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CAD/CAM full-mouth rehabilitation of an elderly patient: One-piece digital complete denture meets multilayered zirconia with gradient technology

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Abstract

Objective: This article highlights a CAD/CAM complete-mouth rehabilitation in an 82-year-old patient by means of a complete maxillary prosthesis and mandibular implant- and tooth-supported fixed restorations made from multilayered zirconia.

Clinical Considerations: Comprehensive complete-mouth rehabilitations in elderly patients with adaptation of the occlusal vertical dimension (OVD) often present particular challenges. This applies especially when exacting functional and esthetic requirements are to be met and the treatment should not cause the patient too much effort, still ensuring the highest level of quality and efficiency and a low intervention rate.

Conclusion: The digital approach used for the present patient allowed for an efficient treatment procedure, facilitated virtual evaluations using a face-scan, and enhanced the predictability of the prosthodontic outcome. The approach enabled some steps required in the conventional protocol to be omitted, resulting in a straightforward clinical treatment with minimal strain on the patient.

Clinical Significance: Because of the comprehensive recording of extraoral and intraoral data, for example with a facial scanner, it was possible to transfer a digital replica of the patient to the dental laboratory technician. With this protocol, many steps can be performed in the absence of the real patient.

KEYWORDS

CAD/CAM, complex rehabilitation, digital complete dental prosthesis, gradient technology, implant prosthodontics, monolithic zirconia, multilayer

1 | INTRODUCTION

Complex rehabilitation in older patients can be challenging for the entire restorative team. This is especially true when the occlusal vertical dimension (OVD) is to be reconstructed or redefined with a combination of removable and fixed prostheses.

The Fifth German Oral Health Study reported that, in 1997, one in four seniors aged between 65 and 74 years (24.8%) was edentulous. In 2016, one in eight seniors (12.4%) was edentulous.[1] Therefore, the number of complete denture wearers in this age group has decreased. However, the reduced demand for complete dentures contrasts with the fact that the absolute number of patients requiring restorative treatment is probably unlikely to fall significantly because of the increase in life expectancy.[2,3] The post-World-War II years with high birth rates could also have generated an additional increase in demand, especially in industrialized countries. Nevertheless, successful contemporary dentistry and preventative measures have delayed complete edentulism until a more advanced age.

Treatment of the elderly presents additional challenges for the dentist and dental laboratory technician. Because of the time required to fabricate complete dentures and the often limited mobility of older patients, existing dental prostheses are often repaired and/or relined instead of providing new ones. Digital technologies in combination with new treatment approaches may reduce the number of treatment sessions for the patient, improve predictability, and, as a result, result in increased acceptance, particularly among older patients.

1.1 | Removable restorations

Digital complete dentures have recently become popular, with several manufacturers offering CAD/CAM complete denture fabrication. However, the methods and the implementation of their workflows differ considerably, and these systems can be classified based on their method of fabrication[4,5] or on the technical manufacturing process, that is, how the prosthesis is produced with digital technology (Figure 1). A distinction can be made between additive and subtractive processes, both of which provide benefits and drawbacks. Especially with additive manufacturing protocols, unresolved issues that require scientific research and evaluation remain.[6] The fully digital subtractive single-component system (Ivotion system, Ivoclar, Schaan, Liechtenstein) seems to provide promising benefits. This technology appears to offer excellent material quality, with straightforward fabrication methods.

Additive fabrication (3d printing) – examples
- Dentca CAD/CAM-Denture (Dentca, Los Angeles, CA, USA)
- dima Print Dentures/Pala Digital Denture (Kulzer, Hanau, Germany)
- Lucitone Digital Print Denture System (Dentsply Sirona and Carbon)
Subtractive fabrication (milling) – examples
Semi-digital approach
- Ceramill Full Denture (Amann Girrbach, Koblach, Austria)
Complete digital approach - bonded teeth
- Ivoclar Digital Denture (Ivoclar Vivadent, Schaan, Liechtenstein)
- AvaDent XCL-1 (AvaDent, Scottsdale, AZ, USA)
- Vita Vionic (Vita Zahnfabrik, Bad Säckingen, Germany)
- Zirkonzahn Totalprothese (Zirkonzahn, Gais, Italy)
Complete digital approach – monolithic
- Merz Dental BDS ("Baltic Denture System") (Merz Dental, Lütjienburg, Germany)
- AvaDent XCL-2 (AvaDent)
- Ivoclar Ivotion Denture ((Ivoclar) Vivadent)

FIGURE 1 Overview of the digital fabrication of complete dentures.

1.2 | Fixed restorations

Metal-ceramic restorations are still considered the standard for definitive fixed prostheses with excellent long-term clinical outcomes,[7,8] especially for fixed partial dentures supported by abutment teeth or implants.[9,10] More recently all-ceramic materials with excellent biocompatibility and esthetics have become an alternative to metal-ceramic restorations in many areas of restorative dentistry. Glass-ceramics have been well-researched for single-tooth restorations in long-term clinical studies. Over a 10-year period and depending on the type of material, they demonstrate comparable clinical success rates for crown restorations.[8,11] The introduction of the first CAD/CAM systems for the fabrication of zirconia ceramic frameworks almost 25 years ago helped extend the indications for all-ceramic restorations, including posterior fixed partial dentures.[12,13]

Since then, the range of materials for zirconia-based restorations has increased. The first systems were based on 3 mol% yttria-stabilized tetragonal zirconia polycrystal (3Y-TZP) doped with a small amount of Al_2O_3 to prevent early hydrolytic degradation. Because of its high opacity, this 3Y-TZP was used almost exclusively as a framework material and manually veneered using sintered ceramics. For different reasons, most of them technical, the rate of chipping of the veneering ceramic was considerably higher than that of established metal-ceramic systems.[14] In vitro studies were able to demonstrate that with an anatomic-contour design, all-ceramic restorations could be produced with reduced fabrication effort, a more anatomic design, and improved mechanical reliability,[15] leading to the popularity of monolithic all-ceramic posterior restorations. Because of their esthetics, translucent glass-ceramics have been primarily used for monolithic single-tooth restorations.

