested was not statistically significant although that of the distance between the electrode and the modiolus neared significance. Between 500 and 3000 Hz NRT thresholds rose steeply before dropping in the 4000-5000 Hz region to then display a dome-like shape with a peak around 10000 Hz. This curve matched perfectly auditory sensitivity curves of normal hearing subjects.

Conclusion: Our data demonstrate that NRTs depend on scalar positioning, impedance of the electrodes and on the residual auditory neuron function. They also reveal that the relationship between NRT and auditory neuron frequency is not linear as previously suggested. Interestingly, NRTs may reflect auditory neuron function above 4000 Hz.

Learning outcome: Factors influencing level of electrophysiological response with cochlear implant

P2-4-9

Cochlear implant mapping in children: Correlations of eCAP and eSRT with most comfortable loudness

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Introduction: Mapping a cochlear implant in a child is challenging. Objective measures of physiologic effects of electrical stimulation, e.g., compound action potentials (eCAP) and stapedius reflex thresholds (eSRT), may prove facilitative. The primary aim of this study is to better understand the correlations between eSRT and eCAP, and the most comfortable loudness (MCL). A secondary aim is to better understand the correlations between eSRT determined intra-operatively by visualizing the stapes, versus post-operative eSRT determined by immittance.

Methods: Prospective study with MED-EL cochlear implants into 20 imaged-normal cochleae. Intra-operatively, stapedius reflexes were detected by viewing through the operative microscope; then post-operatively, eSRT by immittance and eCAP and behavioral responses were done through four months post-operatively.

Results: In surgery, eSRTs for apicad and middle and basal electrodes were seen in two-thirds of ears. At firing-up and one and three months later, eSRTs by immittance were found in less than a third of the ears. eCAPs were obtained in nearly half the ears at firing-up, and at one and three months later. The "qu" for eCAP thresholds, for apicad and middle and basal electrodes, generally were less than for most comfortable loudness levels, which were less than for eSRT by immittance. Intra-operative "qu" values for visualized eSRT, were about the same as were found by immittance through 4-months post-operatively. Post-operatively, obtaining eCAP was easier than determining the most comfortable loudness, which was easier than obtaining eSRT.

Conclusion: These preliminary data do not appear promising for eSRT having efficacy in mapping MED-EL cochlear implants in children. However, the data may endorse the usefulness of eCAP.

P2-4-10

A novel ECAP recording paradigm to acquire fine-grain growth functions

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In a standard clinical setup, recordings of the evoked compound action potential (ECAP) are averaged over 25 to 100 repetitions to allow the detection of an ECAP within the noise floor. To obtain an amplitude growth function (AGF), these measurements are normally performed for 5 to 10 different stimulation levels to reduce the total recording time. We present a novel recording paradigm where the stimulation intensity is increased in quasi-continuous steps and instead of averaging repeated recordings with identical stimulation parameters, running averages over small intervals of stimulation levels are computed. AGFs were recorded within MED-EL CI users using the new proposed ECAP recording paradigm as well as the above described standard clinical procedure. The intra-subject differences of the visual ECAP threshold and the threshold where the ECAP amplitude was larger than one standard deviation of the recording noise floor are presented. Also the total recording time needed to obtain an ECAP threshold is compared between the two paradigms.

P2-4-11

Intra operative Neural Response Telemetry and neural recovery function: a comparative study between adults and children

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NRT (Neural Response Telemetry) is a method of capturing the action potential of the distal portion of the auditory nerve in cochlear implant (CI) users, using the CI itself to elicit and record the answers. In addition, it can also measure the recovery function of the auditory nerve (REC) i.e. the refractory properties of the nerve. No articles were found in the literature comparing the responses between adults and children in these measures intraoperatively. To compare the results of NRT and REC between adults and children undergoing IC surgery intraoperatively. Cross-sectional, descriptive and retrospective study of the results of NRT and REC for patients undergoing IC at our service. The NRT is assessed by the level of amplitude (uV) and REC as a function of 3 parameters : A (aturation level - uV), t0 (absolute refractory period - s) and tau (curve of the model function), and they're both measured in 3 electrodes (apical, medial and basal). 52 patients were evaluated with intraoperative NRT (26 adults and 26 children), and 24 with REC (12 adults and 12 children). No statistically significant difference was found between intra -operative responses of adults and children for NRT or for REC's 3 parameters, except for the parameter A of the basal electrode. The results of intraoperative NRT and REC were not different between adults and children, except for the parameter A of the basal electrode.

P2-4-12

Distinguishing hair cell from neural potentials in round window electrocochleography in a gerbil model of high frequency sensorineural hearing loss

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The signal obtained through round-window (RW) electrocochleography (ECoG) represents a composite of signals from hair cells, including the cochlear microphonic (CM) and the summating potential, and neurally-derived signals, including the compound action potential and the auditory nerve neurophonic (ANN). Recently, the ECoG has been used for intraoperative monitoring of cochlear damage during cochlear implantation (CI) with the goal of preserving hearing as well as assessing surviving hair cell and neuronal populations that could be predictive of auditory outcomes post-CI (e.g., Fitzpatrick et al. *Otol Neurotol* 2014;35:64-71; Radeloff et al. *Otol Neurotol* 2012;33:348-54.) In this study, we sought to characterize the ECoG signal obtained from a gerbil model of high pass sensorineural hearing loss (HP-NIHL) to simulate the common auditory deficit in CI recipients. It has previously been shown that gerbils with HP-NIHL are a better model of adult human CI recipients than normal hearing gerbils (Choudhury et al. *Otol Neurotol* 2011;32:1370-8.) By evaluating the responses to acoustic stimulation before and after application of the neurotoxin kainic acid, we aimed to further identify the contribution from hair cells versus nerve fibers in the ECoG signal from noise-damaged cochleae.

Male gerbils were exposed to a 4 kHz tone at 121 to 122 dB SPL for 4 hours to achieve a sloping pattern of HP-NIHL. Four weeks after exposure, ECoG signals to tones of primarily low frequencies (< 2000 Hz) and varying intensities were recorded at the round window under urethane anesthesia before and after application of 60 mM kainic acid to the RW for 1 hour. Normal hearing gerbils served as controls.

ECoG recordings from the round windows of gerbils with HP-NIHL were smaller and demonstrated saturation of the response growth function at relatively low intensities compared to normal hearing gerbils. The amount of harmonic distortion was greatly increased in the HP-NIHL animals. After KA, the harmonic distortion was greatly reduced, implicating a neural source (the ANN) for much of the distortion to the low frequency stimuli. Overall, the proportion of total ECoG distortion due to the presence of the ANN was greater in the HP-NIHL animals compared to those with normal hearing. These results are consistent with a general model of distortions from nerves and hair cells that arise from different physiologic processes. The factors needed to explain responses in HP-NIHL animals include loss of source generators and spread of excitation.

These results indicate that distortion due to nerve can be discriminated from distortion produced through hair cell transduction. Furthermore, examples showing these same types of distortion are common in ECoG recordings from human cochlear implant subjects. Characterization of this signal is an important translational step toward using ECoG to reduce CI trauma and improve accuracy of ECoG for predicting CI prognosis.

P2-4-13

Evaluation of the electrical compound action potential threshold changes as a function of time and electrode position

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Aim: The objectives of this research are evaluation of the electrical compound action potential threshold changes as a function of time and electrode position.

Materials and methods: In this longitudinal study ECAP measurements were done in 36 patients who underwent cochlear implantation surgery in two time periods: intra-operative and 40 days after the surgery in five electrodes, 1, 6, 11, 16, and 22.

Results: The mean of NRT thresholds was significantly lower in post-operative measurement in all of the measured electrodes ($P< 0.05$). The difference was highest in the 22th electrode and the least difference in 11th electrode. On the other hand, comparing the inter-electrode results, showed higher NRT thresholds in Base electrodes(mean of NRT thresholds in 1 and 6 electrodes) than the Apex ones(mean of NRT thresholds in 22 and 16 electrodes) in both intra-operative and post-operative steps.

Conclusion: The data do suggest that there are changes in thresholds between the intra-operative and post-operative time points. However, when any behavioral or electrophysiological data are not available, mid-array ECAP thresholds may be helpful in creating a first MAP, as they had the least amount of change over time.

P2-4-14

The Comparison of intra-operative ECAP for Cochlear Electrode CI422 and CI512

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Objective: CI422 is the newest electrode from Cochlear Company. Compared to electrode CI512, electrode CI422 is softer and thinner. With its new characteristics, implanting CI422 not only could increase insertion depth, but also minimize surgical trauma to cochlea. The purpose of study is to examine the advantage of implanting CI422 by comparing the intra-operative ECAP of CI422 to CI512 recipients.

Method: Intra-operative ECAP values were measured by using Cochlear software “Custom Sound” from 9 CI512 recipients and 9 CI422 recipients. The mean ECAP values were calculated at each electrode from both implants. Both results were analyzed and compared.

Results: The mean ECAP value among electrodes is around 155-202 CL for CI512 recipients and 167-206 CL for CI422 recipients individually. The ECAP values between two implants has no significant different except electrode 1st to 3rd ($t < 0.05$), which are responsible for high frequency stimulation. The mean ECAP values of Electrode 1^{st} to 3^{rd} are higher for CI422 recipients. Also the ECAP distributions between two implants were statically correlated. The configuration of ECAP values from both implants all reveal that ECAP values were increased with frequency allocation.

Conclusion: Although the configuration of ECAP distribution is similar between CI512 and CI422, the difference is significantly different between electrode 1st to 3^{rd}. Such kind of difference may due to the newer design of CI422.

P2-4-15

Characterization of electrically evoked amplitude modulation following response (EAMFR) measurements

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Introduction: Utilization of the electrically evoked amplitude modulation following response (EAMFR) is a suitable noninvasive examination prior to cochlear implant surgery for a measurement of the hearing nerve function. In previous examinations, this method had already been established. The aim of this study was the investigation of EAMFR results in relation to the age and gender of deafened patients.

Methods: In a prospective study, 88 patients were examined (minimum 14 years, maximum 73 years), 57 women and 31 men. EAMFR thresholds were measured before cochlear implant surgery was carried out.

Results: Between the ages of < 20, 20-40 and > 40 years, no significant EAMFR differences were detected ($p = 0.454$). Furthermore, we observed in these age groups no gender-specific results; for < 20 years $p = 0.663$, for 20-40 years $p = 0.154$, and for > 40 years $p = 0.451$.

Conclusions: Here, it was seen that for deafened patients, EAMFR measurements provide results which are apparently independent of age and gender.

P2-4-16

Correlation of Imp-eABR to preoperative CI candidates characteristics preliminary studies

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Introduction: While cochlear implantation still become the first line option in management of profound hearing loss, many researches showed variation in its auditory skill results. Several factors i.e. onset of hearing loss, cochlear nerve variation and effective preoperative habilitation are believed as major predicting factors in cochlear implantation. These factors may contribute in cochlear implant auditory tract compatibility. Imp-eABR has been studied as good predicting factor for post implantation auditory skills. We reported our preliminary data on intra-operative electrically evoked auditory brainstem responses (Imp-eABR) and its correlation to preoperative candidates profile. This study is the first implant electrophysiology studies from Indonesia.

Methods: All patients were implanted with MED-EL device. Patient were collected from 10 different hospital from Indonesia. Imp-eABR were recorded intra-operatively using 30 qu stimulus (500 cu amplitudes and 60 ms phase duration). Imp-eABR were performed at 3 electrodes representing apex, medial and basal positions. Wave latencies, amplitudes and scoring were correlated to age at implantation, MRI based cochlear nerve area and pre-operative habilitation status. Imp-eABR waves were scored based on latencies and amplitudes according to Sanli.

Results: Imp-eABR responses were clearly seen mostly from apex electrodes. Imp-eABR scores reduced progressively from basal position correlates with cochlear nerve area, onset of hearing loss and history of good responses with hearing aid. Patients with small cochlear nerve area, late implantation with inadequate hearing aid habilitation showed pathologic waves responses.

Conclusion: This preliminary studies showed, variation in Imp-eABR result correlates with preoperative candidates characteristics, that may reflects different auditory tract condition. Many studies showed Imp-eABR could be used as post-operative auditory skill predicting test. We need more follow up studies to confirm those studies since most of previous studies conducted with different implant design. This information may help in programming specific post implantation habilitation in each patient concerning their auditory tract status.

P2-4-17

On the use of electrically-evoked auditory brain-stem responses (eABR) in CI surgery: Clinical experiences and Results

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Background: Several electrophysiological measurements are used today in CI surgery including impedance measurements, eSRT, ECAP or neural response telemetry (NRT, ART) and neural response imaging (NRI). An eABR-measurement gives information about the neural response signals relayed from the first order neurons in the cochlea to the brain stem. It adds valuable information on electrode placement during ABI surgery and neural integrity in CI-patients with inner ear malformations, otosclerosis, acoustic neuroma and genetic abnormalities

Material and methods: Here, we address the clinical use of electrically-evoked brainstem responses (eABR) during CI surgery. We present information from eABR-measurements regarding different channels and electrical parameters, observed waves and latencies which can serve as a set of normal distributed data. Furthermore, we discuss the possible correlation of eABR-data with results from speech audiometry after six months and a one year following implantation.

Results: The eABR-results are shown in Table 1 for 80 patients. Results show average latencies for wave II, III, IV and V and III-V inter-peak distances for low, mid- and high frequency channel excitations. There were no obvious correlations between speech audiometry results and eABR latencies. However we found a modest interdependence between speech audiometric results and inter-peak distance III-V.

Conclusion: Our data suggest that an absent eABR-response is frequently associated with a negative CI outcome.

Wave number	Latency 100-563 Hz (ms)	Latency 707-2567 Hz (ms)	Latency 2574-7938 Hz (ms)
II	1,2958	1,3271	1,3530
III	2,0719	2,0756	2,1963
IV	3,1740	2,8525	3,4150
V	3,8277	3,8888	4,092
III-V	1,7625	1,8137	1,8824

[Summary of average eABR latency data (N=80)]

P2-4-18

Characterization of cortical auditory evoked potentials in individuals with long-term use of cochlear implants

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The physiological changes in the auditory system based on age reflect in the auditory evoked potentials, thus, it is possible to determine that a relationship exists between these changes and the development of auditory skills. The objective of this study was to identify and verify the characteristics of the P_1 component of the cortical auditory evoked potentials in hearing-impaired individuals with long-term use of the cochlear implant and correlate them with speech development, and secondarily, other variables related to the cochlear implant. Thirty (30) cochlear implant users, both male and female, implanted between the ages of two and four years old and use of the electronic device for the time period between six and 14 years, participated in this study. The P_1 component of the cortical auditory evoked potentials was studied with speech stimulation and speech perception evaluated with a list of sentences. The procedures were evaluated in an open environment. As a result, it was found that the P_1 component was recorded in each of the evaluated, with average latent values of 31,87±34,46 ms and amplitude of 2,42±1,46 µV. The occurrence of latency reduction (p=0,539) and the increase in amplitude (p=0,297) of the P_1 component were noted, with the absence of correlation between the groups with less and more than 10 years of use of the electronic device. When analyzing the effort in speech perception and the characteristics of the P_1 component by the behavioral points, the score of >54% was considered “good”, and ≤54% was “poor”, and the later analysis of the latent values of the P_1 component (p=0,753) and the amplitude (p=0,399) in both groups, a statistically significant difference was not found. Thus, the presence of the P_1 component in individual cochlear implant users shows that the cochlear implant restores the capacity to hear. The standard maturity potential of the cortical closely follows that of a hearing child, but with a delay in latency and decrease in amplitude. After a long period of cochlear implant use, the P_1 component is not a lone predictor of speech perception performance.

P2-4-19

Post-implantation changes of electrophysiological parameters in patients with cochlear implants

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Objective: To evaluate the postoperative changes of the basic electrophysiological and psychophysical parameters in cochlear implant patients: the impedance of the electrode contacts, the ECAP thresholds, and the T/C levels.

Study design and setting: Retrospective case review in a quaternary otologic referral centre.

Material and methods: Data on impedance of the electrode contacts, the ECAP thresholds, and the T/C levels have been collected in 20 consecutive CI patients divided into 2 groups. Group 1 comprised 10 prelingually deaf children implanted before the age of 18 months, group 2 comprised 10 postlingually deaf adults (average age of 58 years). All patients were users of the Nucleus 24RECA (Freedom, Contour Advance-of-stylet electrode) cochlear implant.

All implantations were performed via the posterior tympanotomy/cochleostomy approach with Contour Advance-of-stylet electrode insertion technique. Topical steroids (triamcinolone acetonide) mixed with hyaluronic acid (Healon) have been used to cover the cochleostomy site and to soak the electrode before insertion into the cochlea. Fitting in the paediatric group used consecutive (growing) maps based on the tNRT profile with subsequent behavioral adjustments. All data were collected at the European Institute for ENT-HNS in Antwerp, Belgium. Analyses were performed separately for the basal, mid-portion and apical electrodes. As representative for the basal electrodes an average result for electrode contacts No. 3, 4, 5 was calculated, for the mid-portion electrodes an average result for electrode contacts No. 11, 12, 13 and for the apical electrodes an average result for electrode contacts No. 19, 20, 21. All measurements were performed at three different fitting sessions: 1-3 months after surgery, 3-6 months after surgery and 12-24 months after surgery. For the ECAP measurement additionally the intraoperative values have been included.

Statistica 10 by StatSoft was used for the statistical analysis of the data. Friedman test and Wilcoxon signed-rank test were used to compare values from the consecutive fitting sessions.

Results and conclusions:

1. The mid-portion and the apical electrodes show decrease of the impedance values between the 1st and the 6th months postoperatively and stabilization in the later course. Impedance of the most basal electrodes grows during the first postoperative months and stabilizes later on but remains higher than the impedance of the mid-portion and the apical electrodes.
2. The tNRT values tend to decrease within the first 3 months after surgery to reach a plateau afterwards.
3. The behavioral T-levels remain generally stable, except for the basal electrodes where a decrease can be observed. The C-levels show an increase during the first 6 months of the implant use and remain stable afterwards.

Key words: Cochlear implants, impedance, ECAP, NRT, T/C levels, follow-up, postoperative, change

Running head: Postoperative changes

P2-4-20

Intraoperative electrical auditory brainstem response in cochlear implant users and its relation with the fitting process

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Background: The fitting process is still a challenge in the auditory deprivated children in the first months after cochlear implantation (CI). Among the objective measures that may help the fitting process the electrical auditory brainstem response (eABR) may be performed when telemetry methods are not available.

Objective: The objective of this study was to describe the intraoperative use of the eABR and its correlation with the psychoacoustic minimum and comfort thresholds.

Methods: Among 47 patients implanted with the Digisonic® CI between 2011 and 2013, adults with post lingual deafness, no additional or cognitive handicaps and complete insertion of the electrode array were selected. Intraoperative recordings of 20 subjects were collected in an apical, medial and basal electrode using the cochlear implant connected to the corresponding software to stimulate and the evoked potential equipment and external needle electrodes for the recording. Psychophysical thresholds and comfort levels were collected at three months after implantation.

Results: Results showed that wave V was the most consistent wave, identified in 80% of the sample, followed by wave III (60%) and wave IV (50%). Average latencies at 90 of stimulation amplitude and 80µs pulse width were: wave I: 1,34±0,17; wave II: 1,81±0,28; wave III: 2,55±0,40; wave IV: 3,13±0,23; wave V: 3,71±0,28. EABR pulse width thresholds were recorded in 50% of the sample with 70 of stimulation amplitude. The electrophysiological pulse width thresholds in these cases were equivalent to the psychophysical minimum thresholds at three months after CI, except in one patient in which the eABR threshold was taken by the wave III and no equivalency was found with the psychophysical thresholds or comfort levels.

Conclusion: The eABR is a feasible method of intraoperative VIII nerve assessment in cochlear implant surgeries, with 80% of present responses of at least one wave, generally wave V. The eABR threshold may give valuable information of the psychoacoustic minimum stimulation levels or pulse widths when telemetry methods are not available.

P2-4-21

Auditory brainstem responses and auditory steady state responses in partial deafness patients

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The purpose of the study was to determine the effectiveness of auditory brainstem responses (ABRs) and auditory steady state responses (ASSRs) for objective estimation of hearing thresholds in subjects with partial deafness (PD). The PD patients with hearing characterized by normal or slightly elevated thresholds in the low-frequency region, with nearly complete deafness in the higher frequencies, with a ski-slope type of audiogram. Cochlear implantation and combined electric-acoustic stimulation is one of common approaches for improving speech perception for adults and children with this type of impairment. Therefore there is a need for methods of objective diagnostic in candidacy assessment. Pure tone audiometry, standard ABR procedure using as a stimulus click and tone burst of the frequency 500 Hz and 1000 Hz as well as ASSR measurements were performed in a group of PD patients. Thresholds obtained by behavioral and objective methods were compared.

P2-4-22

Model of a setup for bimodal ABR measurement

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Introduction: Over the years, indications for cochlear implantation especially regarding to degree of hearing loss have changed. Nowadays an increasing number of patients use bimodal supply; However little is known about the central processing. Measuring and evaluation of hearing performance of each side separately does not allow to draw any conclusion on the entire hearing performance and thus of the central processing. A challenge in fitting pose patients who show no measurable improvement of speech intelligibility in combination of hearing aid and CI despite presenting with good single supply of both ears (CI, HA). The question is how much of the bimodal benefit is due to binaural processing and how much is due to binaural stimulation.

Aim: To create an objective measurement of bimodal supply, a test setup was developed that performs an ABR while stimulating both sides simultaneously with clicks (bimodal ABR). It also allows to measure click ABR by stimulation via hearing aid.

Method: The ABR system model Corona, Pilot Blankenfelde was used (; hardware filter 30 Hz-3 kHz; 3000 averages). On the cochlea implant side, electrode 11 was stimulated using a biphasic 50 µs pulse with a repetition rate of 35 Hz (Custom Sound CS 3.2 (Cochlear ®).) The stimulus levels started at 50 CL to determine a hearing threshold in quiet. Further stimulus levels were adjusted according to the NRT result. The hearing aid is adjusted to about 60 dB SL according to the audiogram. The ABR measurements were performed both sequentially and simultaneously for CI and HA for the purpose of comparability at 10 patients.

Results: The process of establishing a new measurement method for hearing aid-ABR is illustrated. This includes the HA I/O processing time (latency), development of a TTL trigger control device as well as an analysis tool of EEG information. Results of bimodally supplied patients are exemplified and critically discussed.

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P2-4-23

The audiological evaluation value of joint application multiple auditory steady state responses and behavioral hearing thresholds in cochlear implantation children

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Objective: To compare the difference of threshold estimation determined using the multiple auditory steady state responses(MASSRs) and behavior audiometry in a cochlear implantation children with sensorineural hearing loss (SNHL), to investigate correlation and differences between the response thresholds of MASSRs and behavioral auditory thresholds in deaf children, and to analysis the feasibility of the combined use of both mothed for preoperative audiological evaluation in cochlear implantation children.

Methods: 32 children with sensorineural hearing loss were tested with MASSRs and behavior audiometry at 0.5 kHz, 1 kHz, 2 kHz and 4 kHz. The coherence and correlation were compared between the two measures by t test and correlated modulus t test.

Results: The average thresholds difference of MASSRs and behavior audiometry in all tested frequencies were 8.2 ± 6.0 dB HL, 7.5 ± 6.1 dB HL, 6.2 ± 5.5 dB HL, 5.5 ± 5.6 dB HL. The correlation coefficients (r) at 0.5、1k、2k and 4kHz of the multiple auditory steady state responses(MASSRs) and behavior audiometry thresholds were 0.86, 0.88, 0.90 and 0.89 respectively ($P < 0.001$). There was a significant correlation between MASSRs and behavior audiometry thresholds in sensorineural hearing loss ears.

Conclusions: For too young or severe hearing loss reason, most cochlear implantation children couldn't get the threshold at high frequency by behavior audiometry, and there was a significant correlation between MASSRs and behavior audiometry thresholds in sensorineural hearing loss ears. So joint application of MASSRs and behavior audiometry can provide complete preoperative audiological evaluation in cochlear implantation children, further to provide correct postoperative effect evaluation.

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P2-4-24

Objective measures in pre and postlingual implanted patients

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Objective measures have been included in cochlear implant software as a tool for programming the speech processor of the implanted patients. In this study ECAP responses were obtained in a group of pre and postlingual CI recipients (N=5 and 7 respectively), using a Cochlear Nucleus CI system. All responses were obtained within the first 12 months of implant use.

The amplitude loudness growth was measured intraoperatively and at 3, 6 and 9 months after the activation. The recovery function was measured after 6 months of implant use. ECAP responses could be obtained in almost all patients at different sites of the electrode array. Comparisons between pre and postligual recipients for refractoriness, latency and amplitude of the ECAP responses were carried out. No statistically significant differences between groups were observed for the aforementioned parameters. TNRTs were highest during the surgery and then decreased during the first six months. After this period, TNRTs remained stable in amplitude. Prelingual recipients trend to have larger latencies than postlingual recipients for the amplitude growth function. For the recovery function, postlingual recipients showed a trend towards slower ECAP responses than prelingual recipients.

P2-4-25

Vestibular loss after cochlear implantation may depend (and be used as marker) of inner ear trauma during surgery

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Background: As cochlear implantation techniques and experience continues to develop, new expectations and goals are set. Vestibular function after cochlear implantation has been left out of focus as a lesser priority. Yet, in a similar fashion as to residual hearing preservation, vestibular loss resulting from this surgery may be related to inner ear trauma during implantation.

Aim: To assess vestibular asymmetry on the intervened ear after cochlear implantation. To explore the relationship of vestibular asymmetry and hearing preservation in a subgroup of patients with residual hearing.

Methods: Ongoing study. 34 candidates for cochlear implantation and 60 already implanted patients (18 of which satisfied hearing preservation criteria) were evaluated using cervical vestibular evoked myogenic potentials (VEMP), audiological testing and structured interviewed. The postoperative position of the electrode was checked with flat panel computed tomography in the early postoperative days. Time between implantation and vestibular / audiological testing was more than 6 months in all cases.

Results: Patients already implanted had a significantly (Wilcoxon, p=0,048) worse VEMP asymmetry ratio (39% ratio) in comparison to not yet implanted candidates (19% ratio). Interestingly, only a minority of patients with clearly pathological VEMP responses (only 15% of patients with a more than 35% asymmetry ratio) manifested vertigo, instability or vestibular symptomatology. Moreover in the subgroup satisfying residual hearing criteria, the amount of hearing lost after implantation was highly correlated with the VEMP asymmetry on the implanted ear: a patient with higher hearing preservation presented a lower/healthier vestibular ratio, and vice-versa (Pearson correlation = 0,85; p< 0,001).

Discussion: The important worsening in VEMP response in implanted patients support the notion of the vestibular system being impaired during surgery. This vestibular function loss appears to depend to the same processes that define the loss of residual hearing (as both variables correlated highly), most probably inner ear trauma. These data suggest that a minimally traumatic insertion technique may be beneficial not only for hearing results, but also for vestibular function. Moreover, VEMP asymmetry ratio may represent a valuable marker for assessing inner ear trauma in cochlear implantation.

P2-4-26

Cochlear Coverage vs. hearing performance (MedEl standard and FLEX 20, 24, 28) preliminary results

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The Cochlear Coverage is defined as relation between insertion depth of an electrode and the Cochlear Length. Based on this novel measurement parameters, hearing performance (with electric stimulation only) was correlated.

Methods: CBCT data of 56 unilateral implanted CI patients (MedEl Standard, MedEl Flex 20, 24 and 28) underwent preoperatively Cochlear length determination and postoperatively insertion depth measurement. Data evaluation was performed retrospectively. Statistical testing was performed by using Pearson product-moment correlation coefficient between Cochlear Coverage and hearing performance at 3 and 6 months after surgery. Audiological parameters were Freiburger Monosyllables, HSM sentence test at 65dB and HSM sentence test with noise (+10dB).

Results: A positive correlation between Cochlear Coverage and hearing performance could be seen after 3 months for Freiburger Monosyllables ($r = .325$; $p = .007$), HSM sentence test at 65dB ($r = .267$; $p = .024$) and HSM sentence test with 10dB noise ($r = .275$; $p = .037$). After 6 months no significant correlation could be found: Freiburger Monosyllables ($r = .133$; $p = .189$), HSM sentence test at 65dB ($r = .137$; $p = .185$) and HSM sentence test with 10dB noise ($r = .227$; $p = .088$).

Discussion: Evaluation of individual anatomic parameters in Cochlear Implant imaging has influence on the hearing performance. The Cochlear Coverage is an individualized parameter between insertion depth and individual Cochlear Length. Since Cochlear Length is a preoperatively measureable parameter, electrodes and especially electrode lengths could be chosen according to the individual necessity of an optimal Cochlear Coverage of the individual patient.

P2-4-27

Spread of excitation results with the increase in stimulus level

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Background: The spread of excitation (SOE) might be among the influence factors on programming of the speech processors in cochlear implanted patients. Our hypothesis is that the width of the excitation within the cochlea should be as narrow as the distance between electrodes, to avoid negative channel interaction, and it is known that the increase of the stimulus level leads to a wider SOE. In the clinical practice, we have seen patients whose SOE becomes narrower with the increase of stimulus level, but we are not sure how frequent this effect might be.

Objective: The goal of the study was to determine whether the increase in the width of SOE with higher stimulus levels is equal in the adult and pediatric population.

Design: Among 300 intraoperative SOE functions, fifty-one patients who were assessed in two different stimulus levels above the neural response telemetry threshold (tNRT), implanted with the same device and type of electrode array and tested at electrode 11 were selected. The SOE widths in millimeters (mm) taken at 50%, 75% and 90% of the function were compared between the two stimulus levels.

Results: Thirty-seven children and fourteen adults were assessed with 10 (±1) and 20 (±2) current units above tNRT. Mean and standard deviations of the SOE widths at 50% of the function (software default) were 2.87 mm (±1.52) and 3.56 mm (±1.37) at the two stimulus levels for the pediatric population, and 3.69 mm (±1.58) and 4.14 mm (±1.60) at the two stimulus levels for the adult population. All patients showed an increase in the peak amplitude of the function with the increase of the stimulus level, with a difference varying from 15 µV to 213 µV in the adult population and from 4 µV to 178 µV in the pediatric population. Three adult patients (21%) showed a decrease in the width at 50%, while 5 (35%) showed a decrease at 75% and 90%. In the pediatric population, four (11%) children showed a decrease in the width at 50%, 3 (8%) showed a decrease in the width at 75%, while eight children (21%) showed a decrease in the width at 90%. Two children showed a decrease in the width at all level of the function.

