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ORIGINAL ARTICLE

A pattern of care analysis: Prosthetic rehabilitation of head and neck cancer patients after radiotherapy

Felicitas Wiedenmann DMD[1] | Anja Liebermann DMD, PhD[1] | Florian Probst MD, DMD, PhD[2] | Matthias Troeltzsch MD DMD PhD[2] | Panagiotis Balermpas MD, PhD[3] | Matthias Guckenberger MD, PhD[3] | Daniel Edelhoff DMD, PhD[1] | Michael Mayinger MD[3]

[1]Department of Prosthetic Dentistry, University Hospital, LMU Munich, Munich, Germany

[2]Department of Oral and Maxillofacial Surgery and Facial Plastic Surgery, University Hospital, LMU Munich, Munich, Germany

[3]Department of Radiation Oncology, University Hospital Zurich, University of Zurich, Zurich, Switzerland

Correspondence
Felicitas Wiedenmann, Department of Prosthetic Dentistry, University Hospital, LMU Munich, Goethestrasse 70, 80336 Munich, Germany.
Email: felicitas.wiedenmann@med.uni-muenchen.de

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Abstract

Background: While some medical associations provide guidelines for the implant-prosthetic rehabilitation of head and neck cancer patients, the circulation and implementation in the everyday routine of practicing dentists remain unknown.

Purpose: To analyze patterns of care for the prosthetic rehabilitation of head and neck cancer patients after radiotherapy in German speaking countries.

Materials and methods: An online survey consisting of 34 questions separated into three sections, (a) general inquiries, (b) treatment concepts, and (c) patient cases, was forwarded to university hospital departments for Prosthetic Dentistry and Oral and Maxillofacial Surgery, and members of different medical associations. Statistical differences between groups were analyzed using chi-squared test ($P < .05$).

Results: From May to October 2019, 118 participants completed the survey. The majority practiced in university hospitals, had more than 5 years of work experience, and reported to be involved in <10 post radiation prosthetic rehabilitation cases per year. Rehabilitation protocols involving dental implants were implemented by oral/oral- and maxillofacial surgeons and prosthetic dentists, while general dentists favored implant-free solutions. Xerostomia was recognized as a common problem for a successful prosthetic rehabilitation. The subsequent treatment choice with either fixed dental prostheses or removable dentures was divided among participants.

Conclusions: As treatment planning differed with regard to the participants' field of expertise and work environment, and most practitioners only handle a low number of cases, patients might benefit from centralization in larger institutes with a multidisciplinary structure. A high agreement between the practitioners' treatment

Felicitas Wiedenmann and Anja Liebermann contributed equally to this work.

concepts and the current state of research was observed. While the choice between a mucosa- or tooth-supported, and an implant-supported restoration depends on numerous individual factors, guidelines derived from longitudinal studies would enhance evidence-based treatment in this field.

KEYWORDS
head and neck cancer, implantology, multidisciplinary approach, patterns of care, prosthetic rehabilitation, radiotherapy, survey

1 | INTRODUCTION

The term head and neck cancer describes an array of malignancies in this region ranging from neoplasia of the paranasal sinuses to oral, pharyngeal, or laryngeal carcinoma. Worldwide, head and neck cancer accounts for more than 650 000 cases and 330 000 deaths per year.[1] The average age at diagnosis ranges between 55 and 65 years, with males being affected twice as often as females.[2] Treatment plans for the individual patient vary, as they are dependent on numerous factors, such as the location of the primary tumor, cancer staging, and the patient's general health and age. State of the art treatment is radio(chemo)therapy and/or surgery, with common treatment side effects including mucositis, salivary gland dysfunctions causing xerostomia and osteoradionecrosis (ORN) of the jaw.[3-6] Whereas pulpal tissue can be directly damaged by radiation, the sequelae of xerostomia, such as a decrease in pH, a reduced buffering capacity, and an increased viscosity of the saliva, can lead to radiation caries, characterized by an expedited tooth decay.[6-8]