More translucent zirconia ceramics have been introduced as a monolithic option. Currently four types of zirconia are available, with more to come. The first generation, introduced almost 25 years ago, is the 3 mol% yttria-stabilized tetragonal zirconia polycrystal (3Y-TZP, 0.25 wt% Al_2O_3) with a flexural strength of around 1000 MPa and opacity similar to that of dentin.[16,17] Most long-term studies on zirconia restorations have reported the performance of materials from this first generation. About 10 years ago, a zirconia material was introduced that included a reduced amount of aluminum oxide (3Y-TZP, 0.05 wt% Al_2O_3). This generation had a slight reduction in flexural strength but increased translucency.[18] Soon, a 5 mol% yttria-stabilized tetragonal zirconia polycrystal (5Y-TZP or 5Y-CZP) was developed that is also known as fully stabilized zirconia with a cubic tetragonal microstructure or more commonly as "cubic-phase zirconia."[19,20] A fourth generation was marketed in 2017 with the introduction of a 4 mol% yttria-stabilized tetragonal zirconia polycrystal (4Y-TZP).[21]

Because of the limitations of anatomic-contour zirconia restorations in the esthetic zone, multilayer systems were developed for the various generations. As early as 2013, the first multilayered zirconia (Katana ML, Noritake Kuraray) was marketed, aiming to increase the clinical indications for monolithic zirconia restorations. Multilayer systems are fabricated monolithically but have polychromatic properties with improved replication of the gradient shading of natural

FIGURE 2 Initial situation: Conventional maxillary prosthesis that was over 40 years old and had been extended on several occasions and metal-ceramic restorations with visible crown margins, black triangles, and wear of the unrestored mandibular anterior teeth.

FIGURE 3 Initial maxillary situation: Hopeless residual roots in an otherwise edentulous maxilla.

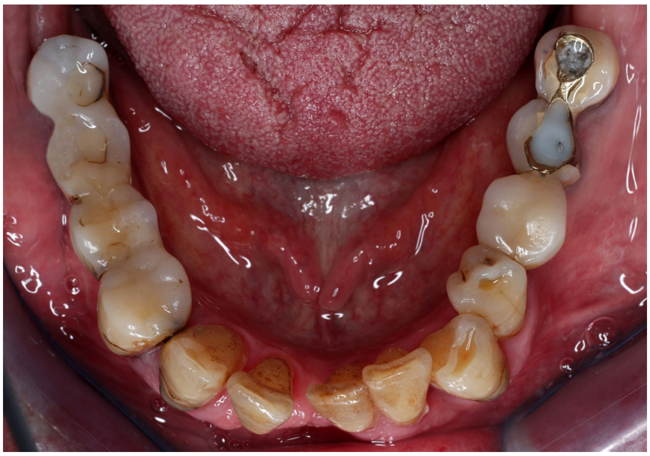

FIGURE 4 Initial mandibular situation: The remaining teeth and four implants in the molar areas restored with metal-ceramic fixed prostheses.

dentition.[22] Imitation of the shade-gradient of natural teeth has been implemented in one zirconia type by using pigmentation (color-gradient). Each multilayered blank consists of the same type of zirconia with the same flexural strength in the different layers.

Recently, another multilayer technology has been introduced, integrating different generations of zirconia in one blank (strength-gradient). The 3Y, 4Y, and 5Y-TZP materials currently available differ considerably in terms of strength (500 to 1200 MPa) and translucency but offer similar Vickers hardnesses (HV 1200 to 1300).[23,24] The combination of the generations is predominantly a high-flexural strength 3Y-TZP in the dentin/body area for higher stability and a high-translucency 5Y-TZP in the incisal or occlusal area to enable enamel like esthetics.

Multilayer zirconia ceramics are now available that offer a gradient of shade and/or of strength,[25] with the aim of merging the advantages of both generations of zirconia. As a result, there is a large range of materials to choose from.[26]

The clinical and dental technological steps in a complete-mouth prosthetic rehabilitation of an 82-year-old patient, including increasing his OVD through removable and fixed restorations, are described. A novel technique for the CAD/CAM fabrication of a maxillary complete denture in which the dental arch and denture base were milled and fabricated from a single prefabricated blank ("one-piece technique") is introduced. In the mandible, crowns and fixed partial dentures were fabricated from milled anatomic-contour multilayer zirconia (gradient technology, 3Y-TZP/5Y-TZP) placed on dental implants and natural teeth.

2 | CASE PRESENTATION

An 82-year-old man requested the replacement of maxillary and mandibular prostheses, both of which had been in service for more than 20 years (Figure 2) and were functionally and esthetically deficient. The maxillary partial prosthesis had been extended several times, and all remaining teeth were fractured and considered hopeless (Figure 3).

In the mandible, the incisors, with the exception of the right central, the canines, and the premolars remained. Four implants (Straumann Classic Octa, ∅ 4.1 mm, length unknown, RN; Straumann, Basel, Switzerland) replaced the first and second molars, which, according to the patient, had been inserted in 1999 (Figure 4). The existing metal implant superstructure in the left mandible was designed as a fixed prosthesis supported by implants replacing the first and second molar. The second premolar as designed as a cantilevered pontic. In the right mandible, a four-unit fixed prosthesis connected two implants in the positions of the molars and the remaining first premolar. The first premolar had been restored with a metal post and core. All implant superstructures were defective with chipped veneers, loosened screws, and one screw fracture (Figure 4). The remaining mandibular incisors were considered hopeless because of progressive attachment loss (Figure 5). Radiological examination showed an impacted and displaced left maxillary third molar (Figure 6). The occlusal planes of the existing restorations did not

FIGURE 5 Mandibular anterior dentition, initial situation: Incisors showed significant mobility (grade II to III).