Conclusion: The majority of the adult and pediatric population showed wider SOE with the increase of stimulus level, but not all of them. Individual differences must be identified in order to help the speech processor programming and the understanding of the effect of increasing of the stimulus level above the neural telemetry thresholds for a customized fitting.

P2-4-28

Spatial spread of excitation measurements within adult cochlear implant users: feasibility, long-term stability and correlation with speech performance

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Objectives: The first purpose was to compare two Electrically evoked Compound Action Potential (ECAP) based methods (Spread Of Excitation, Variable Recording (SOE-VR) and Spread of Excitation Variable Masker (SOE-VM)) within a group of adult CI recipients. The second objective was to perform SOE-VM patterns over repeated trials and hence to explore ECAP long-term stability. The third purpose was to gain insight in the relationship between ECAP spatial forward masking patterns and speech perception to determine how channel interaction relates to speech performance.

Methods: Data were collected from 24 postlingually deafened unilaterally implanted adults.

Results: Experiment 1 revealed that SOE-VR measurements were statistically significantly broader compared to SOE-VM measurements. Within experiment 2, no significant differences could be found in width variations over repeated trials, implying a good long-term stability. Furthermore, results revealed no statistical significant results which could correlate ECAP derived spatial profiles with three speech perception tests.

Conclusions: Normalized SOE-VR functions were broader than normalized SOE-VM functions. Furthermore, long-term stability of SOE-VM patterns for three probe electrode locations over repeated trials showed that SOE-VM measures were highly stable across repeated trials over a one-yr time period. This suggests that physiological spatial forward masking measurements can be re-used when conducting studies that investigate possible relationships between these types of ECAP measures and psychophysical measurements. Furthermore, no significant correlation was found between ECAP derived spatial profiles and speech perception nor relative information transmitted. Moreover, the presence of peak displacements could not account for poorer speech perception results or lower relative information transmitted.

P2-4-29

Monitoring adequacy of audio processor programs and auditory maturity using aided cortical assessment (ACA)

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Background: Access to speech sounds is of major importance to prelingually deafened children learning to listen and speak with a cochlear implant (CI). The clinician needs confirmation that audio processor programs provide the user with adequate access to sound. This can be checked objectively using the automated Fonix®HEARLab System by Frye to check aided cortical resposes to speech tokens. It is expected that once a child is accessed to sound P1 will be recordable and latencies will shorten overtime. Shortening of P1 latencies reflecting auditory maturation can be monitored through repeated ACA. When responses are not optimum adjustments can be made to programs and ACA repeated to check the affect.

Aims: 1. To use ACA to evaluate the appropriateness of pediatric CI users' audio processor programs. 2. To establish the time usually required for P1 latencies to shorten and enter reference ranges.

Methods: This is a prospective, longitudinal study. 55 MED-EL CONCERTO and SONATA^{TI}100 users, mostly implanted at Istanbul Research and Training Hospital, Turkey, fitted by the authors, able to attend regularly for ACA, were included. Cortical responses to 3 speech tokens- /M/, /G/, /T/ presented at 55 dBSPL were repeatedly checked within the first few months after switch on. CI users were split into 2 groups. Group A were implanted ≤ 36 months, Group B ≥ 36 months. After 1 month of CI use, if a response to any speech token was lacking a modification to the CI users' program was made and ACA repeated at the same interval. ACA responses were scored. One point was awarded for each stimulus eliciting a P1 and another for a P1 latency within reference range, giving a total possible score of 6. Mean scores at each test interval for both groups were calculated. Time normally required to score 6 points was calculated for each group. Differences in responses to M, G, and T were examined. Percentage of program modifications leading to improved cortical responses was calculated. The relationship between age at first fit and time taken for latencies to shorten was examined.

Results: No cortical measures were prohibited by artifacts. ACA scores increased overtime. Group A tended to score 6 points within 4 months and Group B 6 points within 5 months of switch on. Group B scores showed more variance than Group A scores with more older implanted children scoring poorly. Responses to /M/ took longer than /G/ or /T/ to mature.

Conclusion: An accurately programmed CI can almost immediately access a child to quiet conversational speech. The mean ACA score was 3.46 within one month of switch on (P1 response to all speech tokens). Small modifications sometimes resulted in improved responses demonstrating the importance of careful fitting. Results of this study support reported findings that P1 responses tend to normalize within 3-6 months of CI switch on. P1 latencies tend to shorten faster for younger implanted children.

P2-4-30

Impedance and fitting parameters variations in cochlear implanted adults

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In patients with cochlear implant, the critical point in the auditory process from sound stimulus to comprehension can be identified in the interface electrode-cochlea. The purpose of this work was to evaluate, in patients with profound hearing loss and cochlear implanted, the longitudinal electrical impedance by comparing the differences in the various cochlear partitions and by relating them to the main psychoacoustic parameters of the fitting.

Methodology: We studied 28 patients, implanted at our Department, adults aged between 18 and 58, implanted in the period between 2009 and 2011. Impedance values and the lowest current levels that evoke an auditory sensation (T-level) and the highest current levels that do not elicit an uncomfortable loud sensation (C-level) were recorded at the time of activation approximately thirty days after implantation, mean 28.5 days (t0), after one month (t1), 3 months (t3), 6 months (t6) and one year (t12). For every case, we used the same type of perimodiolar implant (Cochlear™ Nucleus® CI24RE) with the same surgical technique (soft surgery with cochleostomy). Impedance values were calculated for electrode groups: basal, middle and apical.

Results: Significant changes in impedances were found between t0 and t1. T and C-level showed significant incremental changes between t0 and t1 and between t1 and t3. It was found a significant relationship between the values of the impedance and the fitting parameters until t3 for all the cochlear segments. There was significant and prolonged (up to t12) difference between values of the basal impedance compared to other cochlear sectors.

Conclusions: The results obtained point out at an increase in basal impedance: this figure is explained by the higher proportion of newly formed tissue already emphasized in previous studies. The linear correlation of impedance values with the fitting parameters corresponds to the first Ohm´s law, global correlation are lost after t6. We may speculate that extracochlear factors are later prevalent to obtain sensation levels. The greater slope of changing of T and C level during the first 3 months agrees with a more frequent scheduled fitting sessions in this period.

P2-4-31

Variation in time of electrode impedances in 38 cochlear implant Listeners

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Background: Impedances of the cochlear implants' electrode array affect the fitting of the sound processor directly, since they refer to electrical and physical changes in the cochlea.

Methods: Electrode impedances of 38 Nucleus Freedom™ implants were measured intraoperatively, immediately before first fitting of the implant system, daily during first fitting (FF) and in routine visits after 6-12 months, after 1-2 years and after 3-4 years after FF. Mean impedance profiles were calculated as well as profiles of relative impedance changes and their variation in time.

Results: Intraoperative conditioning of electrodes lowers the mean impedances starting with about ≈10-12 kΩ to about ≈6 kΩ. A postoperative rise of impedances of about ≈ 9 kΩ was observed right before the FF. Remarkably, impedance values of electrodes were frequently higher before FF than in the first intraoperative measurement. The maximum rise was observed for the five most basal electrodes. During FF, mean impedances evenly dropped for about 4.4 kΩ within one day of operation. Until routine visits during 6-12 months after implantation, impedances of the basal half of the electrode array nearly remained constant, while the apical half exhibits a further decrease of mean impedances of about ≈0.5 kΩ to ≈2 kΩ, depending on the specific electrode position. Mean impedances remained almost constant for routine visits during 1-2 and 2-4 years after implantation.

Conclusions: The increase of impedances until first fitting coincides with the observation of mainly basal fibrous tissue and bone growth [1, 2]. Observed short-term changes in impedances are independent of the electrode position while long-term changes mainly affected the apical part of the electrode array. Provided that the growth of fibrous tissue and bone is accompanied by an increase of impedances, the growth mainly occurs within the first 6 weeks after implantation. Afterwards, the growth is presumably decelerated (basally) or ceased (apically). The time course of NRT profiles in a previous study [4] is contrary to the observed variation of electrode impedances. Hence, changes over time of NRT thresholds are not caused by the changes in the electrode impedances.

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P2-4-32

Incidence and implications of individual electrode malfunctions in pediatric cochlear implants

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Intro: The purpose of this investigation was to determine the type, incidence, and time course of individual electrode malfunctions, and their predictive value for internal device failure in a pediatric cochlear implant population.

Methods: A retrospective analysis of prospectively documented patient data was performed at a tertiary referral pediatric cochlear implant center. Impedance telemetry and programming records were studied retrospectively in a series of 733 consecutive pediatric cochlear implantations at Boston Children's Hospital from 1995 to 2013. All 733 implants had been activated for at least 6 months. The following data was extracted: model of implant (including recall status), age of patient at the time of implantation, original versus re-implanted device, full versus partial insertion, occurrence of open circuits and short circuits, time from surgery to electrode faults, and whether the device ultimately developed additional faults or failed. We also analyzed these parameters of electrode malfunctions separately for our subset of 37 devices which required explantation/re-implantation.

Results: While the incidence of electrode faults was relatively high, these malfunctions in isolation were not predictive of device failure. In most cases, re-programming of the processor following the discovery of faulty electrodes preserved the patient's speech recognition ability. In our population of all implants requiring explantation, very few exhibited individual electrode malfunctions prior to explantation. However, electrode arrays with multiple short circuits or open circuits were more likely to occur in devices which ultimately failed.

Discussion: In the United States, implant centers report device failures requiring re-implantation to the manufacturers, who report in turn to the Food and Drug Administration (FDA). However, implant centers do not systematically report malfunction of individual electrodes or electrode pairs (open circuits or short circuits) to the manufacturer. In the event of an electrode fault, the audiologist reprograms the device to minimize perceptual loss, and monitors the device at each future visit. Therefore, the incidence and predictive parameters of electrode faults has not been well reported.

Conclusion: Impedance telemetry measures should be performed and examined at each mapping session so that the audiologist can provide audibility across the desired frequency range through accurate programming. The results of this investigation support a low incidence of eventual device failures in implants that have an individual electrode fault. If multiple electrodes are affected, heightened concern and vigilant monitoring are warranted for eventual device failure and need for re-implantation.

Learning outcome: The incidence of individual electrode faults in pediatric cochlear implants is not uncommon, and the presence of multiple electrode faults is cause for concern for eventual device failure.

P2-4-33

Audiological tests as indicators of prognosis after cochlear implant surgery in the absence of visible cochlear nerve: A case study

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The study was done to describe the pre-and post-cochlear implantation findings of a client with invisible Cochlear nerve. A client with hearing impairment, aged 4 years, reported for the purpose of cochlear implant candidacy assessment. The client was a hearing aid user. Audiological evaluation was done for the client. Pure tone averages were 105 dBHL in the right ear and 88.3 dBHL in the left ear. Speech Awareness Threshold (SAT) was at 70 dBHL in both the ears. Auditory Brainstem Response (ABR) evaluation revealed no response in the right ear upto 90dBnHL for clicks and tone bursts. In the left ear, peak V was obtained only for 500 Hz alternating tone bursts at 90 dBnHL. Auditory Steady State Response was bilaterally absent. Findings were suggestive of bilateral severe-to-profound hearing loss. Left ear and binaural aided free field responses were within the speech spectrum, with SAT at 25 dBHL. Aided responses were not within the speech spectrum for the right ear, with SAT at 60 dBHL. Radiological evaluation revealed bilateral stenosis and duplication of the Internal Acoustic Meatus, and bilateral absence of cochlear nerves. Additional audiological testing was done because of the discrepancy between the results of audiological and radiological evaluations. Early Speech Perception Test results in Kannada language showed some pattern perception, vowel recognition and word identification for the left ear, and minimal pattern perception for the right ear. Client's aided performance on informal temporal perception tasks was found to be fair for short duration stimuli. She was unable to perform on localization tasks. Client could also repeat 3-syllable sequences with the use of hearing aids. Transtympanic Electrical ABR (TTEABR) was present bilaterally, with better morphology on the right side. On the basis of TTEABR results, the client was implanted in the right ear. Intra-operative Neural Response telemetry showed the presence of ECAP in the right ear. Switch on was done a month after implantation. Client is now attending therapy to improve her speech and language skills. Post-implantation audiological test battery revealed improvement in auditory skills. Thus, we conclude that audiological tests can be used to predict the success of cochlear implant surgery in clients with the absence of a visible cochlear nerve.

P2-4-34

0.5 kHz tone-burst evoked otoacoustic emissions in children

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The present study investigates the usefulness of Otoacoustic emissions (OAEs) in the lower frequency range of 0.5-1 kHz evoked by 0.5 kHz tone bursts. OAEs were recorded from the ears of school AGE children in a screening setup. Each ear was tested with a standard click stimulus at 80 dB pSPL (CEOAEs) and with a 0.5 kHz tone burst also at 80 dB pSPL (TBOAEs). Pure tone audiometry and tympanometry were also conducted. Half-octave-band values of OAE signal to noise ratios (SNRs) and response levels were used to assess statistical differences. For the 0.5 kHz tone bursts, evoked responses were very weak at 0.5 kHz and the peak response occurred at 0.7-1 kHz. Generally, CEOAE SNRs were about 10 dB in the 1-4 kHz range, while SNRs for 0.5 kHz TBOAEs were about 10 dB at 0.7-1 kHz. To conclude, 0.5 kHz TBOAEs could be measured in children as effectively as CEOAEs. They can provide additional information about the 0.7-1 kHz frequency range, a range over which CEOAEs do not usually contain responses above the noise floor.

P2-4-35

Intraoperative cochlear implant diagnostics with the handheld CR220 Remote Assistant

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Our two clinics had the first opportunity in Africa to perform intraoperative diagnostics during cochlear implantation surgery using the CR220 Remote Assistant from Cochlear Ltd. (Macquarie Park, Australia). We had great interest in understanding whether the CR220 Remote Assistant could replace the standard clinical set-up and, if so, the implications for comprehensive intraoperative diagnostics to be conducted quickly and efficiently in our hospitals. This study reports on six patients implanted at our hospitals, four at the National Hospital Abuja in Abuja, Nigeria, and two at the Lagos State University Teaching Hospital in Lagos, Nigeria.

The patients were implanted with Nucleus CI24RE cochlear implants with Contour Advance type electrodes. During the surgery, diagnostic measurements were taken with both the standard Custom Sound clinical system (with associated laptop, etc.) and the CR220 Remote Assistant. These diagnostics consisted of measuring the electrode impedances, the electrically Evoked Compound Action Potential (ECAP) thresholds and a stapedius muscle reflex test. In addition to the diagnostics, the time involved with travel to/from the operating theatre, equipment set-up/tear-down and the diagnostic measurement time was noted. This being done to understand the potential cost effectiveness of using the CR220 Remote Assistant compared to the standard clinical set-up.

All surgeries were successfully completed and it was possible in all cases to measure the diagnostics with both the Custom Sound and CR220 Remote Assistant systems. A significant difference was noted in the ECAP threshold measurement time for Custom Sound (M=11.3 mins, SD=4.8) and the CR220 (M=5.5 mins, SD=1.0); $t(5) = 3.01$, $p=0.03$. The ECAP thresholds were similar, but due to the small number of recipients no statement of significance can be deduced.

It was noted that personnel untrained with making intraoperative diagnostic measurements for cochlear implantation could use the CR220 Remote Assistant. Therefore notable was the amount of “associated time” when using the Custom Sound system, e.g., an additional, trained person travelling to the operating theatre, setting up the equipment, etc. This additional person and the time involved would not be required when using the CR220 Remote Assistant in future. An overview of the cost effectiveness will be presented.

Our initial experiences show that the CR220 Remote Assistant can be successfully used for making intraoperative diagnostic measurements for cochlear implant surgery. Less time and less training is required when using this device, compared to the standard clinical system.

P2-5 Cochlear implants around the world

P2-5-1

Facilitating mindful communication

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Listening and Spoken Language specialists team up with parents to elicit active listening in their children. During sessions caregivers practice using strategies such as expectant look or narrating actions as they interact with their child. Little by little listening becomes part of their personality and their everyday life. In the aural habilitation process the speed at which each caregiver becomes aware of listening strategies greatly varies. This presentation will tackle the subject of the different levels of awareness of family members that we serve at our Center and how we proceed to increase mindfulness during interactions. Case studies will be described with the specific steps that were used with our families, video clips and parent surveys will be shared during this presentation.

Learning outcome:

1. Participants will be able to recall one element that affects caregiver awareness of how communicative they are with their child.
2. Participants will be able to describe one way that they can elicit the use of a listening and spoken language strategy.
3. Participants will be able to describe one way that they can help increase mindful communication in the families they serve.

P2-5-2

Profile of the patients implanted in a cochlear implant program in Recife - PE- Brazil

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The ability of communication is one of the most important contributors to the welfare of any individual[1]. Hearing loss may damage not only the individual´s communication, but many others aspects, such as emotional, cognitive, social and educational features[2]. Analyzing and understanding the etiologies of bilateral severe to profound deafness is fundamental to establish more effective preventive and therapeutic measures, as Cochlear Implant (CI).

Results: During a period of 45 months, were performed 100 CI's surgery. 52% were female patients. The minimum age was 17 months while the maximum was 70 years old. The median was 4 years old. Children under 3 years old were the most frequent group (46%). Pre-lingual cases (71%) were more common than post-lingual ones. The most common etiology was idiopathic (41%), followed by infection (22%), which were 8 cases of meningitis, 4 cases due to Cytomegalovirus, 8t cases due to Rubella and 2 cases due to Parotitis. Ototoxic drugs and/or prematurity were found in 14 cases and 4 cases due to congenital malformation. In 2 cases the diagnosis was Otosclerosis and 1was enlarged vestibular aqueduct syndrome. Among 12 cases in which genetic analyses were carried out, in 8 of them it was found the presence of mutation in the gene that encodes the protein Connexin 26. The other etiologies found were traumatic (post-TCE and acoustic trauma), Usher Syndrome and exogenous poisoning by carbamate.

Discussion: As noted in Brazilian and world literatures, although detailed investigations were performed, in most cases it is not possible to find a definitive diagnosis. In this study, idiopathic etiology was the most common. This high frequency reinforces the importance of looking for a definitive diagnosis. Many deafness patients without a definitive diagnosis could be secondary to genetic causes. It is estimated that 70% of all genetic causes of deafness are non-syndromic, and that 80% of them have autosomal recessive inheritance pattern. Mutation in GJB6 gene, the one which encodes the protein connexin 26(Cx26), is responsible for 80% of the genetic deafness cases, and the majority of the mutations is in 35DelG[5]. The fact that genetic analysis is not available in all cases leads to underestimate the genetic etiology in studies. In relation to infectious etiology, the results seen in this study contrast with others in developed countries, where there is reduction or even the total absence of rubella as a cause of deafness[3-5].

Conclusion: In accordance with other studies, most patients that are being submitted to a CI are children, with pre-lingual deafness, whose more common etiology is idiopathic. This fact reinforces the importance of performing more genetic analyses in an attempt to reach a more reliable etiological profile. It is worth emphasizing the presence of rubella and meningitis as causes of deafness in this study, pointing that both etiologies could be prevented with improvement of health care.

P2-5-3

Cochlear implants in the middle east (1983-2013)

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This presentation discusses what happened with the Alexandria CI program in the last 30 years. The problems we faced in the Middle East applies to all developing countries. It included acceptance, patient, team and setup, device and surgical technique. Our experience included 10 different counties, and working with 8 different brands of cochlear implants.

P2-5-4

Cochlear implant program in North Sumatera and South Sulawesi provinces in Indonesia

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The aim of this presentation is to describe the cochlear implant program development in North Sumatera and South Sulawesi provinces in Indonesia. At the Murni Teguh Memorial hospital, North Sumatera, the program started on 15th April 2012, and on 23rd December 2012 at the Wahidin Sudirohusodo General Hospital, South Sulewasi province. Initially, the surgeries were performed by surgeons from Jakarta who helped in the development of the CI team in both provinces. Currently, all surgeries are performed by local surgeons. In both hospitals the CI team is comprised of audiologists, therapists, ENT surgeons, and nurses. A total of 9 patients have been implanted at the Murni Teguh Memorial hospital, North Sumatera province, and 4 patients at the Wahidin Sudirohusodo General Hospital, South Sulawesi province. All of the patients are prelingually deafened and the majority of the aetiologies are idiopathic. Most patients have been implanted with the SONATA MEDEL implant, and currently wearing the OPUS2 speech processor. The vast majority of patients have obtained good outcomes as evidenced by their communication skills, especially language development. In this presentation, a summary of the users' demographics, surgical details and CI outcomes will be presented along with a discussion of the key learning aspects from these CI programs. Finally, an analysis of the main barriers to cochlear implantation in both provinces will be given.

P2-5-5

Cochlear implant program in East Java in Indonesia

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The aim of this presentation is to describe the cochlear implant program development in the Indonesian province of East Java. At the Dr. Ramelan Navy Hospital (East Java Province), the program started on 23rd October 2011. Initially, the surgeries were performed by surgeons from Jakarta who helped in the development of the CI team in this province. Currently, all surgeries are performed by local surgeons. In this hospital the CI team is comprised of audiologists, therapists, ENT surgeons, and nurses. A total of 20 patients have been implanted so far. All of the patients are prelingually deafened and the majority of the aetiologies are idiopathic. Most patients have been implanted with the SONATA MEDEL implant, and currently wearing the OPUS 2 speech processor. The vast majority of patients have obtained good outcomes as evidenced by their communication skills, especially speech and language development. In this presentation, a summary of user demographics, surgical details and CI outcomes will be presented along with a discussion of the key learning aspects from this CI program. Finally, an analysis of the main difficulties encountered during the program will be addressed.

P2-5-6

Cochlear implant outcomes at the ENT Ha Noi Hospital during August/2012 and August/2013

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The aim of this presentation is to evaluate the surgical and rehabilitation results of the cochlear implant program at the ENT Ha Noi hospital during the period August 2012 - August 2013. A total number of 35 patients who were diagnosed with bilateral profound hearing loss received a cochlear implant during the aforementioned period. Patients stayed at the hospital on average during 7 days. Ninety-four point three percent of the electrodes were successfully inserted. Some patients had early complications after the surgery such as dizziness, subcutaneous seroma and VII nerve dysfunction. Late complications were observed in a very small percentage of patients which included allergic reaction to the magnet and skin flap infections. On average, patients showed good progress after 3 mapping sessions. The majority of the patients have reached good aided hearing thresholds and good performance for the 6 ling sounds. A total of 13 patients obtained aided hearing thresholds between 25 and 30 dB after 6 months of CI use. This presentation will address a discussion of the CI outcomes in this group of patients.

P2-5-7

Cochlear implant program in Mongolia

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Mongolia is a landlocked country in Central Asia. Ulaanbaatar, the capital and also the largest city, is home to about 45% of the population. The country covers an area of 1,564,115 square kilometers and its population is estimated in 2,921,287 inhabitants. Cochlear implants were introduced in Mongolia around 6 years ago. The aim of this presentation is to describe the cochlear implant program carried out at the AID ENT Clinic Hearing Implant Center in conjunction with the State Central Hospital of Mongolia. So far, a total of 18 patients have been implanted in both centers. Patients have been implanted with either Pulsar or Sonata MEDEL cochlear implants. From the total number of CI recipients who has been operated in these centers, 5 are children and 13 adults. Most patients (n=11) are postlingual. Patients come from different cities which imposes some difficulties for the audiological follow-up, especially in winter time. Despite these difficulties, the patients and their parents are very pleased with the progress they have obtained. Most of the patients have obtained very good aided thresholds. The paediatric patients with the help of the language therapist have been developed language skills and their oral communication capacities have considerably improved. The postlingual patients have been able to achieve good discrimination scores for open set speech materials. In this presentation, a profile of the CI recipients operated at the aforementioned centers will be given along with a discussion of their results and the difficulties this program has encountered.

P2-5-8

Cochlear implant program in Myanmar

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Myanmar is a sovereign state in Southeast Asia with an area of 676,578 square kilometers (world's 40th largest country and the second largest in Southeast Asia). Myanmar's population is over 60 million inhabitants. A formal cochlear implant program in Myanmar started in 2011 at the ENT hospital. So far, a total of 31 patients have been implanted (16 females) with a mean age of 29 years (4-78). All patients come from at least 7 different cities. Twenty-one of these patients are prelingually deafened and the remaining 10 patients are postligually deafened. Currently three hospitals in the country perform cochlear implant surgery (Victoria hospital, Pun Hlaing hospital, and ENT hospital). Good results have been observed for all patients regarding aided hearing thresholds and speech discrimination scores. Despite the good results, Myanmar still faces some problems and limitations regarding cochlear implants. Such limitations include limited development of audiology and speech-language pathology in the country, limited access to health services and thus follow-up for mapping sessions is difficult, patients have to pay for the devices, and late diagnosis of hearing loss in children.

P2-5-9

Hearing implants around the world - CI in Taiwan

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The first cochlear implant in Taiwan was done in1993. Since then, there have been over 2000 recipients. Among them, 70% are under age of 5. The youngest recipient was 10 months old, and the oldest was 86 years old. The number of bilateral implants is growing increasingly common. The SSD (single-sided deaf) has not yet been accepted as standard criteria for cochlear implants. Besides cochlear implants, middle ear implants, bone bridges, and ABIs have also been approved by Taiwan government. There is no coverage for cochlear implants from either insurance or National Insurance of Health. Therefore, social welfare reimbursement, fund raising and donation become the major source of payment.

Social welfare reimbursement: Between 6,600 and 20,000 USD per case, depending on the financial status of the recipients´ family. If the demands are beyond government budget, recipients under 6 will be prioritized.

Fund raising: Because the reimbursement only covers partial expense of cochlear implantation, many young parents still are unable to pay the rest. Most CI providing hospitals have to seek donation in order to help those young parents. Some hospitals are so successful at fund raising that the recipients in those hospitals do not need to pay any expense.

Taiwan donation: The biggest CI donation is from Taiwan Formosa Plastic Group, which is one of the biggest plastic manufacturers in the world. However, this donation is not for Taiwanese. Its chairman and the founder, Mr. Wang, donated 16,000 Cochlear devices to China, initiated the development of CI researches and deployed service for hearing impaired people in China.

Surgeon: Only qualified Otologists in Taiwan are allowed to do CI operation. These surgeons must have performed at least over 20 cholesteatoma operations, 50 tympanoplasties before receiving a certificate issued by a CI instructor.

Newborn screen: All the newborn babies have to receive aABR hearing screen 36 hours postpartum. Their aABR reports are keyed in daily to the online government network. The public health nurses will monitor babies who have missed the screen and those failed to pass the screen until a final diagnosis is made.

Rehabilitation: There are many institutions in Taiwan that provide sufficient and sophisticated rehabilitation program for the hearing impaired. The New Women League and the Children Foundation are the leaders. They have classes in the northern, central and southern parts of the island. Over 400 hearing impaired children a year take their rehabilitation lessons in these two centers. Ninety-seven percent of these children end up go back to mainstream school by age of 7.

P2-5-10

Cochlear implants in cochlear malformations: The experience of Vietnam National Hospital of Paediatrics

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Since July 2010, 100 patients have been implanted at the Vietnam National Hospital of Paediatrics. From these 100 patients, 2 have presented with cochlear malformations. The aim of this study is to determine the auditory abilities in these patients with cochlear malformations who received a cochlear implant in 2012. Patient 1 was diagnosed with a Mondini malformation and a MED-EL compressed electrode array was selected. This electrode array has a length of 15 mm, and it covers an area within the cochlea of 12.1 mm. This patient has been able to develop language with the help of the therapist and his aided thresholds after 1 year of implantation have reached on average 40 dB across the frequency range (500-4000 Hz). Patient 2 was diagnosed with a bilateral severe hearing loss at the age of 18 months. Imaging studies showed the presence of a cochlear common cavity. Therefore for this patient a MED-EL custom made electrode array was used. After one month of activation, the patient obtained on average 50 dB across the frequency range (500-4000 Hz). It is concluded that patients presenting with cochlear malformation can still benefit from cochlear implantation. The key-aspect for optimal results is the appropriate selection of the electrode array to be used.

P2-5-11

Cochlear implants in South Africa

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Background: The Tygerberg Hospital-University of Stellenbosch Cochlear Implant Unit was established in 1986. At the time, the aim of the unit was to provide cochlear implantation to a large geographic area, train professionals and set standards for subsequent units in the country. To date 510 adults and children have received a cochlear implant system in at least one ear. As in other developing countries, cochlear implant units in South Africa face unique socio-economic challenges. Cochlear implants are not funded on a national level. In a society where resources are severely limited and competition for the allocation of funds intense, every effort should be made to ensure optimal and long term use of these devices.

Objective: The aim of the study was to review cochlear implantation at the unit and describe the characteristics and socio-economic status of the recipients, discuss the funding of devices, describe the educational placement of children and speech perception outcomes for adults.

Study Design: The study was a descriptive retrospective record review of the cohort of patients who received a cochlear implant at a single centre, namely the Tygerberg Hospital-University of Stellenbosch Cochlear Implant Unit from 1986 to 2013. All patients who received their cochlear implant system from and are still under the care of the unit were included in the study. Of the 510 implanted patients, 198 have been referred to other implant units and 18 have passed away.

Learning outcome: Discussion of the clinical outcomes and challenges experienced by a cochlear implant unit in South Africa.

P2-5-12

Auditory performance in implantated children before 2 years old at Mendoza, Argentina

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Objectives: To analyze the auditory abilities of children with a profound prelingual bilateral hearing-impairment when subjected to a cochlear implant (CI) before 2 years of age.

Design: Retrospective cohort single-subject, repeated-measures study of children with profound bilateral hearing impairment subjected to CI in the last 10 years at Hospital Notti, Mendoza, Argentina.

Population: This study analyzed 9 children subjected to multichannel CI for profound prelingual bilateral hearing-impairment. From 2003 to 2013 at Hospital Notti.

Methods: The children were evaluated before, and each year after, the intervention (for up to 5 years) with open-set auditory tests.

Results: Auditory abilities improved significantly in all children after CI compared with normal children (p 0,0493).

Conclusions: When performed before 2 years of age, CI offers a quicker improvement of performance. Future reports may be played do determine the infant´s performance after the earlier implantation, compared with implanted children after 2 years old.

Keywords: Cochlear implantation; hearing impairment; inner ear surgery, treatment outcome; early implantation

P2-5-13

Eight years of cochlear implantation in Vilnius university hospital in Lithuania

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The aim of our presentation is to describe Lithuanian experience in the field of CI, especially in Vilnius University Hospital. In Lithuania cochlear implantation was started in 1999. At the moment there are 240 CI users (18 of them are bilateral) in our country. About 90 percent of users are children. Also, there are 13 VSB and 37 BAHA recipients in Lithuania. Since 2012 the National Health Insurance Fund fully covers costs of the CI, VSB and BAHA for children and partly for adults. Two professional teams perform cochlear implantation in Vilnius and Kaunas university hospitals.