While cancer treatment is routinely conducted in a multidisciplinary setting, with specialist physicians such as ENT/head and neck cancer surgeons and oral- and maxillofacial surgeons performing the surgery, oncologists or radiation oncologists administering chemotherapy, radiation oncologists delivering exact dosages to the target volume and dentists carrying out a perioperative dental evaluation, the subsequent rehabilitation of head and neck cancer patients often involves just one dentist. The question arises, in how far individual dentists are capable of fulfilling this often highly challenging task. There are numerous factors complicating the perioperative dental evaluation and care, such as an increased number of missing teeth after multiple extractions to reduce interventions postradiation and hereby the risk of developing an osteoradionecrosis,[4] or scar tissue impairing mouth opening. In addition, a trismus may limit the dentist's treatment options, as the patient's ability to brush his teeth or incorporate a removable denture can be severely restricted. The primary surgery can furthermore entail extensive defects that call for a prosthetic reconstruction employing obturator prostheses in cases where reconstructive surgery is not an option. To replace missing teeth, a dentist can choose between three options: a removable denture, a fixed dental prosthesis, or implantation.

In patients presenting with a compromised bone and mucosa structure, xerostomia, impaired orofacial motor functions, an impaired denture foundation or anatomical changes after resective and reconstructive surgical procedures, implants can be indicated.[9] An increase of abutments by implantation can improve the masticatory function and fixation of a denture, while reducing the occurrence of pressure marks[10] and a subsequent development of ORN. Improved esthetics and phonetics achieved by the oral rehabilitation with implants can have a positive impact on the patients' psychological and social status. Systematic reviews and meta-analyses have shown promising long-term survival rates, as implant survival in nonirradiated and irradiated native bone may be comparable.[11-13]

On the other hand, removable or fixed dental prostheses can represent the treatment of choice for patients with an increased risk of implant loss and the development of ORN, or a high risk for the occurrence of a second primary carcinoma.[9] In head and neck cancer, second primary tumors occur frequently, as malignant cell transformations caused by alcohol, tobacco or HPV are not limited to the primary tumor site.[14] During radiation treatment, implants can increase dosage in the surrounding tissues through scatter irradiation by up to 25%,[15] hereby raising the risk of developing an ORN. A reduced germ resistance, vascularization, and cell density of irradiation-damaged tissue can impede the osseous integration and long-term success of the implant therapy,[16,17] with the 5-year implant survival for patients suffering from a preexisting ORN being reported to be less than 50%.[18]

Therefore, the advantages of an implant insertion have to be weighed against the risks of implant failure and the development of an ORN. In this context, the individual dentist's work environment (university hospital, medical care center, group private practice, or single private practice) and field of expertise (oral surgery/oral- and maxillofacial surgery, prosthetic dentistry, or general dentistry) might play a crucial role. While some medical associations, such as the German association for oral and maxillofacial surgery (DGMKG), provide a guideline for the implant-prosthetic rehabilitation of head and neck cancer patients,[19] its circulation and implementation in the everyday routine of practicing dentists remains unknown.

The aim of this multidisciplinary study was to analyze patterns of care in the prosthetic rehabilitation of head and neck cancer patients (condition after radiotherapy) in German speaking countries. The tested hypothesis stated that neither the participants' work environment nor their field of expertise affect the subsequent treatment.

2 | MATERIALS AND METHODS

The survey “Prosthetic rehabilitation of head and neck cancer patients after radiotherapy” consisted of 34 questions split into three sections:

(a) general inquiries, (b) treatment concepts, and (c) patient cases (Table S1).

