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Prof. Adrian Lussi
Klinik für Zahnerhaltung, Präventiv- und Kinderzahnmedizin
Freiburgstr. 7
3010 Bern

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Ich bedanke mich bei den unten aufgeführten Kolleginnen und Kollegen für ihre wertvolle Mitarbeit, die sie in den vergangenen zwei Jahren geleistet haben.

Adrian Lussi

Patients with Oral Tumors

Part 1: Prosthetic rehabilitation following tumor resection

Resection prosthetics: surgery, implants and prosthetic treatment

Janine Fierz[1]
Wok Hallermann[2]
Regina Mericske-Stern[3]

[1] Dr. med. dent., Clinic for Prosthodontics, University of Bern, and Private Practice, Bern, Switzerland
[2] Dr. med., Dr. med. dent., Senior Surgeon, Clinic for Craniomaxillofacial Surgery, Inselspital, University of Bern, Switzerland
[3] Prof. Dr. med. dent., Clinic Director, Clinic for Prosthodontics, University of Bern, Switzerland

Correspondence
Prof. R. Mericske-Stern
Klinik für zahnärztliche Prothetik
ZMK Universität Bern
Freiburgstrasse 7
3010 Bern, Switzerland
Tel. +41 (031) 632 25 39
E-Mail:
regina.mericske@zmk.unibe.ch

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Summary The present study reports on the surgical and prosthodontic rehabilitation of 46 patients, 31 male and 15 female, after resection of oral tumors. The treatment was carried out from 2004 to 2007 at the Department of Prosthodontics, University of Bern, with a follow-up time of 3 to 6 years. The average age at diagnosis was 54 years. 76% of all tumors were squamous cell carcinoma, followed by adenocarcinoma. Resection of the tumors including soft and/or hard tissues was performed in all patients. 80% of them additionally underwent radiotherapy and 40% chemotherapy. A full block resection of the mandible was perfomed in 23 patients, and in 10 patients, the tumor resection resulted in an oronasal communication. 29 patients underwent grafting procedures, mostly consisting of a free fibula flap transplant. To enhance the prosthetic treatment outcome and improve the prosthesis stability, a total of 114 implants were placed. However, 14 implants were not loaded because they failed during the healing period or the patient could not complete the final treatment with the prostheses. The survival rate of the implants reached 84.2% after 4 to 5 years.

Many patients were only partially dentate before the tumors were detected, and further teeth had to be extracted in the course of the tumor therapy. Altogether, 31 jaws became or remained edentulous. Implants provide stability and may facilitate the adaptation to the denture, but their survival rate was compromised. Mostly, patients were fitted with removable prostheses with obturators in the maxilla and implant-supported complete dentures with bars in the mandible.

Although sequelae of tumor resection are similar in many patients, the individual intermaxillary relations, facial morphology and functional capacity vary significantly. Thus, individual management is required for prosthetic rehabilitation.

Introduction

From 2002 to 2005, an annual average of 715 men and 296 women developed a malignant tumor of the oral cavity and/or pharynx. This corresponds to an incidence of 0.0136% per year in the Swiss population, which numbered 7,415,102 people in 2009 (Federal Statistics Office, www.bfs.admin.ch). Most new cases occurred in the 50- to 69-year-old age group (Pury et al. 2007). Tobacco and alcohol consumption rank among the greatest risk factors for the development of oral cavity carcinoma (Mashberg et al. 1993).

In the majority of cases, the treatment of malignant oral tumors consists of resection and radiotherapy. In some cases, chemotherapy is also performed.

The removal of tumor tissue leaves hard- and soft-tissue defects of different extents, which can be subsequently covered

and/or prosthetically reconstructed using various surgical techniques. Aside from intraoral structures such as teeth, mucous membranes, maxillary/mandibular bone, or roof of the mouth, in rare cases extra-oral facial areas such as the nose, ear, eye or cheek are also affected by the resection. The free fibula flap, i. e., a free transplant from the fibula including muscle and soft tissues with blood supply, has established itself as the method of choice today for the surgical reconstruction of the mandible (Schrag et al. 2006).