The first cochlear implantation in Vilnius University Hospital Santariskiu Clinics was performed in 2005. Since then 103 patients were implanted (13 operated bilaterally). Our Hearing Implantation Centre's structure consists of three sections: two audiology departments (adults and pediatric) where candidates' hearing assessment, preparation for surgery and recipients monitoring are performed and otosurgery department, where surgery is performed. We try to apply multidisciplinary approach: audiologist, surgeon, pediatrician, neurologist, geneticist, developmental psychologist, auditory-verbal therapist, radiologist, anesthesiologist and acoustic engineer work as a team. Two educational institutions for hearing-impaired children manage Auditory-Verbal habilitation process in Vilnius. The majority of children attend mainstream kindergartens and schools.

In order to review our pediatric population, we have assessed causes of congenital hearing loss, early auditory and speech outcomes in 60 children who underwent cochlear implantation at Vilnius University Hospital. We found that of the causes identified, the genetic mechanism was present in one third of the cases, peripartal problems in another third, and in one third of the cases the etiologic factor remained unknown. The majority of children were implanted before 24 months of age. After implantation the CAP and SIR scores (measured prior to and 12 months after activation of the CI) increased for all children. The majority of children has showed a good progress with performance equal or superior to what is reported in the literature. The follow-up of these children is important to establish therapy goals. Further studies to evaluate late outcomes and quality of life as well as to determine prognostic factors in our population of implanted children are needed. Based on the results of these studies, we plan to improve our CI program and service.

P2-5-14

Pakistan cochlear implant program: 14 years' experience

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Introduction: Pakistan cochlear implant program was established in 2000. Despite financial constraints, the program has gradually grown over the years. There are 502 cochlear implant recipients. Children are the main recipients. Congenital hearing loss associated with consanguinity of the parents is the major aetiological group. We study the socio-demographic profile, type of implant use, complications of surgery, factors associated with re-implantation and other factors which affect the outcome.

Methods and Materials: Retrospective analysis of 502 patients who received cochlear implants between august 2002 and January 2014. 95% of the recipients are children and 64% of them were borne to parents with consanguineous marriages. The aetiology of deafness includes congenital (68%), meningitis (8%), progressive (3%) and other rare causes such as mumps and trauma. Most patients received MED-EL cochlear implant. The majority of the patients were implanted in two major cities of Lahore and Karachi. There were no major complications and 1.6% have minor complications. The rate of reimplantation has been 3.7% and 2.5% reimplantation were due to device failures.

Conclusion: Cochlear implantation services can be safely established in a developing country. Almost all the paediatric patients will receive unilateral implant in foreseeable future. The candidacy criteria is somewhat different from that of developed world.

P2-5-15

Benefits of the applied surgical method of the program of cochlear implantation in Juiz de Fora - Brazil

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Summary: A surgical method from Program of Cochlear Implantation in Juiz de Fora presents a high numbers of patients with total insertion of the electrodes in cochlea and none injuries of facial nerve during the surgery. The results from telemetry of neural answers and the advances with the patients prove the effectiveness of the method.

Objective: Describes the benefits from the method with ours patients.

Material and method: Analysis of the maps and surgical papers of the 107 patients implanted in the Program of Attention the Auditory Health at Juiz de Fora.

Results: Easiness in the insertion of the electrodes in cochlea, even in cases of meningitis and otosclerosis. Absence of nerve injuries.

Conclusion: The surgical technique applied gives security to surgeon and patient. Reflecting at patient's emotional feeling and facilitating the work of the audiologist. The high number of patients with total insertion of the electrodes in the Cochlea was observed, even in cases of meningitis and otosclerosis.

P2-5-16

School age hearing screening - pilot studies from countries around the world

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Introduction and objective: Hearing problems among school age children are social and economic problems. There are different approaches to hearing screening in school age children in many countries. Hook up of the regular program took place in Poland over 6 years ago. As a regular was organized since 2008. On December 2, 2011 the EU Council adopted Conclusions on the Early Detection and Treatment of Communication Disorders in Children, Including the Use of e-Health Tools and innovative Solutions. The main focus now is not only on the efficacy of hearing screening programs in school children, but what should be its general aim and what tests it should include. If there is possibility It is also important to include central auditory processing disorder (CAPD) tests like DDT. The aim of the study reported here is to evaluate the usefulness of the Pure Tonal Audiometry and DDT in detecting central hearing disorders in school-age children. During 2012 and 2013 pilot studies was performed also at other countries of Central Asia and Eastern Europe.

Materials and methods: There was 982 children screened in many countries (like Russia, Tajikistan, Kirgizstan, Moldova, Romania, Azerbaijan, Ukraine) During hearing screening programs conducted in Poland in 2008-10, exactly 235,664 children (7-12 years old) were screened in 9,325 schools. Of this number, 7,642 were examined using the DDT test for CAPD. Screening programs were conducted using the Sense Examination Platform. During international program there was 1123 children screened. Only PTA and questionnaires were performed at international studies.

Results: With the cut-off criterion set at the 5th percentile, results for the DDT applied in a divided attention mode were 11.4% positive for 7-year olds and 11.3% for 12-year olds. In the focused attention mode, the comparable result for 12-year olds was 9.7%. There was a clear right ear advantage. In children with positive DDT results, a higher incidence of other disorders, such as dyslexia, was observed. In PTA results were from 5,6 to 17,7 % positive . In many countries positive results level is around 13%.

Conclusions: PTA as a fast an easy to perform test should be included at standard screening procedure. Very important is to have good conditions to perform test. A test for CAPD should be included in the hearing screening of school-age children. The results of this study form the basis for developing Polish standards in this area and in other programs. There is need for standardization of tests and results interpretation.

P2-5-17

"Cochlear implants in Oman"

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Cochlear implant program started in Oman in 2000 when the first CI was perform, the aim of the study to audit the outcome tell date.

The number of Cochlear Implant tell 2005 Was limited as the cost of the implant was taken by the patient or some civilian society, since 2005 we have performed more than 250 implants majority by MED-EL. Majority of our patient are children 90% and adult mainly post lingual. We have success rate of 82% in hearing post op. We encountered several complications during our implants like bleeding, infections, Failure of implantation, skin necrosis.

P2-5-18

Binaural benefits in bilateral simultaneous cochlear implanatation in Thai

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Objective: To report binaural benefits in Thai deafened adults with bilateral simultaneous cochlear implantation

Methods: Two adult patients were included to measure preoperative and postoperative binaural effects.

Results: Two male adults were included. The mean age was 55. The binaural advantages were measured switchon, 6 months and 1 years after bilateral simultaneous cochlear implantation. The head shadow effect showed 15 dB at; switch-on 6 months and 1 year after implantation. The summation effect was 0, 7, 15 dB; switch-on 6 months and 1 year after implantation. The squelch effect was 0, 3, 5 dB; switch-on 6months and 1 year after implantation.

Discussion: The Bilateral simultaneous cochlear implantation can make the patients restore binaural hearing again. As the results, the head shadow effect showed significantly improvement immediately after switch-on. This benefit is aroud 15 dB. The summation, squelch effect showed improvement 6 months after implantation and continuously improved.

Conclusion: The bilateral simultaneous cochlear implantation can demonstrate the binaural benefits in Thai adult implantees.

P2-5-19

The experience of coltea ENT/HNS clinic Bucharest in cochlear implantation (2009-2013 survey)

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Introduction: The cochlear implantation started in Coltea Clinic Bucharest Romania back in 2009.

Methods: 18 patients. Being beginners in the field of CI surgery, we needed the valuable and competitive support provided by MED-EL which invited renowned foreign surgeons to assist our team (Prof. Georg Sprinzl and Prof. Klaus Boeheim from Innsbruck/St. Poelten). Under these circumstances we only had one major postoperative incident - an implant migration after 3 months. All recipients were strictly followed up and they registered a considerable benefit from their cochlear implants regarding the communication capabilities as well as enhancement of their day by day quality of life.

Results: The following cochlear implant types were used:

- 78% MED-EL
- 11 % Neurelec
- 11% Advanced Bionics

Sex ratio:

- F: 11 61.2 %
- M: 7 38.8 %

Age: all ages, but preferred patients were children, due to financial restraints.

Geographical distribution: all over the country

Equity: no discrimination.

Teaching: voluntarily trained and coordinated staff (doctors and nurses) from Targu Mures ENT Clinic; support them to start their own CI program back in 2011.

Discussions and conclusions: Future plans: in spite of heavy financial restraints, we plan to increase the number of CIs and to introduce new devices (Vibrant Soundbridge and Bonebridge in selected patients)

P2-6 Bimodal/binaural hearing

P2-6-1

Outcome measures of electroacoustic hearing - a questionnaire to evaluate bimodal benefit

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Intro: Many patients who receive a cochlear implant (CI) do have some residual hearing in the opposite ear, but up to 75% of users discontinue use of their hearing aid (Fitzpatrick et al. 2009). Studies have shown bimodal hearing improves speech in noise and localisation (Tange et al. 2009). This multi-centre study aimed to establish whether participants experienced more benefit using bimodal (CIHA) stimulation than a cochlear implant (CI) alone, and whether this increase was related to patient factors. Establishing a candidacy for bimodal use could assist in the audiological management of this population.

Methods: A modified version of the Abbreviated Profile of Hearing Aid Benefit (APHAB) by Cox & Alexander (1995) was sent to participants. The modified APHAB consisted of the original 24 item inventory with four subscales; Aversiveness (AV), Background noise (BN), Ease of communication (EC) Reverberation (RV), and an additional subscale with six questions aimed at localisation and music. Questions related to three conditions; HA, CI and CIHA. Data were collected in Microsoft Excel and each questionnaire was screened for validity. A global score was calculated from the subscales BN, EC and RV. Significance is given where $p< .05$.

Results: Participants were from the United States (n=11, mean age 63.5 years) and United Kingdom (n=16, mean age 66.5 years). Nineteen subjects (70%) reported using their CI and HA together for more than 8 hours per day. Fifteen participants were included in the data analysis after screening for validity. The APHAB global score was significantly different in all three conditions. The results demonstrated a large effect size. Percentage problems were significantly different in the EC, RV, BN subscales for all three conditions. An association between BN percentage problems and hearing thresholds at 250Hz (aided), and EC percentage problems and hearing thresholds at 4 kHz (unaided) was found.

Discussion: The APHAB global score showed a significant decrease in percentage problems for bimodal use compared to hearing aid or cochlear implant on their own. This confirms the subjective benefit in this population who choose to continue to wear a hearing aid in the opposite ear. As hearing at 250Hz (aided) worsens, the subject experiences less problems in the background noise subscale. At 4kHz (unaided), the subject experiences more problems in the ease of communication subscale as hearing worsens. Therefore, subjects with better hearing at 4kHz may gain more benefit from wearing a contralateral hearing aid.

Conclusion: Overall, it has been found that there is significant benefit with bimodal hearing when compared to a cochlear implant alone. This may be due to contralateral aided hearing thresholds at 250kHz and 4kHz but this should be interpreted with caution due to the small sample size in the study.

Learning outcome: To introduce bimodal hearing, and to understand bimodal benefit and the factors that contribute to this.

P2-6-2

Self-assessment of bimodal experiences in daily life

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Background: With inclusion criteria for cochlear implantation (CI) becoming less strict over the years, an increasing number of patients still has residual hearing in the non-implanted ear, which can be fitted with a conventional hearing aid (HA). Combining electric hearing in one ear with acoustic hearing in the opposite ear is known as bimodal hearing. Bimodal benefit is defined as the benefit of wearing a CI combined with a contralateral HA (CIHA) compared to only wearing a unilateral CI. Bimodal hearing can be beneficial for speech understanding in noise, sound source localisation, sound quality and listening effort. However, the degree of benefit can unaccountably vary among subjects. In daily practice, many patients choose not to wear a HA (anymore) after receiving a CI in the other ear. The goal of this study was to investigate the self-reported experiences and motivations of unilateral CI-patients who do or do not use a contralateral HA in daily life.

Methods: A retrospective cohort study among adult unilateral CI-patients (first fit>1year ago) was carried out using a set of questionnaires in the field of disability, HA-use, sound quality, handicap and quality of life.

Results: The primary study parameter is the experienced degree of bimodal benefit in the field of disability. Comparisons between unilateral listeners and bimodal listeners show no difference in self-rated disability between the two groups. This is in line with results in literature. However within the group of bimodal listeners, patients do report a significant bimodal benefit. Experienced bimodal benefit is consistently observed across subscales and appears most prominent in rather simple listening situations.

Conclusion: Self-reported bimodal experiences are assessed by a retrospective questionnaire study in a group of unilaterally implanted patients, with or without a contralateral hearing aid. Results show that bimodal users consistently experience bimodal benefit across daily life listening situations.

P2-6-3

Localisation ability: an evaluation of binaurally aided adults who become bimodal listeners

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Introduction: There has been significant research into the differences in localisation ability of patients with one vs. two hearing aids, with one hearing aid and one cochlear implant (bimodal) vs. one or two cochlear implants. Moreover the significant benefits to speech perception performance following cochlear implantation have also been well documented. This paper investigates the pre-operative localisation ability of binaurally aided adults and whether this changes post-operatively when listening in the in the bimodal condition. Does the change from acoustic to electrical hearing in one ear affect the ability to identify the direction of sound?

Methods: A group of adult patients were tested using the University of York Crescent of Sound to evaluate their ability to localize sound separated by 60°, 30° and 15°. Pre-operative testing was performed in the binaurally aided condition. Tests were repeated post-operatively in the bimodal condition. Speech perception testing was also performed pre and post operatively using BKB sentences in quiet.

Results: Changes in localisation ability from the binaurally aided to the bimodal condition will be evaluated. The relationship between changes in speech perception and localisation scores will be investigated over multiple test sessions.

Discussion: It is expected that speech perception performance will improve significantly following unilateral cochlear implantation of adults. This paper will evaluate whether unilateral implantation with contralateral hearing aid use also results in an improved ability to identify the direction of sound or whether the different inputs (acoustic and electrical) in each ear are actually a negative factor in localisation ability.

Conclusion: Adaptation to bimodal hearing can be challenging but is essential for successful speech perception. This study investigates whether the change from binaural hearing aids to bimodal listening has a positive or adverse effect on localisation ability. The paper also investigates whether this is related to speech perception performance and whether this changes over time.

Learning outcome: The paper explores a new aspect of bimodal hearing in adults.

P2-6-4

The benefit from contralateral hearing aid for cochlear implant recipients

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Objective: To observe long-term rehabilitation outcome with contralateral hearing aid after cochlear implantation. And to investigate the effect of contralateral hearing aid wear to habilitation outcome.

Methods: 69 cochlear implantation children with contralateral hearing aid participated this study. All the children started to wear hearing aid again after half a year of swith-on. They all received speech recognition test and sound localization test one and half year after swith-on. The test materials we used were unified by China Rehabilitation Research Center for Deaf Children. All the children were grouped according to the average hearing threshold with hearing aid (500、1K、2K、4K Hz). 21 children were in group A with hearing threshold< 60dB, 26 children were in group B with hearing threshold>60dB,< 80dB, and 22 children were in group C with hearing threshold>80dB. The SPSS10.0 was used to compare the difference of the speech recognition scores and the ability of sound localization between the three groups.

Results: In the comparison of speech recognition ,the scores in group A were better than it in group B and C. There is statistical significance ($p< 0.05$). The scores in group B were slightly better than it in group C. There is no statistical significance ($p>0.05$). The ability of sound localization in group A and B was improved, but there was no obvious improvement in group C.

Conclusion: The benefit of wearing hearing aid on contralateral ear for cochlear implant recipients lied on the average aided hearing threshold. If the threshold was poorer than 80dB,the benefit was limited. If the threshold was better than 60dB, the improvement of speech recognition and sound localization was significant.

P2-6-5

Monaural and binaural auditory reaction times depend on spectrotemporal properties: Normal-hearing and impaired-hearing simulation

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Intro: Human sensitivity to joint spectral and temporal sound modulations is deemed crucial for speech comprehension. However, sensitivity is usually only measured for pure temporal or spectral modulations, and joint spectrotemporal (ST) sensitivity is implicitly assumed to arise from ST separability. We tested whether this assumption holds for normal-hearing listeners, both for normal-hearing conditions and impaired-hearing simulations. We also investigated how binaural listening affects modulation sensitivity compared to monaural listening.

Methods: Stimuli consisted of a static harmonic complex between 500 and 1500 ms, immediately followed by a dynamic ripple (modulation depth: 50%). These ripples encompassed all combinations of 8 spectral (density: [0-8] cycles/octave) and 17 temporal modulations (velocities: ±[0-64] Hz). To investigate how processing by a cochlear implant (CI) and a hearing aid (HA) affects ST sensitivity, the stimuli were processed with a 6-channel CI vocoder (CIsim) mimicking the Advanced Bionics Harmony processor, and a HA simulation (HAsim) that introduced spectral smearing and low-pass filtering at 500 Hz. Stimuli were presented monaurally and binaurally. Subjects pushed a button as soon as they heard the sound change from static to dynamic ripple. We constructed the ST modulation transfer function from the reaction times (RTs).

Results: Normal hearing conditions yielded faster RTs than all hearing impaired simulations. ST sensitivity showed low-pass and band-pass functions for density and velocity, respectively, with fastest detection at velocities of 16-32 Hz. CIsim performance for spectral modulations became worse at > 0.75 cycles/octave. In contrast, HAsim RTs were longer at low densities, but faster at higher densities. For bimodal hearing (simultaneous contralateral presentation of CIsim and HAsim) RTs were as fast as in the best-performing unimodal condition, except for some ripples in which unimodal hearing outperformed bimodal hearing. The joint ST transfer function could successfully be separated into a temporal and spectral sensitivity function, only for normal-hearing data, but not for hearing-impaired simulations.

Discussion: The question remains how long-term hearing impairment and adaptation to CI/HA input affect ST sensitivity. We plan to study this topic in bimodal patients, all using the AB Harmony CI processor in one ear and a HA (Phonak Naida S IX UP) in the contralateral ear.

Conclusion: Normal hearing conditions showed better sensitivity than simulated hearing impairments. Binaural performance was always slower than the benchmark race model of statistical facilitation of independent monaural signals would predict, suggesting binaural integration.

Learning outcome: The nonseparability of the joint ST transfer function for hearing-impaired simulations emphasizes the importance of measuring joint ST sensitivity in the hearing impaired.

Support: Advanced Bionics (LV) and Radboud Univ. Nijmegen (MvW, DL, AvO)

P2-6-6

The Influence of residual hearing and the use of contralateral hearing aids associated to cochlear implants

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Introduction: In daily practice we understand the difficulty to use cochlear implant associated with contralateral hearing aids (CHA). Many studies suggest the use of CHA mainly to improve speech perception in noise. However, we realize that not all the patients could use it effectively, thus becoming potential candidates for a second implant.

Objective: Our study aimed to assess whether the auditory residue could be a critical factor for the use of CHA.

Method: A clinical study was performed with 82 medical records of adult patients with cochlear implant, who were randomly selected and divided in two groups: Group 1 patients that do not use CHA, and Group 2, patients using CHA.

Results: The analysis of the medical records of patients using cochlear implant revealed that only 10 use CHA (Group 2). These present a pure tone average of 107 dB, which was considered significant (p-value < 0.05) by the Mann-Whitney parametric test when compared to patients that were not using CHA, who presented a pure-tone average of 117 dB.

Conclusion: in our study the auditory residue was critical for the use of CHA. Therefore, this is one of the criteria to be considered for indications of bilateral cochlear implant.

	GROUP 1	GROUP 2	P-VALUE 0.0051
n	72	10	
MEAN	117.76	107.2	
STANDART DEVIATION	9.46	10.77	
MEDIAN	125	103	

[Between-group statistical analysis of PTA]

P2-6-7

Benefit of speech understanding with cochlear implantation of single-sided deaf patients

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Introduction: Single-sided deaf patients are treated with a cochlear implant (CI) for several years. In contrast to conventional systems with contra-lateral routing of signals or bone anchored hearing aids it is possible to rehabilitate the hearing of the deaf ear with a CI. The fusion of the normal ear with the contra-lateral CI causes a bin-aural benefit, which can be specified by an enhancement of speech intelligibility in noise and a better localization of sound sources.

Methods: In the present study participated 9 unilaterally deaf patients aged 21-76 years (median = 38.7 years). Eight of these patients use a CI24RECA or a CI512 from Cochlear company. The time of use was a median of 12.1 months (min. 6 months, max. 35 months). The speech intelligibility in noise is determined by the Oldenburg sentence test with an adaptive algorithm (OLSA) in the free field and the Oldenburg noise fixed at a level of 65 dB. The ability for spatial localization is evaluated with two different methods:

First in a circular array of 12 speakers in an anechoic room over 360°, the spatial orientation is determined by means of speech signals. In addition a narrow-band noise of 60 dB is presented to the patient randomly from the front, from the right or from the left using three sound sources (-90°; 0°; +90 °). This is repeated with each of the four frequencies 0.5 1, 2 and 4 kHz 25 times and the subjective directional information of the patients are registered.

Results: When the speech signal of OLSA is presented on the CI side, we obtain an average improvement on the L50 to -4.7dB ± 5.2 dB. In determining the direction of 12 sound sources in the circle, the RMS average value of 75,2° has been improved to 48,1° ± 10.2°.

Conclusion: Providing single-sided deaf patients with a CI increases their bin-aural abilities highly. This affects the speech understanding in noise, especially in the difficult situation, when speech is presented on the deaf side.

P2-6-8

Determining the speech discrimination at the contralateral ear for BAHS using patients

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Purpose and reason: It's known that, when stimulation is given from any point of the head, the stimulation is heard by the both side of the cochlea. For this reason, it's thought that, the single side usage is enough for the patient but some suggest that, the bilateral usage is also important. At various studies, different hearing profiles are examined at bilateral applications. Even some part of these studies are based on an objective measurement, most of them are the result of the questionnaires. Some of the articles report that, bilateral usage of BAHS is much more effective whereas some articles report that, there is not any measurable significant difference between unilateral and bilateral usage. The aim of this study is to determine the effectiveness of the contralateral ear by measuring the speech discrimination of the patients who use unilateral BAHS at the noisy environment.

Material and method: Twelve BAHS users (8 male, 4 female) with bilateral conductive or mixed hearing loss were included in this study. For all participants, the followings were determined; air conductive hearing levels between 250-6000 Hz, masked and unmasked bone conductive HL between 250 - 4000 Hz and speech discrimination scores (SDS). All patients were using Oticon Medical Ponto Pro and Ponto Pro Power. 8 of the patients were using at right side, 4 of the patients were using at left side. The loudspeaker was positioned at the front of the patient with 1 meter distance and 0 azimuth. SDS test was performed by giving single and 3-syllabic words at quiet environment at the level of 70 db HL. Later, the implanted ear was masked unilaterally with wide band noise by using insert earphones and the test was repeated. We carefully paid attention to the over masking and measured the ideal level of the masking for each patient.

Results and discussion: The speech discrimination of the patients were determined and discussed under the criterion of contralateral unmasked BC thresholds. There has been a positive correlation between the unmasked bone conduction thresholds of the contralateral ear and it's speech discrimination. Consequently, the contralateral ear's unmasked thresholds measurement is very important to understand the effectiveness of the BAHS implementation.

P2-6-9

Speech recognition of bimodal cochlear implant in elderly adults

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Objective: To describe speech recognition performance in elderly adults with cochlear implantation when using cochlear implant with hearing aid, and only a cochlear implant, and only a hearing aid on the non-implant ear.

Participants: Ten older adult was received cochlear implantation at the Seoul Veterans Hospital; all patients have used cochlear implant with hearing aid on other side.

Methods: Each subject was tested on three listening conditions-individual device alone (single CI, or hearing aid [HA] alone) and combined use of devices (CI + HA). The study of the main characteristics associated with CI user was performed with speech assessment (monosyllabic word, bi-syllabic word and sentence test) at the 3, 6 and 12 month post-operative follow-up intervals.

Results: There were significant differences between the mean score of the bimodal at 6, 12 month test. In patients implanted significant improvement in speech understanding was demonstrated in performance scores using bi-syllabic words, sentences at 3, 6, and 12 months on three listening device conditions.

Conclusions: It showed speech recognition ability of only HA listening condition was higher than other conditions at 3 month, but significant improvement was showed in auditory performance tests at 6, 12 month combined use of CI + HA condition.

P2-7 Cochlear implants in the elderly

P2-7-1

Cochlear implantation in patients over 70 years of age

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Aim: The aim of this study was to determine the benefits and problems of cochlear implantation in elderly patients with severe hearing loss and to employ this information for their rehabilitation.

Methods: The study sample consisted of participants in two age cohorts: one, an older group (n = 33, AV ± SD = 80.2 ± 5.0) who were >70 years of age at implant, and the other of younger group (n = 83, AV± SD = 59.5 ± 13.5). The objective assessment (hearing thresholds and speech recognition with cochlear implantation and the subjective valuation (usefulness, change of life, satisfaction, and dissatisfaction) were analyzed for each group.

Results: In the objective assessment, “hearing thresholds” following cochlear implant had similar average scores for each group: the older group was 31.5 dB, the younger group was 30.0 dB. Results for “speech recognition” of words under quiet circumstances were also similar: the older group was 60.7%, the younger group was 68.5%. In sentence related results, the older group (60.8%) was inferior to the younger group (73.4%). The reason may be a delay in the processing speed, their memory, and the ability to guess language due to aging; therefore, further study is required. In the subjective valuation, the answer to the questionnaire, “usefulness” and “change of life”, were affirmative in both groups. However, “satisfaction”, in the elder group was inferior to the younger. The “dissatisfaction” in the older group was related to problems such as the management operation of their device, difficulty in comprehending and clearly explaining their hearing demands, and understanding the device.

Conclusion: According to the group comparison, cochlear implantation in elderly patients (>70 years of age at implant) provided improvement in auditory performance, psychological changes such as reduction in aggressiveness, and benefits in daily activity. Based on these results, we conclude that cochlear implantation is a successful treatment to improve the quality of life in elderly patients with severe hearing loss. However, elderly patients had problems with management, operation, understanding of their device, and difficulties in comprehending and explaining their hearing issues. The results for this study indicate that it is important to support elderly patients and their close relatives to maximize the benefits of cochlear implantation.

P2-7-2

Audiological and speech perception results of cochlear implantation in deafened elderly (over 65 years old)

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Aim: The aim of this study was to assess benefits of cochlear implantation in elderly based on audiological and speech perception assessment.

Material and methods: This retrospective study analyzes data of 30 patients with postlingual deafness. The patients underwent unilateral implantation with a multichannel cochlear implant at the age of ≥ 65 year old (minimum 66 y, maximum 87 y). Audiological testing included preoperative and postoperative pure-tone audiometry and monosyllabic word recognition test presented from recorded material in free field. Speech perception tests were performed by speech therapist. The study analyses data at 3, 6, and 12 months post-implantation time intervals.

Results: The mean age at the time of cochlear implantation was 76 years old. The mean post-implantation follow-up time was 2.74 years (minimum 1 year). All patients significantly improved their audiological and speech perception results. The postoperative PTA after 1 year was 36.3 dB HL. After the surgery mean monosyllabic word recognition reached 43.8%. Speech perception tests showed statistically significant improvement in speech recognition and after one year of implant usage they reached 91.0% score in Ling's six sound test, 36.6% of syllable discrimination, 45.2% and 70.3% of monosyllable and multisyllable words recognition respectively.

Conclusions: The results showed that cochlear implantation in deafened elderly (over 65 years old) is a successful treatment method for improving speech recognition. Therefore, they can be good candidates for cochlear implantation. It has been proved that age alone should not be a relevant factor when choosing candidates for cochlear implantation.

P2-7-3

Short and long term outcomes for elderly cochlear implant recipients

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Intro: We seek to measure the outcomes of postlingually deafened elderly patients as compared to adult matched controls in the short and long term follow-up periods after CI implantation.

Methods: Retrospective chart review of 33 elderly-control matched pairs with fewer than 12 months of CI usage, as well as 12 elderly-control matched pairs with at least 12 months of CI usage. Elderly patients are defined as those implanted at 75 years of age or greater. Patients were matched for preoperative PTA and duration of deafness. Postoperative evaluation included AzBio sentences in quiet and 4-tone average PTA.

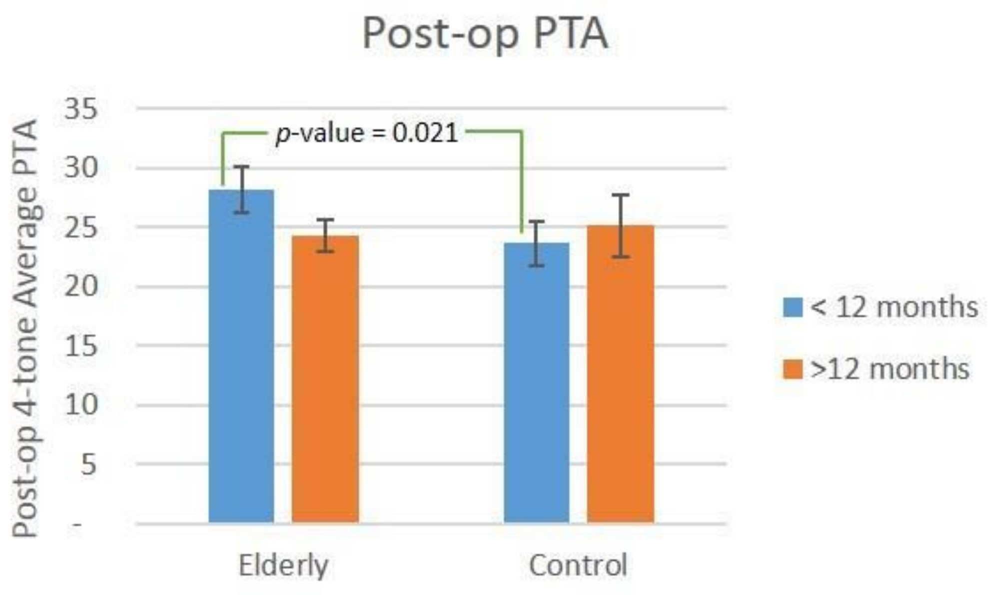
Results: Elderly patients with fewer than 12 months of CI usage performed significantly worse than matched controls on AzBio sentences (50.4 and 72.6%, respectively; *p*-value = 0.001), this difference became non-significant after 12 months of usage (66.1 and 65.1%, respectively; *p*-value = 0.62) (Figure 1). Similarly, elderly patients with fewer than 12 months of CI usage performed significantly worse than matched controls on postoperative PTA (28.2 and 23.6, respectively; *p*-value = 0.021), this difference became non-significant after 12 months of usage (24.3 and 25.1, respectively; *p*-value = 0.59) (Figure 2).

