Long-Term Results of Endosteal Implants Following Radical Oral Cancer Surgery with and without Adjuvant Radiation Therapy

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ABSTRACT

Purpose: The aim of this study was to analyze the long-term survival of implants and implant-retained prostheses in patients after ablative surgery of oral cancer with or without adjunctive radiation therapy.

Materials and Methods: Between 1997 and 2008, 66 patients who had undergone ablative tumor surgery in the oral cavity were treated with dental implants ($n = 262$). Thirty-four patients received radiation therapy in daily fractions of 2 Gy administered on 18 to 30 days. Implants were inserted in the maxilla (49; 18.7%) or mandible (213; 81.3%), in non-irradiated residual (65; 24.8%) or grafted bone (44; 16.8%) and in irradiated residual (15.6%) or grafted bone (39; 14.9%). Seventeen fixed protheses and 53 removable dentures (34 bar attachments, 9 telescopic and 10 ball retained dentures) were inserted.

Results: Mean follow-up after implant insertion was 47.99 (±34.31) months (range 12–140 months). The overall 1-, 5-, and 10-year survival rates of all implants were 96.6%, 96.6%, and 86.9%, respectively. Fourteen implants were lost in nine patients (5.3% of all implants); eight implants were primary losses, and five secondary losses because of an operation of tumor recurrence. There was no significantly lower implant survival for implants inserted into irradiated bone ($p = .302$), bone and/or soft-tissue grafts ($p = .436$), and maxilla or mandible ($p = .563$). All prosthetic restorations in patients without tumor recurrence could be maintained during the observation period.

Conclusions: Implant survival is not significantly influenced by radiation therapy, grafts (bone and/or soft tissue), or location (maxilla or mandible). However, implants placed in irradiated bone exhibit a higher failure rate during the healing period than those placed in non-irradiated bone. No superstructure was particularly favorable. Osseointegrated implants can be used successfully in patients with prior history of ablative surgery with and without additional radiation therapy.

KEY WORDS: bone transplant, maxillofacial prosthesis, oral implants, radiotherapy

INTRODUCTION

Patients with head and neck cancer are usually treated by a combination of ablative surgery and radiation therapy. Following cancer surgery, most patients suffer from hard and soft tissue defects, and either deficit may result in functional disabilities and aesthetic deformity. These defects can only be restored to a certain extent by plastic-reconstructive measures. Additionally, resections result in a reduced number of teeth, scar formation that affects muscular coordination, and disturbed sensitivity. Following maxillectomy, the epithelial lining of the defect cannot bear much load caused by obturators. Depending on the height and contour of the residual alveolar ridge and the location of the remaining teeth, obturators

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cause unfavorable strains. Defects are often reconstructed with bone grafts and covered with vascularized or non-vascularized flaps. However, neither tissue offers sufficient strength to provide the necessary buffer effect.

Adjuvant radiation therapy may result in irradiation caries, xerostomia, progressive fibrosis of blood vessels and soft tissue, and reduces the healing capacity of the vessels and tissue.[1] The severity of effects from radiation therapy correlates with the dose of radiation delivered.[2]

Ablative surgery, as well as radiotherapy, hampers dental rehabilitation, which aims to obtain normal aesthetic appearance and function (such as eating, swallowing, breathing, salivation, and speech).[3,4] Depending on the dimensions of the defect, height and contour of the residual alveolar ridge and location of the residual teeth, conventional prosthetic rehabilitation is often unsatisfactory or even impossible.[3] Restoring an edentulous patient can be extremely challenging.[3] Dental implants enable a more effective oral rehabilitation with regard to improvement of retention, support, and stability of prosthetic devices.[3,4] Circumstances that may increase implant failure in these patients compared with healthy patients include overloading of the implants, induced by altered oral anatomy following ablative surgery or reconstruction by grafts and flaps,[5] and the reduced healing capacity of oral tissues following radiation therapy.[5,6]

This study evaluated the long-term survival of implants in patients with oral cancer after radical oral cancer surgery with or without adjuvant radiation therapy. Implant survival with regard to irradiated bone, grafted/residual bone or soft tissue, implantation site (maxilla or mandible), and prosthetic superstructure was examined.