The goal of all prosthetic and therapeutic interventions is to improve the patient's quality of life. Functionally, the phonation and ability to chew should be improved, morphological deficits covered, and – in cases of an open oronasal space – the oroesophageal and respiratory passages separated (Taylor 2000, Tang et al. 2008). Frequently, an oral cavity suffering from neglect with missing teeth, open carious lesions, and periodontitis are found when the tumor is diagnosed. Radical treatments are necessary, and the patient will be left with few if any teeth, especially in the jaw affected by the tumor resection. Prosthetic treatment will be complex, due to the consequences of resection and the resulting intermaxillary changes. Radiotherapy or combined radio/chemotherapy will have an additional negative effect on the remaining teeth and oral mucosa.

In a study conducted in 1994 on resection patients who were chiefly treated with classical prosthetic methods (Mericske-Stern et al. 1994), implants were seldom used. A few years later, another study followed up the progress of 25 resection patients, 17 of whom had received implants (Mericske-Stern et al. 1999). Today, implants are being increasingly used in tumor patients. Particularly in an edentulous mandible, prosthetic anchoring can be greatly improved or made possible by implants (Schoen et al. 2007).

The course of treatment of patients with oral tumors involves many steps and is individually tailored, requiring a number of different operators. Frequently, the various types and stages of treatment are poorly coordinated. Thus, it is desirable that the maxillofacial surgeons contact the prosthetic specialists early on and discuss, plan and perform treatment in an interdisciplinary manner. About 9 years ago, joint consultation hours were established by the Clinic for Prosthodontics and the Clinic for Craniomaxillofacial Surgery at the Inselspital in Bern, with the purpose of integrating the planning of prosthetic rehabilitation earlier in the entire treatment process of tumor patients.

The aim of the present study was to document the different therapeutic measures performed in patients with oral tumors and critically assess the subsequent (implant-borne) prosthetic rehabilitation in the context of the complex problems inherent to malignant tumors.

Materials and Methods

Data collection

Over a period of 4 years (2004–2007), 46 consecutive patients who attended the interdisciplinary consultation hours of the Clinic for Prosthodontics and the Clinic for Craniomaxillofacial Surgery were examined and slated for prosthetic rehabilitation. For all patients, disease progression and treatment success were followed up as far as possible in recall appointments, and the findings were recorded up to the year 2010, i. e., over a period of 3 to 6 years. At the time of the first examination for prosthetic planning and treatment, all patients had already undergone various urgent treatments as part of tumor therapy, e.g., tooth extractions, resections, or radiotherapy. The following information was anonymously obtained from various records, surgical reports, protocols from the consultation hours, and medical histories, and evaluated in this study:

Patients
- Gender and age at the time of tumor diagnosis
- Any alcohol or nicotine abuse
- Loss of patients through death or dropout during the observation period

Tumor diagnostics
- Tumor type and staging (T;M;N)
- Tumor location, i. e., maxilla or mandible, hard and soft tissue
- Location of the resected structures and consequences of resection such as oral-antral communication, loss of mandibular continuity
- Total dosage of radiotherapy, if performed
- Chemotherapy, if performed

Grafts
- Tissue replacement through grafts, i. e., bone grafts including plates, soft-tissue transplants

Implants
- Number and location of implants inserted
- Condition of the bone during implantation: local bone at implant site, transplant, radiation
- Implant loss: during the healing phase prior to loading, and after loading with the prosthetic reconstructions

Prostheses
- Type of prosthetic reconstruction for the jaw affected by the tumor, as well as for the opposite jaw

Course of treatment

As a standard example of close interdisciplinary cooperation, the course of treatment for a patient without major, new complications consisted of 13 appointments. However, the course of treatment for many patients was not free of complications or delays. An average of more than 260 days passed between the first interdisciplinary consultation and completion of prosthetic treatment. Following the first interdisciplinary consultation and contemporary examination by the Clinic for Prosthodontics, many therapeutic steps with joint re-evaluation were performed by the time treatment was definitively concluded. The implants were largely performed at the Department of Maxillofacial Surgery, often with the attendant dentist from the Clinic for Prosthodontics present. Some patients returned to their private dental practitioner for follow-up treatment, while others remained in recall at the Clinic for Prosthodontics, as they had previously not been to a private-practice dentist for a long period of time.

Statistical Analysis

The descriptive data on patients, tumors, transplants, implants, and prosthetic treatment were recorded in an Excel table (Microsoft Office).