To generate the questionnaire, relevant issues and arising questions of this field were discussed in a multidisciplinary setting of dentists, oral- and maxillofacial surgeons, and radiation oncologists. Questions were then formulated and a test run was performed to check that all questions were clearly stated and answers were easy to choose from. After validation within the test group (n = 10 participants), the questionnaire was adapted and the link to the online survey was forwarded to all German speaking university hospital departments for Prosthetic Dentistry and Oral and Maxillofacial Surgery, and members of the different medical associations (ie, DGZMK, DGMKG, DGPro, DGOI, BDIZ EDI, BDO). The survey followed the ethics of survey research by ensuring a maintenance of confidentiality and anonymity and was previously approved by the ethics committee (19-358 KB).

To analyze potential variations in the treatment of irradiated head and neck cancer patients across different medical care institutions, the first section of the survey concentrated on enquiring the work environment and experience of each participant. While the second section of the survey addressed different treatment concepts for this patient cohort, the survey's third section of exemplary patient cases included free text answers to allow participants to voice individual prosthetic treatment plans for the exemplary patient John Smith.

Statistical differences between groups were determined using chi-squared test ($P < .05$). Data were analyzed with SPSS version 25.0 (IBM, Armonk, New York).

3 | RESULTS

In total, 118 participants completed the online survey between May and October 2019. As was to be expected in this highly specialized area, most participants originated from a university hospital background (55%). On average, 16 (±13) dentists/oral surgeons/oral- and maxillofacial surgeons were employed in the participants' hospital/practice. The participant's position at work is depicted in Figure 1, with the majority (74%) possessing more than 5 years of work experience. One-third of the participants specified possessing more than 20 years of work experience. The field of expertise of the participants is shown in Figure 2. When asked how many patients that received

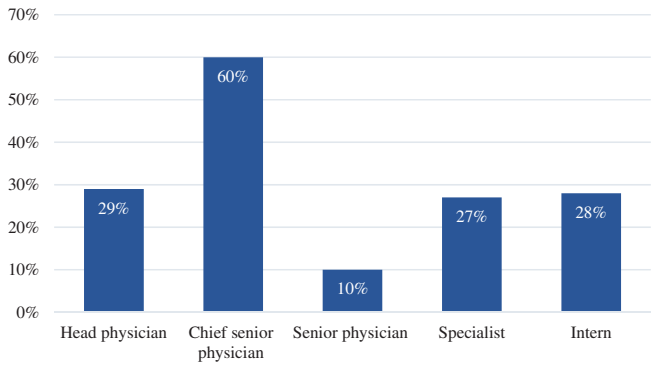

FIGURE 1 Position at work of the 118 participants (%)

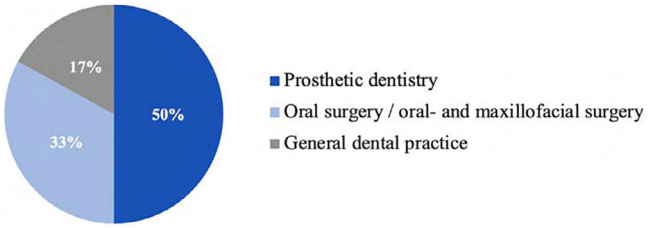

FIGURE 2 Field of expertise of the 118 participants (%)

radiotherapy to the head and neck region participants treated with a prosthetic restoration each year, the majority (72%) indicated treating up to 10 patients, while 19% provided care for more than 25 patients each year.

