



SURVIVAL ANALYSIS AND CLINICAL EVALUATION OF IMPLANT-RETAINED PROSTHESES IN ORAL CANCER RESECTION PATIENTS OVER A MEAN FOLLOW-UP PERIOD OF 10 YEARS

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Statement of problem. Dental implants have been increasingly used for prosthodontic rehabilitation of patients following oral tumor resection and postsurgical radiotherapy. However, only a few long-term studies have examined the implant survival rate and other factors related to prosthodontic treatment in oral tumor resection patients.

Purpose. The purpose of this study was to evaluate the long-term survival of dental implants and implant-retained prostheses in oral cancer resection patients.

Material and methods. Ninety-three patients (63 men, 30 women) with a mean age of 59 years (range of 26-89 years) received 435 implants after the resection of a head and neck tumor. Twenty-nine patients received postsurgical radiotherapy prior to implant placement. The factors related to implant survival or failure were monitored over a mean observation period of 10.3 years (range of 5 to 161 months). Prosthodontic rehabilitation was evaluated with respect to the rates of technical failures and complications. Data were analyzed using a Kaplan-Meier curve and comparisons were made with the log-rank test or the Wilcoxon test ($\alpha=.05$).

Results. Of the 435 implants, 43 implants were lost; the cumulative survival rate was 92%, 84%, and 69% after 3.5, 8.5, and 13 years, respectively. Twenty-eight implants in 6 patients were counted as lost since the patients had died. Twenty-nine irradiated patients received 124 implants, of which 6 implants were lost prior to prosthodontic rehabilitation. In 68 patients with 78 rigid bar-retained dentures, only minor technical complications were identified. However, all 25 fixed implant-supported restorations had no technical component failures and did not require technical maintenance.

Conclusions. This study demonstrates that implant-retained and -supported prostheses in oral cancer resection patients, irrespective of the cancer treatment procedure, show lower long-term survival rates than those in patients without prior cancer surgery. Rigid fixation of the implant-supported prosthesis appears to minimize the complication rates. The poor implant survival rate was due to the higher mortality rate among these patients, and not to a lack of osseointegration. (*J Prosthet Dent* 2007;98:405-410)

CLINICAL IMPLICATIONS

Implants used for prosthodontic restoration in oral cancer patients following surgical resection and radiation therapy have a lower long-term survival rate than implants in healthy individuals due to oral cancer patients' increased mortality rate. Rigid fixation of the implant-supported removable and fixed prostheses appears to be favorable, as it minimizes technical and biological complications.

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The prosthodontic rehabilitation of partially and completely edentulous patients using implants is a well documented and reliable treatment method.¹⁻³ The use of endosseous implants has increased in patients after oral surgical resections.⁴⁻⁶ Surgical therapy often results in hard and soft tissue deficiencies that require either reconstructive tissue grafting and/or prosthodontic treatment. Advanced surgical techniques have improved the restoration of bony and soft tissue orofacial defects in many patients, which has allowed conventional prostheses to be used.⁷ Prosthodontic treatment of oral cancer patients is a challenge due to multiple factors, including altered anatomy, irradiation-induced xerostomia and associated fragile mucosa, the presence of vulnerable tissues, and impaired muscular function.^{7,8} The use of conventional prostheses is rather limited in these patients; thus, implant-retained or -supported prostheses are often necessary.^{9,10} Few studies have evaluated the clinical success of the different types of retention of implant-supported restorations.¹¹⁻¹³ Other factors that can jeopardize the success of implants in these patients are often associated with the irradiated tissue.^{14,15} Only a small number of long-term studies have analyzed the factors that can affect implant survival rates and evaluated prosthodontic treatment of oral cancer resection patients.¹⁶⁻¹⁸ The aim of the present study was to evaluate the long-term implant survival rate, as well as the implant-retained rehabilitation, of oral cancer resection patients.

MATERIAL AND METHODS

The patients were treated at the Department of Oral and Maxillofacial Surgery, Humboldt University, Berlin, over a period of 13 years, beginning in 1992, after the patients provided written consent. The study was approved by the university's institutional ethics committee. The patient group consisted of 93 subjects (63 men, 30

women). In all patients, prior to implant placement, a malignant tumor was removed surgically (25 in the maxillary region, 68 in the mandibular region); 29 patients also had postsurgical radiotherapy (up to 72 Gy) prior to implant placement. Radiation therapy was delivered in fractions of 2 Gy given daily for 5 days each week.