A life table analysis according to Cutler and Ederer (1954) was created for the implants. The term "survival rate" was chosen, which means that the implants were in situ, stable, and free of complications, acute inflammation, and suppuration.

The stricter success criteria based on periodontal and radiological parameters were not used, because annual radiographic measurement of crestal bone was not performed. Furthermore, peri-implant parameters for implants with grafted material and sometimes very thick split-skin flaps are not reliable.
In short:
– implants which had to be explanted due to inflammation, pain and/or motility before or after loading with the definitive prosthesis were considered failures.
– loaded implants which fulfilled their function and remained in the oral cavity were given a "survival" rating in the survival statistics.

Results

Patients, tumor specification and staging

The patient group consisted of 31 men and 15 women with an average age of 57 ± 7.2 years at the time of tumor diagnosis. 21 patients reported regular consumption of tobacco and alcohol. 25 patients declined to provide information on this question. At the time of data collection, 19 patients could no longer be contacted, since 13 had already died and 6 were in very poor general condition.

The most frequent malignoma was squamous cell carcinoma (76%), followed by adenocarcinoma (9%), and various types of tumors (15%). All tumors were at stage T2–T4, and 55% of the patients already exhibited stage T3 or T4. In decreasing order, most carcinomas were diagnosed in the mandibular region as location of origin, followed by other oral structures, then the maxillary region, the floor of the mouth, and the tongue. Often, the tumors simultaneously infiltrated different tissues in the oral cavity. Table I provides an overview of tumor type, location, and consequences of resection.

Tab.I Tumor type, location, consequences of resection

Tumor type	Number of patients	In %
Squamous cell carcinoma	35	(76%)
Adenocarcinoma	4	(9%)
Non-Hodgkins lymphoma	1	(2%)
Angiosarcoma	1	(2%)
Multifocal plasmocytoma	1	(2%)
Verrucous carcinoma	1	(2%)
Esthesioneuroblastoma	1	(2%)
Uncertain, metastases	2	(5%)
Tumor location*		
Mandible	21	
Maxilla	14	
Floor of the mouth	9	
Tongue	6	
Other oral structures	15	
Consequences of resection		
Bone/soft-tissue grafts	29	
Mandibular continuity loss	23	
Oral-antral communication	12	
Ocular enucleation	2	
Nasal resection	1	

* Multiple tumor locations per patient are possible

Tumor therapy and transplants

Surgery was performed on all 46 patients; in 21 patients, this included a radical uni- or bilateral neck dissection. A uni- or bilateral ocular enucleation as well as a subtotal nasal amputation was also necessary in 3 patients and performed elsewhere. In 9 patients, the tumor or metastases had primarily infiltrated the soft tissue. In the other 37 patients, hard tissue was also resected, and in 3 patients, both the maxilla and the mandible were involved. A total of 29 patients received grafts (Fig. 1). 22 patients received both soft-tissue and bone grafts. The free fibula flap was most commonly employed. 32 patients underwent radiotherapy with an average total dose between 56 and 81.6 Gray. 12 patients had radiotherapy before receiving a transplant, and 18 underwent chemotherapy. 13 patients underwent both.

Implants

In 28 patients, a total of 104 dental implants were place, i.e., an average of 3.7 implants per patient. However, 14 implants were never loaded, because osseointegration did not occur in 4 of them, and 5 were removed due to infection and osteoradionecrosis. One patient died before his 4 implants could be loaded, and one other implant was never uncovered. Implantation was performed at different time points in the treatment protocol and at various locations in both jaws (Fig. 2). Table II shows implant location in terms of bone characteristics. Table III presents a life table analysis of the load-bearing implants.

Prosthetic rehabilitation

Treatment took only 13 appointments in complication-free cases, and was seldom straightforward. Treatment lasted a minimum of 77 days and sometimes went on for over a year before prosthetic therapy could be completed. The difference in treatment duration resulted from the individual disease progression and complications, such as infections, necroses, or tumor recurrence. This led to changes in the original treatment plan or delays in further prosthetic treatment. Finally, the poor general condition of some patients led to interruption or cessation of treatment.