MATERIALS AND METHODS

Between 1997 and 2008, 66 patients (23 females, 43 males) were treated with dental implants after ablative surgery with or without adjunctive radiation therapy. Prior to implant placement, all patients had a malignant tumor surgically removed (10 in the maxilla, 56 in the mandible/floor of the mouth). Squamous cell carcinoma was diagnosed in the majority of patients ($n = 46$), ameloblastoma in six patients, adenoid-cystic carcinoma and keratocysts in two patients each, and 10 patients were diagnosed with carcinoma of different origin. The mean age (SD) of the patients at the time of surgery was 55.7 (±16.25) years (range, 6–82 years). Post-operative radiation therapy was delivered before implant placement to 34 patients in daily fractions of 2 Gy. The target volume was treated to a total dose of 36 Gy in 26 patients and a total dose of 60 Gy in eight patients. Bone that was not directly irradiated was considered as non-irradiated bone in this study.

The time interval between radical oral cancer surgery, radiation therapy and implant placement, respectively, ranged from 6 to 126 months (mean, 41.04 months). A total of 262 implants were inserted in a two-stage surgical procedure. Two implant types were used in the procedure: Brånemark (Nobelpharma, Gotheburg, Sweden) implants (258, or 98.4%) and Straumann (Straumann, Freiburg, Germany) implants (four, or 1.5%). Both types of implants used were those with machined and rough surfaces (titanium oxide ionized). The minimum length of all implants was 10 mm. A total of 246 implants were placed in the jaw affected by surgical resection, while 16 implants in four patients were placed in the opposing jaw of the surgical site. The healing period (SD), starting at implant insertion and ending with abutment operation, lasted an average of 4.9 months (±1.1; range, 3–8 months).

Various attachments (fixed prosthesis and removable overdentures) were used to provide prosthetic rehabilitation. Mean follow-up (SD) after implant insertion was 47.99 months (±34.31; range, 12–140 months). Patients had a routine follow-up with oral hygiene instruction at least every 6 months. Further annual intraoral radiographs were examined for peri-implant pathology.

Implants were considered successful if they were without pain, mobility and recurrent peri-implant infection and radiolucency.[7] Patients with implant failure were subdivided as early or late failures: early failure was defined as occurring before or at abutment operation (lack of primary osseointegration during unloaded healing period), and late failure was defined as a lack of osseointegration after incooperation of the superstructure and loading of the implant (biomechanical overloading). Survival time was measured from implant insertion to failure or last control of the implant. Hyperbaric oxygen therapy was not performed in this group.

Statistical Methods

Implant success rates were analyzed as cumulative survival, according to Kaplan-Meier and colleagues[8], data

were calculated on implant survival, using logrank tests, in the different subgroups. The parameters included previous radiation therapy, implant location (maxilla or mandible), implantation into bone or soft tissue grafts, patient gender, and prosthetic superstructure. Cox regression analysis was used as a multivariate approach to identify the variables of relevance by taking into account interactions between the parameters. The entire study population was examined, and evaluation of previous radiation therapy and use of bone and/or soft tissue grafts was included in the analysis.

RESULTS

The mean follow-up time after implant insertion was 47.99 (±34.31) months (3.99 years) (range, 12–140 months). Four patients (16 implants) with mandibular and maxillary implants died during the observation period. A total of 262 implants were inserted in the mandible (213, or 81.3%) and maxilla (49, 18.7%) in either non-irradiated (135, 51.5%) or irradiated (127, 48.5%) bone. Of these, 62 implants were inserted following rim resections, 77 after resection of the jaw body in the reconstructed mandible, 28 in residual bone following resection of the jaw body without bony reconstruction (discontinuity resection of the mandible or hemimaxillectomy), 75 after resection of the floor of the mouth, and four after resection of the soft palate. In each case, eight implants were placed in the opposing jaw of the surgical site (Table 1).

Altogether, 106 implants were placed in residual hard and soft tissue, 27 into bone grafts but residual soft tissue, 52 in hard and soft tissue grafts, and 77 in residual bone but soft tissue grafts (Table 2).