The majority of the participants (73%) indicated that they routinely enquire the total received radiation dose of the region where they are planning an implant-prosthetic rehabilitation in head and neck cancer patients (condition after radiotherapy). Significant differences in answering this question were observed with regard to the participants' field of expertise (prosthetic dentistry compared to general dentistry and oral/oral- and maxillofacial surgery; $P = .004$) and work environment (university hospital compared with a medical care center/group private practice/single private practice; $P = .01$), with only 36% of the general dentists requesting this information, while 83% of participants from a university hospital background and 89% of oral/oral- and maxillofacial surgeons indicated this as a routine enquiry prior to implantation in irradiated head and neck cancer patients. Of those enquiring for the total received radiation dose, 92% stated that this information influences their treatment concept, with one-third specifying a total dose of 30 Gy, and the majority (72%) a total dose of 50 Gy as a critical factor that changes their subsequent treatment concept. With regard to the treatment modality (Intensity Modulated Radiation Therapy [IMRT], stereotactic radiotherapy, tomotherapy, brachytherapy, proton therapy), the majority (66%) indicated no impact on their subsequent treatment. While 54% of the participants do not perceive a pretreatment with chemotherapy as an influential factor for their implant-prosthetic treatment concept, the wide majority (99%) takes the combination of risk factors (smoking, alcohol, diabetes mellitus, bisphosphonate/antiresorptive therapy) into account. Furthermore, 92% of the participants stated that the time lapse from radiotherapy until implant-prosthetic rehabilitation has an influence on their treatment concept, with 92% indicating 1 year after completion of the radiotherapy being considered as an adequate time to establish a stable situation for their prosthetic rehabilitation.

In total, 69% of the participants do not routinely insert implants in the irradiated region of head and neck cancer patients. The computation of chi-squared test yielded significant differences ($P = .006$) between groups based on the participants' field of expertise, with general dentists refraining from implantation, while a higher number of prosthetic dentists (26%) and oral/oral- and maxillofacial surgeons (44%) indicated a routine implant placement. The participants' work environment also showed an impact ($P = .002$), with participants

from a university hospital background choosing a routine placement of implants more frequently (46%). Only 36% of the participants indicated increasing the planned number of implants for irradiated head and neck cancer patients in comparison to nonirradiated patients. When asked about a preferred region for their implant-prosthetic rehabilitation, 46% of the participants stated their planning to be independent of a region, while 38% indicated the anterior mandible to be their preferred region. In regard to the best time for treatment, 86% of the participants waited at least 1 year after completion of radiotherapy for placing an implant in the irradiated region. While none indicated the immediate loading of an implant in the irradiated region as a possible option, two-thirds of the participants routinely load implants after a period of 6 months. One-third of the participants stated that they treat irradiated patients with bone augmentation. Perioperative systemic antibiotics are routinely prescribed by a wide majority (93%), while only a small number administered a pretreatment with Vitamin E (8%) or hyperbaric oxygen therapy (5%). When asked about common consequences of the radiotherapy treatment, 42% to 45% of the participants stated bone resorption and ORN to appear more frequently, with half of those indicating a causal link to a prosthetic rehabilitation with removable prostheses, while 35% did not observe any changes. The wide majority of participants (94%) stated a reduced or absent saliva production after radiotherapy to influence their prosthetic rehabilitation, with 52% of those preferring a subsequent treatment with fixed dental prostheses. No significant differences between choosing a rehabilitation with removable or fixed dental prostheses were observed with regard to the participants' field of expertise ($P = .4$) or work environment ($P = .5$).

The third section of the survey enquired about prosthetic treatment concepts neglecting financial aspects for the patient John Smith (condition after resection of an oropharyngeal carcinoma, adjuvant radiotherapy with a total dose of 60 Gy and a median dose of 5 Gy on the maxilla, chemotherapy with Cisplatin weekly 40 mg/kgBW, 64, male). The preferred treatment options for a varying number of residual teeth in the maxilla and mandible are depicted in Figure 3. Free text answers included the reference to form a close collaboration with the treating family dentist and taking into account the patient's saliva production and maximum mouth opening. While only 4% of the participants chose ball head anchors, bar constructions, locators, and telescopes were equally common.

4 | DISCUSSION

The aim of this multidisciplinary study was to analyze patterns of care in the prosthetic rehabilitation of head and neck cancer patients (condition after radiotherapy) in German speaking countries. The tested hypothesis stating that neither the participants' work environment nor their field of expertise affects the subsequent treatment had to be rejected.