Prosthetic designs varied greatly depending on the destruction of the normal anatomy and morphology of the oral cavity and face. For instance, dislocation and strong anterior curvature of the mandible occurred, which was comparable to a sagittal Class III malocclusion, or the floor of the mouth and/or vestibule were missing, and the partially resected tongue was attached to the floor of the mouth by scar tissue. In patients with severely reducted lingual mobility, the occlusal plane was set low so that the tongue could more easily transport food particles to the lower dentition. It was not always possible to design the normal extent of the prosthesis saddle in the resection area, which resulted in shortened dental arches or even unilateral occlusion. In contrast, the prosthesis base was highly overcontoured to support the cheek and lip.

Owing to uncertain prognoses and poor general condition, 2 of the 46 patients kept their provisional prostheses, and 1 patient initially received only a vacuum-drawn splint. Another patient died before treatment was definitively completed.

In 11 patients primarily the maxilla and in 26 primarily the mandible was affected by the resection. In the majority of the patients, the opposite jaw was also fitted with a prosthesis. Tables IVa and IVb show the prosthetic reconstructions of the resected jaws and their antagonists. In 9 patients, resection of both jaws was performed for the following reasons:

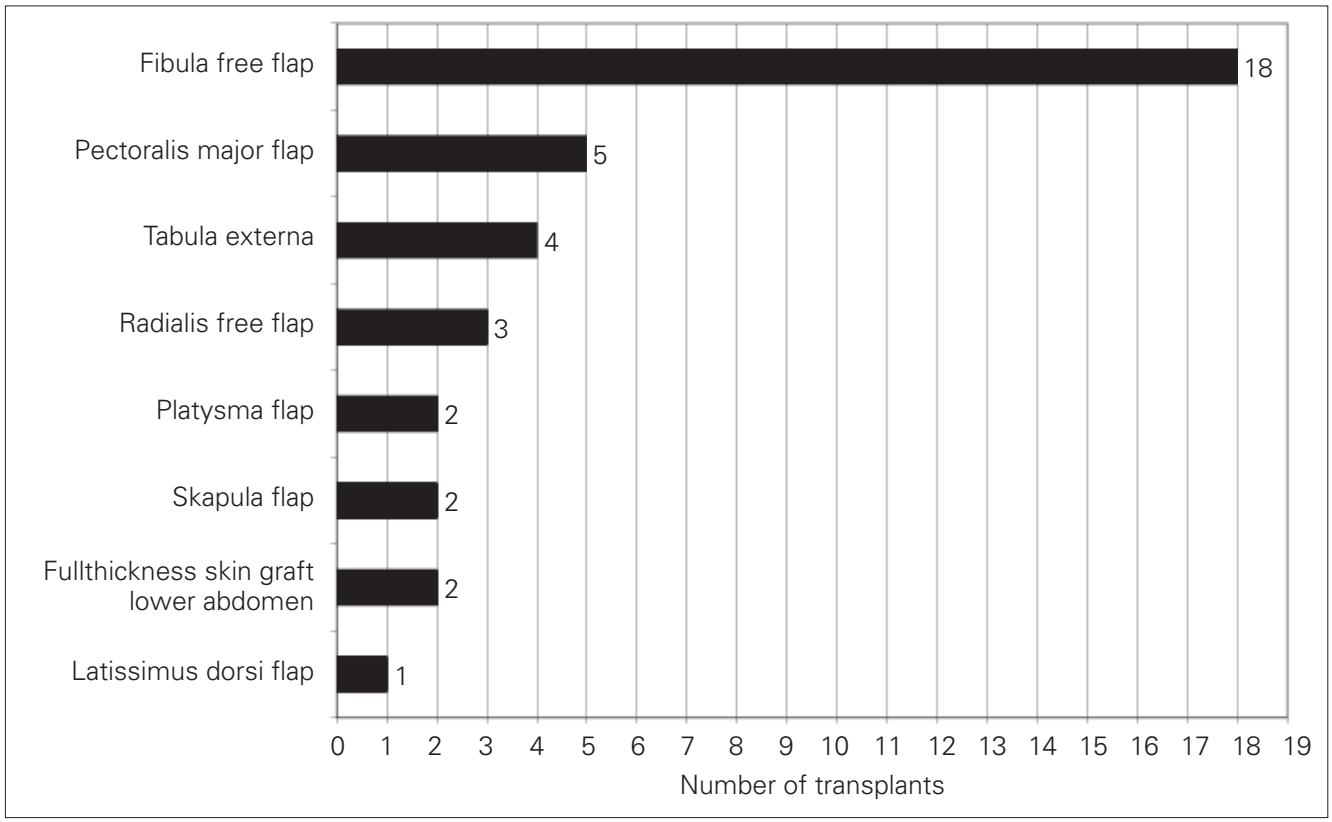

Fig. 1 Transplants: type and number

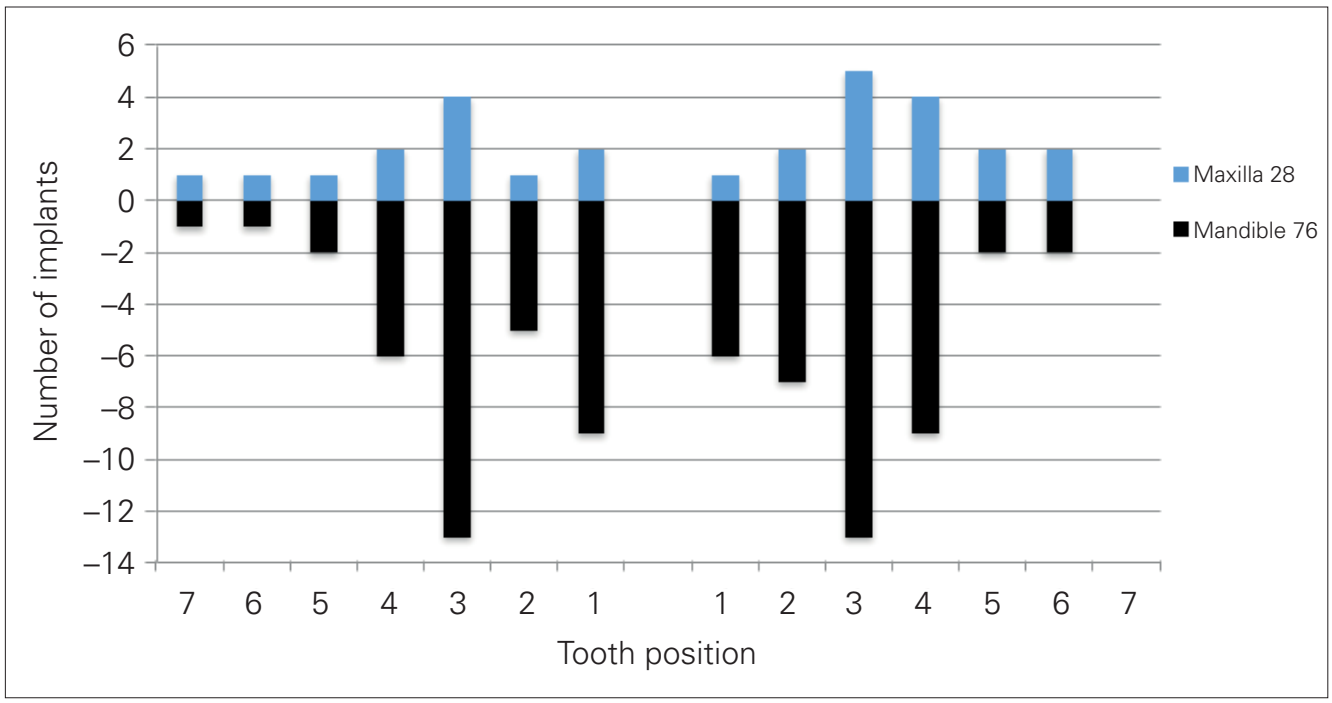

Fig. 2 Implant location in maxilla and mandible

1. widespread tumors or metastases which can lead to total resection of the palate or complete loss of mandibular continuity (Figs. 3, 4, 5).
2. side-effects of tumor treatment (radiothearpy and osteoradionecrosis) led to further operations in both jaws.

Table V presents a list of all prostheses made for these 9 patients.