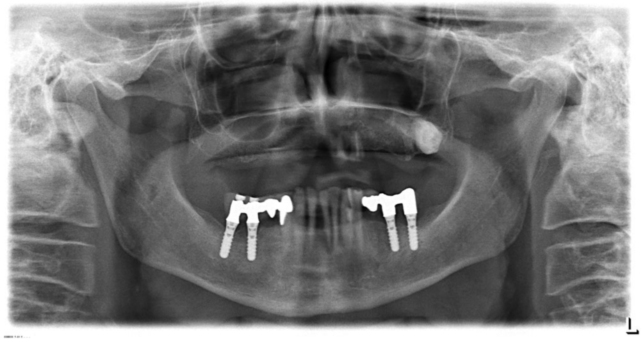

FIGURE 6 Pretreatment panoramic radiograph: Radiological examination revealed reduced attachment of the mandibular anterior teeth. Impacted and displaced maxillary left third molar was also evident.

correspond to esthetic or functional guidelines and requirements (Figure 2).

2.1 | Treatment planning

Extraoral and intraoral photographs were obtained to orientate the dental laboratory technician to the clinical situation. Preliminary impressions of both jaws were then made, diagnostic casts were poured, and a 3D facial scan using a transfer fork with Face Hunter (Zirkonzahn, Gais, Italy) was obtained (Figure 7). The transfer fork was used for facial orientation of the occlusal plane.

Following laboratory and clinical analysis, as well as evaluation of the benefits and risks of alternative restoration options, the patient and the treatment team opted for the following treatment plan:

- Creation of a diagnostic virtual design for the reconstruction of an esthetically and functionally appropriate occlusal position with correction of the occlusal plane.
- Intraoral evaluation of the design by the patient regarding esthetics and speech with chairside-fabricated trial restorations.
- Fine adjustment of the trial restorations together with the patient.
- Maxillary arch: Provision of a one-piece complete denture fabricated using CAD/CAM technology.
- Mandibular arch: Crowns and fixed prostheses from monolithic zirconia (multilayer gradient technology):

A fixed partial denture supported by the canines replaced the incisors. The first premolars were restored with single crowns and implant-supported cantilever fixed prostheses replaced the molars and second premolars.

2.2 | Pretreatment, preparation, and temporary restorations

Following professional prophylaxis, a clinical evaluation of the virtual design was performed using two different techniques: In the maxilla, a milled monolithic and monochromatic first version of the virtually designed complete denture (ProArt CAD Try-In (Ivoclar)) was used. For the mandible, an additive shell CAD/CAM-PMMA derived from the digital waxing and placed onto the pre-existing restorations was used as a trial restoration. Before removal of the remaining maxillary roots and hopeless mandibular incisors, the canines were prepared for the placement of an interim fixed partial denture (Telio CS C&B, shade A3, Ivoclar) that was fabricated chairside to replace the mandibular incisors. Definitive treatment was initiated after a 12-week healing period.

2.3 | Definitive treatment

The digital complete denture was fabricated by scanning an analog functional impression made in a custom tray fabricated on the preoperative gypsum cast using a light-polymerizing polymer (Palatray XL, Kulzer Dental, Hanau, Germany). This custom tray was border molded with a thermoplastic material (GC bite compound, GC International, Luzern, Switzerland) paying special attention to the functional areas during dynamic movements. A low-viscosity polyvinylsiloxane impression material (Aquasil Ultra LV Low Viscosity, Dentsply Sirona) was used for the definitive functional impression.

In the mandible, the teeth were reprepared, and a definitive impression made. The maxillomandibular relationship was recorded in the centric relation position. The OVD was defined according to multiple parameters, including the incisal edge position of the maxillary central incisors, the width-to-length ratio of the incisors, the phonetic distance, the freeway space, and the facial profile (upper and lower proportion of the face). After gypsum casts had been fabricated and digitized, the planned restorations were fabricated by using digital technology. The information concerning OVD and the maxillomandibular relationship was transferred into the software program by scanning the entire articulator, including the gypsum casts (Laboratory scanner: Zirkonzahn S 900).

The Ivotion system (Ivoclar) was used for the complete maxillary denture. Mandibular anatomic-contour monolithic restorations were fabricated from multilayer zirconia (IPS e.max ZirCAD Prime; Ivoclar).

FIGURE 7 3D facial scan (Face Hunter) of the initial situation with and without the use of a transfer fork. The 3D facial scan enables virtual evaluations while the transfer fork facilitates facial orientation of the occlusal plane.

FIGURE 8 A completely digital option for restoring the existing Straumann Classic Octa implants placed in 1999 was lacking. For this reason, titanium abutments were fabricated using an analog approach in a parallel milling unit.

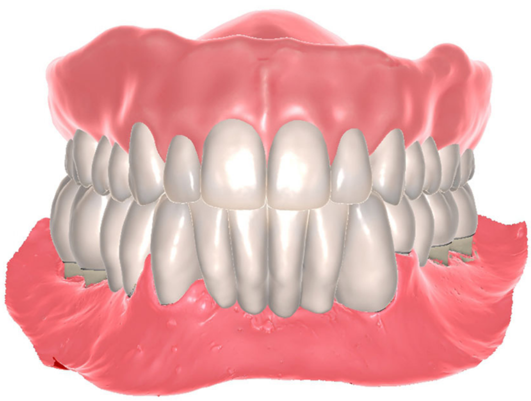

FIGURE 9 Definitive CAD design of the mandibular restorations and the maxillary tooth arrangement.

As a digital option was unavailable to restore the Straumann Classic Octa implants placed in 1999, titanium abutments were milled using an analog approach in a parallel milling unit (Figure 8). Subsequently, the analog casts were digitized together with the completed titanium abutments by using a 3D laboratory scanner S900 (Zirkonzahn) (Figure 8). The 3D facial scan was then input into the software program (Figure 7). The transfer fork allowed for the fusion of the intraoral surface data and the extraoral face and enabled correct orientation of the digitized casts.[27]

2.4 | Fabrication of the restorations

Based on the casts aligned with the patient's face, mandibular anatomic-contour crowns and fixed prostheses were designed, and a tooth arrangement carried out for the maxillary complete denture with a CAD software program (Modellier, version v6173_6843_x64; Zirkonzahn) (Figure 9). Particular attention was paid to the alignment of the restorations in relation to the skull in terms of the orientation planes and lines, especially the alignment of the occlusal planes in accordance with Camper's plane while also taking the interpupillary line and facial midline into consideration (Figure 10). The facial scan was also used to verify the length of the maxillary incisors and to design a positive anterior arch from the frontal view ("incisal curvature"). An anterior guided (canine-protected) occlusion was used for the occlusal scheme since the patient's anatomy indicated that the complete denture would have sufficient stability and retention. The occlusal concept comprised ABC contacts in static occlusion and "freedom in centric" in dynamic occlusion.