The majority of the participants indicated routinely enquiring for the total received radiation dose prior to planning an implant-prosthetic rehabilitation. As significant differences in answering this question were observed with regard to the participants' field of expertise and work environment, this finding underlines the need to gather experience and produce prospective data in larger centers and patient cohorts. A multidisciplinary approach, from the initial planning to the implementation of treatment, based on a patient's individual constellation of findings and personal wishes, is the prerequisite for therapeutic success[20] and has been shown to improve patient treatment and overall survival in head and neck cancer patients.[21]

Participants stated radiation thresholds of 30 and 50 Gy as pivotal to alter their treatment concept. While animal testing has shown an explicit dependency between radiation dose and implant prognosis,[22] one retrospective clinical study did not observe an impact on the radiation dose (<50 or ≥50 Gy) on implant survival.[23] Recent studies do, however, give evidence of a significantly decreased implant survival, for total radiation doses of 50 Gy,[24] 55 Gy,[12] or 70 Gy.[25] Further studies investigating the relationship between total dose and complication probability, especially with regard to the bone structure, soft tissue, and the resulting osseointegration of implants, are warranted. Participants did not perceive the employed treatment modality as influential on the subsequent implant-prosthetic treatment. IMRT, a technique that allows high doses of radiation to be applied to the target volume, while sparing adjacent tissues and thus limiting the damage to vital surrounding organs, represents the current gold standard in the treatment of head and neck cancer patients.[26] While one recent study did not observe an influence of using either 3-D conformal radiotherapy or IMRT on crestal bone loss and implant survival,[27] another investigation with a median follow-up of 7.4 years could show a preceding radiation using IMRT to result in superior outcome regarding implant survival.[28]

While not even half of the participants take a pretreatment with chemotherapy into account for their implant-prosthetic treatment concept, the wide majority include risk factors such as smoking, alcohol, diabetes mellitus, or bisphosphonate/antiresorptive therapy. One retrospective clinical study concluded that chemotherapy with cis- or carboplatin and 5-fluorouracil was not detrimental to the survival and success of dental implants in the mandible.[29] Other studies have, however, shown a higher prevalence of mucositis after radiochemotherapy in comparison with radiotherapy alone,[30] just as a negative effect of cisplatin on the osseointegration of dental implants was seen in a rabbit model.[31] Prior to implantation, individual risk factors should be taken into account and put into context with the potential benefits of implant insertion.[9]

While general dentists refrained from implantation, a small number of prosthetic dentists and close to half the oral/oral- and maxillofacial surgeons indicated a routine placement of implants in the irradiated region of head and neck cancer patients. Implantation in this patient cohort seems to be centered in university hospitals, where a routine placement of implants occurred more frequently. As reviews have observed promising long-term survival rates for an implantation in the irradiated jaw,[11-13] only one-third of the participants indicated an increase of their planned number of implants for irradiated head and neck cancer patients in comparison to nonirradiated patients.