The 93 patients had a total of 435 titanium implants placed from the following manufacturers: CAMLOG ROOT-LINE (CAMLOG Biotechnologies, Basel, Switzerland); Steri-Oss (Nobel Biocare AB, Goteborg, Sweden), Branemark MKII (Nobel Biocare AB); or ITI (Straumann AG, Basel, Switzerland). Most implants (n=384) were placed in the jaw affected by surgical resection, while 51 implants in 10 patients were placed in the opposing jaw of the surgical site. The patient inclusion criteria were surgical treatment for oral cancer with or without radiation therapy and/or chemotherapy, after which conventional prostheses could not be used. Patients with poor general health were excluded from implant therapy. Patients with apparent heavy nicotine abuse (>10 cigarettes/day), who also had received radiation therapy, were excluded from this study. In irradiated patients, all implants were placed within the radiation field after a minimum of 6 months following radiation therapy. In all patients, whether or not they were irradiated, the implants were allowed to osseointegrate for 3 months in the mandible and 6 months in the maxilla. Irradiated patients were given an antibiotic regimen using clindamycin, 300 mg 3 times daily, pre- and postoperatively (1 day preoperatively and 3 days postoperatively), to minimize the risk of osteoradionecrosis.¹⁹ Two weeks after second-stage surgery, an impression was made using an open-impression tray technique with a polyether impression material (Impregum; 3M ESPE, Seefeld, Germany). Sixty-eight patients received 78 removable overdentures retained by an individually fabricated bar using a high-gold alloy (ORPLID CF; C. Hafner GmbH, Pforzheim, Germany) (Fig. 1). In 10 patients, implant-supported dentures were placed in the maxilla and mandible. In all removable prostheses, acrylic resin artificial teeth (Creaparl; Amann Girrbach GmbH, Pforzheim, Germany, and SR Vivodent or Orthotyp PE; Ivoclar Vivadent, Schaan, Liechtenstein) were used. Screw-retained fixed dentures were fabricated for 25 patients (5 edentulous, 20 partially edentulous) (Fig. 2).

The patients were clinically evaluated every 6 months using a standard protocol that included visual and digital inspection of the prosthetic restoration and/or implants, torquing of the abutment screw, and measurements of modified bleeding index and modified plaque index. Mechanical and biological complications were monitored. The implants were



1 Individually fabricated bar for rigid fixation of implant-retained prosthesis.



2 Implant-retained fixed partial denture in patient with reconstructed mandible with vascularized fibula graft.

TABLE I. Implant distribution and failures

Implant Systems	Number of Implants Placed	Number of Implants Lost	Number of Implants in Nonirradiated Patients (Number of Implants Failed)	Number of Implants in Irradiated Patients (Number of Implants Failed)	Number of Implant Failures in Deceased Patients	Number of Implant Failures Due to Surgical Removal
Branemark MKII	113	9	76 (1)	37 (0)	8	
Steri-Oss	127	27	90 (1)	37 (6)	20	
CAMLOG ROOT-LINE	156	6	108 (1)	48 (1)		4
ITI Straumann	39	1	37 (1)	2 (0)		
Total number	435	43	311 (4)	124 (7)	28	4

regularly assessed according to the criteria of Buser et al.²⁰ These criteria comprise the absence of persistent complaints, such as pain or dysesthesia (this is limited to those patients that do not have existing paresthesiae from tumor surgery), and the absence of repeated periimplant infection, fistula, or abscess. Furthermore, the mobility and radiolucency around the implant were assessed. Implant survival was analyzed using the Kaplan-Meier curve, and the statistical significance ($\alpha=.05$) of the results was determined. The survival curves were compared using either the log-rank test or the Wilcoxon Mann-Whitney U

test. These analyses were performed using statistical software (SPSS, version 11.0; SPSS Inc, Chicago, Ill).

RESULTS

The mean age of the patients was 59 years (range of 26-89 years) and the average observation period was 10.3 years (range of 5-161 months). Of the 93 subjects, 21 were observed for a period of 7 to 13.5 years, 21 for a period of 5 to 7 years, and 31 for more than 3 years. Six patients died during the observation period.