Discussion: Although elderly patients initially performed poorly as compared to matched controls, differences in outcomes diminished after 12 months of usage. This may be due to slower learning capability of elderly individuals.

Conclusion: Patients over the age of 75 can perform as well as their younger counterparts after 1 year of follow-up time.

Learning outcome: To understand how elderly patients perform with cochlear implant usage in the short and long term.

[Figure 1]



[Figure 2]

P2-7-4

The effects of age on sentence recognition testing among cochlear implant recipients: AzBio vs. HINT

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Intro: We seek to identify the effects of age at CI implantation on sentence recognition performance as measured by AzBio and HINT testing.

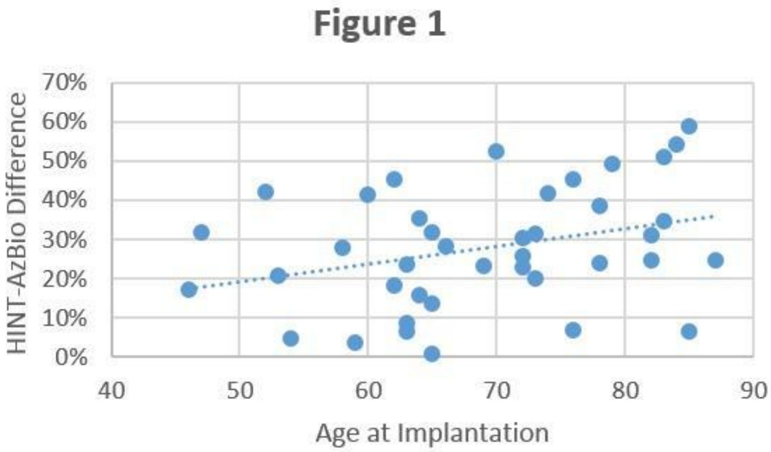
Methods: Retrospective chart review of 121 postlingually deafened adults who received unilateral CIs. Postoperative outcomes were assessed with AzBio and/or HINT sentences under quiet, +10 dB, and +5 dB SNR conditions.

Results: Difference in each patient's performance on AzBio and HINT sentences significantly increased with increasing age-at-implantation (AAI) (Figure 1). Stratification analyses revealed that patients with AAI of 60-79, and 80 and older performed significantly worse than patients with AAI of 18-39 on HINT testing under quiet conditions. Group analyses revealed that patients 65 years of age and older performed significantly worse than patients under the age of 65 on HINT testing at +10 and +5 dB SNR (Figure 2). The difficulty of each sentence test was found to be linearly correlated with the *p*-value for each group analysis; easier tests yielded a more statistically significant *p*-value (Figure 3).

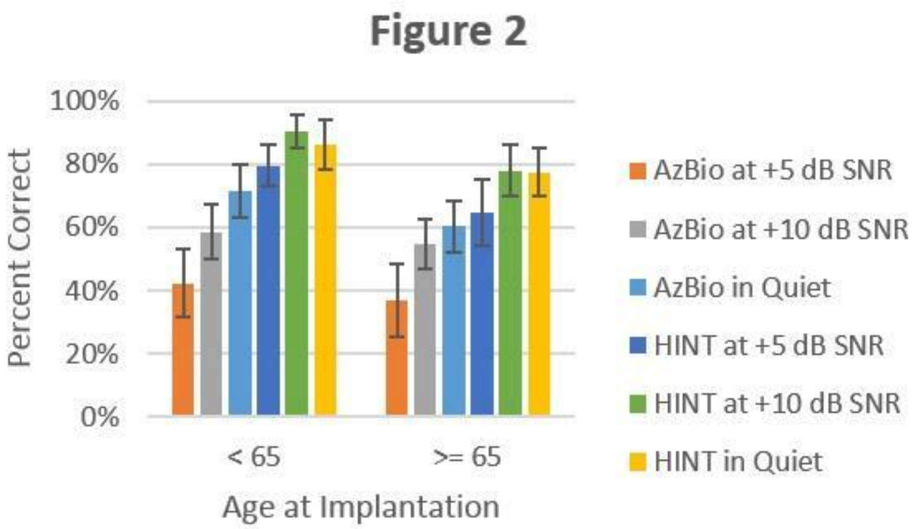
Discussion: Age-related decline in performance was more prominent with HINT testing. It is possible that the difficulty of the test determines elasticity with respect to AAI.

Conclusion: More difficult tests are less likely to reveal age-related decline in performance.

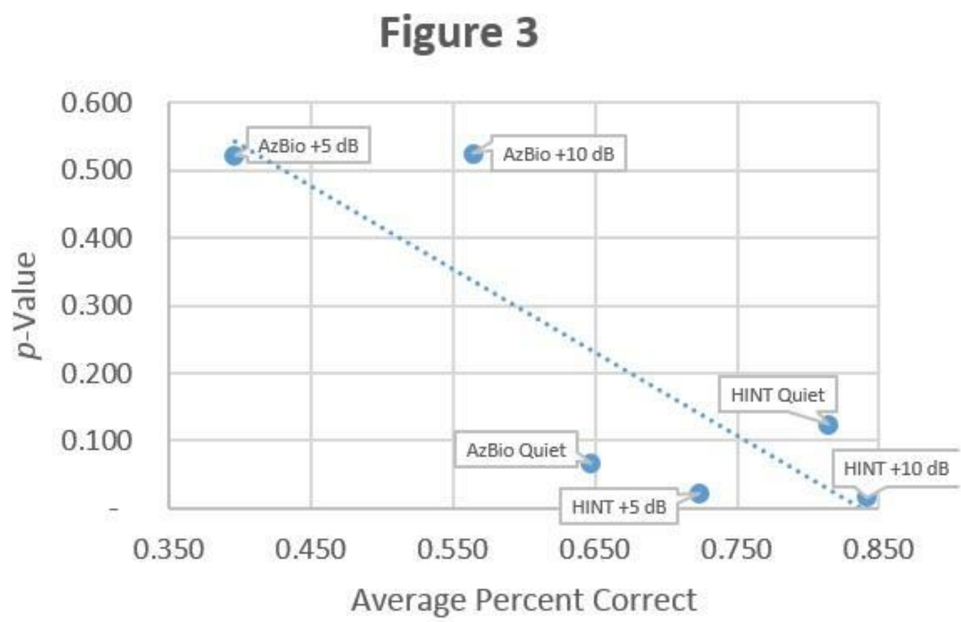
Learning outcome: To understand how each sentence recognition test is affected by AAI in order to most appropriately follow patient outcomes post-implantation.



[Figure 1]



[Figure 2]



[Figure 3]

P2-7-5

Cochlea implantation in the elderly

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Objective: The aim of the study was to compare the audiological outcomes and quality of life scores of geriatric patients who underwent cochlea implantation with younger aged patients

Study design: Retrospective analysis

Patients: 48 patients underwent cochlea implantation because of a bilateral severe to profound hearing loss. We divided patients in 3 groups: Group 1: patients aged 30– 50 years, Group 2: 50– 70 years, Group 3: > 70 years of age and compared the audiological outcomes

Measurement: All patients were tested with the HSM-sentence test at 6 and 12 month after cochlea implantation .Quality of life was requested with the SSQ questionnaire.

Implants: 45 patients were implanted with MED-EL devices, 3 patients with Cochlear devices

Results: Elderly patients showed good improvement in audiological performance after cochlea implantation but speech understanding was slightly poorer than in the younger groups. The benefit in quality of life was in the geriatric group as good as in the younger groups.

Conclusion: Even elderly patients have a remarkable benefit from cochlea implantation and showed a significant benefit in quality of life

P2-7-6

Old age, rather than reduced cognition, may worsen hearing post cochlear implantation

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Introduction: Late onset hearing loss is associated with the development of poor cognition; poor cognition may worsen speech discrimination. Which is more important for predicting outcome after cochlear implantation (CI)? This is increasingly important for assessing those who are elderly or those with reduced cognition, especially in light of recent evidence to support improving cognition by improving hearing in the elderly.

Methods: A retrospective study was performed of 24 adult patients that had received CI in the last 5 years. They were divided in relation to cognition (MMSE) and age and assessed as to their follow up with speech and language therapy.

Results: There was no significant difference in improvement between those patients with low compared to normal cognition within the first year post-CI. Although the under 70 year old patient group reported significantly better speech reading BKB scores at 1 year than those over 70, the elderly patients still showed significant improvements in listening-only BKB and reductions in hearing handicap.

Conclusion: Our study suggests that cognition does not affect a patient's improvement post-CI. However, younger patients do report a better quality of hearing post-CI. This could indicate that intervention at a younger age would improve overall outcomes of CI.

P2-7-7

Cochlear implantation in elderly patients

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Introduction: In the last years the extension of the indication of cochlear implantation could be discovered. One of these directions was the surgical therapy in elderly patients with hearing deafness. However the cochlear implantation require special regards in the course of patient instruction, programming and rehabilitation in this patient group.

Methods: We performed 24 cochlear implantations in patients with age above 60 years. We studied their MAP pattern, hearing level, speech recognition performance and satisfaction level after implantation.

Results and discussion: Our results show that elderly deaf patients had good hearing and speech recognition level in early postoperative period by the aid of cochlear implant. But most of them are dissatisfied with this condition. Generally the normal fitting is not sufficient in these cases. They demand special custom programming of the speech processor.

P2-9 Music therapy

P2-9-1

Results of an international questionnaire examining use of musical (re)habilitation for CI users

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Background: The main objective of cochlear implantation is to enable postlingual users to perceive speech and prelingually deafened children to develop spoken language. As well as being able to talk with a CI, improved technology and changes in CI candidacy are enabling CI users to appreciate music and participate in musical activities, to some extent. However, CI user's perception of music is generally reported as poor due to limited processing and inadequate transmission of the complex acoustic features of music via cochlear implants. Whereas it is accepted that speech perception is enhanced by training both in prelingually and postlingually deafened CI users, little has been reported about training of music perception. Some small studies have reported improvement in pitch and timbre recognition after specific training and progress in ability to participate in musical activities such as singing, dancing, and rhythm keeping after regular participation in music based 'classes'. Outside of studies little is known about the extent to which music is included in (re)habilitation programs for CI users.

Objective: To obtain an overview about extent of use of musical activities and training in (re)habilitation programs all over the world, for CI users of all ages.

Method: A digital questionnaire was prepared by the authors and mailed to various cochlear implant centers and rehabilitation institutions all over the world. The questionnaire distinguishes between musical activities and formal musical training. Centers including music in (re)habilitation are asked to provide detailed information about types of activity, frequency, qualifications of instructors and age of CI users. The questionnaire also examines professional views about efficacy of including music in (re)habilitation and reasons why use of music is limited.

Results: Music is included in (re)habilitation of preschool and school age children more than for adults. Most centers include musical activities but not training in (re)habilitation. Professionals rarely have special qualifications in music. Nearly all encourage carers of CI users to engage in musical activities at home and outside the home. Nearly all say it would be useful to include more musical activities and training in (re)habilitation. Main reasons for not doing so are lack of equipment, suitable training programs, resource materials and expertise. Some express the view that (re)habilitation needs to focus on language related listening and verbal speech tasks and that music can be done in regular classes.

Conclusion: The results of the questionnaire provide some insight into current worldwide practice regarding use of music in (re)habilitation.

P2-9-2

Development of a music style identification test for cochlear implant and hearing aid users

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Intro: Although there is a gamut of music perception tests for cochlear implant (CI) recipients, these have all focused on rhythm, pitch, melody and instrument identification. However, as music is a multi-dimensional stimulus, perceptual accuracy can be evaluated on a host of levels. Musical style is one area not yet considered in existing test batteries. The accurate perception of music style is a more holistic, higher-level task, requiring integration of several fundamental elements including rhythm, pitch and instruments. To address this, a music style identification test was developed to assess CI and hearing aid (HA) users.

Methods: Two versions of the test were created, for administration in pre-post intervention study designs. The development involved two phases. Firstly, 10 normally hearing (NH) adults were presented with 80 10-second excerpts extracted from commercially-available compact discs, in a closed-set identification task. There were 10 extracts from each of these styles: i) Classical - Solo; ii) Classical - Group; iii) Jazz; iv) Modern/Pop (1990s onwards); v) 1960s-1980s; vi) Pre 1960's; vii) Country & Western; and viii) Eastern. Confusion matrixes were then used to identify and remove the two excerpts from each style with the highest numbers of confusions. From the remaining 64 excerpts, four excerpts per style were randomly allocated to Version 1 or Version 2. These were tested on two groups of five NH participants; group A completed version 1 before version 2, and vice-versa for Group B.

Results: The mean percent-correct score for the phase one was 88.3% (SD = 4.06). The mean score for version 1 was 91.57% (SD = 6.77) correct, and 93.77% (SD = 7.07) correct for version 2. There was no significant difference between these scores (z = -0.634, p = 0.526). Test order was not a significant factor for either version 1 or version 2 of the test ($F_{(1,8)}$ = 0.508, p = 0.496; and $F_{(1,8)}$ = 0.674, p = 0.436). Reliability analyses produced Cronbach's alphas of 0.542 for Version 1 and 0.721 for Version 2.

Discussion and conclusions: Based on their equivalency and the minimal learning effect, the two versions were considered appropriate for use in evaluating outcomes for CI recipients and HA users, and subsequently trialled in a larger-scale study.

Learning outcomes: Participants will learn about a new perceptual test of music outcomes, this one evaluating music styles. This is the first published music style identification test developed for cochlear implant recipients.

P2-9-3

Contribution of non-implanted ear to pitch perception for prelingually deafened cochlear implantees

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Introduction: Bimodal stimulation (BMS) has been shown to be beneficial for the performance of pitch ranking in postlingually deafened adults. However, the contribution of non-implanted ears to pitch perception with respect to duration of hearing aids (HAs) use for prelingually cochlear implantees remained unclear. This study aimed to investigate whether or not experiences/duration of HAs use in the non-implanted ear improved pitch perception ability in this population of subjects.

Materials and methods: Twenty-nine children with congenital/prelingual deafness of profound degree were studied. Test stimuli consisted of two sequential piano tones, ranging from C (256 Hz) to B (495 Hz). Children were asked to identify the pitch relationship between the two tones (i.e. same, higher, or lower).

Results: Duration of HAs use was the major factor related to the correct rate for pitch perception (p=0.001). Other factors included duration of music training (p=0.017), age (p=0.004), and duration of **HAs** use before implantation (p=0.024). Overall correct rate for pitch perception (O) could be best predicted by the model combining both duration of HAs use (DuA) and duration of music training (DuM) (O=0.58XDuA+0.377XDuM, r^2=0. 457, p< 0.001).

Discussion: Experiences of HAs use appear to improve pitch perception ability in prelingually cochlear implantees. This suggests that incorporation of HAs use early in life and through the post-operative rehabilitation program for prelingually deafened children with cochlear implants would be beneficial. A longitudinal study is needed to show whether improvement of music performance with duration of HAs use in these children is measurable using auditory evoked potentials.

P2-9-4

Evaluation of music perception using Fine Structure Processing (FSP) versus High Definition Continuous Interleaved Sampling (HDCIS)

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Intro: Postoperative assessment of cochlear implantation typically includes speech perception measures; however, recipients often report changes in quality of life beyond improved communication abilities. One facet of the reported improvement in quality of life is increased music appreciation as compared to preoperative abilities with conventional amplification. What is relatively unknown is whether a specific signal coding strategy may enhance postoperative music appreciation. The aim of this study was to investigate whether there was a difference in music discrimination abilities between subjects listening exclusively to either High Definition Continuous Interleaved Sampling (HDCIS) or Fine Structure Processing (FSP) with the MED-EL device.

Methods: Subjects were newly implanted cochlear implant recipients, randomly assigned to either the FSP or HDCIS strategy at initial activation of the external speech processor. Subjects listened exclusively to the assigned coding strategy during the first 6 months of listening experience. Music perception was evaluated at the 6-month follow-up interval using the Musical Sounds in Cochlear Implants (Mu.S.I.C.) Test. Testing was completed in the sound field with the subject interacting with a touchscreen. The following subtests were evaluated: rhythm, melody, chord discrimination, instrument identification, and pitch perception.

Results: Current trends indicate no difference between music perception abilities when listening with HDCIS versus FSP on the Mu.S.I.C. subtests.

Discussion: Initial findings do not suggest a difference in music perception abilities when listening exclusively with FSP versus HDCIS during the first 6 months of listening experience.

Conclusion: Analysis of new processing strategies should include tests of music perception and appreciation. Continued assessment of these receptive musical abilities could augment the assessment of cochlear implant recipients' quality of life.

Learning outcome: The participant will understand the differences between the FSP and HDCIS coding strategies and evaluate outcomes using a music perception test.

P2-9-5

Music perception and enjoyment in Brazilian cochlear implant users: A multicenter study

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Objective: assess music perception and enjoyment in Brazilian cochlear implant (IC) users.

Method: fifty two adult CI users with post-lingual hearing impairment composed the experimental group and represented different CI models and signal processing strategies. The control group included nineteen normal-hearing adult volunteers. Participants were recruited from three Cochlear Implant centers in the state of Sao Paulo: Audiological Research Center, Hospital of Rehabilitation of Craniofacial Anomalies, University of Sao Paulo - USP; Hospital das Clinicas, Faculty of Medicine - USP; and Nucleo Ouvido Bionico, Hospital Samaritano - SP. The assessment protocol comprised: the Clinical Assessment of Music Perception (CAMP) test and the Munich Music Questionnaire (MUMU) - Portuguese adaptation, both applied during routine follow-up with patients in their respective CI centers. The questionnaire was applied only to the experimental group. CAMP was applied in free field at 65dBA with HP Pavilion notebook model dv2760BR. CAMP subtests used included: pitch direction discrimination and timbre recognition, the first being an adaptive procedure that determines pitch differences in a range from 1 to 12 semitones, and the second including 8 musical instruments playing a sequence of five identical notes. MUMU comprised 25 questions covering past and present activities related to the habit of listening to music.

Results: in the experimental group, pitch discrimination performance ranged from 1.3 to 10.6 semitones (mean=5.00; standard deviation=2.4). As regards timbre recognition, the performance ranged from 4.1% to 54.1% (mean=27.3%; standard deviation=11.6%). The duration of CI use and pitch were positively correlated. Statistically significant differences were found between the signal processing strategies and the pitch test. Significant difference for pitch and question 1 of MUMU in the post-fitting period showed that CI users who used to listen to music frequently had a better performance in the pitch subtest. Normal hearing volunteers were also tested to demonstrate differences in performance in the two populations. CAMP results for normal-hearing participants were: mean of 1.2 semitones and 73.3% for pitch and timbre subtests, respectively.

Conclusion: CAMP findings indicated significant differences in the perception of musical elements and are consistent with international findings. The protocol used, besides providing additional measures, adds value to the assessment of implanted adults, as music perception is a major issue in the rehabilitation of this population.

P2-10 Sound coding

P2-10-1

The prerequisites for language acquisition: how congenitally deaf children process vowel length after cochlear implantation - an EEG study

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Background: Congenitally deaf and severely hearing-impaired children can get access to hearing when receiving a cochlear implant - a neuroprosthesis that directly stimulates the auditory nerve. If implanted at a young age (< 4 years), chances are good for acquiring normal oral speech, despite the prolonged absence of any auditory stimulation and the non-natural input.

Understanding what infants actually hear with the implant in the critical age of language acquisition would help to both understand the auditory system and its plasticity after an input-deprived period as well as how language acquisition evolves if it starts considerably later than normal due to the absence of sensory input. This is even more the case when considering studies with normal hearing children where a lack of sensitivity to basic auditory cues such as vowel length or syllable stress co-occurs with later language impairment (Friedrich et al., 2004, 2009). In order to assess which features children process when presented with their first auditory input, we used electroencephalography. We were especially interested in auditory features essential for further language development and how the processing of these features develops in the first months of implant use. We thus began investigating vowel length as one of the most basic but linguistically relevant cues. In German lengthening of a vowel can be both semantically relevant as well as a marker of syllable stress, which is relevant for speech segmentation and thus for language acquisition.

Methods: 14 congenitally deaf children (age at implantation: 0;9-3;7 years, mean: 1;7 years - time of implant use: 0-10 months) were tested repeatedly electrophysiologically: 1) before the implantation as a baseline condition, 2) directly after first fitting and after 3) two, 4) four, 5) six and 6) eight months of implant use. Syllables with either short or long vowel duration were presented in a classical oddball paradigm to elicit the mismatch negativity (MMN) (adopted from Friederici et al., 2002). A control group matched gender and age of implanted children measured after 4 months of implant use.

Results: 2 months after the first hearing experience with the implant, the deviating long stimulus elicited a typical negative deflection in the difference wave (effect of stimulus length: $p < 0.001$). No mismatch response was detectable for the implanted children pre-operatively and at the time of first fitting. After four months of implant use, the ERPs were strikingly similar to those of the control group.

Conclusion: Whereas directly after first activation of the implant there is no sign of discrimination between long and short syllables, a robust response can be seen after 2 months of hearing experience. Already after four months the discriminative response of implanted children resembles that of age peers. Thus one of the fundaments for further language acquisition is laid after a relatively short period of time.

P2-10-2

The effect of the stimulation rate on the newest fine structure speech coding strategies

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Introduction: A few years ago, speech coding strategies for cochlear implants using envelope and fine structure information have been introduced into the market. Fine structure seems to be important for directional hearing, music listening and speech understanding in noisy environments. The first fine structure speech coding strategy from MEDEL was the strategy FSP (fine structure processing). This particular implementation usually offers two fine structure channels in the low frequencies. FS4 is the successor strategy and enables the guaranteed use of four fine-structure channels. The stimulation rate of the remaining CIS channels, however, lies below the one of the former implementation FSP. In the latest version of FS4, it is now possible to use higher stimulation rates. This could possibly offer an advantage, because in the past it has been shown that in some systems a higher rate may result in an improvement in hearing performance. In this study the strategy FS4 LR (low rate) is compared with FS4 HR (high rate) under the consideration of speech understanding and sound quality.

Materials and methods: Fifteen experienced FS4-LR users will be included into the study. At the baseline appointment they receive FS4-HR for permanent use. The study will last 3 months with an interim appointment after one month. At each date speech understanding in noise is measured with both strategies. As test material the Freiburg monosyllables, the HSM sentence test in noise and the Oldenburg sentence test is used. The sound quality of both strategies is compared by evaluating different sound samples. The perceived quality of hearing and music perception are enquired with the HISQUI and Munich Music Questionnaire.

Results and conclusion: The data for the comparison of FS4-LR vs. FS4-HR will be presented at the time of the upgrade (acute), at the 1 month and 3 months appointment. It will be discussed if learning effects occur over time. First results indicate substantial differences in sound quality between the two implementations.

P2-10-3

Investigating the use of varying stimulation rates for different electrodes

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Recent studies showed that signal processing strategies based on amplitude modulations only are not sufficient for cochlear implant users' performance in noisy environments and recognition of music melodies and speakers [1-3]. Contemporary signal processing strategies such as Continuous Interleaved Sampling (CIS) or ACE (Advanced Combinational Encoder) which are based on amplitude modulated carrier signals are not optimal solutions. As a result, alternative methods were proposed that can extract frequency modulation in addition to amplitude modulation such as Frequency Amplitude Modulation Encoding (FAME). In this method amplitude and frequency modulations are extracted in two parallel pathways for each band [1].

The results of the present study based on spectrogram analyses and questionnaires demonstrate that the FAME strategy contains potentially more acoustic information compared to the CIS strategy. However, there is a need for sample reduction techniques which transmit the information adequately. Three different sample reduction methods are proposed in this study. Eventually, these methods may also be useful to determine the optimal stimulus rate for intracochlear electrodes. Although delivering temporal fine structure cues can improve speech perception for cochlear implant users, there are some limitations. The upper limit for temporal pitch and rate discrimination in cochlear implant users discourages attempts to improve CI speech processors by directly encoding the temporal fine structure of the signal [4]. In addition, the trade-off between high rate stimulation and electrode interaction may pose a practical upper limit for high rate stimulation [3]. Therefore, the reduction of the simultaneous stimulation or channel interaction during electrical stimulation has been a major challenge when designing new algorithms to deliver fine structure cues. Objective measures which can provide information about interaction effects in individual patients may be helpful in this context.

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P2-10-4

Speech understanding and preference of cochlear implant recipients using FSP speech coding strategy (MedEl) after conversion to FS4-LR and FS4-HR

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Speech coding strategies commonly transmit additional signal envelope information to enhance speech perception but nevertheless, the processing of temporal fine structure remains poor. Therefore zero crossings of the sound signal are identified and computed in addition to the envelope by the Fine Structure Processing strategies FSP and FS4 (MedEl, Austria). The information can be transmitted at a varied number of 1 to 3 apical electrodes with channel specific sampling sequences (CSSS) in the FSP-strategy or fixed in four electrodes in the FS4-strategy. Because the stimulation of the fine structure beyond 1 kHz takes more time, higher stimulation-levels with increased pulse-width result in a decrease of CSSS-channels in the standard FSP strategy. As the number of CSSS-channels in FS4 is fixed at low stimulation rate (FS4-LR) the stimulation may result in a loss of information in higher frequencies. In additional development of the FS4 coding strategy, MedEl increased the stimulation rate (FS4-HR) to compensate information loss.

In a prospective double blind study with classic crossover design, postlingually deafened adult CI users (n=14) were randomly provided with speech coding strategy FSP and converted for the period of 6 weeks to the encoding strategy FS4-LR. After a period of at least 6 months, the same population (n=9) with the same experimental protocol received FS4-HR. The evaluation of speech intelligibility was performed with standardized speech tests in silence and noise (Freiburger, Oldenburger (OLSA) and Göttinger (GOESA) speech tests). In a simple preference test at the end of the study, the subjects were asked to decide with which coding strategy speech understanding is better. Statistics were performed with SPSS (Wilcoxon, $p < 0.05$).

In Freiburger, GOESA and OLSA in silence, the subjects achieved significantly worse results after conversion to FS4. Thus, the understanding of Freiburger-monosyllables at 65 dB SPL in quiet decreased from 55.42% to 41.67%, in the OLSA from 89.83% to 84% and from 75.70% to 60.02% in GOESA. In noise the decrease was smaller, but comparable in tendency. For the FS4-HR coding strategy, the results are still pending. While the majority of subjects in the preference test decided against FS4-LR in the first cycle, FS4-HR were evaluated in the second section as equally well with the default Strategy (FSP).

The hypothesis that an increased and fixed number of fine-structure channels, as well as the higher temporal resolution and the related accurate transmission of the sound characteristics at lower frequencies could result in improved speech understanding, could not be confirmed on the basis of our data for the FS4-LR coding strategy. To what extent the modified FS4 speech coding strategy (FS4-HR) provides a better speech understanding, the analysis of the second part study data will demonstrate. The subjective acceptance of FS4 HR compared to FS4-LR is obviously higher.

P2-10-5

Time-domain pitch determination - the pitch picker

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Intro: Pitch determination algorithms (PDAs) analyze an audio signal by partitioning it into segments and calculating the respective fundamental frequencies. The length of each segment (data window) is a function of the minimum frequency or the maximum period to be determined. Algorithms that work in time domain usually use an autocorrelation to detect a periodicity. For a correct frequency estimation, the data segment has to be at least twice as long as the maximum expected period. To detect frequencies down to e.g. 50 Hz, the data segment in real time PDAs thus has to contain a history of 40 ms of audio signal at any time. This results in a time delay of the estimates and leads to a discrepancy between the calculated and the actual frequency.

Methods: The basic idea of the pitch picker is a cross-correlation of a data segment with the sample by sample shifted speech signal. Similar to an autocorrelation, maxima appear at points where the most exact match between the data segment and the shifted speech signal occurs. These maxima are detected by a peak detector and are a measure of the period duration which is the inverse of the fundamental frequency. Thus, the speech signal is shifted sample by sample until a peak in the correlation curve is found and a pitch estimate can be calculated. After every calculation of an estimate, the data segment is replaced by an updated one which contains a cutout of the current speech signal. In contrast to common autocorrelation algorithms, the length of the data window in this case is only once the maximum expected period.

Results: As a result, the data contained in the segment is updated and a pitch estimate is calculated, whenever a peak in the correlation sum is detected. The length of the data segment is only half as long as for an algorithm based on autocorrelation, which enables to calculate pitch estimates with less delay. At the same time, less averaging takes place and more accurate estimates can be achieved again due to the shorter length of the data window.

Conclusion: The pitch picker shows an excellent performance for fundamental frequency determination, combined with a short response time, simplicity and accuracy. The shorter length of the data segment provides advantage over a common autocorrelation algorithm in time delay, while the computational effort and the accuracy are of the same order of magnitude. Areas of possible applications for the pitch picker are devices in speech communication, e.g. cochlear implants, which need to have a short response time.

P2-10-6

Investigation of modeled potential distributions inside the electrically stimulated cochlea

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One objective in current cochlear implant (CI) research is to improve signal transmission between CI electrodes and stimulated nerve cells. For this purpose deeper knowledge about the effects of electrical stimulation inside the complex geometry of the cochlea is required. However, experimental investigations are impeded by the small dimensions of the cochlea. Therefore, models of the electrically stimulated cochlea are a more feasible option.

We developed a virtual three-dimensional model of the human cochlea, which consists of detailed representations of the most important cochlear structures. Based on this we created a volume conductor model using finite element method. This model allows for the numerical computation of the electrical potential distributions inside the modeled structures caused by current applied to the CI electrodes. For the sake of accuracy, emphasis was put on a detailed and realistic representation of the cochlear structures. This, however, implicates high computational complexity. Therefore, for efficient modeling a compromise between accuracy and computational effort has to be found. For this purpose, we investigate the influence of the modeled structures on resulting potential distributions by iterative modifications of the model. Main focus of the evaluation is on the electrical potentials in the nerve tissue, as these are responsible for neural excitation and therefore cause auditory perception.

The results show the differences in potential distributions for the analyzed model variations. As a result, structures with a minor effect on electrical potentials are identified. This could contribute to more efficient modeling.

P2-10-7

Spectral contrast enhancement in CI coding strategies: A real-time implementation

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Hearing performance in difficult situations as in noisy or reverberant environments has been shown to correlate with the ability to resolve spectral information. In hearing impaired listeners this ability is often poor since spectral sharpening mechanisms of the inner ear are affected by the hearing loss. Previous studies observed an improvement of the quality and intelligibility of speech in noise in hearing impaired listeners when enhancing the spectral contrast of the speech signals and thus compensating the effect of spectral smearing. In a recent study identification of spectrally smeared vowels and consonants was improved by spectral contrast enhancement (SCE) in a group of 166 normal hearing listeners [Alexander et al.]. Spectral resolution for CI users is degraded because of the limited number of stimulation electrodes and overlapping electric fields activating the nervous system through the bony structure of the cochlear. Loizou et al. showed that CI users need a higher spectral contrast than normal hearing listeners in vowel identification tasks. Also, SCE can improve phoneme and sentence perception in noise.