The completed design for the mandibular restorations was imported to the CAM software program (Programill CAM V4.2.14.0 Advanced; Ivoclar), where it was further edited for CNC milling. The scan of the edentulous maxilla was then loaded to the complete dental prosthesis module of the CAD software program (DentalDesigner 2020; 3Shape, Copenhagen, Denmark). The virtual maxillary tooth arrangement was imported as "prepreparation scan" data. The entire

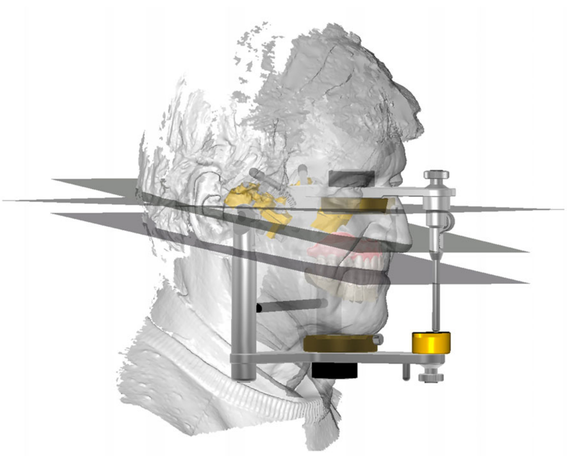

FIGURE 10 The use of 3D facial scanning enabled particular attention to be paid to the alignment of the restorations in relation to the skull in terms of the orientation planes and lines.

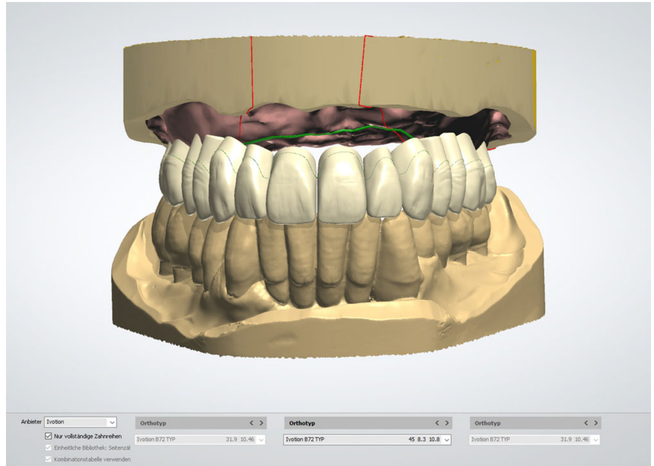

FIGURE 11 When designing the Ivotion dental prosthesis, the teeth were first selected from a tooth library and correctly positioned.

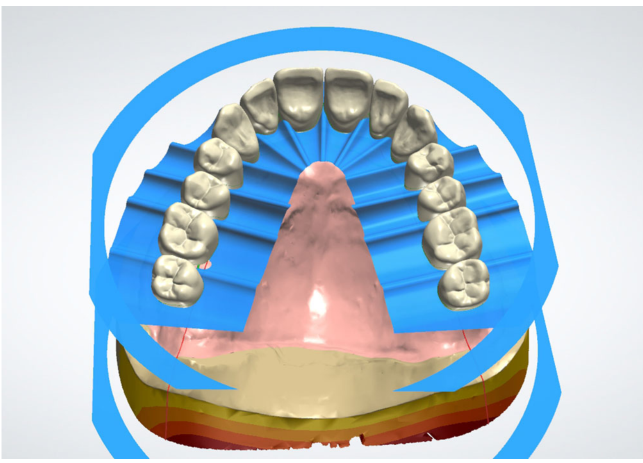

FIGURE 12 The next step was alignment of the virtual disc using the "Shell Geometry" to achieve optimum adaptation of the gingival contour in relation to the dentition.

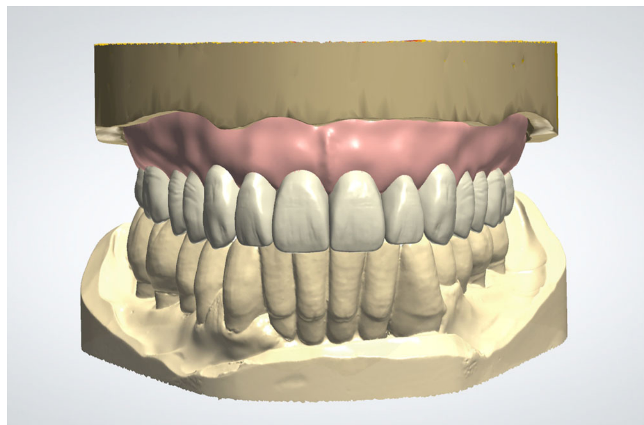

FIGURE 13 Modeling of the gingival areas was the final step in designing the Ivotion dental prosthesis.

mandibular restorative design was merged virtually with the mandibular cast (Modellier; Zirkonzahn) and then imported as an opposing cast in the 3Shape complete dental prosthesis module.