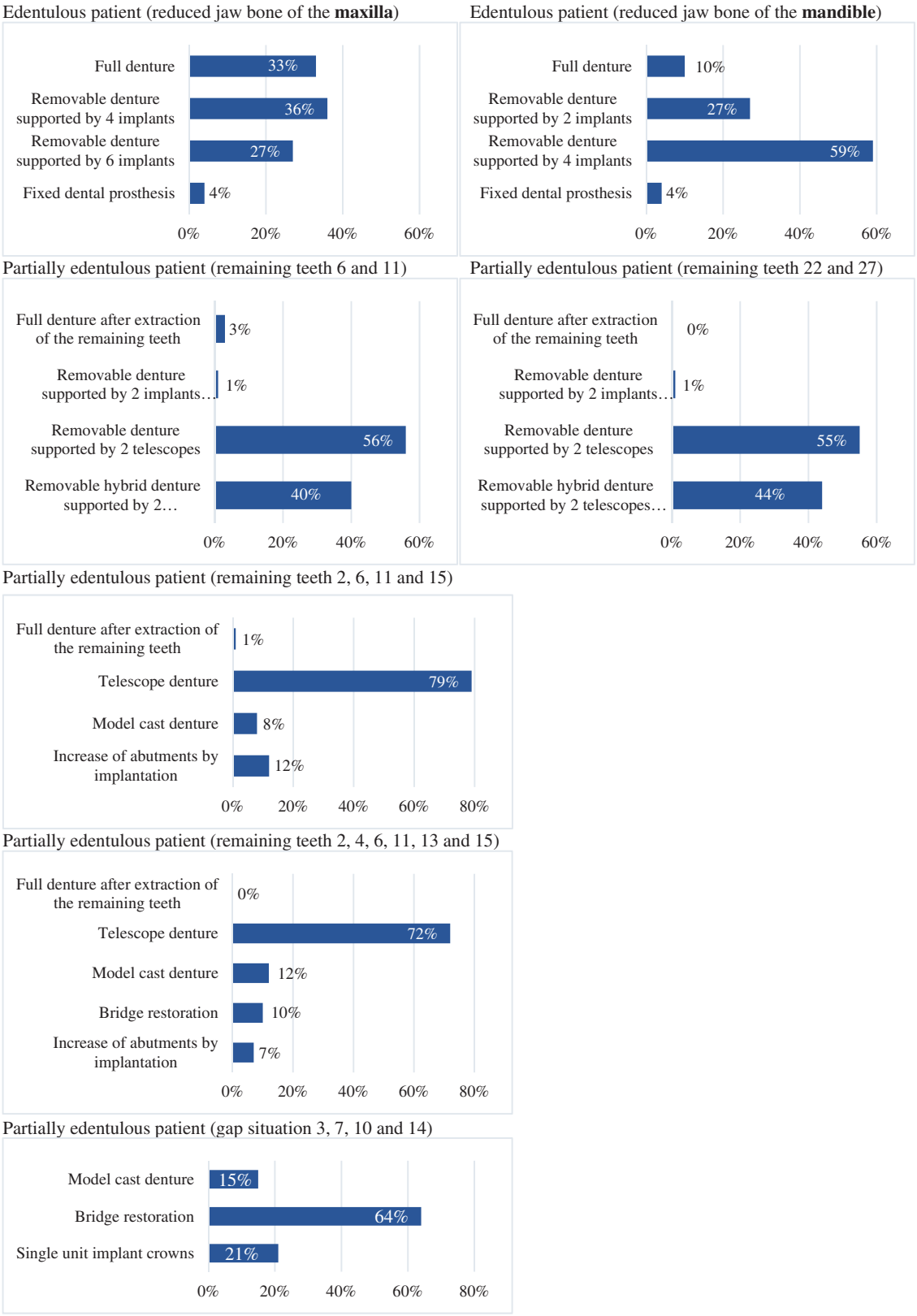

FIGURE 3 Preferred treatment options for a varying number of residual teeth in the maxilla and mandible

Half of the participants stated their planning to be independent of a region, while 38% indicated the mandible anterior region as their preferred region for implantation. Current literature shows an implant placement in the mandible to be less prone to failure than in the maxilla, just as implants in the posterior region carry a higher risk of failure than those placed in the anterior region.[32]

The majority of participants stated the time lapse from radiotherapy until implant-prosthetic rehabilitation to hold an influence on their treatment concept, with 1 year (after completion of radiotherapy) being considered as an adequate time to establish a stable situation for an implant-prosthetic rehabilitation. Implant insertion during the primary tumor surgery can however reduce the number of surgical procedures, while resulting in high implant survival rates.[33,34] Furthermore, implant placement during ablative surgery can lead to functional benefits, as overdentures retained on implants that were inserted during ablative surgery compared to a postponed placement presented a higher bite force and masticatory performance.[35] Although implants placed in the primary surgery can cause backscattering during radiotherapy, which can lead to increased doses on the surrounding tissue and a subsequent loss of the implant, this risk is considered to be lower than for implants placed in the irradiated bone after radiotherapy. Immediate implant placement can furthermore shorten the time period until prosthetic rehabilitation,[36] thus improving the patients' quality of life, and lower the individual costs of implant placement.[37] As portrayed in the participants answers, implant placement after radiotherapy is, however, still more common.[38,39] For this setting, a systematic review has shown periods shorter than 12 months after radiotherapy to result in a higher risk of implant failure.[40] Future investigations should focus on ascertaining the optimal time period for the insertion of implants in the oral cavity in regard to radiotherapy.