Implants in the Mandible

Of the 262 implants, 213 (81.3%) were inserted in the mandible (Table 1). Forty-two implants were inserted following rim resections (10 in non-irradiated bone and 32 in irradiated bone), 77 were placed into corticocancellous iliac bone grafts (50 non-irradiated, 27 irradiated bone), 28 into residual bone after mandibular discontinuity operation without reconstruction (all in irradiated bone), and 79 after resections of the floor of the mouth not involving the mandibular bone (37 non-irradiated, 38 irradiated bone). Eight mandibular implants were placed in the mandible following surgical procedures in the maxilla (six in non-irradiated, two in irradiated bone; Table 1).

Of the 213 mandibular implants, 103 (48.4%) were inserted in non-irradiated bone: 41 implants (39.8%) in residual bone and soft tissue, 15 implants (14.6%) in grafted bone and residual soft tissue, 25 implants (24.3%) in hard- and soft-tissue grafts, and 22 implants (21.4%) in residual bone and soft-tissue grafts. The other 110 (51.6%) were inserted into irradiated bone: 37 (33.6%) were placed in irradiated residual bone and soft tissue, 30 (27.2%) were placed in irradiated hard- and soft-tissue grafts, and 43 (39.1%) in irradiated residual bone and soft-tissue grafts.

TABLE 1 Implants Related to Surgical Site

Adjuvant radiation therapy	All implants	Rim resection	Resection of jaw body (with bone graft)	Resection of jaw body (without reconstruction)	Resection of floor of mouth/soft palate	Opposing jaw
All implants						
All	262	62	77	28	79	16
No	135	19	52	13	41	10
Yes	127	46	22	19	34	6
Mandible						
All	213	42	77	11	75	8
No	103	10	50	/	37	6
Yes	110	32	27	11	38	2
Maxilla						
All	49	20	—	17	4	8
No	32	9	—	13	4	6
Yes	17	11	—	4	—	2

TABLE 2 Implant and Survival Data

	Implants (%)	Loss (relative %)	Survival (%)		
			12-month	60-month	120-month
All implants	262 (100)	14 (5.3)	96.6	96.6	86.9
Radiotherapy					
Non-irradiated bone	135 (51.5)	6 (4.4)	99.3	99.3	84.7
Irradiated bone	68 (26.0)	3 (4.4)	95.6	95.6	95.6
Irradiated bone and chemotherapy	59 (22.5)	5 (8.5)	91.5	91.5	—
Grafts					
No grafts	106 (40.5)	4 (3.7)	96.2	96.2	—
Bone graft	27 (10.3)	1 (3.7)	96.3	96.3	—
Bone and soft tissue graft	52 (19.8)	7 (13.4)	96.2	96.2	79.0
Soft tissue graft	77 (29.4)	2 (2.6)	97.4	97.4	97.4
Location					
Maxilla	49 (18.7)	1 (2.0)	98.0	98.0	—
Mandible	213 (81.3)	13 (6.1)	96.2	96.2	86.6
Gender					
Males	176 (67.2)	7 (4.0)	96.0	96.0	96.0
Females	86 (32.8)	7 (8.1)	97.7	97.7	74.4

Implants in the Maxilla

Of the 262 implants, 49 (18.7%) were inserted in the maxilla (Table 1). Implants were placed following rim resection (20 implants: nine in non-irradiated, 11 in irradiated bone), resection of the jaw body with access to paranasal sinus or hemimaxillectomy (17 implants: 13 in non-irradiated, four in irradiated bone), and resection of the soft palate (four implants, all in non-irradiated bone). Eight implants were inserted opposite the surgical site of the mandible (six in non-irradiated bone, two in irradiated bone; Table 1).

Of the 49 maxillary implants, 36 (73.5%) were inserted in non-irradiated bone and 13 (26.5%) in irradiated bone. Among implants inserted into non-irradiated maxilla, 24 implants (66.7%) were inserted into residual bone and soft-tissue, four implants (11.1%) into bone graft (sinus elevation) and residual soft tissue, and eight implants (22.2%) into residual bone and soft tissue grafts. Among implants inserted into irradiated maxillary bone, five implants (38.5%) were inserted into residual bone and soft tissue, and eight implants (61.5%) into bone graft (sinus elevation) and residual soft tissue.