The complete denture was designed as an Ivoclar Ivotion dental prosthesis. Therefore, the correct spatial orientation of the disc had to be considered in addition to the tooth arrangement. This is necessary because the single Ivoclar Ivotion disc comprises a section for the dental prosthesis base, as well as a section for the teeth. The boundary between both sections is designed as the "Shell Geometry" that replicates the gingival contour along the teeth; this enables a natural design for the complete dental prosthesis, especially in the transition between pink and white resin. Using the prepreparation scan, The appropriate teeth (shape, size) for the Ivotion dental prosthesis could be selected from a virtual tooth library and correctly positioned (Figure 11). Alignment of the virtual disc was also carried out by using the Shell Geometry to achieve optimal adaption of the gingival contour in relation to the dentition (Figure 12). Modeling of the gingival areas was the final step in designing the Ivotion denture (Figure 13).

Following CAD design, the data were saved in the CAM5 output format that included all the necessary information (including alignment, tooth definition, and denture base definition) for CAM fabrication. The CAM calculation of the milling paths for the mandibular monolithic restorations made from IPS e.max ZirCAD Prime and the maxillary Ivotion complete denture was carried out with the CAM software program (Programill CAM V4.2.14.0; Advanced). The zirconia material used was a disc (gradient technology) that enabled a layering for shade, translucency, and strength (5Y-CZP/3Y-TZP) (Figure 14). Thus, it was possible to position the restorations at custom heights in the CAM software program. For strength, the fixed prosthesis connectors must be located as close to the edentulous ridge as possible.

When positioning the maxillary complete denture in the CAM software program, five holding pins were created on the outside of the denture base (Figure 15) to retain the disc. Calculation of the

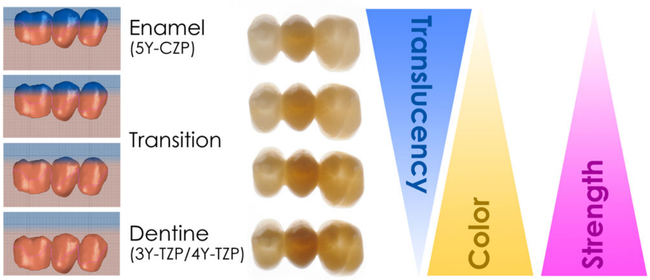

FIGURE 14 The zirconia material used (IPS e.max ZirCAD Prime) is designed as a disc with gradient technology that provides gradients for shade, translucency, and strength.

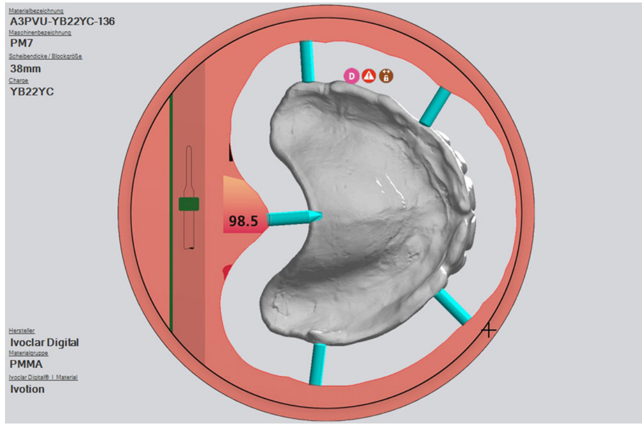

FIGURE 15 The Ivotion maxillary complete denture was designed in the CAM software program with allowance for the circular working area and was retained in the milling disc using five holding pins.

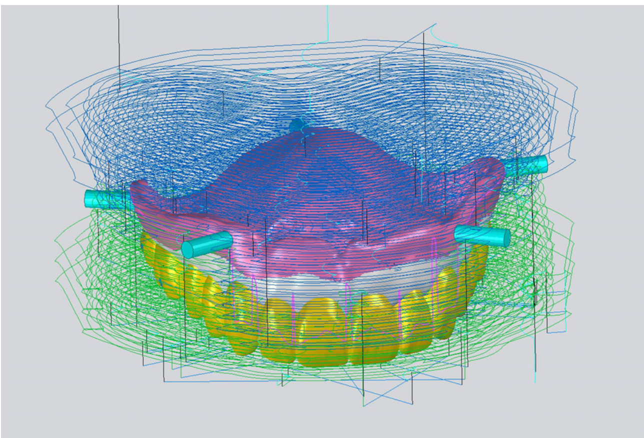

FIGURE 16 Simulation of the different milling paths of the maxillary Ivotion complete denture in the PrograMill CAM V4.2.14.0 (Advanced) CAM software program from Ivoclar.

FIGURE 17 Posterior fixed prosthesis made from IPS e.max ZirCAD Prime before final sintering on the sintering tray. [Correction added on April 6, 2023, after first online publication: Figure 17 caption have been altered.]

milling paths (Figure 16) was then followed by postprocessing that included generation of the CNC files for the PM7 milling machine (Ivoclar). The zirconia restorations and the Ivotion complete denture were fabricated. Once milled, the fixed partial dentures were separated from the disc, and the holding pins removed. Before sintering, a cross-cut milling tool and a special zirconia-rubber polisher "2 IN 1" (Komet Dental/Gebr. Brasseler, Lemgo, Germany) were used to customize the surface texture so that postprocessing of the densely sintered object was only required for adaption of the occlusal and proximal contacts. Sintering was carried out in a furnace (Programat S1 1600; Ivoclar) using the standard sintering program at 1500°C in 9 h 50 min (Figures 17 and 18). Following dense sintering, finishing was carried out with the Ivocolor system (Ivoclar) at 710°C with several stain and glaze firing cycles (Figure 19). When firing large restorations, including fixed partial dentures, thermal strain must be avoided by using a low heating rate (15°C/min) as well as slow cooling.

After the complete denture had been milled, it was removed from the Ivotion disc, the holding bars were ground away, and minor finishing steps were carried out. This was limited to separation of the denture teeth, surface texturing the denture teeth and denture base, and final polishing (Figure 20A,B).

2.5 | Delivery of the restorations

The maxillary complete denture was delivered first. Healing had been uneventful (Figure 21), and attention was paid to the congruence of the denture bearing area to the denture base, the extension of the prosthesis borders and posterior palatal seal, the positional stability, and the necessary freedom of movement for the vestibular frenula.