Discussion

In the present study, many more men (67%) than women (33%) were treated for oral cavity tumors. This result agrees with the data of the Swiss Association of Cancer Registries 1986–2005 (Pury et al. 2007). The risk of oral cavity carcinoma is 6 to 15 times greater in people who consume both

Tab. II Characteristics of the implant bed and relative implant losses

Bone quality	Number of inserted implants	Loss before/after loading	Relative losses (%)
Local, not irradiated	16 (15%)	2/0	12.5%
Local, irradiated	42 (41%)	6/2	19.0%
Transplant, not irradiated	26 (25%)	0/2	7.6%
Transplant, irradiated	20 (19%)	6/0	30.0%
Total	**104**	**14/4**	**17.3%**

Tab. III Life table analysis of all 104 inserted implants

Year	Implants	Failures	Survival time interval (%)	Survival time total (%)
0	104	14	87.5	87.5
0–1	90	0	100	87.5
1–2	78	2	87.5	86.2
2–3	45	0	100	85.2
3–4	24	2	85.2	84.2
4–5	9	0	100	84.2

Implants were inserted in 26 patients

Tab. IVa Prosthetic treatment after maxillary resection

Prosthetic reconstruction in maxilla	No
Obturator prosthesis with implant	7
Partial/complete prosthesis with obturator	3
Provisional prosthesis only	1
Prosth. reconstr. in opposing jaw	**No**
Own teeth	7
Partial prosthesis	2
Complete prosthesis	1
Bridges, crowns	1

(Total 11 patients, 5 with large oronasal communication)

Fig. 3 Maxilla with large oral-antral communication after resection of palate and left alveolar crest

Tab. IVb Prosthetic treatment after mandibular resection

Prosthetic reconstruction in mandible	No
Bar prosthesis with implant	11
Prosthesis with endodontic post cap	3
Clasp prosthesis	1
Complete prosthesis	1
Bridges, crowns	6
Own dentition, conservative	2
None, provisional restoration	2
Opposing jaw	**No**
Complete prosthesis	6
Telescoping prosthesis	5
Prosthesis with endodontic post cap	1
Bridges, crowns	1
Own dentition, conservative	8
None, provisional restoration	5

(Total 26 patients)

Fig. 4 Obturator prosthesis

tobacco and alcohol than it is among non-smokers and non-drinkers (McCoy et al. 1979, Blot et al. 1988, Lissowska et al. 2003). The data of this study show that less than 50% of the patients regularly smoked and/or drank alcohol, but this does not seem to reflect the actual behavior of many patients, since 50% gave no comment on this issue. Quitting smoking can

Tab. V Prosthetic treatment after tumor resection in both jaws

Maxillary prosthesis	No
Complete prosthesis	4
Obturator prosthesis with bar (impl.)	1
Obturator prosthesis on ball anchor (impl.)	1
Clasp prosthesis	1
Partial prosthesis	2
Mandibular prosthesis	**No**
Complete prosthesis	2
Clasp prosthesis	2
Bar prosthesis on 2 implants	2
Partial prosthesis	1
Fixed bridge	1
Vacuum-drawn splint	1
(Total 9 patients)	

greatly reduce the risk of developing cancer within 5 to 10 years (Blot et al. 1988, Garrote et al. 2001). According to the World Health Organisation, oral cavity or pharyngeal cancer was the eighth most common tumor type in men in 2002. Malignoma of the oral cavity and/or pharynx is not among the 10 most common types of tumors in women (World Health Organisation, 2009 www.who.int).

Different authors report different tumor frequencies related to location in the oral cavity. In descending order, the following locations are affected: floor of the mouth, tongue, alveolar crest, mesopharynx, hard and soft palate, cheek, oral commissure, labial mucosa, transition to epidermis (Fröhlich et al. 1992, Krutchkoff et al. 1990, Höltje et al. 1992). Caution must be used when comparing these results with those of the present study, since in the latter, only oral-tumor patients were included who needed new dental treatment. Nonetheless, the mandible and the floor of the mouth were the most common tumor locations in this study as well.

In tumor resection and neck dissection surgery, conserving a maximum of function is always a priority (Ord et al. 2000). Despite such efforts, the side-effects of dramatic morphological changes in the oral cavity, restricted mouth opening, and hard scar tissue are major. They make the fitting of prosthetic reconstructions very difficult. One study showed that post-operative problems after free fibula flap surgery were perceived differently according to sex. After reconstructive surgery, men tended to emphasize functional problems with swallowing and speech. Women, more content with the function, were bothered most by the esthetic result (Hölzle et al. 2007). From a prosthetic and hygienic point of view, the thickness of the grafted tissue created problems by constricting the prosthetic space and by becoming inflammed and forming pseudosulci at the implant penetration site.