We implemented a modified version of the algorithm introduced by Loizou et al. within a CI coding strategy using Matlab Simulink. Our implementation keeps all prominent formant peaks within a speech signal constant while attenuating valleys in the spectrum, thus increasing the spectral contrast. The amount of SCE depends on the original contrast found in the signal and can be controlled by a single parameter which we call the SCE factor. For a clinical evaluation of the algorithm, the Simulink model was compiled on an XPC real-time target to test subjects in a sound attenuated chamber. Speech and noise were presented in free field simultaneously through the same loudspeaker in front of the subject at a 1 m distance. The SNR was adapted to the performance of each CI user such that they scored between 25% and 75% on the HSM sentence test. Two lists were presented for each condition (SCE enabled and disabled) and the amount of correct words was counted and averaged for each study participant.

Preliminary results from 7 CI users show an average of 6% improvement of correct words in CCITT noise using an SCE factor of 1. 6 out of 7 subjects obtained an improvement with SCE enabled and only 1 out of 7 decreased in performance. Generally, bad CI performers obtained a higher improvement than better CI performers.

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P2-10-8

Informational masking and stream segregation of psychophysical stimuli in bilateral cochlear implant users

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The ability to perceive a target signal can often be degraded by the presence of an interfering signal that is said to 'mask' the target. Masking can occur when competing signals have overlapping spectral content that compete for representation at the auditory periphery (energetic masking, EM). It can also result from confusions at a central processing level (informational masking, IM) that make it difficult to perceptually segregate target from interferer (stream segregation). IM is often alleviated in normal hearing listeners if differences exist between competing signals to 'cue' stream segregation. Ear-of-entry and temporal structure can provide two such cues. The present study aimed to explore the potential of ear-of-entry and temporal cues to provide IM release and promote stream segregation in bilateral cochlear implant (BiCI) users via direct stimulation of the electrodes in each ear.

Target pulse-train bursts sequences were applied to a single mid-array electrode. Masker sequences consisted of four-electrode stimuli with two electrodes located more apical, and two more basal than the target. Masker components were spaced at least ±5 electrodes from the target to minimize EM and observed masking effects are assumed to be due to IM The target was presented monotically while maskers were presented either ipsilateral (Ipsi) or contralateral to the target (Contra), or to both ears diotically (Diotic). Target burst rate was either matched to the masker, or halved such that target bursts coincided with every second masker burst. In Part A of the study, target-in-masker detection thresholds were determined for each condition via an adaptive 2-down-1-up procedure. Lower detection thresholds indicate reduced masking. Part B involved a subjective lateralization task in which participants listened to a subset of stimuli from Part A, and indicated whether competing signals were heard as a single sound or as two segregated sounds, and where those sounds were heard intracranially.

Target detection thresholds were not significantly different across Ipsi, Contra and Diotic conditions, nor were Ipsi thresholds different for matched and halved target rates. However, thresholds for the halved-rate Contra condition were substantially lower than for the matched-rate Contra and halved-rate Ipsi conditions, and in fact approached target thresholds in quiet. Outcomes from the lateralization task indicated that stimuli in the matched-rate Contra condition were perceived as a single percept whose location depended on the relative levels of competing stimuli. In contrast, target and masker in the halved-rate Contra condition were heard as separate percepts situated in opposite hemifields near their respective ears-of-entry. The findings suggest that while either ear-of-entry or temporal structure cues are alone insufficient to provide IM release and promote stream segregation, the combination of the two cues can yield considerable benefit to CI users.

P2-10-9

Preferences of patients in the speech processor upgrades with new strategies

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Introduction: The new strategies of speech encoding intend improve the performance of the patient, but represent changes during adaptation, which may require time for plasticity. The literature shows that the range of frequencies is an important parameter in adapting to new technologies. It is important to review the settings and preferences of patients in updates with new strategies.

Objective: To verify the frequency range and preferred strategy in the speech processor update.

Method: The study included eleven patients who used the speech processor Tempo+ and upgraded to Opus 2. The maps for Opus 2 were as follows: frequency range 100 - 8500Hz and CIS strategy; frequency range 100 - 8500Hz and FS4 strategy; frequency range 300 - 8500Hz and CIS strategy; frequency range 300 - 8500Hz and FS4 strategy. It was also analyzed the number of active electrodes, because this value may influence the applied frequency range applied. After at least three months of home experience with all maps, free field audiometry and speech perception tests (recognition of sentences in open set and monosyllables) were performed with the preferred map. These results were compared with hearing thresholds and speech perception tests most recently applied with Tempo+ speech processor.

Results: The CI mean time of use was 118 months. In the map used with Tempo+, six patients (54 %) used a frequency ranges of 300 - 8500Hz, and five (46 %) used other ranges varying from 250Hz and 7000Hz or 8000Hz. Mean home experience was 4.6 months, most patients opted for a new range of frequencies with low frequency in the lower limit (between 70 and 150Hz). With Opus 2 speech processor, six users (54 %) preferred the FS4 strategy. Regarding the number of active electrodes, three users (25 %) had all active electrodes. Hearing thresholds of users with Tempo+ were 36dB while with Opus2 they were 34dB. In speech perception tests, users had an average of 66 % accuracy for open set sentences and 47 % recognition for monosyllabic using Tempo+. With the Opus 2, the mean score was 58 % and 36 % respectively for the same tests.

Discussion and conclusion: after upgrade of the speech processor, the patients showed better slight improvement in hearing thresholds. Speech perception tests showed worse in performance with the new processor. This may have happened due to the new tonotopy that requires longer periods of adaptation.

P2-10-10

Time course of stream segregation in CI users

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Intro: To segregate the sounds of a certain sound source from the concurrent environment represents a basic ability of auditory scene analysis. Key experiments on stream segregation present rapid tone sequences of alternating pitches in an ABAB order. Whereas at a low pitch contrast of the A and B sounds the sequence is perceived as a single melody, a percept of two parallel lines (stream segregation) prevails at enhanced pitch contrasts. Integration into a single stream was widely assumed as the generic initial state of percept, and segregation was regarded to evolve with time (build-up). This generality was recently questioned by taking into account the probability of any given response (Deike et al., 2012). In cochlear implant (CI) users, evidence of stream segregation at present is controversial. In this study, the previous method to monitor the changing percept is applied to CI users. The proportion of time assigned to one of the two percepts is analyzed, the type of response given first and the time course of the percept probabilities.

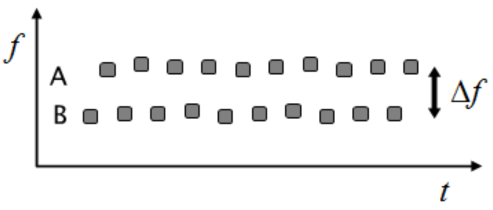
Methods: 9 CI users listened to the sounds through a frontal speaker, using their everyday processor settings. Tone complexes with different fundamental frequencies from two sets (A and B) alternated in 30-s long sequences. In four experimental conditions the average frequency contrast of the A and B sounds was varied from 2 semitones, close to the difference limen of the average CI user, to 14 semitones. The CI users responded continuously whether they heard a single or two segregated streams.

Results: On average, the proportion of time assigned to segregation increased with pitch contrast, whereas the proportion of single-stream dropped, consistent with stream segregation. However, 4 subjects showed no such or a different dependence. In the subjects responding consistent with stream segregation, the first decision of a sequence varied from a single stream at the smallest frequency contrast to segregation at the highest contrast. When taking the probability of any given response into account, at the highest contrast the probability of segregation remained on a high level throughout the sequence. A build-up like drift from a single-stream percept towards segregation is found at intermediate frequency contrasts only.

Discussion: About half of the subjects respond consistent with stream segregation. In these subjects, the dependence of the first decision and the time course on the frequency contrast is similar to data of normal-hearing listeners. The influence of factors such as frequency discrimination will be discussed.

Conclusion: Only part of the CI users showed behavior in agreement with stream segregation. In these CI users, the type of the first decision and the time evolution of the percept is comparable to normal hearing listeners.

Reference: Deike S, Heil P, Böckmann-Barthel M, Brechmann A. (2012). The build-up of auditory stream segregation: a different perspective. Frontiers in Psychology 3, 461



[Sketch of stimulus presentation]

P2-10-11

Gender identification and intelligibility of whispered speech in cochlear implant users: evaluation and analysis

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Cochlear implant (CI) devices, in general, enable profoundly deafened individuals to identify clean and neutral speech to a great extent. CI users understand spectrally reduced speech (SRS) quite well as long as no distortion is introduced to the signal. These distortions may be associated with the listening environment due to room reverberation and background noise, or due to speaking style of speakers, for example, shouted or whispered speech. CI users' ability to recognize speech drops substantially in challenging listening scenarios due to the limited temporal and spectral resolution of speech signal processed by CIs. Whispering, in particular, changes temporal fine structure of speech and consequently results in deteriorated speech perception in CI listeners. The primary aim of this study is to evaluate the effect of whispering on speech intelligibility in CIs.

In addition to speech understanding, speaker and/or gender identification is an important factor in recovering linguistic information. It has been shown that fundamental frequency and formant frequencies are important factors in speaker gender classification. Despite the reduced temporal and spectral cues of processed speech, CI users can correctly identify speaker gender to a great extent for quiet and neutral speech. The perceived pitch of whispered vowels corresponds to the first and second formant frequencies. Therefore, whispered speech gender identification task becomes challenging for CI listeners with SRS. As a secondary goal of this study, we assess the effect of whispering on speaker gender identification in CI users.

CI listeners were tested with the speech sentences from the TIMIT database spoken by native speakers of American English recorded under neutral and whispered vocal efforts. For the intelligibility listening tests, 20 sentences (10 spoken by a female and 10 spoken by a male speaker) were used for each vocal effort condition (neutral and whisper). Sentences spoken by the female speakers with F_0 = 197 Hz and 198 Hz were used for neutral and whispered listening conditions, respectively. Speech from the male speakers with F_0 = 117 Hz and 114 Hz were used for the neutral and whispered intelligibility tests, respectively. For gender classification under each condition (neutral or whisper), twenty sentences were used from 10 female speakers (149 Hz < $F_{0\_Nuetral}$ < 204 Hz and 153 Hz < $F_{0\_Whisper}$ < 214 Hz) and 10 male speakers (97 Hz < $F_{0\_Nuetral}$ < 136 Hz and 96 Hz < $F_{0\_Whisper}$ < 156 Hz). The results indicate a significant difference between neutral and whispered speech both for intelligibility and speaker gender identification tasks. The intelligibility and speaker gender identification scores were also evaluated for each class of speakers (male and female) separately, in order to better assess the conditions in which CI users' performance drops more significantly.

P2-10-12

Distribution of tryptophan hydroxylase immunoreactivity in the spiral ganglion neurons of mouse cochlea

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Although serotonin (5-hydroxytryptamine, 5-HT) is an important neuromodulator/neurotransmitter in the nervous system, its physiological role in the peripheral afferent auditory nervous system is little known. Spiral ganglion neuron (SGN) is the first station of the peripheral afferent auditory nervous system. We have previously demonstrated the presence of positive serotonin immunoreactivity in mouse SGNs. Whether serotonin in the SGNs is absorbed from the circumstances, or is synthesized by the neurons themselves is unknown. In this study, we detected tryptophan hydroxylase, the rate-limiting enzyme in the biosynthesis of serotonin in the mouse SGNs using immunohistochemistry. The positive immunostaining was observed in the cytoplasm of these neurons. Our results suggest that SGNs can synthesize serotonin by themselves, and they may serve as an additional source of serotonin in the cochlea. The SGNs are serotonergic neurons. The receptor of serotonin on the membrane of SGNs interacts with serotonin as autoreceptors. Serotonin in these neurons play its physiological role in an autocrine/paracrine way.

Keywords: Tryptophan hydroxylase; serotonin; spiral ganglion neuron; immunohistochemistry

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P2-10-13

Automated program selection - a better option by the speech-processor?

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The new speech-processor of the Cochlear Nucleus® 6 System includes a new feature named „SmartSound iQ“. Herewith the possibility is given that the processor changes programs automatically and hence adapts the best program for the user, for example „focus“ in a noisy situation with speech.

The subjective perception described by a few patients fitted this new option shows no discrepancy between the different program options. The interest of this evaluation is to examine if there is a better understanding in noise with the new program option in variable situations. Therefore the standard program will be compared with this new optional program in different situations. To find out how the program works in everyday life the patient will keep a diary about the hearing situation in daily life for one week. After the week the memory of the data viewer from the processor will be read out and the results will be compared with the patient's diary. In addition speech test in noise as performed routinely in the rehabilitation work will be evaluated.

As the system has been on the market since August 2013 we will report about our preliminary data how the SmartSound iQ behave in daily routine use and if there is a measurable difference in test situation with speech in noise in the booth.

P2-10-14

Using channel-specific models to detect and mitigate reverberation in cochlear implant pulse trains

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The limited spectral and temporal information that is presented to cochlear implant (CI) listeners results in speech recognition that degrades rapidly in noisy and reverberant environments (e.g. Kokkinakis and Loizou, 2011). Therefore, this study focuses on reverberation mitigation via direct manipulations on the CI pulse train. Prior to reverberation mitigation, a reverberation detection algorithm was developed to control the switching between a mitigation speech processing algorithm and a standard speech processing strategy free from mitigation. Reverberation was then divided into two effects and the benefit of ideally removing each effect was studied. Next, a reverberation mitigation algorithm was developed, and the efficacy of this algorithm at improving speech recognition in reverberant environments was studied in simulation and with normal hearing listeners using an acoustic model.

Although an ideal reverberation mitigation algorithm would remove reverberation effects without affecting anechoic stimuli, noise and reverberation mitigation algorithms often make errors and should be applied only when necessary. Therefore, this study implemented a reverberation detection algorithm by developing features from the frequency-time matrices resulting from the standard CI speech processing strategy. A maximum a posteriori classifier used these features to successfully discriminate speech in quiet, reverberation, speech shaped noise, and white Gaussian noise with 94% accuracy (Desmond et al., 2013).

Next, this study investigated the benefit of mitigating two different effects of reverberation, self-masking (masking within individual phonemes) and overlap-masking (masking of one phoneme by a preceding phoneme) (e.g. Bolt and MacDonald, 1949) by comparing speech recognition in reverberation to speech after either ideal self-masking mitigation or ideal overlap-masking mitigation. Testing was completed with both normal hearing listeners via an acoustic model and with CI listeners using their clinical devices. Mitigating either effect was found to improve speech recognition for CI listeners in reverberant environments.

This study then implemented an overlap-masking mitigation algorithm to be applied once reverberation is detected in speech stimuli. Overlap-masking, which occurs after active speech has terminated, may be present in one channel while active speech occurs in a different channel. Therefore, the strategy developed in this study mitigates overlap-masking effects by detecting its presence on a channel-by-channel basis and subsequently removing the masking pulses. Performance was first evaluated in simulation, followed by a study using normal hearing listeners and an acoustic model. These results provide insight into the potential for overlap-masking mitigation to improve performance for CI listeners and will be used to guide future CI research.

P2-10-15

Study of temporal and place pitch percepts with single- and dual-electrode stimulation in the apex

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Intro: Previous studies have investigated the effects of electrode separation and stimulation pulse rate on pitch perception for dual-electrode stimuli in cochlear implant users. Results were mixed in that some studies suggested that subjects hear an aggregate temporal pitch, while other studies did not. A lack of an aggregate pitch suggests more independence between CI channels. The present work specifically focuses on the apical region where channels are known to be tonotopically similar.

Methods: Pitch perception for single- and dual-electrode stimuli in monopolar configuration was investigated for pairs of neighboring electrode contacts. In a first study, eight MED-EL subjects with long MED-EL standard or MED-EL FlexSoft electrodes took part in the experiments. Loudness-balanced single- and dual-electrode contact stimuli were pitch ranked. Stimuli consisted of unmodulated trains of biphasic pulses at different rate and inter-electrode phase delay. They were applied to pairs E1/E2, E3/E4 and E7/E8 of electrode contacts at six rates between 92 and 552 pulses per second with no phase delay and a delay of half the stimulation rate (with E1 denoting the most apical and E12 the most basal electrode). A second study was performed to further support the findings of the first study and to investigate the effects of pulse shapes when triphasic pulses were used.

Results: Results show large inter-subject variability. Some subjects are not able to discriminate stimuli by place of stimulation for the apical electrode contacts E1/E2. However, all of them perceive an increase in pitch for increasing pulse rates up to 300 pulses per second and more. None of the subjects perceive an aggregate temporal pitch for any presented stimulation rate or place of stimulation. Preliminary results for triphasic pulses are shown.

Conclusion: We conclude that there is more independence between neighboring electrode contacts than previously thought. This seems to be true even for apical electrode contacts, also in cases where no place information can be perceived.

P2-10-16

Performance of young children first fitted with the HiRes 120™ strategy: two years of follow-up

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Intro: The HiRes 120™ sound coding strategy from Advanced Bionics implements virtual channels by current steering between two adjacent electrodes. Therefore, the number of stimulation sites is no longer limited to the 16 physical electrodes, but may be extended to up to 120 locations sites. The aim of this project was to evaluate the benefit of the HiRes 120 strategy for speech production, perception and music development over a 24 month period in children.

Methods: Children between seven months and five years of age were included in the evaluation. All subjects were first fitted with HiRes 120 using either their Harmony™ or Platinum Sound™ processors. Pre-implantation, baseline was evaluated using the Children's Implant Profile (Nottingham Version) and a free field audiogram if available. The children were evaluated with a series of questionnaires: MUSS, (IT) MAIS, SIR, CAP, PRISE and a Musical Stages Profile at approximately 3, 6, 9, 12, 18 and 24 months.

Results: 40 subjects from 8 centres were included in the evaluation. The mean age at implantation was 31 months (SD=14.7). The data showed a clear increase of the scores from session to session for all the questionnaires until two years of follow-up. In addition, these children developed abilities at a similar rate as the normal hearing children over time: the (IT)MAIS and PRISE results were within the normal hearing range.

Discussion: The tendency confirmed previous results showing benefits with earlier implantation.

Conclusion: The HiRes 120 strategy was well accepted by children and provided a consistent progress in performance over time.

Learning outcome: The outcomes are very positive in terms of acceptance and performance with the HiRes 120 strategy first fitted in children.

P2-10-17

The effect of adaptive dynamic range optimization on speech intelligibility in adverse listening environments for cochlear implant users

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Electric hearing presents challenges in terms of the real-state available for mapping the input dynamic range of the acoustic signal (~ 90dB) to the limited output electric dynamic range (which could be as low as 5 dB). This emphasizes the need to perform intelligent compression to optimally place the characteristic features of speech in the limited output range for better intelligibility and quality. Commonly used cochlear implant (CI) sound coding strategies such as CIS and ACE use a global compression scheme at the output level to compensate for the loudness growth. Adaptive Dynamic Range Optimization (ADRO), on the other hand, is a multichannel signal equalization strategy to improve the audibility, comfort, and intelligibility of sounds for individuals who use CIs and/or hearing aids (HA).

ADRO uses statistical features of the acoustic signal to select the most information-rich section of input dynamic range in multiple frequency channels and adaptively adjusts the channel gains based on a set of fuzzy logic rules to optimally place the signal in the users´ hearing range. It is used in conjunction with sound processing in clinical HA and CI processors as a pre-processing strategy. Clinical studies with new and experienced HA and CI users indicate preference for ADRO over alternative amplification strategies for speech in noise. However, past studies have not considered naturalistic everyday listening conditions where CI users are challenged to understand speech in the presence of both reverberation and noise. CI users´ speech perception score drops substantially in the reverberant environments when early and late reflections of the direct sound are added to speech and blur temporal and spectral characteristics of speech. In this study, we aim to investigate the effect of ADRO on speech identification for CI users in adverse listening conditions involving noise and reverberation.

Ten adult CI users were tested acutely for speech intelligibility task in five unique listening environments: anechoic quiet ($T_{60} \approx 0.0$ s), reverberant ($T_{60} = 0.6$ s), noisy (SNR = 10 dB), noisy reverberant (NR) ($T_{60} = 0.6$ s, RSNR = 10 dB), and reverberant noisy (RN) (SNR = 10 dB, $T_{60} = 0.6$ s) each with and without ADRO. Results indicated statistically significant improvement with speech in noise but the performance in the reverberant environments was highly subjective. While there was no significant advantage of ADRO on mean intelligibility scores, one group (6 out of 10 subjects) reported significant reduction in performance with ADRO in reverberant, NR and RN environments. The effect was particularly pronounced in RN environment. The findings from this study suggest that ADRO may not be equally beneficial in diverse listening environments and, in fact, may reduce the speech intelligibility in some conditions. These results will be beneficial in designing environment specific speech processing strategies.

P2-10-18

Speech perception in children with cochlear implants with two sound processing strategy of the HiResolution system

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Improvements in speech perception with cochlear implant (CI) over the years is related, among others factors, to the technological advance of the sound processing strategy. The purpose of the present study was to investigate speech perception performance in CI children, with two different Advanced Bionics sound processing strategy. Subjects were 11 prelingually deafened children implanted with the HiRes 90K cochlear implant and used a platinum body-worn sound processor. All subjects showed evidence of open-set speech recognition. A within-subjects design was used to compare performance with standard HiRes and HiRes 120. Baseline performance was assessed with *HiResolution* 120 (HiRes 120). Subjects then were fitted with *HiResolution* (HiRes) and returned for re-evaluation after three months of use. After three months of HiRes experience, subjects were refitted with HiRes 120 and returned three months later for reassessment. During test sessions, subject's performance was evaluated by warble-tone sound-field thresholds, the Brazilian Hearing in Noise test (HINT) in quiet and in noise and Parents' Evaluation of Aural/oral Performance of Children questionnaire (PEACH). The speech perception in quiet and the CI benefit in daily life were similar for both sound processing strategy. There was a trend toward better hearing performance in noise with HiRes 120, which indicates that more precise spectral representation of the acoustic signal provided by the HiRes 120 can result in an improvement in the speech perception in noise by CI children. It reinforces the importance of clinical observation and speech perception in noise assessment in the sound processing strategy selection, in order to optimize the auditory performance of CI users.

P2-10-19

An industry first: Wind noise reduction for Nucleus® 6 cochlear implant recipients

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Aim: Wind-noise is highly disturbing to hearing-impaired individuals, including Cochlear Implant recipients. Wind noise has a typically intense low-frequency spectrum that significantly reduces SNR resulting in reduced speech intelligibility and comfort for the listener. A new Nucleus 6 sound processor algorithm called wind noise reduction (WNR) will detect and cancel wind noise. The aim of this study was to evaluate the performance of CI recipients when WNR is active.

Material and methods: Up to 25 subjects were evaluated during an acute in-booth test session. Wind was created in the sound booth and recipients were tested with an adaptive SRT test in noise.

Results: Speech performance results in wind with different Nucleus 6 program settings, including WNR enabled and disabled were collected. Recipients also judged the subjective comfort of different programs in wind.

Conclusions: The Nucleus 6 WNR algorithm successfully detects and suppresses wind noise providing benefit for CI recipients outdoors.

P2-10-20

Evaluation of the battery lifetime improvement with the HiRes Optima™ strategy in Harmony™ cochlear implant users

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Intro: Together with the launch of its new sound processor, the Naída CI Q70 (Naída CI), Advanced Bionics launched a new version of its fitting software, SoundWave 2.2. The latter offers the possibility to fit a new sound processing strategy, HiRes Optima™. It is designed to optimize battery life while delivering the same great performance as that of HiRes Fidelity 120™ with Advanced Bionics's unique current steering technology. This new sound processing strategy may be used with the Naída CI, the Neptune™ or the Harmony™ processors. The objective of this project is to evaluate the battery lifetime improvement when using the new sound processing strategy, HiRes Optima.

Methods: This project is conducted in multiple centres in India. New cochlear implant users (children only) fitted with a Harmony™ sound processor will use in a random order the HiRes 120 strategy and the new HiRes Optima strategy. Parents will report the battery lifetime of the various battery options via a battery log.

Results: A previous study conducted in adults showed an average battery life improvement of 53%, ranging from 25% to 109% for individual Harmony processors. Centres and subjects inclusions (30 subjects expected) are still ongoing and the preliminary results from this evaluation will be presented.

Conclusion: This evaluation will confirm the previous study outcomes showing an improvement of the battery lifetime when using the new HiRes Optima strategy.

Learning outcome: The HiRes Optima strategy is a new option for Advanced Bionics users which substantially improves the battery lifetime and does not compromise speech performance as it was shown in a previous study in adults.

P2-11 Complications

P2-11-1

Correlation of vestibular testing with subjective symptoms before and after cochlea implantation

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Objectives: To quantify the incidence of vestibular dysfunction in patients after cochlear implantation in our clinic and to evaluate the presence of dizziness symptoms before and after implantation we performed a retrospective study.

Methods: From October 2011 until May 2013 64 patients received a cochlear implant at the University Hospital Zurich. 4 patients had a revision done of the implant and no vestibular testing either pre- or postoperative. 3 patients had no or only partial preoperative vestibular testing and 18 patients had no or only partial postoperative vestibular testing. In this retrospective study, 39 patients with pre- and postoperative vestibular function tests (all tests or only 1 test missing) aged 19 to 84 years undergoing unilateral cochlear implantation were included. Four different implants were used and operation was performed via a retroauricular transmastoidal approach. Pre- and postoperative vestibular function was measured by video-documented horizontal head impulse test (HIT), dynamic visual acuity (DVA), caloric irrigation of the outer hearing channel, cervical (cVEMP) and ocular vestibular evoked myogenic potentials (oVEMP), vertigo or imbalance symptoms were documented.

Results: 20 of 39 patients suffered from postoperative dizziness, 10 of them with new onset. Compared to the group without any dizziness before and after cochlea implantation (18%), there is no higher incidence of pathologic test results in the „new dizziness group“ (21%), with the exception of caloric testing (0% in the never dizziness group versus 33% in the new dizziness group). Tests of the horizontal canal (HIT, DVA) and the oVEMPs showed comparable results between these two groups, whereas the cVEMPS interestingly were significantly more often pathologic in the group without dizziness (46% to 22%). Patients with dizziness in the pre- and postoperative period exhibited the highest prevalence of newly detected pathologic test results (34%), half of the patients featured a newly pathologic DVA. 13% (5/39) of the entire group even reported total absence of dizziness after the implantation in contrast to the preoperative situation.

Conclusion: Vestibular dysfunction after cochlea implantation occurs in patients with dizziness symptoms similar to patients without any previous suffering. Vestibular function testing before and after cochlea implantation does not correlate with the subjective symptom of dizziness. In our retrospective study there was no single test correlating with the patient's symptoms. However cVEMPs were increased in the group without any dizziness and should therefore not be used as a single test for vestibular testing.

P2-11-2

Electrophysiologic detection of scalar changing cochlea electrode arrays - a blinded study

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Introduction: The position of the cochlea implant electrode array within the scala tympani is essential for the best audiological outcome. If the electrode array changes the scala a worse audiological benefit can be estimated. In our previous study we observed a correlation between the intracochlear position of the electrode array and a NRT ratio. A NRT-ratio was established which supports the detection of the intracochlear electrode array position. The aim of this study was to validate the electrophysiologic ratio with external radiological observations and NRT measurements.

Material and methods: Electrophysiologic intraoperative measurements and postoperative radiological evaluation of the intracochlear electrode position of 80 patients were evaluated. All patients were implanted with a Nucleus Advance Conture electrode in the University Hospital of Freiburg. The NRT ratio was estimated for all patients blindly compared with the radiologic results and statistically evaluated.

Results: A good correlation was seen between the radiologic results and the NRT-ratio. Scala vestibuli positions showed a similar electrophysiologic pattern as scala tympani positions.

Discussion: For the first time we were able to show that using the NRT-ratio in a large external group of patients, is a reliable tool to support the estimation of intracochlear electrode position.

P2-11-3

Late sequela of recurrent acute otitis media in children after cochlear implantation

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Introduction: Chronic otitis media (OM) is considered a late sequela of both recurrent acute OM and also of ventilating tubes. In children with a cochlear implant, the risks of middle ear infection and its potential spread along the electrode array into the cochlea and central nervous system are relatively high, mandating an aggressive management including insertion of ventilating tubes (VT). Although the rate of acute OM episodes diminishes after cochlear implantation, it remains high in OM prone children, thus might lead to repeated VT insertions. Information regarding the incidence of chronic OM in children after cochlear implantation is scarce. The aim of the study is to determine the incidence of chronic OM in pediatric implantees and to define influencing factors.

Methods: A prospective study including 200 pediatric implantees. Mean age at CI was 32.58±17.83 months and mean post-operative follow-up was 72.41±35.27 months. Management was based on a structured acute OM control protocol.

Results: 126 children (63%) were classified as OM prone and 74 (27%) as non-OM prone. 38 children (19%) underwent ≥ 2 VT insertions. Chronic OM developed in 15 children (7.5%). Seven children had a tympanic membrane perforation, 7 had atelectatic middle ear disease and one more had cholesteatoma. Myringosclerosis appeared in 22 children (11%). Myringosclerosis was positively correlated with VT insertion. No correlation was established between number of VT insertions and the development of chronic OM.

Discussion: Pediatric OM prone cochlear implantees continue to suffer from sequela of recurrent episodes of acute OM. Significantly more myringosclerosis is found in both OM-prone children who underwent repeated VT insertions and non OM-prone children. OM-prone children are at increased risk for the development of chronic OM, unrelated to the number of VT insertions.

Conclusion: OM-prone implantees should be followed regularly for early diagnosis and surgical intervention when indicated.

P2-11-4

Biofilm detection on cochlear implants

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Cochlear implantation is well-established in the treatment of deafness and sensorineural hearing loss. Despite perioperative antibiotic treatment and standard vaccination against Pneumococcus and H. influencae, patients may sometimes develop postoperative complications. These include wound healing disorders and local infections up to meningitis that may require the explantation of the device as a last resort.

The origin of such cochlear implant infections remains largely unknown and dedicated investigations are necessary to further our understanding. In many previous studies in related fields, the formation of microbial biofilms has proven to be relevant for chronic infections and resistance to antibiotics. The aim of this study is to investigate the role of biofilm formation in complications after cochlear implantation and related infections.

Up to now we have analyzed a variety of cochlea implants that underwent explantation due to infections or technical defects. The explanted products were analyzed biochemically via PCR (Polymerase Chain Reaction) and SSCP (single strand conformation polymorphism). A subset of devices was also analyzed via CLSM (confocal laser scanning microscopy) and some examples of the surrounding tissue were analyzed via FISH (fluorescence in situ hybridization).