Survival Rate

The overall 1-, 5-, and 10-year cumulative survival rates of the 262 implants were 96.6%, 96.6%, and 86.9%, respectively (Table 1). Fourteen implants were lost in nine patients (5.3% of all implants) during the observation period (Table 3); 13 implant losses occurred in the lower jaw and one in the maxilla. Five implants were lost in one patient as secondary losses because of an operation of tumor recurrence following resection of the jaw body reconstructed with iliac bone and covered by mucosal flap. Seven patients each lost one implant and one patient two implants as primary losses: eight losses after radiation therapy (six losses after a total dose of 36 Gy, and two after 60 Gy), in non-irradiated bone, residual bone and soft tissue (four losses), in grafted bone (one loss), grafted bone and soft tissue (two losses), or residual bone but grafted soft tissue (two losses; Table 3).

The percentage of the survival of implants inserted in non-irradiated bone (135 implants) was 84.7% (observation period of 140 months), compared with 95.6% of implants inserted in irradiated bone (68 implants, observation period of 128 months), and 91.5% of implants in irradiated bone and chemotherapy (59 implants, observation period of 115 months) (Figure 1). The differences among the survival times were not significant ($p = .302$). This result is attributed to the secondary loss of five implants in one patient with implants in non-irradiated bone because of an operation of tumor recurrence after 82 months (6.8 years). When statistically adjusted, the success rate for non-

TABLE 3 Implant Losses Related to Time of Loss, Radiation Therapy, and Tissue Graft

	No graft	Bone graft	Bone and soft tissue graft	Soft tissue graft
All losses				
Primary-loss				
Non-irradiated bone	—	1	—	—
Irradiated bone	1	—	1	1
Irradiated bone and chemotherapy	3	—	1	1
Secondary-loss (non-irradiated bone)	—	—	5	—

irradiated bone was 99.2% (140 months) and logrank test resulted in significantly better survival of implants in non-irradiated bone ($p = .025$).

The survival rate of implants placed without hard or soft-tissue graft was 96.2% (observation period of 82 months), 96.3% (107 months) when placed into a bone graft and residual soft tissue, 79.0% (140 months) when placed into bone as well as soft tissue graft, and 97.4% (120 months) when placed into residual bone but soft tissue graft (Figure 2); the difference among these rates was not statistically significant ($p = .436$).

Evaluation of the influence of implant location (Figure 2) showed that success rate was 86.8% (140 months) in the mandible and 98.0% (64 months) in the maxilla; success rate had no significant effect on implant survival ($p = .563$). Likewise, no significant effect was found regarding the influence of patient gender on implant survival ($p = .274$); implant survival in females was 74.4% (120 months), and 96.0% (140 months) in males.

Prosthetic Rehabilitation

The mean follow-up time after prosthetic rehabilitation was 41.1 (±33.5) months (2.8 years) (range, 7–133 months). Prosthetic rehabilitation was performed by 17 fixed prosthesis and 53 removable overdentures (34 bar-, 9 telescopic-, and 10 ball/locator-retained). Fifty-nine suprastructures were only implant-borne while 11 suprastructures were both implant- and tooth-borne (2 fixed prosthesis, 3 bar-, 3 telescopic-, and 3 ball/locator-retained removable prosthesis). During the observation period, all loaded implants and prosthetic restorations in patients without tumor recurrence remained functional. There was no evidence of fractures or failed prosthetic components. Removable appliances were regularly adjusted by relining.

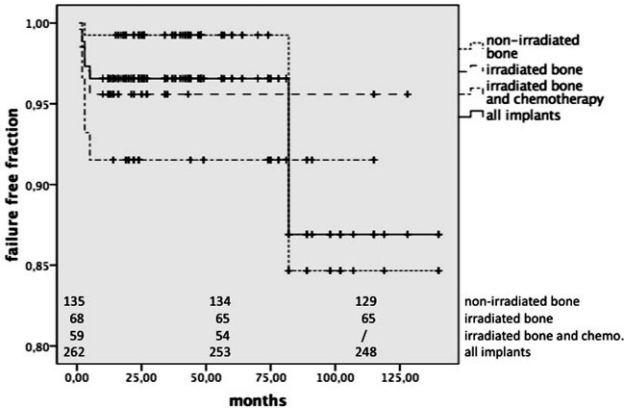

Figure 1 Kaplan-Meier analysis of the implants placed into non-irradiated, irradiated bone, irradiated bone and chemotherapy, and overall cumulative survival rate of all implants (logrank: $p = .302$). Number above time axis gives the number of implants still at risk at the respective time point.