In the 93 patients, 435 implants were placed (156 CAMLOG ROOT-

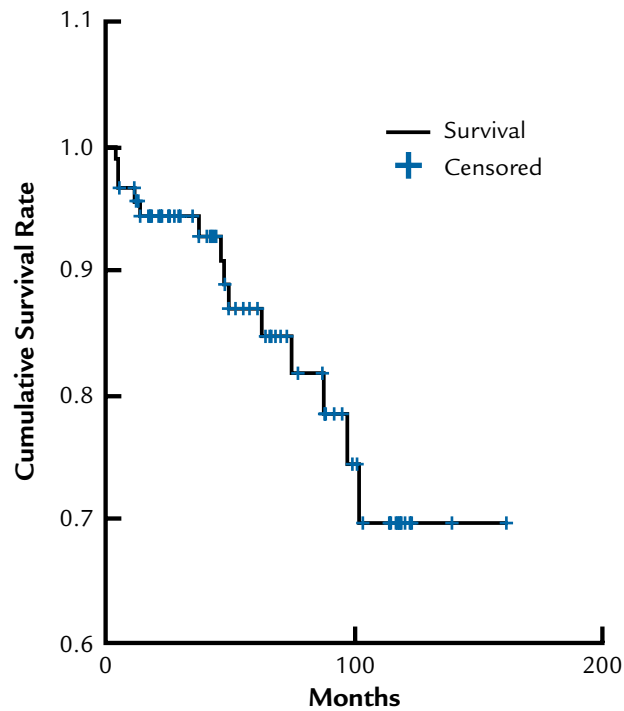
LINE; 127 Steri-Oss; 113 Branemark MKII; 39 ITI Straumann); 281 in the mandible and 154 in the maxilla. The mean number of implants placed per patient was 4.6 (range, 3 to 8). Of the 435 implants, 43 were lost; 28 of these implants were unavailable because they were placed in 6 patients who died during the observation period. Nonirradiated patients lost 4 implants, 1 of each of the implant systems used (Table I). Overall implant survival in patients after surgical ablation for an oral tumor was 92%, 84%, and 69% after 3.5, 8.5, and 13 years, respectively.

The 5-year Kaplan-Meier implant



survival rate was 85% for men and women (Fig. 3). After 8 years, the survival rate was 70% for both genders. There were no statistically significant differences between the genders at these time points ($P=.66$). After 4 years, the cumulative survival rate of implants was 70% for those placed in the maxilla and 92% for implants placed in the mandible ($P=.26$). After 8 years, the implant survival rate was 75% for both the maxillary and mandibular implants. Over the entire observation period, none of the differences was statistically significant.

After oral cancer resection, 29 subjects with 124 implants received radiotherapy, and 7 implants were lost; of these 7 implants, 6 implants of the Steri-Oss system were lost in 2 patients prior to the prosthodontic treatment (Table I). In 1 of the 2 subjects, prosthodontic treatment could not be provided. The cumulative implant survival rate in patients who received radiotherapy was 84% at 46 months and 54% after 13.5 years. The difference in the implant survival rate between irradiated jaws and nonirradiated jaws was not significant ($P=.08$). The 2 irradiated patients with implant failures were heavy nicotine users (> 20 cigarettes/day); a statistical analysis of nicotine usage was not performed due to lack of information from other patients. Further statistical testing of the group of irradiated subjects was not performed due to the small sample size and low rate of failure throughout the observation period. In 17 patients, maxillary or mandibular grafts were placed. Ninety-five implants were placed in grafts (85 implants in iliac bone, 10 implants in fibula bone); there were 76 nongrafted patients (Table II). The difference in the implant survival rate between implants placed in grafted and nongrafted sites was not significant ($P=.71$). In 85 patients, the initial prosthodontic treatment was maintained throughout the observation period. Six patients were deceased, and 1 patient had a recurrence, which required a second surgical interven-



3 Kaplan-Meier survival analysis for implants placed in oral cancer resection patients. Diagram shows overall survival of all implants for observation period of 13 years.

TABLE II. Implant location

Bone	Maxilla	Mandible	Total Number of Implants
Irradiated	41	83	124
Grafts	30	65	95
Fibula	0	10	10
Ilium	30	55	85
Nonirradiated	113	198	311
No grafts	109	231	340

tion during which all 4 mandibular implants had to be removed. One additional irradiated patient lost all implants prior to prosthodontic therapy. In 91.3% of patients the prosthodontic restoration was successfully maintained during the observation period. The technical complications encountered with the prosthodontic rehabilitation included the need to replace the matrix retainers in 11 bar-retained dentures. Mucosal ulcers were seen in 2 patients after loss of retention of the removable denture. Dehiscence and disturbed wound healing after first-stage surgery occurred in 3

irradiated patients; in all 3 patients, implant surgery was performed more than 1 year after radiotherapy.

DISCUSSION

Studies have shown that treatment using implant-supported overdentures has become increasingly successful in head and neck cancer resection patients, and that the methods used in the oral rehabilitation of oral cancer patients have changed in the past decade.^{7,14,15} In the present study of oral cancer resection patients, the long-term cumulative sur-

vival of osseointegrated implants was 69% after a mean of 10.3 years, which is comparable to the results reported by Granstrom.¹⁵ The implant survival rate was lower than that in nontumor implant patients, who had an implant survival rate of more than 90% after 10 years.^{12,13} In the present study, mandibular implants had a significantly better survival rate than maxillary implants in the first 5 years, although long-term survival rates were equivalent.⁶ This was due, in part, to the fact that 64% of all implants were placed in the mandible, and that 82% of mandibular implant losses were due to patient death. The overall survival rate of oral cancer resection patients is lower than that of noncancer patients; 65% of the implants were categorized as failures due to patient death, which contributed to the lower survival rate of implants placed in oral cancer resection patients. The present study had a long observation period and used different implant systems. These implant systems were found to have an equivalent osseointegration potential, even though they display different surface topographies. In 2 of the systems (Branemark MK II and Steri-Oss implants), the implants had a machined surface, whereas in the others (CAMLOG ROOT-LINE and ITI Straumann), the implants had a rough surface obtained by combined treatment involving acid-etching and airborne-particle abrasion.