Preliminary data show a colonization of implants with germs commonly known to be responsible for chronic ear infections as well as dental germs, which are commonly found in the oral cavity. Interestingly we could find germs on several implants that have been explanted due to technical defect only, without any signs of infections.

This identification of the existent germ spectrum is an important step, however further diagnostic methods for infected implants still have to be established. It is necessary to clarify the role of biofilm formation in cochlear implants in order to prevent further severe implant infections and the development of resistances against antibiotics. We have a special interest in developing methods for drug administration, i.e. via bioactive coatings. This is an important step towards a sustainable and effective treatment of patients with cochlear implants and other hearing systems.

P2-11-5

Effect of dexamethasone to reduce post-auricular swelling in the first day after cochlear implant

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Introduction: Dexamethasone known type of steroid work as anti-inflammatory drug, We notice in some of our patient swelling at post-auricular area in the first day post cochlear implant we try to study effect on dexamethasone on the swelling

Methods: Twenty patients were selected for our study informed consent was taken from all of them, Ten of them as a control group we gave paracetamol 15mg/kg per dose every eight hours in addition to that we give oral cefixime 8mg/kg without given dexamethasone five patients cochlear implant were done as simultaneous bilateral other five patients done as sequential second side, so total of cochlear implants for the control group were 15 implants. the tested group also were ten patients in addition to paracetamol and cefixime the same dose as in the control group we gave dexamethasone with 0.1mg/kg per dose, three doses in the 24 hrs post cochlear implant, Six of them bilateral simultaneous other four patients done as sequential second side in this group the total number on implant was 16 implants. For all of patients in the, both group order of medication was written and follow up with one surgeon and the assessment of post auricular swelling was done by another surgeon who does not know if the patient was given dexamethasone or not. Any degree of swelling was consider as positive result

Results: In the control group out of fifteen ear implanted five patient developed swelling while in the group who receive dexamethasone out of sixteen patient only one patient develop swelling in the first post op day.

Discussion: Dexamethasone is known to reduce many of side effects of anaesthesia as postoperative nausea vomiting and pain at site of operation as in post tonsillectomy patients .In our study we tried to concentrate on its effect on reduction of edema and swelling in the first day post op .In the tested group whom received dexamethasone only one patient developed edema at one surgical site (bilateral simultaneous implant was done for him), We couldn't study other effect of dexamethasone like pain reduction and vertigo because most of our patient were under age of four years.

Learning outcome: Use of dexamethasone help to reduce post op edema ,further study needed to evaluate its effect on the other side effect that can be induced by cochlear implant as vertigo ,tinnitus and pain.

P2-11-6

Vacuum delivery - needs extra consideration before potentially cochlear implantation?

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Introduction: Vacuum extraction has largely replaced forceps delivery. Still it is used up to 1/12 of all births during the vaginal delivery, also in developed countries. In all instrumental assisted vaginal deliveries some local trauma on the surface and in subcutaneous tissue of the head could be detected.

Methods: Ten months old deaf boy planed for cochlear implantation is presented. Parents reported no history regarding and possible cause resulting with deafness. After confirming his deafness with negative ElCochl and after positive EABR the all standard preoperative testing, including the computer tomography (CT) of the temporal bone at his age of six months were normal. Timpanometry (TY) result was A - normal. At his 10 months the cochlear implantation on his right side was planed. During the surgery mastoid cavity was filed with grey mass, tympanic cavity also totally filed with tissue and our working diagnosis was a latent OMA. Biopsy was sending for histological examination and total removal of the mass from mastoid cavity (mastoidectomy) and partially from middle ear cavity was performed. Systemic antibiotics were introduced for 14 days. The first histology result was; suspected for rhabdomiosarcoma. After two weeks the second surgery was performed, the mastoid cavity was again filed with gray tissue and it was largely removed from mastoid and from middle ear cavity only small part was removed. The second histological diagnosis was confirmed as cranial fasciitis. According to the literature data cranial fasciitis is described as mass that grew rapidly, meningothelial origin, especially in young boys. The advised therapy is surgery and also where there is no total removal possible, spontain remission of small left over is described and is almost always connected with trauma of the head in babies with forceps delivery. The third surgery was performed in his right ear, the tumor was totally removed from mastoid and also from middle ear cavity, and only some thin »unpeeling part« was left on the second genus of the facial nerve and he was implanted with cochlear implant on the left side. After our precise questioning of the parents they recall that there was used vacuum help during vaginal delivery but the perinatologists informed them that this is no risk for any condition.

Result: Three months after surgery the tympanic membrane is microscopically normal, TY is type A and no problems on his right side. The CT reveals only small soft tissue over the exposed second genus of the right facial nerve with no functional disturbances. He is starting to use more than 20 words and he is using his CI on the left side all the time and no problems on his right auricular area.

Conclusion: There are some conditions, which cannot be preoperatively predicted and discussed with the patient before the surgery.

Learning outcome: Also detail history regarding instrumental vaginal delivery without any detected neurological complications should be taken.

P2-11-7

BAHA surgery and complications depending on different strategies of surgery

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Bone anchored hearing solutions are a type of hearing aids stimulating the inner ear cells via bone conduction. It is mainly used in patients suffering from chronic ear diseases where no conservative hearing aid in or behind the ear can be worn and in patients with malformations of the outer ear canal.

There are two different types of surgical procedures. In one step surgery implant and abutment are placed into the bone together while in two step surgery you give the implant time for osseointegration before placing the abutment. While in the first years two step surgery with U-flap was performed a change was made to one step surgery with vertical incision. The aim of the study was to compare the major (loss of implant) and minor (skin overgrowth) in both groups.

In the years 2008 to 2013 there were 33 ears in 31 patients treated with a bone anchored hearing aid (BAHA, Cochlear®) at the ENT-Department of AMEOS Klinikum Halberstadt. The 14 male and 17 female patients were from 8 till 87 years old. Two stage surgery was performed 13 times, one stage surgery in 21 cases. The rate of minor complications in one stage surgery patients was 16% (n=3) and there were 3 cases of total loss of implant (16%). In two stage surgery patients were two patients who lost the implant (15%) but the rate of minor complications was higher with 23% (n=4).

The development of new implant technologies like *Baha® 3 system* and the change to the one stage-surgery with vertical incision show a benefit for the patients. The hospitalization time is decreasing as well as the minor complications of skin overgrowth. In our small group we can´t find a difference of implant loss in the two groups. Further investigations are required.

P2-11-8

Pain in cochlear implant recipients - An uncommon, yet serious consequence of cochlear implantation

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Aim: To report our experience with receiver-stimulator associated pain after cochlear implantation.

Materials and methods: A review of all patients who in the years 2009-2013 complained of pain related to their cochlear implant (CI).

Results: Thirty two patients (3%) complained so far of pain related to their CI. The patients were implanted from 3 months to 17 years before presentation of pain. The pattern of pain in most subjects was typical, and was located to specific pin-point sites surrounding the receiver-stimulator. The pain was present even with the processor off. Nineteen patients were treated with antibiotics, 13 were treated with anti-inflammatories and 3 needed no treatment. The response rate to either treatment was variable. Five patients eventually required reimplantation.

Conclusion: Pin-point pain is an uncommon, yet serious consequence of CI. Reports in the literature are scarce.

P2-11-9

Cochlear implantation surgery - what are the risk factors for postoperative complications?

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Cochlear implant surgery provides great benefit in the treatment of patients with severe sensorineural hearing loss and deafness with a comparably low complication rate. The handling and prevention of postoperative complications plays an important role in this matter. It is important to understand the significant pre- and postoperative conditions that play a role in the development of postoperative complication.

As a cochlear implant center with more than 6,000 cochlear implantations since 1985 we have a large database at hand for the analysis of cochlear implant related treatment courses. In this study a retrospective database research was performed on all cochlear implantations between 2006 to 2010. We evaluated the patients history, possible risk factors like age, lifestyle habits (smoking, weight), pre-existing conditions (i.e. diabetes, cardiovascular diseases) These data were related to postoperative complications such as swellings, wound healing disorders, otitis and also reimplantation due to infections or technical failures.

To further reduce complication rates and provide safer surgery for a large variety of patients, it is essential to understand causative and predictive risk factors. A promising approach in this matter will be the preoperative classification of patients with risk scores into well-defined groups that provide orientation for the further perioperative and postoperative treatment.

P2-11-10

Approaches for the treatment of the cochlear implant users with long-term suppurative perifocal complications

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The complications after CI are well-known. Among them the inflammatory changes of different severity are encountered complications in a certain frequency. Conservative treatment of this Inflammation in the proximity of the receiver-stimulator, especially accompanied by a defect of the skin (extrusion), is possible for the preservation of the implant in place only for a very short period after the problem started. Later on, the biofilm is formed around the implant which excludes the possibility to eliminate the inflammation and save the implant. Development of purulent inflammation around the cochlear implant should not be excluded in the late postoperative period. From 1991 to 2013 in our center 2073 CI were performed in children and adults, aging from 6 months to 71 year. In 76% of patients the etiology of deafness was congenital, in 11%- meningitis, in 6%- injury. 1549 patients were implanted with the cochlear implants from Cochlear (including 37 double-array and 1 Hybrid), 495 patient with the devices from Advanced Bionics, 9 patients with MED-EL and 20 with Neurelec. Straight and perimodiolar electrode arrays were presented equally. There were 6 patients with the inflammatory changes around the receiver-stimulator occurred in a period from 1 to 4 years after the surgery. In one case the inflammation was associated with acute suppurative otitis media, in all other cases trauma has preceded the inflammation. 3 patients after the trauma had the receiver-stimulator extrusion took place. In 1 patient the duration of the purulent inflammation around the implant was more than 3 weeks, in this case it was impossible to save the implant. All patients received the anti-inflammatory therapy. In patient with acute otitis media the tympanostomy with the removal of purulent discharge and the puncture of the infiltrate around the receiver-stimulator with the removal of purulent exudates were performed. In 2 patients with extrusion of the implant in the behind-the-ear area after a local anti-inflammatory therapy the crossing skin flap technique was applied to eliminate the defect, the receiver-stimulator was moved into the newly performed receiver-stimulator bed. Thus, in the late postoperative period the cochlear implant can be saved in case of the purulent inflammation, but it depends on the duration of the inflammation and its etiology. In our opinion, treatment of such patients with the possibility to save the implant in place is very difficult in case of the existing extrusion of the receiver-stimulator.

P2-11-11

Complications in cochlear implantation

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Cochlear implantation complications have been extensively reported in Literature. We present a comprehensive Literature review and results of our experience on 807 cochlear implantation performed by the senior Author. We focused on the expected long-term course after implantation and the longevity of cochlear implant (CI) devices that are still being determined. Data regarding failures, surgical complications, revision surgery and medical complications are presented. Furthermore, the vestibular impairment strictly related to cochlear implantation surgery is assessed. The results of the present study raise issues regarding the selection of candidates for bilateral cochlear implantation and the pre-operative assessment of candidates.

P2-11-12

Normalization of balance by vibrotactile neurofeedback therapy in cochlear implant patients with postoperative vertigo

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Cochlear implant patients can suffer from postoperative vertigo due to a destruction of the otolith (saccular) receptor cells induced by the implant electrode. As shown before, otolith disorders are poorly compensated during conventional vestibular rehab programs, especially in the elderly. The present study therefore investigated the efficacy of a novel vibrotactile neurofeedback therapy (NFT) in cochlear implantees chronically suffering from postoperative vertigo. The NFT was performed by eleven cochlear implantees with the Vertiguard-RT-system daily over 2 weeks (15 min/day) based on an individual body sway analysis in 14 everyday-life stance and gait conditions (20 s each). The basic principle of NFT is to give the patient an intuitive, vibrotactile signal at the hip in that direction which showed a higher body sway than the preset threshold. The NFT induced a significant mean reduction of the risk to fall and of the body sway in roll and pitch direction. Furthermore, the Vertigo Symptom Score decreased significantly. The present data shows that the vibrotactile neurofeedback therapy improves the balance in everyday-life conditions significantly with minimal efforts for the patients. The method seems to be well suited for home or group training since the tasks are easy to perform and all relevant individual values are stored in a small body-worn device.

P2-11-13

Electrode migration in cochlear implant recipients

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Cochlear Implantation is known as a reliable and safe procedure in any patients with profound hearing impairment. Especially in children the development of a physiological auditory neural plasticity can be expected. Also the incidence of complications is very low.

In a prospective clinical observation we experienced a number of Cochlear Implant (CI) recipients who showed a migration of electrode out of the cochlea. In any of the cases the electrode was totally found outside of the cochlea. In all cases 1 up to 10 electrode contacts were found being outside of the cochlea and so called “migrated” compared to the postoperative x-ray control.

The clinical suspicion in all the patient were based on reduced speech understanding, loss of good speech understanding, increase impedances and / or changed eCAP thresholds. Additionally almost in all cases patients with so called “structure-preserving” electrodes were affected. The time between implantation and migration is from 6 weeks up to more than 12 months.

All patients coming up with those symptoms, independent from electrode type were evaluated via a control x-ray (CT or DVT). In about 4% of implanted patients we could observe this migration. Analyzing the cause we did not find any characteristic trauma, infection or other significant changes in health status.

In this presentation we will report on the phenomenon, the corrective action we are performing and the need of electrode change.

P2-11-14

Surgical and medical management for complications in 700 consecutive cochlear implantations

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Intro: To evaluate cochlear implant complications & failures to determine possible causes and discuss medical and surgical management.

Method: A retrospective study of total of 700 cochlear implants for a period of 1994-2013 were evaluated. The sample consisted of 632 Pre-lingual and 68 postlingual, 398 male and 302 female, 636 children below 18 years and 64 adults above 18 years, 660 unilateral and 20 bilateral subjects, 497 normal anatomy and 203 abnormal ears were taken.

Results: The overall rate of complications was 7.0% (49 of 660), with 37 (5.28%) minor complications and 12(1.71%) major complications, All were treated medically and surgically.

Conclusions: Cochlear implantation is a safe technique with a relatively low complication rate; however, certain complications may require specific attention to prevent or correct them. It is important to keep studying the causes of such complications and failure to find possible solutions that can lead to lowering and resolving its appearance.

Learning outcome: Types of complications in cochlear implant surgeries and its management.

Keywords: Cochlear implant, complications, failures, medical and surgical management

P2-11-15

Cochlear implant complications in Costa Rica: 11 years' experience

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The national program of cochlear implants in Costa Rica is done by an otorhinolaryngology Service at Hospital Mexico, which is part of the sole public health system: the Caja Costarricense del Seguro Social (CCSS). This same group of surgeons is also allowed to privately perform cochlear implants surgery.

The national cochlear implant program was initiated in the year 2002 and since then, we have performed 238 cochlear implant surgeries.

In this paper, we conducted a retrospective study to evaluate the complications of cochlear implants performed in a period of 11 years between 2002-2013. During this time, 238 cochlear implants where performed. In total, 107 were children below the age of 12, and 131 were adolescent and adults older than 13 years. From the total patients, 99 were male and 139 were female.

The complications were classified as surgical and non-surgical. Non-surgical would include for example the abnormal heating of the magnet in a patient post implant. The surgical complications have been further divided in perioperative/early complications and late complications. The most common complication was the facial paresis in 3.36%. There was one facial paralysis, representing less than 1%. A total of 6 extrusions were documented corresponding to a 2.5% of all our patients. Out of these, 2 were in a patient who was implanted with two different brands. We also had 4 particular cases that deserve mentioning due to failed implantation, in 3 out of the 4 cases, we were unable to identify the cochlear canal.

We want to analyze the causes that lead to complications when performing cochlear implant surgery in a third world country. We wish to discuss the different possible factors such as lack of experience or practice from the performing surgeon as well as the complications not due to human error; but instead, to complications secondary to the introduction of an artifact (cochlear implant) in humans.

The cochlear implant surgery is not exempt of complications. Nonetheless, it has been proved that it carries a low surgical risk and low comorbidity. The cochlear implant continues to be of great benefit for patients, as shown in this study. These characteristics encourage this particular group of surgeons to continue with the national program of cochlear implant in Costa Rica.

The otorhinolaryngology service of Hospital Mexico is part of the CCSS, a public health entity that provides coverage to 100% of the Costa Rican population. Therefore, it is the Hospital Mexico ENT´s service duty, to provide service for all of the national territory. This is at the same time a university hospital, where residents are being taught, for this reason the group of surgeons conducting the surgeries include not only attending staff but also last year ENT residents as well.

P2-11-16

Cochlear implants' complications

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Introduction: Patients with profound hearing loss can be treated with application of cochlear implants. Anatomical variability, congenital malformations in the middle or inner ear, as well as disturbances of the healing process, inflammations or post-op trauma are responsible for occurrence of complications.

Aim: Our aim was to evaluate the result of using different surgical techniques in cochlear implantation (cochleostomy, round window, various skin incision technic) on the rate of postoperative complications.

Material and method: Our method of choice in treatment of severe hearing impairments in presented cases was cochlear Implantation. We have used various cochlear implants types, with various electrodes. Our material consists of patients with various inner ear malformations, haematomas, after head trauma, inflammation around implant, extrusion of implant, dislocation, or device failure.

Results: Authors discuss the surgical results after implantation and various kind of complications after cochlear implantation.

Conclusions: Cochlear implants and surgical techniques used during implantation are safe and involve a small risk to the patient, disproportionately small for a gain of possible aids.

P2-11-17

Skin flap complications after cochlear implantation

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The aim of this study is the evaluation of frequency of skin flap complications after cochlear implantation and presentation of our methods of treatment in such cases.

Material and methods: The cochlear implant program in the Department of Otolaryngology in Poznan started in 1994. Till the end of 2013 year 1076 cochlear implantations were performed. In this group major skin flap complications occurred in 19 cases (1,8%). We have analyzed the surgical methods of treatment in such situation and its results.

Results: In all cases (19) with major skin flap complications (infection and loss of soft tissue usually with exposition of implant) intensive therapy with antibiotics was followed by surgical procedure of cleaning the wound and covering the implant by local flaps. In 2 patients surgery was repeated. In 4 patients the skin flap was maintained giving the possibility to use their devices. In this group 1 patient uses speech processor on the opposite site since 8 years, 2 patients use speech processor on the primary site, 1 patient is bilaterally implanted. In 15 cases (13 patients) explantation was necessary, enabling very good healing of this area. In 5 cases the delay between surgery and explantation was 1 year, in 3 cases between 1 and 3 and in 7 cases between 3 and 6.5.

Conclusions: Skin flap complications after cochlear implantations are rare, but it's treatment is complex and difficult. Different factors could influence the skin flap problem, including infection, trauma, haematoma, poor skin quality, social negligence. Only in few cases it is possible to preserve the implant, but an option could be implantation of contralateral ear.

P2-11-18

Case report: an accidental fall that could have required an MRI in the early stages after cochlear implantation surgery

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Introduction: This report examines a case involving a child who took a serious accidental fall soon after receiving a cochlear implant (CI), a situation that could have necessitated the immediate need for MRI scanning even though the child was still at an early postoperative stage.

Case: A two-year-old boy with bilateral severe cochlear malformations received a MED-EL SONATA (Compressed) cochlear implant in the right ear. With the CI in place, his speech developed slowly but favorably. However, five months and two weeks after the procedure, he fell from the second floor of a building and struck the right side of his head. He was diagnosed via computed tomography (CT) as having bilateral linear fractures of the temporoparietal bone, a right epidural hematoma and brain contusion of the left temporoparietal region. He was admitted to the hospital's neurosurgery department and received conservative care. After one week, he was transferred to Nagasaki University Hospital in order to evaluate the functioning of his CI. The telemetry response of his CI appeared to indicate no reaction. Although his condition was stable, we wanted to evaluate the condition of his brain using MRI to determine the potential for future deterioration. However, the MED-EL implant's safety recommendations and guidelines for MRI scanning indicated that he should not undergo MRI scanning for the following reasons:

- MRI scanning should not be done on a patient sooner than six months post-implantation.
- Patients with mechanically damaged implants should not undergo MRI.
- The bone beneath the implant's magnet should be thick enough to withstand a torque force of 5 newtons (N), which act on the implant magnet and exert rotation pressure in an MRI scanner.

The young patient's cochlear implant had been fixed to the temporal bone, which was suspected as fractured, so we didn't know whether the bone would be able to withstand a 5 N force. We informed his parents we didn't believe he'd be able to safely undergo MRI scanning for these reasons, and that we advised taking a “watch and wait” approach for several months until the bone became stable. The boy's parents agreed with us that if his neurological condition worsened, an emergency MRI could be performed. Fortunately, the boy's neurological condition remained stable, and we re-implanted a new device, a MED-EL CONCERTO PIN (Compressed), three months after his fall. We plan to place another CI in his left ear in the near future.

Discussions: These days, CI users are able to undergo MRI scanning without surgical removal of the magnet in conformity with the implant's MRI safety requirements and guidelines. As written, however, these guidelines apply to planned MRI scans, such as those that might be done as part of a postoperative follow-up on a patient with neurofibromatosis Type 2. So, it is important to keep in mind that an emergency MRI scan may not be always safe for a patient with a CI.

P2-11-19

Dura mater perforation caused by electrode migration - 14 years after cochlear implantation

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There is no doubt that cochlear implantation is a safe and reliable surgical procedure which is routinely performed to rehabilitate patients (PAT) with profound hearing loss. The following case documents a rare but severe complication after cochlear implantation. 14 years after cochlear implant surgery we faced a situation of late electrode migration.

We report on a case of an 18 year old female PAT who needed late revision surgery caused by electrode migration of the cochlear implant (CI) through dura mater (DM). We report preoperative symptoms and intraoperative findings.

At the age of 3 years the PAT with profound hearing loss had undergone cochlear implantation unilaterally. The preoperative MRI had shown a malformation of the vestibule with a lack of the lateral semicircular canal. She had also suffered from pneumococcal meningitis when she was 8 months old. The operation had gone well. Intraoperative findings described scala tympani to be basal ossified and a deep set cochlea. However, the electrode array had been inserted easily. Hearing rehabilitation had been very successful and the PAT went through regular school career. She had an uncomplicated and smooth course with the CI-system for more than 10 years. Out of a sudden she complained of an initially non-painful swelling in projection to the implant site. Afterwards, headache occurred while in the further course no more swelling was notable. Pain sensations localized round the implant site worsened both, during stimulation and later without stimulation. The integrity test showed a proper functioning of the device. The CT scans revealed the presumed cause: The electrode carrier seemed dislocated intracranial, lying in the middle cranial fossa. Revision surgery confirmed the suspicion. The migrated electrode laid - 2 cm after its outlet- on surface of the temporal lobe. DM showed a perforation and cerebrospinal fluid (CF) came out. Reconstruction of the bone and DM were performed. A new device became necessary, intraoperative measurements were normal. Uneventful and successful rehabilitation followed.

Swelling at the implant site must be interpreted as CF lacking through the perforated DM. The pain sensation can be explained by a meningeal irritation by the migrated electrode. The cause of this late complication remains unclear. Bone remodeling processes might play a role caused by continuous pressure of the electrode. Discussed is also a higher amount of electrode migration in CI PAT with a malformation or meningitis in their history.

Non-specific and persistent symptoms must be taken seriously even in PAT with a long and uneventful course after cochlear implantation. This case of electrode migration through dura mater neither was linked to decreased CI performance nor to conspicuous technical measurements. Persistent symptoms in CI PAT require further CT examination. Last but not least explorative revision surgery must be performed in unclear situations.

P2-11-20

A new method to prevent magnet migration

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In the last three years we observed four magnet migrations occurred after 1.5 Tesla MRI scanning: two in adult recipients and two in children. Two of them (1 adult and 1 child) underwent MRI in two different hospitals in emergency and two in Varese: the receivers were dressed as recommended by the Company.

After MRI we observed a mild dislocation in two cases, a severe dislocation in another one and in one of them a migration. Three were manually reduced and one needed surgical reposition. We purpose a new method to prevent magnet migration in 1.5 Tesla MRI positioning an adesive patch on the skin over the magnet before dressing. This method prevented magnet migration and pain in two different occasions of MRI under 1.5 Tesla.

P2-11-21

Perioperative fever in children following cochlear implants surgery

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Objectives: To determine the incidence, the course and outcome of perioperative fever (PF) in children undergoing cochlear implant (CI) surgery.

Settings: Tertiary care university hospital.

Patients and methods: A retrospective chart review of all CI surgery procedures in children between the years 2004-2012, was performed. Clinical data collected included the presence of PF, demographics, type of surgery (unilateral bilateral or revision), length of hospitalization, antibiotic treatment and the type and result of the fever workup.

Results: One hundred and sixty patients aged 9 months to 6 years mean (2.5 y) underwent 135 surgical procedures. Twenty five procedures were simultaneous bilateral CI and 5 were revisions. Four surgeries were for postmeninigitis deafness and three were following inner ear congenital malformations. All patients received 24 hour perioperative intravenous amoxicillin- clavulanic acid (25mg/ kg X3). In the first 40 procedures (until 2008) the same antibiotic was continued for one week, orally. PF was observed in 21 procedures (13 %), as documented in at least one measurement. Fever appeared on the first and second postoperative day. Eighteen of them underwent an investigation of fever, including an otolaryngologic and pediatric exam, chest x-ray, complete blood count, and urinary test). Four patients had blood cultures taken and one patient with persistent fever reaching 40^{0}C had a lumber puncture. All exams were normal.

No relation was found between the presence of PF and the patients´ and the procedure´s characteristics. The presence of PF lengthened the hospitalization from a mean of 2 to 2.6 days.

Conclusion: PF in children undergoing C I surgery is not unusual and it seems to be a benign condition. In our opinion this fever does not require further evaluation if it is not persistent, it measures below 38.5^{0}C, and when the child is in good general condition.

P2-11-22

Evaluation effect of retained stylet in rehabilitation: A case report

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Background: Advance Off-Stylet insertion technique(AOS) was proven to enable more atraumatic insertions of Contour electrodes with Softip and to provide very reliable perimodiolar placements using internal devise as CI512 with Contour Advance Electrode.

Case report: A case is described of a Thai adult male of 66 years who developed bilateral profound hearing loss in last 10 years and no benefit for hearing aid used . The case undergone cochlear implantation in right ear after cochlear apparatus imaging was done as unremarkable. During operation we found obliteration of the cochlear due to osteoneogenesis led to limited cochlear implantation. Further, a round window concealed by oval window. We do insertion by AOS technique normally. When extraction of stylet , stylet was fractured and retained in cochlear around 7 mm. after cochlear implantation 4 weeks, We started first mapping and rehabilitation simultaneously evaluation effect of retained stylet in this case.

Conclusion: No adverse effect of retained stylet in rehabilitation was observed after switch on the device, during mapping and using in daily life. After undergone cochlear implantation for 3months, he able to use telephone for interactive conversation. Long- term follow- up was done by authors at 6, 12, 18 and 24 months and no complication can observed.

P2-11-23

Cochlear implants, complications in Oman

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Cochlear implant program started in Oman in 2000 when the first CI was perform, the aim of the study to highlight the complicated as well the complication we went through during this period.

The number of Cochlear Implant tell 2013, Was limited as the cost of the implant was taken by the patient or some civilian society, since 2005 we have performed more than 250 implants majority by MED-EL. Majority of our patient are children 90% and adult mainly post lingual. We have success rate of 82% in hearing post op. We encountered several complications during our implants like bleeding, infections, Failure of implantation, skin necrosis, diverted electrodes and facial nerve palsy

P2-11-24

Postoperative complications of cochlear implantation surgery: Experience in Beni Messous Hospital, Algiers

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Introduction: the purpose of this study is to determine the incidence of postoperative complications following cochlear implantation surgery and to describe their management.

Material and methods: The present study includes a total of 165 cochlear implantation surgeries performed in our department between June 2007 and march 2013. Mean age at implantation was 10,2 years ranging from 18months to 52years . Patients have been followed up regularly after implantation, typically at yearly intervals after the first year. The mean duration of follow-up at the time of the study was 4 years (range : 8 months- 6 years).The complications were identified as "minor" or "major" . Minor complications included those that either settled spontaneously or could be treated medically . Major complications were defined as life threatening or those requiring further surgery .

Results: We obtained an overall complication rate of 10,9 %.

Minor complications occurred in 6 patients (3,6%) , including transient facial paralysis (4 patients), and tinnitus (2patients).Twelve patients (7,2%) had major complications, consisting of post traumatic device failure (4 patients), software device failure (1 patient), tympanic membrane perforation with electrode exposed (1 patient), magnet displacement (1patient), extracochlear position of the electrodes (3 patients), Cholesteatoma (2 patients). Reimplantation was achieved in 7 patients (4,2%). Whereas revision surgery without reimplantation was performed in 4 patients, including tympanopalsty (1patient), cholesteatoma surgery (2 patients), magnet replacement (1patient).

Conclusion: Cochlear implantation is considered as a safe and reliable procedure. However with the increasing number of cochlear implanted patients and the long term follow up, complications and failures are more often observed. In our study, complication rate is comparable to that reported in the literature. We observed more major complications, mainly related to electrode problems. Revision surgery was successfully achieved.

Learning outcome: To determine the incidence of major and minor complications

To describe the medical and surgical management of such complications

P2-11-25

Cochlear Implant surgery without shaving: our experience

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Background: Cochlear implant surgeons routinely shave the skin of the incision site pre-operatively. However, evidence from some surgical series suggests that pre-surgical shaving may increase the postsurgical infection rate. To our knowledge, no previously published study addressed this issue with cochlear implant surgery.

Objective: To determine whether or not shaving the incision site before cochlear implant surgery would influence the risk of surgical site infection (SSI)

Study design: A retrospective chart review study.

Methods: A total of 237 charts for patients who underwent cochlear implant surgery were reviewed. 123 patients underwent the classical incision (0.5 cm posterior to the post-auricular sulcus) with shaving the operative site in the operation room immediately before surgery (shaved group), and 114 patients had a modified post-auricular incision approximately 3 cm away from hair line. Shaving in this group was not performed (unshaved group). The two groups were comparable in in demography, pre-operative preparation (antibiotic prophylaxes), operative time, type of suture material and post-operative antibiotic usage. The operative duration and the infection rates for both groups were recorded and compared.

Results: Four cases of the group who underwent pre-operative site shaving (n=123) presented with surgical site infection. None of the non-shaved group (n=114) cases had surgical site infection. Patients without infections (n = 233) had operative durations of 151 ± 50 min. Patients with infection (n = 4) had operative durations of 180 ± 49 min ($p < 0.001$).

Conclusion: Shaving of the operative site immediately before cochlear implant surgery may increase the rate of postoperative infection. Increased operative time is associated with increased infection risk as well .