At >60 Gy, the total radiation dose was high in this group of patients. Some authors have stated that no negative consequences for implantation are expected using up to 45 Gy (Colella et al. 2007); others have mentioned 50 or ⩽60 Gy as the limit (Visch et al. 2002, Wagner et al.1998). The comparison with earlier studies shows that the use of implants has increased in the same clinical situation despite high radiation doses (Mericske-Stern et al. 1994, 1999). In this study, 28 of 46 patients received implants. The anterior implant position between the canines or first premolars is suitable in tumor patients, because restricted mouth opening makes any manipulation of the implants – e. g., impression taking – almost impossible in the posterior region. The preferred mandibular canine position resulted from edentulous mandibles, where chiefly bar prostheses were inserted on 2 to 4 implants.

In the current study, the 5-year survival rate was 84.2%. This is comparable to a previous study with a survival of 90% after 5 years (Mericske-Stern et al. 1999). Due to the fact that the dropout and mortality rates are very high shortly after prosthesis insertion, the number of observed implants was low after 5 years, as shown in the life table analysis. Another study reported a 5-year survival rate of 91%, decreasing to 75% after 8 years (Yerit et al. 2006). Compared to non-radiated patients, radiotherapy has a pronounced detrimental effect on the osseointegration and survival duration of the implants (Moy et