Of note, unlike previously reported, comparable studies,^{7,16} a significant difference in the survival of implants in irradiated versus non-irradiated patients was not found in the present study. This might, in part, be due to the fact that, after complications were observed in irradiated patients who smoked, irradiated patients who obviously abused nicotine were excluded from implant therapy. The association of nicotine use and a higher implant failure rate in irradiated patients cannot be concluded from the present study; the data collected regarding this aspect was insufficient for statistical analysis. Most implant

failures seen in irradiated patients occurred shortly after implant placement. The number of late implant failures (0.81%) was comparable to that seen in nonirradiated patients (1.29%).

It is known that, in oral cancer resection patients, the retention elements used in implant-supported restorations are related to prosthesis-related lesions.⁹ In the present study, all patients had rigid fixation of the implant-retained prosthesis, which minimized mucosal complications. In irradiated patients, fragile mucosa and severe mucositis are commonly observed long after irradiation therapy, which increases the risk that prosthetic pressure lesions will result in septic osteoradionecrosis.^{8,9} A minimum of 3 implants per jaw was placed to ensure a rigid fixation in edentulous patients with a bar-retained denture. The bar-retained dentures required little maintenance and showed good retention up to 13 years. The matrix retainers for the bar attachments can be activated or, when plastic retainers are used, easily replaced at a low cost.^{11,12} Fixed implant-supported restorations were primarily used in young patients or in partially edentulous patients with a minor deficiency in soft and hard tissue.¹³ The majority of the patients (73%) received a bar-retained overdenture, in part to compensate for existing soft and hard tissue deficiencies and to avoid mucosal irritation. Treating oral cancer resection patients with rigid bar-retained overdentures or implant-supported fixed prostheses minimized the technical and biological complications usually encountered in such a compromised environment. Although the overall survival rate of endosseous implants placed in oral cancer resection patients appears to be low, and unfavorable conditions, such as radiation therapy and tissue deficiencies, are present, long-term implant prosthodontic rehabilitation is possible in such patients.

Recall bias was minimized within this retrospective analysis, as an ex-

isting standardized recall protocol was used. However, the confounder, nicotine abuse, could not be evaluated statistically, as it had not been monitored consistently. Future studies should focus on the causes of early implant loss in irradiated patients with emphasis on nicotine abuse in this sample group.

CONCLUSIONS

This study evaluated the long-term outcomes of oral cancer resection patients treated with dental implants. The mean 10.3-year survival rate was low (69%), and there was no statistically significant difference in implant survival between irradiated and non-irradiated patients. This increased failure rate was caused by the higher mortality rate of the patients; it was not the result of lack of osseointegration. The completely implant-supported prostheses observed in this study minimized mucosal lesions and technical complications.

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NOTEWORTHY ABSTRACTS OF THE CURRENT LITERATURE

Effect of in-office tooth bleaching on the microhardness of six dental esthetic restorative materials

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Dent Mater 2007;23:153-8.

Objectives. The aim of this in vitro study was to evaluate the effect of the in-office bleaching technique on the microhardness of six dental esthetic restorative materials.

Methods. Four composite resins (a hybrid, a flowable, a micro-hybrid and a nano-hybrid), an ormocer and a ceramic were tested, after the use of an in-office bleaching product. Fourteen specimens of each composite and the ormocer were fabricated and randomly divided into two groups of seven samples each. One group was polished and the other group remained unpolished. For the ceramic, seven polished samples were fabricated. Two samples of each group were used as negative controls. The specimens were bleached for 15, 30 and 45 min. Five Knoop microhardness measurements were made on each sample, for each of the following periods tested: before bleaching, after 15, 30 and 45 min of bleaching, 24 h and 1 month after the bleaching procedure. Data were analyzed by the repeated measures analysis of variance with three between factors and one within.

Results. The differences in the microhardness values between the bleached and the control samples for the composites and the ceramic, were not statistically significant (hybrid: $P=.264$; flow: $P=.584$; micro-hybrid: $P=.278$; nano-hybrid: $P=.405$; ceramic: $P=.819$). For the ormocer, although bleaching did not have any significant effect on the unpolished samples ($P=.115$), it caused an increase on microhardness of the polished samples.

Significance. Bleaching with 38% hydrogen peroxide does not reduce the microhardness of the restorative materials tested. Therefore, no replacement of restorations is required after bleaching.

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