After removal of the mandibular interim restorations, the abutment teeth were cleaned with a small nylon brush (order no. 9531.204.020, Komet Dental) and a fluoride-free paste (Zircate Prophy Paste, Dentsply Sirona, Constance, Germany). On the implants, (Straumann Classic Octa) transparent insertion aids were used for the initial screw attachment of custom-fabricated titanium abutments (Figure 22A–C). This was necessary, since an antirotational feature was not present at the implant-abutment interface with the Straumann Classic Octa implants. The two monolithic zirconia fixed partial dentures to be supported by implants were evaluated, as was

FIGURE 18 Fixed prosthesis after sintering completed.

FIGURE 19 Anatomic-contour mandibular anterior fixed partial denture made from IPS e.max ZirCAD Prime after staining and glazing.

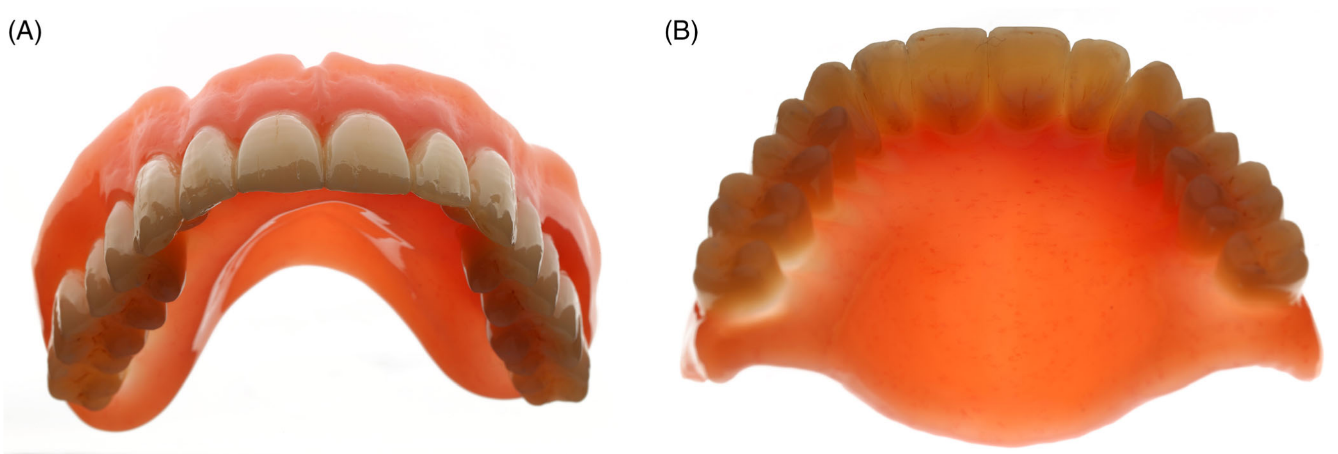

FIGURE 20 Definitive digital maxillary complete denture (A: frontal aspect; B: palatal aspect).

FIGURE 21 Edentulous maxilla after uneventful healing.

the zirconia fixed partial denture on natural teeth and the two zirconia single crowns, beginning with verification of the proximal contacts. Using a fit checker (Fit Test C&B, Voco, Cuxhaven, Germany), the fit of the individual restorations was then reviewed on the abutment teeth. Occlusion was then verified, and minor corrections were only carried out on part of the maxillary complete CAD/CAM denture. No adjustments to the newly fabricated all-ceramic restorations were required.

Following clinical evaluation, mechanical cleaning of the preparation surfaces and intaglio surfaces of the restorations was repeated with brushes and fluoride-free pumice to remove any residual silicone from the fit checker. On the abutment teeth, a relatively dry environment was established by placing nonimpregnated displacement cord (Ultrapak, size #000; Ultradent Products, Inc) in the sulcus apical to the preparation margin. A dual-polymerizing luting composite resin (Variolink Esthetic DC; Ivoclar) was used for the definitive cementation of the crowns and fixed partial dentures on the natural abutment teeth. The intaglio surfaces of the zirconia restorations were airborne-particle abraded with aluminum oxide (Al_2O_3 particle size 50 µm, distance: 10 mm, pressure: 0.1 MPa, abrasion time per unit: 10 s) and coated with a bonding resin (Monobond Plus, reaction time 60 s; Ivoclar). A universal adhesive (Adhese Universal; Ivoclar) was used on part of the teeth. The restorations on the implants were cemented with a glass-ionomer cement (Vivaglass CEM PL, universal shade; Ivoclar) (Figure 22D).