While none of the participants chose the immediate loading of an implant in the irradiated region as a possible option, the majority routinely load implants after a period of 6 months, as a delayed loading protocol can enhance the chances of a successful implant osseointegration, stability and ultimately, an effective dental rehabilitation.[38,39]

One-third of the participants stated that they treated irradiated patients with bone augmentation. As implant survival has been reported to be significantly lower in grafted bone (8-year survival of only 54%), even when compared with irradiated residual bone, bone augmentation after radiotherapy should be avoided.[41] The combination of grafted bone and radiotherapy has been identified as a negative prognostic factor on implant survival.[11,39] In addition, the placement of dental implants in vascularized grafts at the time of reconstructive surgery is not recommended, as this led to increased failure rates and prosthetically unusable or sub-optimally placed implants.[16] In some cases, short dental implants (6-8 mm) might present an alternative to advanced and complicated surgical bone augmentation.[42]

A perioperative systemic anti-infective is routinely prescribed by a wide majority, as recommended in guidelines for dental implantology after radiation therapy.[43] Only a small number administered a pretreatment with Vitamin E or hyperbaric oxygen therapy. Though critically discussed in numerous publications, the pretreatment with hyperbaric oxygen may not offer any appreciable clinical benefits.[44]

Bone resorption and ORN were indicated as common consequences of a preceding radiotherapy by nearly half the participants, with some specifying a causal relationship with removable prostheses. Using IMRT and a delineation of the mandible as an organ at risk, the incidence of ORN could be reduced to 0% to 6%.[45] A maximum dose of 70 Gy to the mandible is recommended following dosimetric analyses, with the volume receiving 50 and 60 Gy being restricted to 62% and 20% respectively.[45,46] In this context, a multidisciplinary approach, as suggested in a retrospective dosimetry review for oropharyngeal cancer,[47] is recommended by the authors, with radiation oncologists, oral- and maxillofacial surgeons, and dentists not only jointly planning preoperative measures and the surgical- and radio-oncologic treatment of the tumor, but also the subsequent prosthetic rehabilitation. The delineation of important jaw structures for an ensuing implantation, as far as considered feasible from an oncologic standpoint, could improve long-term survival of both the remaining teeth and placed implants, and in consequence the patient's quality of life.

While the majority of participants stated a reduced or absent saliva production after radiotherapy to influence their prosthetic rehabilitation, the subsequent choice of employing either a fixed dental prosthesis or a removable denture was divided. In this context, the administering of amifostine prior to IMRT has been reported to protect the mucosa and salivary glands from the effects of radiation,[48] but is interestingly not widely implemented. The mean doses to contralateral structures should not exceed certain thresholds (parotid: 26 Gy, submandibular gland: 39 Gy). Additionally, the dose to any uninvolved surface of the oral cavity should, if possible, be limited to 30 Gy, as this minimizes damage to the minor salivary glands.[49] While some patients with radiation-induced xerostomia do not tolerate a rehabilitation with prostheses due to a reduced hold, others benefit from mucosa-supported dentures, as the high mucosa coverage, for example seen for maxillary total prostheses, can reduce tissue dehydration. Nevertheless, removable prostheses usually require extensive follow-up care[10]; as a result, implant supported restorations could constitute both a time and cost efficient alternative.