P2-11-26

The risk of „silent“ labyrinthitis in patients after cochlear implantation

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Introduction: A 69-years old woman presented to our department complaining about a draining ear on the right side 1.5 years after cochlear implantation with preexisted canal-wall-down mastoid cavity. Examination of the ear revealed a moist and not well arranged radical cavity with the electrode of the implant uncovered on the ground. Revision surgery was performed and the cochlear implant removed. The electrode was cut off in the round window and left as a dummy. A few weeks later the patient presented with facial nerve palsy on the same side.

Methods: An MRI with contrast agent showed an enhancement in the cochlea and the inner ear canal. The radiologist assumed an acoustic neurinoma. Immediately revision surgery was performed with removal of the remained electrode. A massive inflammatory change of the tympanic mucosa and the facial nerve was seen and granulation tissue in the tympanic canal. Pseudomonas aeruginosa was detected and treated by intravenous antibiotics.

Results: Facial nerve palsy was promptly diminishing. An MRI-scan 3 weeks after surgery showed reduced enhancement of the inner ear canal. 4 weeks later signs for inflammation resolved also in the cochlea and mastoid.

Discussion: In this patient the draining ear followed by facial nerve palsy was the only clinical sign for an acute labyrinthitis. Enhancement of the cochlea and the inner ear canal in MRI scans indicated the inflammation of the inner ear and even revealed progression towards the brain.

Conclusion: In deaf patients, especially after cochlear implantation, typical symptoms for labyrinthitis as vertigo or hearing loss can easily be missing. The imminent risk of intracerebral spread, signed in our patient by the enhancement of the inner ear canal, thus can easily remain unnoticed in the beginning.

Learning outcome: The appropriate assessment of the imaging and the crucial bit of information by the ENT-specialist is all the more important to avoid fatal misinterpretations or delay of therapy in case of complications after cochlear implantation.

P2-11-27

Pain with failure of cochlear implant device: A 5-patient pediatric experience

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Cochlear implantation has become common. Complications are infrequent. When complications do occur they manifest as malfunction of the stimulator or electrode array, or as medical/surgical complications. Instances of the latter include dizziness and facial nerve stimulation (typically managed non-surgically by programming) and wound infections.

A less common complication is pain at the site of the receiver-stimulator package, unrelated to either clinical infection or trauma, including excessive magnet pressure on the intervening scalp tissues. We present data of five cases of pain of unknown origin, from a sole-surgeon pediatric practice (600+ implant surgeries; about even proportions of Advanced Bionics, Cochlear Corporation, and MED-EL devices). The onset of pain ranged from 2 to 16 years post implantation, was not associated with infection or trauma or external hardware event, and was not amenable to conventional medical therapy. In all cases pain was present regardless of whether or not the external appliance was "on", or even being worn on the head. Interestingly, 4 of the 5 patients were bilaterally implanted, but the "painful failure" was only at one ear.

Clinical management ultimately included revision surgery in all 5 cases, with immediate resolution of the pain in 4 of 5 cases. For those 4 cases, the replacement CI performed well, without pain; the other patient fears pain if her replacement device is used, but continues enjoying her contralateral implant.

From our experiences, we offer a flowchart for the care of "painful CI failure" patients, encourage a worldwide registry of such cases, and offer ideas to try to understand better the problem.

P2-11-28

Electrode array misplacement into the superior semicircular canal: as a rare complication of cochlear implantation

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Objective: To report electrode array misplacement into the superior semicircular canal occurring as an rare complication of cochlear implantation, and to explore the causative association between electrode array misplacement and cochlear implantation surgical techniques.

Methods: A chart review of the electrode array misplacement into the superior semicircular canal and their management in 695 patients undergoing cochlear implantation was undertaken from January 2003 and January 2014 in Anhui Provincial Hospital.

Results: There were two children of electrode array misplacement into the superior semicircular canal complication, and the rate is 0.28%.

Conclusions: Electrode array misplacement into the superior semicircular canal associated with cochlear implantation is rare. Surgeons should be aware of that the smaller round window maybe the reason of electrode array misplacement under round window insertion. Intra-operative neural response telemetry and X-ray can alert the surgeon the problem with the array's misplacement, which can be identified by postoperative CT.

P2-11-29

Reparation of external auditory canal with osteostimulation after secondary cholesteatoma in one patient with cochlear implant

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Intro: necrosis of posterior wall of the external auditory canal and a secondary cholesteatoma could be complications of cochlear implant surgery. The posterior wall could be repair with bone substitute materials.

Methods: We present the case of one patient which a cochlear implant that develops a secondary cholesteatoma seven years after. The cholesteatoma destroyed de posterior wall of the external auditory canal. A bone substitute was used to protect the cochlear implant and to repair the auditory canal. In the surgery to remove the cholesteatoma we used granules for bone regeneration (osteostimulation) as bone graft substitute. The granules is a slowly resorbable bioactive glass based biomaterial with the composition: 53% SiO_2, 23% Na_2O, 20% CaO, 4% P_2O_5.

Results: The patient presented 3 months after the surgery a closed external auditory canal wall, a mastoid without signs of cholesteatoma and a functional cochlear implant.

Discussion: The granules used for this patient have the main objective to the replace the missed bone One of the main characteristics of these granules is the unique feature of inhibiting bacterial growth making it an effective tool for bone cavity filling in the treatment of chronic osteittis.

Conclusion: The commercial granules used in this patients could be an option to close bone defects of posterior canal wall and protect the cochlear implant.

P2-11-31

Vestibular aspects in cochlear implant procedure

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Cochlear implantation procedures are nowadays accepted surgical procedure around the world. During recent years indication were extended and we can observe long period results with patients after Partial Deafness Treatment. Also there are many studies among patients with cochlear implantation performed in over 65 years old - patient’s age.

Aim of the study was analyze of possible vestibular complication during surgery and vestibular disorders among cochlear implanted patients. In material Institute of Physiology and Pathology Hearing there is 3913 cochlear implanted ears. Huge majority unilateral. We analyzed patients in different groups including Partial Deafness Treatment.

Vestibular failures and surgical complications are not common in centers which perform many oto surgeries including many cochlear implants. Pre-operative analyze of radiological assessment is preferable and allow to perform safety surgery. There is many experiences among centers which perform cochlear implantation which we analyzed during the study to compare Our experiences. VEMP could be a standard in evaluation of patients after cochlear implantation, but more clinical studies should be performed.

P2-11-32

Speech discrimination following re-implantation of cochlear implants

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Introduction: It is inevitable that a proportion of cochlear implants will fail during their lifetime and this is likely to become increasingly significant as the duration of implantation becomes increasingly longer. These patients require re-implantation. This paper investigates the effect on speech discrimination outcomes of re-implantation following failure of a cochlear implant.

Methods: A prospectively updated database was used to identify patients who have required re-implantation. Speech discrimination with the initial device and with the new device were measured in quiet and in noise using BKB scores. Factors influencing outcomes were analysed. There were 30 adults (15 males and 15 females; 16 right and 14 left) who had re-implantation in the same ear. There were 26 children (8 males and 11 females).

Results: The reasons for explantation were infection or device failure in most cases. For the adults, mean age at first implant was 47.4 years (SD 14.8) and second implant 52.1 years (SD 15.7) with a mean duration to reimplantation of 52.9 months (SD 55.3). For the first implant, mean BKB scores in quiet and noise were 55.5% (SD 41.1) and 44% (SD 38.5) respectively. For the second implant, mean BKB scores in quiet and noise were 63.9 (SD 37.1) and 48% (SD 36.7). The mean change in BKB score in quiet was 11.2% (SD 23.4). This was not statistically significant (p=0.08). The mean change in BKB score in noise was 4.7% (SD 29.3). This was also not statistically significant (p=0.4).For the children, mean age at first implant was 3.4 years and second implant 5.7 years. Speech discrimination outcomes in this group will also be presented.

Conclusion: There is a trend to improvement of speech discrimination score following reimplantation but this is not statistically significant. This is reassuring given that many patients are likely to require replacement of their implant at some point during their lives.

Learning outcome: Reimplantation of a cochlear implant provides a similar benefit in terms of speech discrimination to that of the original surgery

P2-11-33

A model to evaluate explant force and trauma of intracochlear electrodes post chronic implantation

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Objectives: To develop an in-vitro model to characterise electrode explant force and trauma post chronic implantation.

Study design: Cochlear implant (CI) explantation can be required for many reasons, with removal of the intra-cochlear electrode array potentially resulting in trauma. Literature on electrode explant trauma or force typically involves explant immediately post implantation in models or in human temporal bones which do not take into consideration the foreign body reactions that have taken place around the electrode. Clinically explantation typically occurs many years post implantation at which point a fibrous capsule has typically formed and potentially some greater level of fibrosis and/or ossification around the electrode array. An in-vitro model using gels to represent tissue surrounding the electrode was used to examine the explant dynamics of electrode arrays and measure explant forces.

Results: Explant forces can vary considerably depending on the amount and type of material (tissue) surrounding electrode. This also has a significant influence on the electrode explant trajectory and dynamics and also the potential trauma of tissue formed post implantation which then impacts other intracochlear structures.

Conclusion: Measurement of electrode explant forces and dynamics in patent scala tympani is not a representative model of explantation which typically occurs some years after initial implantation clinically. Modeling of tissue formation around the electrode to represents in-vivo conditions provides a more relevant understanding of the electrode forces and interactions that are likely encountered in the cochlea during explant.

P2-11-34

Revision cochlear implant surgery in adults and children

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Objectives: To identify the incidence and common causes for revision cochlear implant (CI) surgeries.

Study design: Retrospective case series.

Methods: Operative and medical records were reviewed for all cases underwent to CI surgery from 1994 and 2013. The causes for revision surgeries were classified as hard device failure, soft device failure, exposure/infection, magnet migration, electrode wrong insertion, osteomastoiditis and sub-periosteum hematoma.

Results: Eight hundred and ninety cochlear implants were performed during the study period including 33 (3.7%) revision procedures. The revision rate was 5.4% for children and 2.8% for children. The mean time to revision surgery was 9.2 years in children and 2.6 years in adults. Causes of revision CI surgeries were: six hard failures, five soft failures, one traumatic hard failure, six exposure/infections, two otomastoiditis, five sub-periosteum hematomas and two magnet migrations. We had one cases underwent at first surgery at other institution of electrode array misplaced into the vestibular system. Audiologic performances were stable or improved following re-implantation in 90% of cases.

Conclusions: Revision cochlear implant surgery is an infrequent occurrence. Its incidence seems to be higher in children than in adults. Audiologists and otologists should be competent in diagnosing and managing divice failure and medical complications requiring CI revision surgery.

P2-11-35

Indonesian experiences in cochlear implant revision surgeries

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Introduction: Since started in 2002, approximately 300 ears has been implanted in Indonesia. Since 2010 79 patients (137 ears) has been implanted using MED-EL Cochlear Implant devices by our collaboration program. This program consists of 10 hospitals in 5 different cities in Indonesia. According to Wiet (2011), cochlear implant revision surgery occurred in 3-8 % cases, 40-80 % caused by total implant damage. Other reasons for cochlear implant revision surgery includes skin infection, implant migration, implant damage during insertion or implant rejection.

Method: Case report of 4 patients whom underwent cochlear implant revision surgery.

Result: Four patients underwent cochlear implant revision surgery based on cochlear implant team evaluation. One patient has infection at receiver bed caused by suture's allergic reaction, 2 patients has infection caused by wire migration, 1 patient was reimplanted due to progressive electrodes damage. Careful imaging and audiological evaluation were performed pre-operatively to decide best surgical approaches. Retroauricular approach was performed in 3 patients and transcanal endoscopic approaches was performed in 1 patient with wire migration to ear canal. Receiver fixation techniques and position were proposed to prevent other infection incident in the future. One year follow up in reimplanted patient showed stable condition and good after implant performance. Detail preoperative evaluation and surgical approach for each patient will be discussed.

Conclusion: Cochlear implant revision surgery should be based on team evaluation to decide best approach in each cases. This surgeries should only be performed by experienced otologist.

P2-11-36

Hearing thresholds assessment of patients following 10 years of cochlear reimplant surgery

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Introduction: The first cochlear implant surgery in the Cochlear Implant Program of the Audiological Research Center at the Hospital for Rehabilitation of Craniofacial Anomalies, Audiological Research Center, Bauru, Brazil was performed in 1990. Since then, more than 1,100 patients have been implanted. In these 24 years, 86 patients needed re-implant surgery due to extrusion or failure of the internal device, owing to otitis media, trauma or due to any other reasons. The re-implant surgery consists in removing the internal component, previously implanted in the patient, and replacing the electrode bundle inserted within the cochlea. The insertion of electrodes in the tympanic scale may cause trauma in the spiral ligament and in the basilar membrane at the basal turn region, however, the electrical stimulation generated by the bundle of electrodes may be kept efficiently, even following the surgical trauma. Several studies have demonstrated that re-implants are feasible; however, possible alterations in the patient´s hearing performance have been questioned.

Objective: The present study aims at assessing the hearing thresholds of patients submitted to re-implant surgery, thus analyzing possible alterations in their performance in terms of hearing detection.

Material and method: The research was performed in the Cochlear Implant Program of the Audiological Research Center of the Craniofacial Anomalies Rehabilitation Hospital, University of São Paulo. Sixteen patients submitted to cochlear re-implant surgery for presenting failure in the cochlear implant internal component, participated in this research. A retrospective study was done through the analysis of medical records, comparing the hearing thresholds of 16 patients following activation of the first cochlear implant surgery, after activation of cochlear re-implant and follow-up of thresholds for 10 years of effective use of the device.

Results: There was a significant improvement of the hearing thresholds for the analyzed frequencies of 500, 1000, 2000 and 4000 Hz which may be explained by the neuronal plasticity, process of rehabilitation and replacement of speech processors by modern ones. No worsening was observed in the hearing thresholds related to the cochlear re-implant surgery, immediately following the procedure or after a 10-year period.

Conclusion: The results suggest no substantial intra-cochlear structural changes that prevent or impair peripheral stimulation of the cochlear nerve, so there is no contraindicating for the surgical re-approach.

P2-11-37

Hearing performance after two re-implant: a case study

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Introduction: Cochlear implant surgeries, just like any other surgery, may present some complications which might occur right after the surgery, in the short, medium and long term, requiring, many times, surgical review and/or explant followed by re-implant of the device. The main reasons for failure of the internal device involve infections, defects of the internal component, local trauma and extrusion of the electrodes bundle.

Objective: To assess the hearing performance of a patient submitted to two cochlear re-implant surgeries owing to internal device failure.

Method: It is a case study developed in the Cochlear Implant Program of the Hospital for Rehabilitation of Craniofacial Anomalies, Audiological Research Center, Bauru, Brazil. GAA, female, 19 years old, presents profound post lingual sensorineural hearing loss, owing to an episode of meningitis. She underwent the first cochlear implant surgery in May 2001, the second surgery in March 2002 and the third one in February 2004. The data from the medical records were assessed: 1. Free field audiometry performed with the cochlear implant; 2. Speech perception tests (GASP speech perception test, list of dissyllable words by DELGADO and BEVILACQUA (1999) and sentence recognition list) which allowed the classification of the patient´s auditory performance in the hearing categories proposed by Geers, in 1994.

Results: It was verified that on the first cochlear implant activation, the patient already presented benefits with the CI, being the thresholds obtained for the frequencies 500 to 4000 Hz between 25 and 35 dB. Her hearing skills were classified within hearing category 6. On the second activation, following re-implant, the patient obtained thresholds for the frequencies 500 to 4000 Hz between 20 and 40 dB, and kept hearing category 6. After the third activation, the patient kept the same performance, being the thresholds obtained for frequencies 500 to 4000 Hz between 25 and 40 dB and hearing category 6. Actually, the patient presented hearing performance on the HINT test of 60,5 dB in silence and 15,3 dB in noise, as well as hearing thresholds in 20 dB 500 to 4000Hz. It was observed that even after three cochlear implant surgeries, the patient´s hearing performance was the same and that she presented a good evolution since the last surgery was performed. Currently, she presents no complaints to communicate in daily activities even in noisy environments, reporting good communication on the phone as well as good musical perception.

Conclusion: It can observed by the study that, even after three surgeries, being two related to re-implant, no negative impact was seen in the threshold and speech perception of the patient.

P2-11-38

A case report: a little girl with advanced Bionics cochlear implant, surgically treated twice for skin flap necrosis, and subsequently explanted and then re-implanted with MED-EL cochlear implant. Management and results

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M.L. born in 2009 deaf and blind. In February 2012 we performed surgery cochlear implant in right ear (AB Neptune). In April there was the presence of a skin flap necrosis of the ear region overlyng the magnet. The patient was surgically treated twice in May and July and subjected to cycles of hyperbaric therapy. After the second recurrence she was explanted and then re-implanted with MED-EL cochlear implant. We discuss on management and results.

P2-12 Quality of life and economics

P2-12-1

Promotion in the media of the cochlear implantation (technology/surgery/rehabilitation/outcomes) to sensitize the public and decision/policy makers

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Intro: Although it is a popular technology for over 20 years in the West and remains an advanced technology research and development continuously, unfortunately in Romania it was introduced after 2000. Lack of public knowledge was not only common, but even ENT doctors. The first CI surgeries were performed more experimentally, shy and in numbers no more than 5-10 per year. In this way, technology has remained virtually very little known. Also, we tried to properly inform the target population regarding hearing loss and the means for rehabilitation (from hearing aids to cochlear implant).

Methods: We decided, therefore, to create a paradigm shift in mindset and Romania among the population and among family doctors and even among ENT doctors. We chose addressability media with the widest and free (1st channel of the Romanian National Television - TVR, the 2nd channel of TVR, the 3rd channel of TVR), we searched then interact with the Romanian diaspora, using the international channel of the national television (TVR International). We added young viewers segment oriented technology and quality tv here using high definition channel TVR. A second segment was called media (Hope Channel - Adventist Media Center) - by addressing a niche audience, but loyal one. A third channel of information were television online, the most important being Senso TV Romania. Another target was medical journals: Romanian Journal of Otolaryngology and Medical Journal GALENUS. Also large audience online magazines in Spain (Magazine Maria) and Germany (Stuttgart AGERO Magazine) were with us in this effort.

Results: Starting with 2010, we have informed and we have raised this issue of profound hearing loss (pathology, medical technology, rehabilitation, real outcomes, quality of life) in public attention - number of potential viewers - 22 million Romanian citizens in Romania and in the Diaspora. We asked in public media at every opportunity as health policy makers to pay attention and proper funding of this hearing loss pathology and technologies that can eradicate (cochlear implant).

Discussion: Television and the Internet are the best way to reach the public visibility, to challenge and to change the public view, to update professional info for GPs and even for ENT/ORL physicians.

Conclusion: This was the first Romanian joint media-medical project to bring in the front the issue of cochlear implantation, the real problem of severe and hearing loss, the social and economic importance of complete rehabilitation of the patients.

P2-12-2

Implications for clinical cost effectiveness using new intraoperative measuring technology

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Aim: Previous research with the first generation CR120 intraoperative remote assistant produced by Cochlear Ltd. proved with a high degree of confidence that a hand held device can replace the standard clinical computer set-up for cochlear implant (CI) intraoperative measurements. The second generation CR220 remote assistant has now been released and the focus is now changed to investigate the hypothesised improvement in cost effectiveness which may be achievable. This is through measurements made: i) more efficiently; ii) more quickly; and iii) by non-expert audiologists. The aim of this study was to determine the cost effectiveness by measuring the complete time for the threshold measurement process, including travel time, waiting time, etc., and relating this to the cost-to-clinic of having an expert audiologist specifically performing this activity. Attention was also paid to whether equivalent threshold results were achieved with the new remote assistant, including success of making measurements, compared to the standard clinical set-up.

Material and methods: A specially developed “intraoperative session survey” was developed which recorded the time taken for every stage of the measurement activity. For example, the time taken to get to the operating theatre, time required for equipment set-up, etc. were included in this time of the measurement activity. General subject demographic information was also collected to determine if age or aetiology factors impacted the measurement process.

Results: 113 patients to date have been included in the study at two sites in Moscow, Russia, and Almaty, Kazakhstan. The time spent “unproductively” - travelling, waiting or setting up/tearing down equipment - is considerable, measured in hours rather than minutes. The ECAP threshold measurement time with the CR220 remote assistant is on average less than with the standard clinical equipment. However, the “unproductive” time is significantly greater than the measurement time with either system. No relationship has been identified between measurement time and aetiology or patient demographic. A full overview of the study results will be presented, with an estimate of cost effectiveness for a non-expert audiologist to conduct the measurement activity.

Conclusions: The results achieved to date immediately indicate that considerable time is spent travelling to and from, and waiting in, the operating theatre. This “unproductive” time is not only wasteful, but also means the audiologist is not available in the clinic seeing patients, where their expert skills are of most value. The availability of the easy-to-use, handheld CR220 remote assistant therefore provides considerable opportunities for increases in cost effectiveness of the CI implantation and clinical process.

P2-12-3

Sufficient organization of a cochlear implant team with rising patient numbers as a constant challenge - a problem-solving approach from Halberstadt

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In the last two decades, the number of hearing-impaired patients with the desire for a Cochlear Implant has increased significantly. That is known to be a result of new indications and technical innovations. A cochlear implantation (CI) means for supplying a clinic a lifelong commitment. A high number of appointments have to be organized before and after a steadily growing number of Cochlear Implantations for a multi- professional team.

The organization of the cochlear implant differs in several aspects from the actual organization of other patient flows. In many patients, due to hearing impairment a direct verbal communication by phone is not possible and must be partly contributed about family members and a variety of different communication channels. The work is characterized by a special empathy for the patients and their problems. It becomes apparent that especially in elderly patients, a number of additional problems exist.

A second peculiarity is the close contact to health insurances and public social institutions. Personal communication with a single sufficient contact in the clinic can solve many problems directly without long correspondence. Especially patients benefit from a single point of contact as a direct and well-ordered access to the place that hopefully solves their problems.

With increasing numbers of patients a central organization for all patients and the whole team from a single source is a useful tool for the structured task management. As a point of contact for therapists, physicians, audiologists on the one hand and patients on the other hand, this site developed quickly to one of the key elements of Cochlear Implantation in Halberstadt.

P2-12-4

Speech perception and communication adaptation in patients with cochlear implants.

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Purpose: For severe-to-profound hearing impaired patients, it is thought that cochlear implants are the most helpful devices for auditory treatment. The study is to investigate the circumstances of speech perception and communication adaptation for patients with cochlear implants in Taiwan.

Method: Thirty-seven cochlear implanters participated in this study. It included 19 females and 18 males, and the mean age is 17.17 years old. In this study, the participants received a lexical tone recognition test and filled out a questionnaire about communication adaptation. The questionnaire contains three aspects of communication disabilities: the difficulty of speech listening, the distress of communicational mentation, and the use of communicational strategies. To understand the relationship between the participants' speech perception and their communication adaptation, five variables (the age of cochlear implanter, lexical tone recognition, and the three aspects of the questionnaire) were conducted correlation analysis.

Results: Correlation analysis showed that-

I. The difficulty of speech listening is negatively correlated with lexical tone recognition, but positively correlated with the distress of communicational mentation.

II. The distress of communicational mentation is negatively correlated with lexical tone recognition, but positively correlated with the age and the difficulty of speech listening.

III. The use of communicational strategies is not correlated with the other variables.

Conclusion: According to the results, we generally conclude that the CI users performing better speech perception tend to have less difficulty on speech listening and have less distress on communicational mentation. Most of the CI users seem to have a much positive attitude on the use of communicational strategies. Moreover, for younger CI users, parents, teachers, and speech therapists should not only focus on their speech perception but also should pay more attention to their communication adaptation under various scenarios in daily life.

P2-12-5

Cochlear implantation in prelingually deaf children: Effect on quality of life and speech perception

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Objective: To assess the impact of cochlear implantation on Quality of life and compare these changes with speech perception.

Materials and methods: Twenty-eight prelingually deaf children, between the ages of 5 and 15 with hearing experience of at least one year with a cochlear implant, were investigated. Quality of Life was examined by means of the Sanders Profile Questionnaire for Rating Communicative Performance in a Home Environment for Children. The speech perception tests included a comprehension test of 16 sentences and a word recognition test of 25 two-syllable words.

Results: The average Quality of Life score was 37.25 out of 54.00. The average recognition and comprehension was 76.50% and 89.46% respectively.

Conclusion: Cochlear implants contribute positively in the Quality of Life of prelingually deaf children and their ability to perceive speech as well.

P2-12-6

Influence of psychological aspects on quality of life of pre and post-lingual cochlear implant users

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Introduction: Bilateral profound sensorineural hearing loss may lead the patient to behavioral abnormalities and difficulties to meet the demands generated by the hearing society, which causes a negative impact on quality of life. These consequences brought up by the hearing impairment may be solved in some patients with the use of cochlear implants (CI). Having the possibility of hearing better by using the CI, the user will have better social conditions to meet the demands of the society.

Objective: To assess and characterize the psychological aspects of pre and post-lingual hearing impaired adult users of cochlear implants.

Material and method: The interviewed patients were adults who had received their implants between 2004 and 2011 at the Department of Otolaryngology, *Hospital de Irmandade Santa Casa de Misericordia de Sao Paulo (ISCMSP)*. The investigator used the questionnaire WHOQoL-BREF to analyze the psychological domain (which assesses positive feelings, thinking, learning, memory and concentration, self-esteem, body image and appearance, negative feelings, spirituality, religion and personal beliefs) and checked whether the hearing loss had happened before or after language acquisition.

Results: Out of 25 interviewed patients, there were 52% male and 48% female patients. The mean age was 39 years, being 68% (n=17) post-lingual and 32% (n=8) pre-lingual subjects. Regarding the psychological aspect of the questionnaire, the mean total score (within a 0-100 range) was 78.1 for pre-lingual and 77.4 for post-lingual. The similar score made us realize that these patients see themselves differently in the society, in addition to sometimes presenting negative feelings, accepting their appearance, being satisfied with their thoughts and learning, which are some of the factors assessed by this domain of the questionnaire. All these assessed factors may be exemplified by questions, which were scored from 0-5, except for question 26 that had an inverted scale. They are: Q6) To what extent do you think your life makes sense? (pre = 4.67; post = 4.74); Q19) How satisfied are you with yourself? (pre = 4.58; post = 4.48); Q26) How frequently do you have negative feelings such as bad mood, despair, anxiety, depression? (pre = 2.67; post = 2.74). Losing hearing before or after language acquisition has had no significant impact on the behavior of these groups (pre and post-lingual patients). What really matters is that they start acting differently in face of the demands imposed by the hearing society.

Conclusion: The psychological domain is directly related with the challenge of the hearing impaired, whose motivation includes hearing performance. The better the communication strategies, the better quality of life, respect and consideration with the patient will be.

P2-12-7

Novel communication systems for the deaf people in a major disaster

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Objective: Based on the field work regarding difficulties the deaf faced during the earthquakes in Japan, we designed a visual information delivery system using Android mobile devices and cloud networking during a major disaster to communicate information about the evacuation and the shelter to them quickly. We present the results of the evaluation test of this system.

Methods: Evaluation tests were carried out at a school for the deaf. Subjects were 75 people with hearing impairment (HI) and 34 with normal hearing (NH), aged 12 to 65 and 51 females and 58 males. Visual information delivery system consisted of Android mobile devices with Wi-Fi, cloud networking system, and LED display. Evaluation items were 1) recognition of LED display, 2) usefulness of the system, 3) size of the characters on LED, 4) color of the characters on LED and 5) speed of the character scroll on LED. Results were statistically analyzed.

Results: The LED display was recognized by 88% in the HI group and 92% in the NH group. Usefulness was highly evaluated by 93 % in HI and 92% in NH. Larger sized characters were evaluated by 92% in HI and 95% in NH. Green color was evaluated more in HI. Faster scroll was evaluated more in HI ($p < 0.05$).

Conclusions: These findings suggested that this system was useful for the deaf, and they preferred green character on faster scroll on LED .

P2-12-8

Children using hearing implants - quality of life, validation and initial results

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Background: Currently, there exists a paucity of data concerning long-term outcomes and Quality of Life following implantation of hearing devices in children. To address this need, we have developed a multinational patient outcomes registry for paediatric recipients. As part of this study, a new quality of life instrument was required to assess the impact of hearing implants on the quality of life of very young children, their parents' expectations and family environment. The Health Utilities Index, Mark 3 is suitable for children > 10 years of age.

Methods: Quality of Life and hearing health measures and questionnaires previously deployed for paediatric patients administered to parent proxies as well as in hearing health were evaluated to determine relevant domains, content, construct and criterion for inclusion. The resulting 25 item parent reported, 4 week recall, *Children Using Hearing Implants Quality of Life* (CuHIQoL) questionnaire is divided into three sections: i) Parental Expectations ii) Impact on the Family iii) Quality of Life of the Child. The questionnaire was developed in consultation with leading industry experts and was piloted in multiple settings by parents and providers before being introduced into the study. It is now available in more than 10 national languages and is being used across a variety of cultural settings.

Results: This paper will report on the design, development, validation methodology, and initial results of the CuHIQoL, as used in the Cochlear Paediatric Implant Recipient Observational Study (P-IROS), a prospective international patient outcomes registry for children (< 10 years) who are implanted with one or more hearing devices.

Conclusions: The CuHI QoL instrument provides the implantable hearing industry with a disease specific health related quality of life instrument for use with patients who are < 10 years of age at the time of their first implant. This is significant as large populations of patients are < 4 years of age at the time of intervention and patient reported outcomes are becoming increasingly important to providers and payers.

P2-12-9

Reliability of MED-EL cochlear implants in Romania

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Introduction: A failed CI is a very problematic event for the patient and family. Device failure after implantation at a young age seems to be inevitable. This is a retrospective review aimed to evaluate the failure rate of MED-EL devices implanted in the four major centers across Romania.

Materials: We designed a questionnaire to assess the incidence, the time elapsed and the mode of total device failure and we sent it to the other three centers. Medical-surgical data were collected from patients who received MED-EL cochlear implants - adults and children - since the start of the program in 2001. A minimum period of follow up of 12 months was mandatory to be included in the study.

Results: There were 307 patients included in this study. Failure Rate (7.49%) and Cumulative Survival Rate (94,79%) at 10 years were calculated. Analysis was further continued separately for children and adults, for every type of MED-EL device used and for different causes of device failure.

Conclusion: Cochlear implant reliability data should be considered during the choice of an implant for each individual patient. This study results confirm the safety and efficacy of MED-EL cochlear implants both in children and adults.