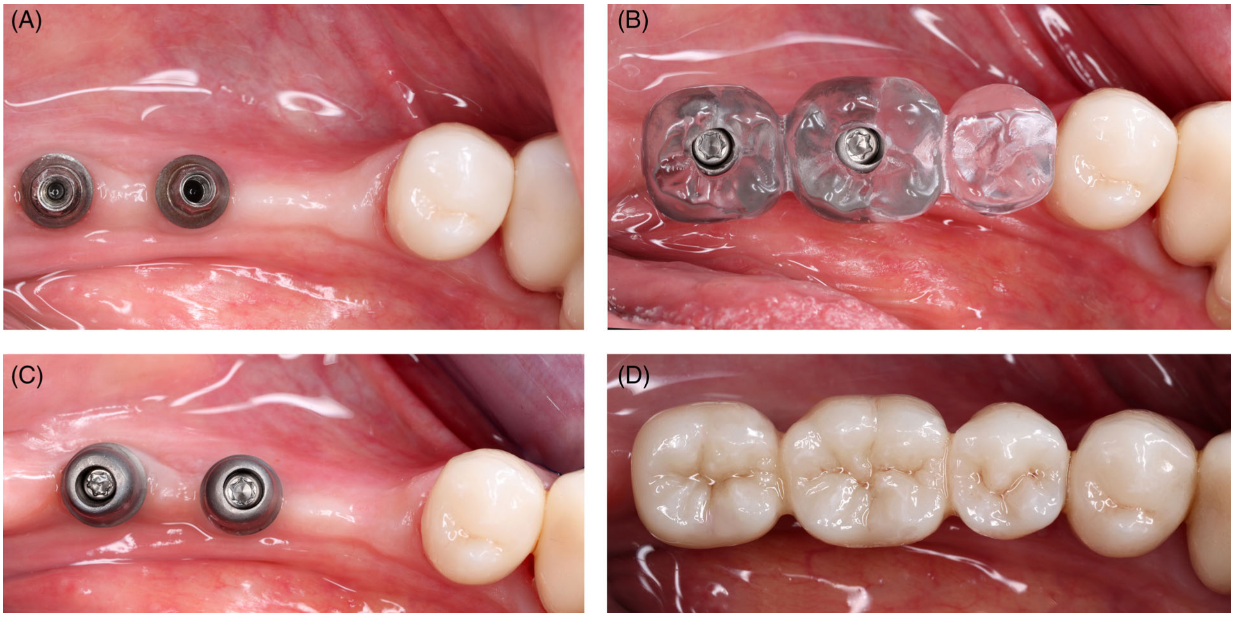

FIGURE 22 Placement on the existing implants (A) of the titanium abutments with an insertion template milled from transparent PMMA (B, C). The monolithic zirconia cantilever fixed prosthesis made from IPS e.max ZirCAD Prime cemented to the titanium abutments (D) using glass-ionomer cement (Vivaglass).

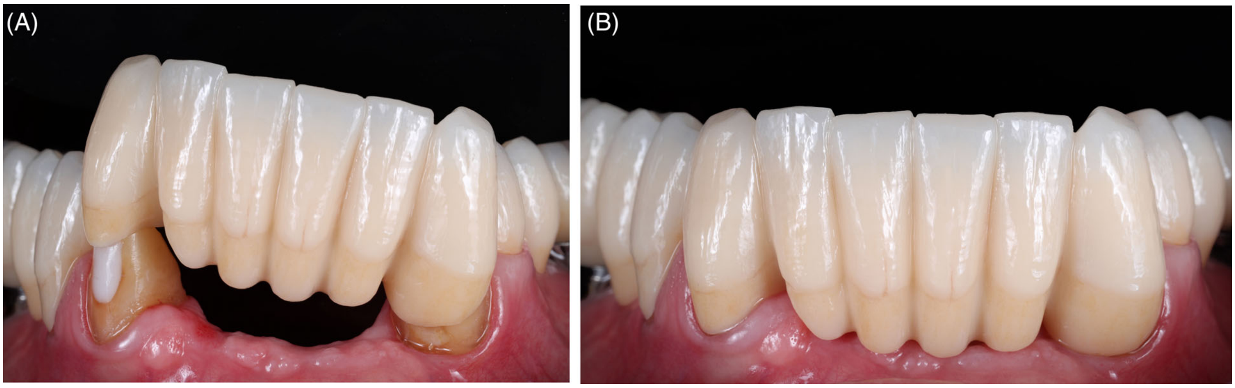

FIGURE 23 Clinical evaluation of the 6-unit anterior fixed partial denture made from IPS e.max ZirCAD Prime. Enlarged connector areas between the abutment teeth and pontics was possible because of the length of the canines after significant bone resorption.

Following definitive cementation of the mandibular fixed anterior restorations (Figure 23A,B), the static and dynamic occlusion with the complete denture was evaluated (Figure 24A–C). The patient was satisfied with the result (Figure 25A,B) and was scheduled for recall appointments.

3 | DISCUSSION

Complete dentures fabricated with subtractive CAD/CAM technologies have significant benefits compared with conventional manufacturing, including improved biocompatibility and fit, as well as greater homogeneity and reproducibility.[28,29] When comparing different fabrication processes (conventional, additive, and subtractive fabrication) for complete denture bases, milled denture bases have been reported to have the best fit.[4] Moreover, as a result of the digital workflow during design (CAD), critical additional information from the patient can be integrated (e.g., by using facial scans) into the software program. This allows the dental laboratory technician to generate a digital replica of the patient that is available at any time, which, in turn, reduces the number of treatment appointments and improves predictability because of the option of virtual evaluations.[27] The Ivotion system used was perceived to be straightforward in terms of handling, efficiency, esthetics, and material quality (i.e., homogeneity, polishing). It was not necessary to bond separate acrylic resin denture teeth to the denture base, further reducing the amount of monomer; as a result, the monomer elution of the complete dental prosthesis compared with that of semi-digital systems.[30] The industrially