When asked about concrete implant-prosthetic treatment plans for an exemplary patient (condition after radiotherapy), several trends were observed. While the rehabilitation with a full denture was considered an appropriate treatment modality for the edentulous maxilla, participants preferred an increase of abutments by implantation to anchor a removable denture in the edentulous mandible. While the anatomical conditions of the maxilla usually allow for satisfactory results in the rehabilitation with total prostheses, achieving a sufficient hold of a full denture in the mandible can be demanding or even unfeasible. When paired with two further aspects, namely the mandibles higher susceptibility to ORN due to is poor vascularization and high bone density, and the greater success of implant osseointegration in the irradiated mandible when compared to the irradiated maxilla,[25] the participants' answers can be retraced. For the rehabilitation of the edentulous mandible, participants primarily chose a restoration anchored on four implants. While an implant-prosthetic rehabilitation of head and neck cancer patients with two or four implant-supported overdentures in the mandible can improve the patients' quality of life,[50] no significant difference between the placement of two or four implants could be observed.[51] Overall, implant-

supported overdentures have been demonstrated to lead to higher bite forces than conventional prostheses and reduce functional problems associated with solid foods.[35]

If the exemplary patient did, however, retain teeth in an optimal static position, the treatment concepts of the maxilla and mandible aligned, and a removable denture anchored on telescopes became the chosen treatment modality. The telescope denture maintained being the favorite treatment choice for a remaining number of both four and six teeth, while bridge restorations were primarily chosen as the restoration of choice for single-tooth gaps. With radiation exhibiting long-term detrimental effects on the natural tooth structure, single-unit implants might constitute a valid treatment option, as indicated by one-fifth of the participants. Longitudinal studies examining the long-term survival of fixed dental prostheses anchored on natural teeth of the irradiated jaw are warranted, in particular when compared with implant restorations.

The main limitation of this pattern of care analysis is its limited number of participants, which can affect the representativity of the collected data. When regarding the work environment and field of expertise of the participants, it becomes clear that in this highly specialized field, treatment is primarily provided by university hospitals, and even there specialized and experienced dentists only treat a limited number of patients per year. This observation underlines the importance of raising awareness about possible treatment concepts and their respective advantages and disadvantages, as the rehabilitation of this patient cohort is far from routine. One further limitation of this study is constituted by the origin of its respondents, as the survey was only conducted in German speaking countries. It would be interesting to enquire whether and, if applicable, what differences occur in the implant-prosthetic treatment of head and neck cancer patients worldwide. Two, as of today however outdated, surveys conducted in the United Kingdom observed a wide heterogeneity in the dental and oral rehabilitation of head and neck cancer patients.[52,53] While this study provides information about the prevalence of different treatment methods and critically evaluates these trends with regard to the current literature, future studies should concentrate on expanding our knowledge about the long-term clinical outcome of different implant-prosthetic treatment plans for head and neck cancer patients, paying special attention to the patients' quality of life. If endosseous implants are placed in the irradiated jaw bone, a long-term follow-up is the prerequisite to monitor the condition of the peri-implant tissues, hereby enabling an early detection of complications like ORN.

5 | CONCLUSIONS

Within the limitations of this study, the following conclusions can be drawn:

1 As treatment planning differed with regard to the participants' field of expertise and work environment, treatment of head and neck cancer patients (condition after radiotherapy) should be centralized to enhance the experience of the practitioners. Patients might also benefit from a multidisciplinary structure.
2 A high agreement between the practitioners' treatment concepts and the current state of research was observed.
3 While the choice between a mucosa- or tooth-supported, and an implant-supported restoration depends on numerous individual factors, guidelines derived from prospective, longitudinal studies would enhance evidence-based treatment in this field.

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CONFLICT OF INTEREST

The authors declare no potential conflict of interest.

ORCID

Felicitas Wiedenmann https://orcid.org/0000-0003-0089-9995

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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