P2-12-10

Satisfaction evaluation between Digisonic SP monaural and binaural

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Introduction: Although unilateral cochlear implant provides good speech understanding in quiet conditions , implanted patients often report difficulty understanding speech when exposed to background noise and also in sound localization. Since these two functions require binaural stimulation in normal subjects and hearing aid users, it is not surprising that there is growing interest in binaural cochlear implants. The best performance for sound localization in bilateral cochlear implant users depends on the head shadow effect, the " squelch " effect and the effect of binaural summation.

Methods: Retrospective study. Patients fitted with binaural or monaural cochlear implant, 5 patients with binaural and 7 with monaural implant..

Inclusion Criteria: 1.severe or deep sensorineural bilateral hearing loss; 2.patient without benefit after experience with the use of hearing aids for a minimum period of 3 months in severe hearing loss; 3.proper motivation of the family to use the cochlear implant and to develop intervention; 4.presence of linguistic code established and properly rehabilitated by the oral method.

Exclusion Criteria: 1.appropriate gain after fitting a hearing aid; 2.improperly rehabilitation by the oral method; 3.unfavorable psychological assessment; and 4.absence of cochlea and cochlear nerve.

Results: Overall score and three subscales of binaural patients were more satisfied compared to monaural. We take into account also the average time of use of the device, which monaural implants was 22 months and for binaural was 9.6 months. This demonstrates that even with less time to use binaural implanted patients were more satisfied with the use of their devices and this may mean that they can achieve good listening levels faster.

Discussion: Although psychoacoustic literature has long demonstrated the benefits of binaural hearing, only recently studies have showed improvement in speech intelligibility with bilateral implants compared with unilateral implants. Of the three known binaural mechanisms, the shadow effect of the head provides greater benefit than squelch or binaural summation. In addition, the binaural cochlear implants improve the ability to localize sound. Ideally, the benefit of bilateral implantation for speech intelligibility in noise can be much higher than has been reported. This benefit is considerably greater than the reported benefits of summation or the squelch effect and is robust in reverberation when the interference source is close. We can compare the level of satisfaction among patients using monaural versus binaural implant through the SADL questionnaire. This questionnaire consists of 15 questions, evaluates the overall patient satisfaction in relation to the CI as well as items like the benefit of CI use, adverse effects, costs and personal image associated with the use of this electronic device.

Conclusion: The global satisfaction with binaural implant is higher than monaural implant.

P2-12-11

Comfort and satisfaction with the nucleus CP810 cochlear implant processor

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Introduction: Cochlear implant technology has progressed over the last 30 years, achieving greater performance and comfort for implanted patients. The performance of new processors currently available has been recently studied. However, there is scarce information about the experience of implanted patients with the hardware and how they perceive auditory performance. There are currently no publications in the literature that assess adaptation, comfort and level of satisfaction with new processors. The main objective of this study is to describe the level of adaptation, comfort and satisfaction of patients with processor Nucleus CP810.

Materials and methods: Twenty-four cochlear implant patients (average age: 35 years, age range: 3-79 years) were included. All patients had at least 1 year of experience with the implant at the time of the study. CP810 was the first processor for 46% of patients and the remaining 54% had their previous processor replaced by a Nucleus 5 CP810. At least 4 months after using it, they underwent audiometric testing and filled in a questionnaire evaluating their level of satisfaction with the new processor.

Results: Generally, patients reported to be satisfied with the Nucleus 5 CP810 processor in terms of comfort (83%), size (71%) and fit (75%). However, they reported not being satisfied with the average battery life (34%) and accessories are generally not used (95%). Also, 80% reported being satisfied with the discrimination capacity at a distance and 21% are not satisfied with discrimination in adverse and noisy environments. Besides, 80% of patients need to remove the processor to press buttons and 75% do not use the remote control. It is significant that 100% of patients are satisfied with the performance of this processor compared with the previous one.

Conclusions: Patients are satisfied with the usability and performance of the Nucleus 5 CP810. No patient rejected the device. However, they are not satisfied with the battery life and the usefulness of accessories, including the remote control.

P2-12-12

CI in an adult active population

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Introduction: Adults suffering from a large decrease in their hearing do have in general difficulties in maintaining a good active professional life. After a CI and some months of using it, these adults recuperate a large amount of hearing and are able again to communicate correctly with others. Therefore, we assume that they are able to recuperate their level of professional activity and even develop it further. The objective of this project is to evaluate the impact of CI implantation in the professional life of severely to profound bilateral deaf patients.

Material and method: The study look both retrospectively and prospectively at 30 patients implanted, aged from 30 to 65 years old, subjects within the standard criteria for Cochlear Implant and at least 6 months of working experience. Single-subject design was used in which each subject acts as his/her own control. Two questionnaires (Prospective and Retrospective) were created and the subjects will have to answer the questions in relation to the status of their professional activity and their satisfaction at work, comparing their professional situation before and after implantation.

Results: The questionnaire identified an increase of active patients after CI, a higher satisfaction at work for CI users, with significant improvement in their communication with their hearing colleagues. In general, CI user feel that CI do improve their careers

Conclusions: CI has a significant impact on professional life of the subject, and on their productivity for the general economy. An increase in number of active patients and a better satisfaction at work was observed. This data can use to show health care providers the benefit in funding this treatment.

Conflict of interest: This study has been supported by Cochlear AG

P2-12-13

Evaluation of benefit from cochlear implantation in patients over 60 yoa in terms of quality of life, speech comprehension, spatial hearing and speech quality

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Introduction: It is currently insufficient to exclusively prove that the device is safe and effective for its intended purpose. It is now important to demonstrate that intervention is clinically useful in a real world environment in different group of patients.

Objective: To address this need this observational study has been designed to prospectively gather patient-related data for implanted patients including true baseline interval data gathered prior to implant or first activation of the device and subsequent longitudinal follow-up at consistently timed evaluation intervals.

Method: Each patient is evaluated at or immediately prior to the first switch on to obtain baseline responses related to their hearing experiences and perception of quality of life in their preimplant hearing condition. Two standard clinical tools: the SSQ and HUI Mark III are available for use and a non-standard general questionnaire in two versions: Clinician version and the Patient version, designed specifically to capture additional patient characteristic information for individuals registered into the observational study. Each patient is to be followed up through routine clinical procedures and in parallel asked to complete the post-implant versions of the questionnaires at their 1st year, 2nd year and 3rd year(optional) follow-up appointment + 2 months of the expected time frame.

Results: 10 patients over 60 yoa who received a cochlear implant in the Department of Otolaryngology of the Medical University in Lublin were included in the study. Demographic and epidemiological data were gathered. Results obtained through standard clinical questionnaires the SSQ and HUI Mark III as well as from the non-standard general questionnaires were analyzed.

P2-12-14

Cochlear implantation in Macedonia

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Cochlear implantation In Macedonia started in 2006. In a population of 2,2 mill. there is 6000 registered cases of deafness or profound hearing loss (2,7‰)[1]. Till December 2013 there were 37 implantations of which 35 children and 2 adults. Male to female children ratio is 21 to 14. Average age of the implanted children was 4,7 years. Adults were 26 (prelingual deafness) and 49 (postlingual deafness) years old. Surgical techniques used were: transcanal (pericanal) approach -3 cases, mastoidectomy-posterior tympanotomy -34 cases. Complications experienced were: removal of the implant due to intolerance-1 case and due to extrusion of the electrode (transcanal approach)-1 case, recurrent ear infection/reimplantation of the other ear 2 cases, surgical problem with electrode placement/reimplantation of the other ear-1case,skin flap inflammation due intolerance-1 case, slight skin inflammation -1 case.

[1] Source: Association of deaf and hearing impaired people in MKD.

P2-12-15

Historical role of a leading cochlear implant center in Brazil

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The Audiological Research Center (CPA) is one of the units of the Hospital for Rehabilitation of Craniofacial Anomalies, from University of São Paulo, campus Bauru, São Paulo, Brazil, for the diagnosis and treatment of hearing impaired people. This center is accredited by the Brazilian Ministry of Health, and it is there that the very first multichannel cochlear implant was performed in the country, in 1990. This presentation reviews the activities of this Center in the last 24 years, totaling, up to December 2013, over than 1,100 implanted patients from different regions of the country, most from the low social strata, benefited by services fully provided by the Federal National Health System. CPA aims at providing services, teaching and research. The activities developed at this Center involve audiological and otolaryngological diagnoses, associated with image studies, when necessary (MRI and CT scans), with posterior conduct definition which includes indication and fitting of hearing aids, indication and surgery of semi-implantable devices and cochlear implant. It is specifically in the cochlear implant program that the pre-surgical and surgical follow-up is performed, as well as the activation and mapping of the electrodes and regular follow-up developed by a specialized interdisciplinary team formed by physician, speech pathologists, audiologist, psychologist and social worker. As far as teaching is concerned, CPA is a human resources forming center, providing specialization courses in Audiology, Social Work and Psychology, ENT residency, multi-professional residency in hearing health. Also, welcomes students from undergraduation and graduation courses provided by the Audiology and Speech Pathology Course. Taking into account the continental dimensions of Brazil, strategies were developed so as to provide specialized and up-to-date assistance to professionals from the patients´ towns. Thus, telehealth actions are being developed in partnership with the Ministry of Education and Ministry of Health, allowing the permanent education courses. The impact of the results obtained and the development of research reflect in the public health policies assumed by the federal government, benefiting users of electronic devices such as hearing aids, FM system, cochlear implant and implantable hearing aids. Thus, this presentation is a way of socializing information on the training and development of a Center which, following the technological evolution in the area, stands as reference institution, maintaining exchanges with practitioners, researchers and international institutions, always seeking excellence in service and production of knowledge in the field of hearing loss.

P2-12-16

Hearing and life quality assessment in post-language patients following cochlear implant

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Introduction: Hearing loss affects millions of people worldwide, leading some of those to economic impairment, social segregation, and a worse quality of life.

Cochlear implants have shown advantages over other treatment alternatives, for it provides considerable hearing gains and therefore greater social interaction possibilities to the affected individuals.

Objectives: to assess the hearing perception and the quality of life of post-lingual individuals with severe and profound bilateral neurosensorial hearing loss who received MED-EL cochlear implant, using speech perception testing and the World Health Organization´s Quality of Life Questionnaire (WHOQOL).

Method: speech perception tests were applied to selected subjects prior to and following the cochlear implant using MED-EL, Sonata Ti^{100} and flex devices; the questionnaires assessing quality of life were answered afterwards.

Results: there was an improvement in the audiometry thresholds, and the patients presented a good quality of life after cochlear implant.

Conclusion: the evaluation of these subjects permits to conclude there are improvements in hearing, and that patients perceive their quality of life to be good after being subjected to cochlear implant.

P2-12-17

Changes in quality of life in prelingually and perilingually deaf adults following cochlear implantation

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Cochlear implantation (CI) in prelingually and perilingually deaf adults is a controversial issue. Indications in this population are very restricted, as most patients will not significantly improve open speech perception skills, because of auditory cortical plasticity. Advances in CI technology and speech processing strategies have led to an increase of the number of pre- and perilingually deafened persons who undergo CI.

This study aims to investigate whether carefully selected pre- and perilingually deafened adults experience subjective benefit after CI.

Nine and six prelingual and perilingually deafened subjects, respectively, participated in this study. Prelingual subjects were implanted at a mean age of 32yr (range, 18-54), and perilingual at 40yr (range, 20-50) with a Nucleus or MED-EL cochlear implant device. Quality of life (QoL) from the implantees was collected at least 6 months postimplantation with the Glasgow Benefit Inventory (GBI) and the Nijmegen Cochlear Implant Questionnaire (NCIQ). The NCIQ test was filled in twice, with results according to QoL previous and after CI, and the improvement was calculated.

7 out of 9 prelingually subjects (77%), and 5 out of 6 perilingually adults (83%) answered the questionnaires. Subjective questionnaires revealed significant changes after CI in both groups of patients and in all subdomains. The mean total GBI score (mean±standard deviation) was 32.1±22,9 and 48.9±23.9, in pre- vs perilingual subjects, respectively. No patients scored negatively. There was no significant difference between the pre- and perilingual patients' results when both tests were evaluated. Mean improvement of pre- and perilingually subjects in each NCIQ subcategory was as follows: basic sound 56.2±29.3, advanced sound 22.0±20.6, speech production 37.7±19.3, self-steem 16.1±14.2, activity 12.2±13.9, social 11.4±15.2.

In the case of severely hearing-impaired adults with prelingual or perilingual deafness, CI must be indicated very carefully, only in highly selected and motivated patients, following a very detailed and adjusted counseling. In these selected population, an improvement of QoL may be expected, with a high inter-subject variability.

Participants will learn how carefully selected prelingually and perilingually deaf adults may improve their QoL after CI. The importance of QoL performance outcomes obtained in this group of patients will be emphasized.

P2-12-18

Cochlear Iiplantation in a patient with a long history of dual sensory deprivation of deafness and blindness secondary to Nasopharyngeal Carcinoma: A case report

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Objective: To report the outcome of cochlear implantation of a patient who is deaf and blind with a chronic middle ear condition.

Patient: 62 year old female who, 20 years ago, had Nasopharyngeal Carcinoma (NPC) extending to the skull base, reaching the optic nerve. She developed bilateral mixed hearing loss (HL) that progressed into profound sensorineural HL 4 years ago. Her visual acuity was also dropped before developing total blindness for over 10 years.

Pre-Surgery: Patient was fitted with monaural hearing aid (HA) on the right after diagnosed with mixed HL at moderate level on the right and severe on the left. She stopped using HA after 13 years when the level of HL became profound 9 months prior to Cochlear Implant (CI) surgery. Unaided and Aided Response Tests showed no response bilaterally. The significant hearing drop caused her unable to comprehend verbal communication. Her basic needs were communicated through simple tactile-hand movements developed by her family. Her limited communication caused self-isolation, subsequently led to severe depression and hallucination in which antidepressant was prescribed. Her family was noted to be psychoemotionally affected.

Temporal Bone CT Scan showed opacity of the middle ear and mastoid cavity, raising a concern for chronic middle ear problem. Cholesteatoma was suspected but not diagnosed. Despite this, CI surgery was decided because her quality of life was significantly deteriorated.

Surgery & Intraoperative Tests: Medel Concerto Standard electrode was implanted on the right through the round window (RW). The middle ear cavity was found to be filled with thick fibrous tissues causing difficulties in exposing the RW. Complete insertion of electrode was not achieved. Impedance Telemetry indicated good electrode status. Auditory Nerve Response Telemetry showed no response.

Post-Surgery: Patient was switched-on 3 weeks post-surgery using Medel Rondo Speech Processor. Her reaction during the initial stimulation of an electrode was a surprised facial expression before she started to take part actively in the mapping process. At Live Mode, she was able to immediately detect, discriminate and identify sounds including speech. She was unexpectedly noted to be very cheerful and motivated.

Follow-up session within a week post switch-on revealed patient's Aided Responses at an average of 40dBHL. She scored 75% in the Arabic Sentence Test. Further follow-up sessions revealed ability to comprehend speech through multiple mediums such as telephone and radio. Hers and her family's quality of life improved significantly within a short period of time. The antidepressant was stopped.

Conclusion: Despite the challenges before and during the CI surgery, the outcome of CI for the patient was remarkable. Her cortical compensation following the prolong deprivation of sensory input; intellectual ability; internal and external motivations are believe to lead to an immediate excellent outcome from CI.

P2-12-19

The impact of overlooked cerumen and or otitis media on the hearing threshold shift, and hearing acuity of speech in children with bilateral sensorineural hearing loss, a public health care problem

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Introduction: Sensorineural hearing loss is accounted as a major public health problem. Auditory function in these children is poor and their hearing threshold could be influenced by some factors such as otitis media and wax. In this paper, our interest is to seek the impact of overlooked ear diseases on hearing threshold shift (HTS), and hearing acuity (HA) in these children.

Methods: This is a quasi-experimental study that was conducted in 54 bilateral sensorineural hearing impaired children (SNHIC) with ear disease in the better ear, without serious ear complains at the low socioeconomic population. Hearing threshold (HT) in the better ear was more than 30 dB (HL), and they aged between 5-20 years. Six cases needed surgical intervention(3 cases had perforated tympanic membrane and the other 3 cases needed insertion of ventilation tube) and were excluded. Modes of interventions were: wax removing (WR), medical treatment of otitis media(OM), and both of modes. Two indices such as (SRT) changes and hearing acuity improvement (HAI) were used before and after (MI) to indicate the (HTS). SRT examined through pure tone audiometer, and scored by dB (HL). (HAI) evaluated by self-reporting of the case, after (MI).

Results: The mean score of SRT shift was 3.9 dB (SD=8.4) for (WR), 15 dB (SD=6.4) for (OM), and25 dB (SD=10) for both of modes. A significant relation was found between modes of (MI) and frequency of SRT shift pv≤0.0001. But these relationship was not statistically significant between the frequency of (HAI) and different modes PV = 0.79. The degree of SRT shift between different modes of (MI) showed significant differences pv≤0.0001. The relation between SRT changes and frequency of (HAI) was statistically significant too.pv≤0.0001

Discussion: ***(OM)*** affect the ***low frequencies*** of auditory signals, which play a determinant role in both: the level of audibility or (HT), and also clearness of speech or (HA). ***Excessive wax*** in the ear canal may involves ***high frequencies*** component of speech, and compromises speech clearness or (HA) .When it occludes the ear canal, it would add a flat conductive hearing loss to (HT). Thus, ear wax plays an efficient role in both audibility status and also in receiving clear speech. From health care point of view, this study shows that an integrated intervention and active role of public health care is a necessity, and should be looked upon more in developing countries.

Conclusion: This study shows that SRT decreased in more than 50% of cases ,and (HA) improved in 38 cases (79.2%) after (MI) .Although the impact of treatment of (OM) on SRT shift was more prominent than (WR) ,but wax had a considerable effect on (HAI) .

Learning outcome: The rehabilitation of (SNHIC) in developing countries is complicated and very expensive, but to look at an overlooked public healthcare services is cost benefit and would also play an efficient role in outcomes of rehabilitation.

P2-12-20

Hearing quality in cochlear implant users over 65 years

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Aim: Determine the hearing quality of elderly patients who received a cochlear implant after 65 years

Introduction: In older adults, hearing loss is relatively common. A third of people over 60 years and 50% of those over 85 years suffer some form of hearing loss. In 10%, hearing impairment is so severe that the benefits that provide hearing aids are minimal. In this group, the hearing losses are one of the causes of behavioral changes, irritability and lack of interest in the world. For this reason, it is important to alleviate hearing problems.

Methods: A multicenter study was conducted, where the sound quality on two groups of cochlear implant users compared. Group 1 consisted of adults between 21 to 65 years (N = 23) (mean: 43.42 years), and group 2 consisted of older adults than 65 years (N = 29) (mean: 70.5 years). The minimum experience with implant was 1 year. All subjects had severe to deep bilateral hearing loss post-lingual. The questionnaire HISQUI sound quality was used to assess their perception of patients about their hearing abilities in different sound environments. Audiometric results, tests of discrimination and speech perception compared. The average auditory deprivation time was: 22.05 years and 32.95 years respectively.

Results: In HISQUI questionnaire, 47 % of patients in Group 1 reported having a very good sound quality, 29 % good, 18 % regular and 6% bad. In group 2, in HISQUI, 32% had very good sound quality, 32% good, 18% regular and 14% bad. In both groups the greatest difficulties were presented in highly competitive situations hearing. The results are slightly worse in group 2, but not statistically significant. The results in the audiometric tests were similar in both groups (mean: Group 1: 22.83 dB; Group 2: 23.38 dB). In tests of perception, 53 % of subjects in group 1 are in category 6 of speech perception (Moog and Geers, 1995), 29 % are in category 5 and 18 % in category 4. In group 2, 45 % of the subjects are in category 6, 23 % in category 5, 23 % in category 4, 4.5 % in category 3 and 4.5 % in category 2. In discrimination tests, group 1 showed 92.57 % discrimination in disyllabic words phonetically balanced. Group 2 showed 83.09 % discrimination. In monosyllabic words, group 1 presented a percentage of discrimination of 84.29 %. Group 2 showed a percentage of 73.63 %. In both groups, the patients with longer auditory deprivation scored lower on tests HISQUI and discrimination and speech perception.

Conclusion: When comparing both groups results sound quality, discrimination and speech perception, slightly higher in group 1 vs group 2 are appreciated. However, this difference is not statistically significant. If a person over 65 years with severe to profound SNHL, which does not benefit from hearing aids use, and have realistic expectations about how much to what to expect from a cochlear implant, the age should not be a reason to exclude it to be a potential candidate for a cochlear implant.

P2-12-21

Classroom participation and academic competence of cochlear implanted junior high school students in Japan

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Background: Worldwide popularization of social inclusion policies, neonatal hearing screenings, and pediatric cochlear implants has led to an increasing number of students with hearing disorders attending general junior high schools, rather than schools for the deaf. However, there are two serious concerns regarding the education of hearing-disabled students in Japanese general schools: excessively large class sizes (35 students to one teacher, as a national rule) and a lack of additional support (e.g., note-takers, itinerant teachers).

Objectives: This study investigated the effects of classroom participation on academic competence among junior high school students with cochlear implant(s) or CI(s).

Methodology: Participants were 42 junior high school students with CI(s), including 23 who were attending schools for the deaf and 19 who were students in mainstream schools. There were 25 boys and 17 girls; their average age at the time of the study was 14.3 years (SD: 0.89 y). They had received CIs around the age of 4.8 years (mean; SD: 1.97 y), and had been using CI(s) for an average duration of 9.3 years (SD: 2.22 y). The hearing levels of ears with CIs averaged 26.5 dB (SPL), while the mean speech audiometry score was 82.6%. To assess students' functional outcomes in classroom participation, a Japanese edition of the Classroom Participation Questionnaire for the school-aged hearing disabled was employed (Saito et al., 2013), which was based on the Classroom Participation Questionnaire or CPQ (Antia, et al., 2007). It consists of 16 items rated on 4-point Likert scales, across four subscales: “Understanding Teachers/UT,” “Understanding Students/US,” “Positive Affect/PA,” and “Negative Affect/NA.” Academic competence was measured with the 10-item Japanese version of the Perceived Competence Scale for Children or JPCSC (Sakurai, 1992). Participants were asked to read and respond to these questionnaires in speech therapy rooms in our hospital. To confirm the internal consistency reliability of the Japanese version of the CPQ and the JPCSC, Cronbach's α was calculated.

Results: Cronbach's α was over 0.7 for the total scales and subscales, indicating that both measures had adequate internal consistency. Pearson's correlation analysis on the relationship between classroom participation and academic competence revealed that UT is related to academic competence. This relationship remained significant in partial correlation analysis controlling for verbal IQ and types of participants' schools.

Conclusions: Regardless of the type of schools they were attending, the subjective feelings of students with CIs about classroom participation play a significant role in improving their academic competence.

P2-12-22

Relation between outcome and quality of life in elderly patients with unilateral cochlear implant

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Problem: The benefits of cochlear implant (CI) in patients with profound sensorineural hearing loss is scientifically undeniable when the sound amplification is not enough to get a proper hearing gain. The problem under study is the impact of post- linguistic IC in their auditory perception regarding quality of life elderly patients.

Objective: The objective of this study is to demonstrate through standardized tests and surveys the impact of IC on quality of life in elderly users.

Materials and methods: 26 elderly patients in the ages between 55 to 83 years CI users were included in the study; with cochlear implants from different manufacturers all of them were post-lingually deaf and use unilateral CI. Evidence of functional gain, evidence of discrimination in the closed and open set in Spanish language, questionnaires NCIQ, SF36, and Hearing Handicap Inventory, were performed. Results using the SPSS 20.0 statistical tool using a multivariate regression analyzes.

Results: An average age of 62.4 years with an average use of IC 3.7 years and an average of 6.96 hours per day everyday use was observed. The results reflect the functional gain thresholds averaged conversational frequencies 18.3 dB SPL. The case of speech perception tests, the distribution was symmetrical without noticing impact of age on this result, there is a marginally significant difference in discrimination of sentences and comprehension is affected with age. The impact of IC NCIQ respect to social interaction is important in social activity and self-esteem. SF36 shows moderate to slight impact on quality of life related to the age of the patient.

Conclusion: A significant auditory impact and gain is observed in this population, this impact is not seen in QoL and this may due to related no CI related conditions not measurable by the instruments used and very little information on the impact of cognitive abilities that affect the auditory performance and interaction.

P2-12-23

Tîrgu Mureș, the youngest cochlear implant center in Romania

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The hearing status of the Romanian population implies a real need for effective rehabilitation of these major impairment cases. Besides Iași, the ENT center which first introduced the cochlear implantation in Romania in 2000, followed by Bucharest, Timișoara and Cluj -Napoca, the Transylvania´s population (with a significant percentage of Hungarian and German languages native speakers) made it necessary to include in the National Healthcare Programs of the Romanian Ministry of Health the ENT Clinic - Tîrgu Mureș - which is now complying to these modern methods of hearing recovery.

Started in 2010: the first two hearing rehabilitation devices implanted in Tîrgu Mureș ENT Clinic were a Vibrant Soundbridge and a Cochlear Implant provided by MED-EL. A development strategy was initiated through increasing the number of implanted patients from 4 in 2012 to 6 in 2013, as the necessary conditions were reached.

Table I./a-b presents the cases selected and prepared with the support of our colleagues in Bucharest (Colțea ENT-HNS Clinic and Audiologos Hearing Center).

Nr.	Name	Birth date	Date of CI surgery	Type of CI's electrode	Comorbidities	Postoperative problems
1	I.S.T.	05.03. 1957	02.02. 2010	VSB		
2	D.O.	14.12. 2005	02.02. 2010	Sonata		
3	P.B-CS.	16.05. 1970	23.03. 2012	Pulsar Standard		
4	G.V.	05.02. 1946	24.03. 2012	Sonata Compressed	Incomplete cochlear ossification, labirinthised otosclerosis, vertigo	Facial palsy on implanted side. Severe tinnitus first 6 months post-surgery, currently remitted
5	A.V.B.	03.01. 2010	24.03. 2012	Concerto Standard	Eye symptoms, slightly autistic	
6	D.D.	02.04. 1997	24.03. 2012	Concerto Standard		

[Table I./a]

7	V.I.M.	29.07. 2002	23.03. 2013	Concerto Standard		
8	A.G.P.	09.09. 2011	23.03. 2013	Concerto Flex Soft		
9	M.H.	03.12. 2007	15.11. 2013	Concerto Flex28		
10	B.A.M.	04.06.2008	15.11. 2013	Concerto Flex28	Eye coloboma, Left spastic hemiparesis	
11	A.C.	15.04. 1971	16.11. 2013	Sonata Standard	Otosclerosis	
12	B.G.P.	19.07.1995	16.11. 2013	Concerto Standard	Prior implantation surgery: septal deviation, chronic hypertrophic rhinitis	Sensitive skin in implant area, headaches, vertigo on implant activation

[Table I./b]

Being beginners in the field of CI surgery, we needed the valuable and competitive support provided by MED-EL which invited renowned foreign surgeons to assist our team. Under these circumstances we only had one major postoperative incident - a case of facial palsy. All recipients were strictly followed up and they registered a considerable benefit from their hearing implants regarding the communication capabilities as well as enhancement of their day by day quality of life.

In consensus with our development policy of the CI surgery Program, we planned 8 implants for 2014 and 10 for 2015 although the waiting list is much longer. Based on our early good results, we want to submit to the ENT-HNS National Commission at the Ministry of Health a proposal regarding the foundation of a CI Department. By this we will try to implement some good practice management in patient selection criteria and statistical follow up of recipients.

P2-12-24

Change in attitude to cochlear implants in born deaf adults

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Introduction: Traditionally born deaf adults who use British Sign Language as their prime mode of communication have not been candidates for cochlear implantation. At the Midlands Hearing Implant Programme we have seen an increase of referrals from this group who are seeking or exploring the possibility of cochlear implantation.

We decided to explore this apparent change in attitude.

Method: A notes review was conducted over several years looking adults who received a unilateral cochlear implant in line with -National Institute of Clinical Excellence (NICE) guidelines.

This group through an interview completed a questionnaire covering aspects such as change in attitude, motivation, expectations and the role of social media in influencing them seeking a cochlear implant. Outcomes from this group will be evaluated looking at City University New York (CUNY) sentence tests with and without the cochlear implant and the Glasgow Health Status Inventory.

Results: Results of questionnaires were examined and these results show a clear change in attitude over the last years to issues regarding cochlear implantation. Including motivation to receive a cochlear implant in the born deaf population.

Discussion: Discussion around possible reasons for this change in attitude will be presented.

Conclusion: More born deaf adults are coming forward for cochlear implantation. Outcomes for this group can be beneficial.

P2-12-25

High charge electrical stimulation is associated with hearing loss after hearing preservation cochlear implantation

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Objective: Mild loss of residual low frequency hearing occurs after insertion of a hearing preservation cochlear implant (average 10-12dB) and has been attributed to surgical trauma. The majority of patients subsequently demonstrate stable or even improved thresholds. A small cohort of patients, however, experience accelerated loss of acoustic hearing after activation of the implant. Here, we sought to determine whether high electrical charge increases the odds of developing late ipsilateral hearing loss after hearing preservation cochlear implantation.

Methods: Retrospective cohort study

Results: 43 implantees met criteria for inclusion. Hearing loss, maximum current levels and pulse widths after the initial post-implantation period were examined. When comparing the rate of hearing loss after activation with maximum charge levels, the Pearson correlation coefficient was 0.366 (p=0.016) indicating a significant, moderate association of hearing loss with stimulation charge. Next, we divided the patients into groups based on the rate of hearing loss after activation (>10dB/mo or < 10dB/mo) and maximum charge (>18nC or < 18nC). This current level represents a 2-fold higher charge level than the average level for patients with standard electrode arrays. Of these 43 patients, seven experienced a rapid rate of ipsilateral hearing loss (>10dB/mo) subsequent to or concurrent with high maximum charge (>18nC); two individuals experienced no acceleration after high charge exposure, four individuals had a high rate of hearing loss with no significant charge exposure while 30 individuals had stable hearing in the absence of high charge. Thus, the odds ratio for a rapid rate of hearing loss after exposure to high charge is 26.25 - further confirming a robust and statistically significant association (Fisher's exact test, p< 0.001).

Conclusions: Ipsilateral loss of acoustic hearing after hearing preservation cochlear implantation may limit benefit from combined modes of hearing. We show that high charge levels are associated with delayed hearing loss in the few patients that lose significant acoustic hearing after electrode activation. As the charge levels used here were still within the safe limits of electrical stimulation, this hearing loss might be due to a combination of electric stimulation coupled with acoustic amplification resulting in excitotoxic neural damage, similar to that seen in acute noise trauma. These data suggest that limiting exposure to potentially excitotoxic stimuli (e.g. loud noise, high pulse amplitude and pulse width) may be critical for protection of low frequency hearing in susceptible individuals.

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