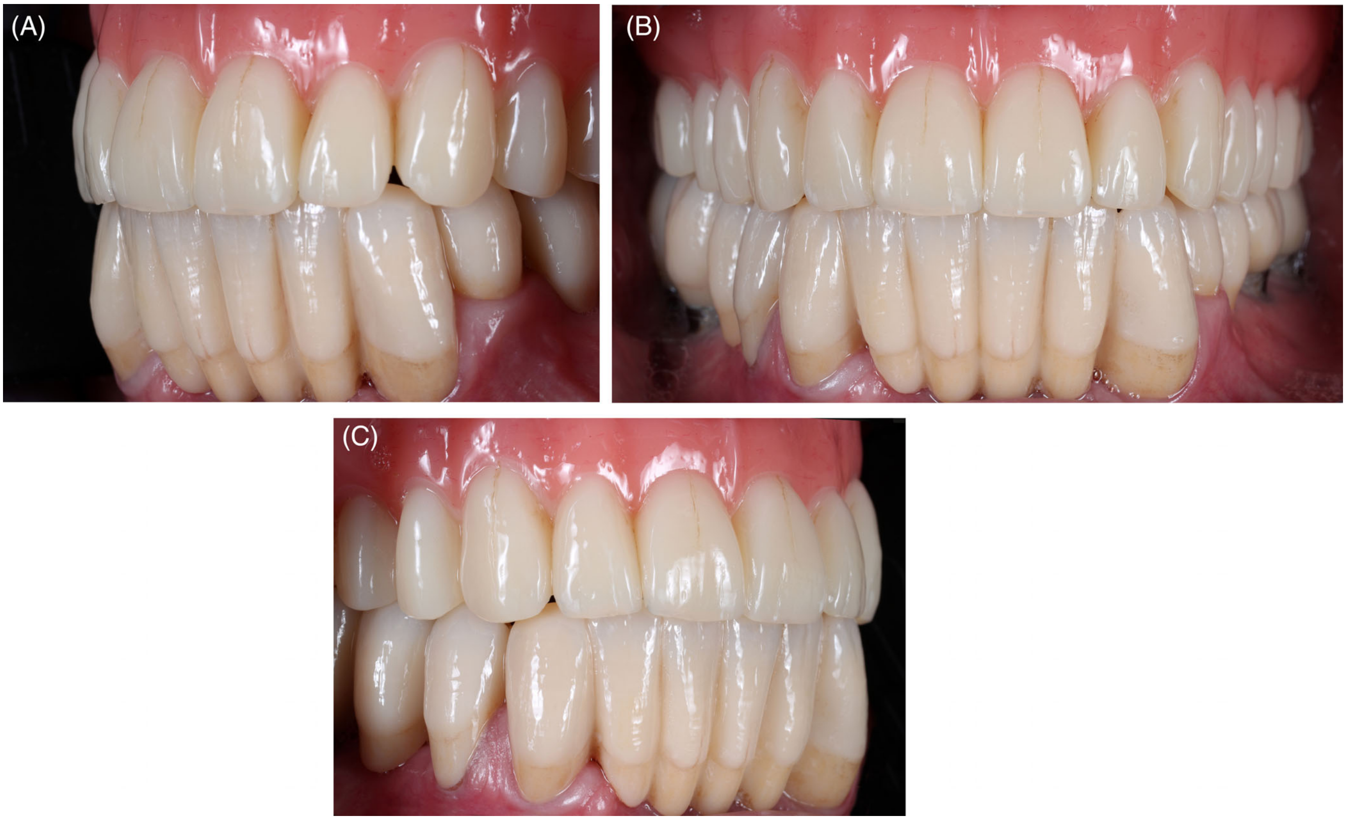

FIGURE 24 Left lateral (A), frontal (B), and right lateral (C) view of the definitive restorations.

FIGURE 25 Portrait view of the patient before (A) and after the complex rehabilitation (B).

fabricated Ivotion monobloc may also deliver greater stability compared with dentures fabricated using two components.

A recent guideline for "all-ceramic single crowns and fixed dental prostheses" published by the German Society for Prosthetic Dentistry and Biomaterials in March 2021 provides a fundamental decision-making tool for selecting dental ceramic materials.[31] Based on evidence, this guideline recommends three-unit all-ceramic zirconia fixed partial dentures with a veneered framework of 3Y-TZP for the anterior area. The six-unit mandibular anterior fixed partial denture provided for this patient, therefore, did not correspond to the evidence-based recommendation. As sufficient clinical data are not yet available, these guidelines cannot consider developments that have only recently been launched onto the market such as modern translucent zirconia materials or those that offer multilayer gradient technology. The scientific data on zirconia with gradient technology are currently limited primarily to in vitro studies and case reports.[22,25] Although only a few studies are available on the long-term clinical behavior of monolithic crowns and fixed partial dentures, preliminary in vitro studies have reported positive results, such as for IPS e.max ZirCAD Prime.[25] An American dental laboratory analysis on returns of almost 190,000 lithium disilicate and zirconia restorations reported very promising results. Over an observation period of 7.5 years, monolithic crowns and fixed partial dentures made from different zirconia materials achieved the best results.[32]

In laboratory testing, zirconia monolithic crowns demonstrated higher fracture load values than crowns fabricated from alternative ceramics such as lithium disilicate.[33] Greater strength allows for a less invasive tooth preparation for restorations made from monolithic zirconia.[34] Following thermal cycling and mechanical load testing in an in vitro study, single crowns made from zirconia with a layer thickness of 0.5 mm achieved acceptable results for fracture load and survival rate, regardless of the type of bonding or cementation used.[35] Nevertheless, given the clinical preparation geometries, the preferred recommendation is adhesive luting in order to safeguard against loss of retention,[36] especially for fixed partial denture abutments.[12]

The abrasion of restoration materials against the opposing dentition should also be considered when selecting a restoration material. Sufficient clinical data, nevertheless, are not yet available to present a final objective argument either in favor of or against certain materials or material classes.[37–39] A review of the current literature found that, compared with the wear caused by natural dentition to the enamel of opposing dentition, either a similar or greater level of wear is caused by zirconia; this wear is still less than the wear caused by metal-ceramic restorations.[40] Accordingly, the restorative team must implement the most balanced occlusal concept possible to prevent localized instances of excessive strain. Due to the high hardness of zirconia, appropriate selection of the material and surface treatment is essential, particularly for implant-supported restorations, to prevent biological and technical complications.[24,41] The authors are unaware of clinical studies testing the combination of materials used for this patient, maxillary Ivotion resin and mandibular zirconia. In in vitro studies, polymer-based restoration materials had the highest wear rates but produced little wear on the opposing dentition, while polished zirconia surfaces showed either only a very small amount of wear or no wear at all.[25,38] For this reason, the wear rate of the complete maxillary denture will be followed with interest during recall examinations.

4 | SUMMARY

In contemporary prosthodontics, there is a particular focus on straightforward digital fabrication processes. Interesting materials such as polymers and ceramics, which are currently applied most efficiently in subtractive milling from monolithic materials, can be used. In a CAD/CAM based complete-mouth prosthetic rehabilitation in an 82-year-old patient, it was possible to demonstrate that, with state-of-the-art technology, fixed zirconia restorations with modern gradient technology can be easily combined with a monolithic complete denture. The patient was enthusiastic about the efficient treatment without excessive effort and also that, with digital data available, the maxillary complete denture can be easily refabricated in case of loss, fracture, or wear. Regular recall examinations will determine the long-term wear behavior of the maxillary complete denture contacting the opposing monolithic zirconia restorations.

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