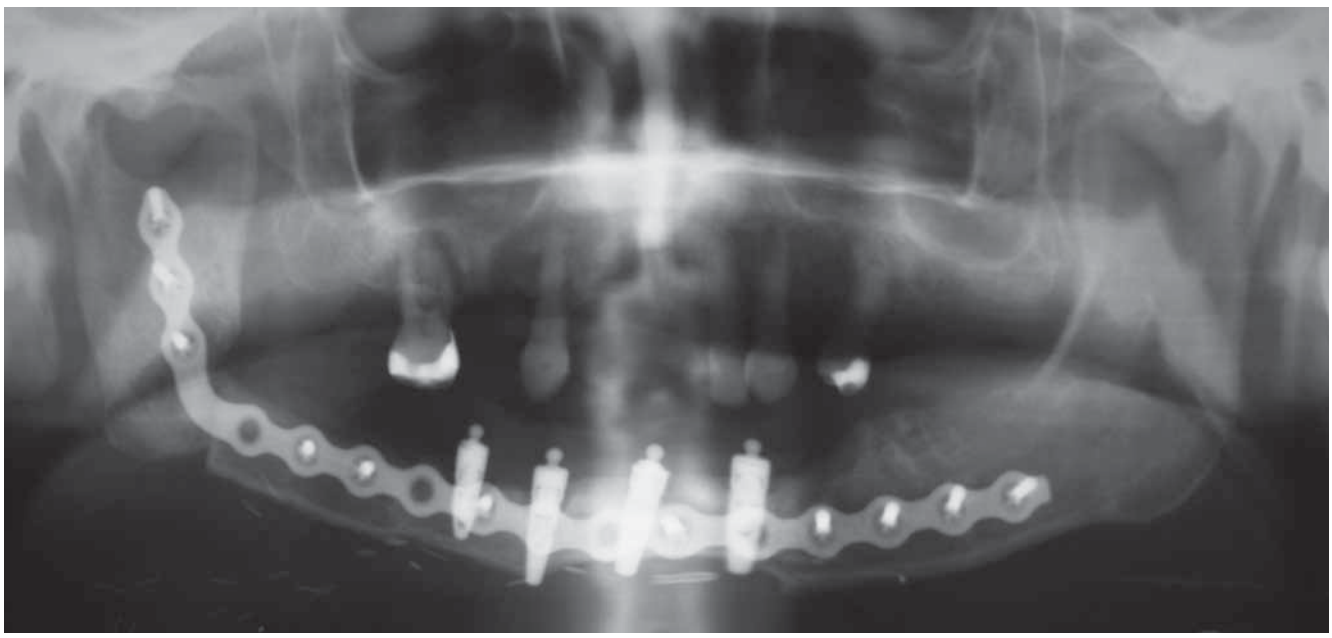

Fig. 5 Resection in mandible with complete loss of continuity on the left

al. 2005, Nelson et al. 2007). Where radiotherapy was performed prior to surgery, the survival rate dropped with increasing total dosage and duration of radiation (Granström 2005). Nonetheless, today radiotherapy is not seen an absolute contraindication, because the positive effect for rehabilitation is considered more important. Once the implants are osseointegrated, the survival rate seems to become more favorable (Schoen et al. 2001). In the present study, 41% of the implants were placed in local but irradiated bone. The most premature losses due to failed osseointegration (30%) were found with implants in transplanted bone combined with radiotherapy. Patients with premature or late failures were usually affected by the loss of several to all implants, which may in the broadest sense be considered a clustering effect. Of the 28 patients total who received implants, 7 lost them; in other words, 25% of the patients lost implants, which must be considered a high rate.

A published review demonstrated that the literature contains no information on the specific characteristics of resection prostheses in patients with oral tumors (Tang et al. 2008). In the present group of patients, removable reconstructions were mostly used, because these patients had few to no teeth left. The asymmetrical distribution of anchors (teeth and/or implants) and edentate jaw sections, which functionally could no longer be included in the reconstruction due to unfavorable intermaxillary or morphological configuration, also made removable prostheses necessary. There are considerably more publications on implant-supported prostheses for the mandible than for the maxilla (Tang et al. 2008). Where one study reported that no prosthesis type provided particular advantages (Linsen et al. 2009), others preferred implant-anchored prostheses despite reduced survival rates (Weischer et al. 1999). Removable prostheses can be considered advantageous, because they facilitate not only regular inspection of the oral cavity and resected area but also hygiene. Due to limited space, fixed bridge prostheses would have been better in some cases. The prosthesis had to be designed to fit the shape of the defects and altered oral morphology, and thus in many cases did not fulfill standard requirements of occlusal and base design. Thus, it was not possible to determine certain objectifiable differences in function with the prostheses in this study.

Conclusion

Despite comparable consequences of tumor therapy, the patients were variously affected by post-operative problems. In some cases, the resection of oral tumors created massive changes in the intraoral space, intermaxillary relations, facial morphology, and appearance. Accordingly, prosthetic rehabilitation is difficult and requires that the reconstructions be individually designed. Due to insufficient remaining dentition or complete edentulousness, removable prostheses are employed in most cases. Today, implants are often inserted despite radio- and chemotherapy, providing better anchorage but possessing a lower average survival rate than in healthy patients with favorable initial conditions. Long-term observation of tumor patients and implants is inherently limited, because the chance of survival given late-stage tumors is greatly reduced.

Résumé

Cette étude rapporte sur la réhabilitation chirurgicale et prothétique de 46 patients dont 31 hommes et 15 femmes après résection de tumeurs orales. Le traitement a eu lieu entre 2004 et 2007 dans le Département de prothèse de l'Université de Berne avec un suivi de 3 à 6 ans. L'âge moyen des patients était de 56 ans lors du diagnostic initial de la tumeur. 76% des tumeurs étaient des carcinomes épidermoïdes, suivis par les adénocarcinomes. Tous les patients ont subi une résection de la tumeur incluant les tissus mous et/ou tissus durs. En sus, 80% des patients ont reçu une radiothérapie et 40% une chimiothérapie. Une chirurgie interruptrice latérale mandibulaire a dû être exécutée sur 23 patients, tandis que chez 10 patients la résection de la tumeur a créé une perte de substance oro-nasale. 29 patients ont reçu des greffes principalement sous forme d'un lambeau péroné libre. Afin d'améliorer le résultat du traitement prothétique et la stabilité de la prothèse, 114 implants ont été placés. Toutefois, 14 implants n'ont pu être chargés à cause d'une perte prématurée durant la phase de guérison ou parce que le patient ne pouvait pas finir le traitement prothétique. La survie des implants était de 84,2% après 4 à 5 ans.

Plusieurs patients présentaient une dentition réduite avant le diagnostic de la tumeur, et d'autres dents ont dû être extraites durant le traitement de la tumeur. En tout, 31 mâchoires sont restées édentées. Les implants offrent de la stabilité et facilitent l'adaptation à la prothèse, mais leur taux de survie est compromis. Au maxillaire supérieur, ce sont principalement des prothèses amovibles avec obturateurs qui ont été réalisées, tandis qu'à la mandibule, les prothèses totales étaient supportées par des barres sur implants.

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