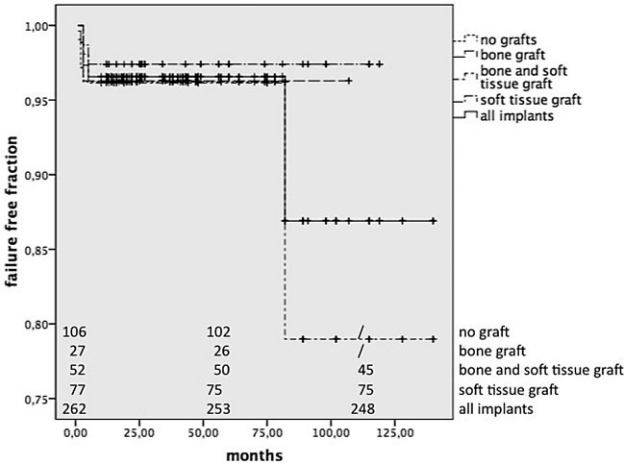

Figure 2 Kaplan-Meier analysis of the implant groups with and without tissue grafts and cumulative survival rate of all implants (logrank: $p = .436$). Number above time axis gives the number of implants still at risk at the respective time point.

Cox regression analysis for all implants identified no parameters of relevance among the variables radiation therapy ($p = .208$), and bone and/or soft tissue graft ($p = .448$).

Peri-Implant Infection

Peri-implant infection without marginal bone loss was observed in 12 patients (31 implants, 11.8%). None of these implants lost osseointegration. Peri-implant infection (SD) occurred on an average of 22.7 (±25.5) months after prosthetic rehabilitation (range, 2–84 months). Nine implants were provided with fixed prosthesis and 22 with removable overdentures (16 bar-, 3 telescopic-, and 3 ball-retained) were involved. Eighteen (58.1%) implants were placed in irradiated bone, six in residual bone, four in grafted bone and soft tissue, and eight in residual bone but soft tissue graft. In non-irradiated sites (13 implants, 41.9%), three implants were placed in residual bone, three in grafted bone, two in bone and soft tissue grafts, and five in residual bone but soft tissue graft. Conservative therapy (removal of debris, chlorhexidine irrigation, and oral hygiene instructions) was performed, as diminished oral hygiene was the reason for peri-implant infection.

DISCUSSION

Implant survival is generally influenced by various factors. In addition to the experience of the surgeon and bone quality, technical aspects, such as implant brand, length, diameter, or primary stability are also involved. After oral cancer surgery, additional factors influence osseointegration of implants, such as topography and size of resection, applied irradiation dose, and the timing of implant placement in relation to the end of radiotherapy. Unfavorable peri-implant conditions caused by hard- and soft-tissue transplants, reduced general health, diminished oral hygiene, and nicotine and alcohol abuse reduce implant survival.

Implants in Irradiated Bone

Implant placement in irradiated bone remains controversial. Success rates differ among most studies, depending on the observation period, with rates from 50%[9–11] to more than 90%.[12] The results of this study show no significant difference in the survival of all implants inserted in irradiated (93.7%) and non-irradiated (84.7%) bone as examined over a 10-year observation period ($p = .246$; Figure 1). However, statistical adjustment by the exclusion of one patient with five losses following surgery of tumor recurrence implant showed that survival in non-irradiated bone is significantly better ($p = .016$).

In general, radiation therapy has two antagonistic effects with regard to recovery of irradiated tissue: a short-term positive cellular effect resulting in the improvement of reduced bone-healing capacity,[6] and a long-term negative effect resulting in permanent damage of osteoprogenitor cells[13] and a gradual, progressive endarteritis obliterans according to the Marx[14] 3h-characteristics. These characteristics describe an increased vascular damage as a result of hypoxic, hypocellular, and hypovascular tissue that leads to a negative tissue balance and tissue break-down.[15] For this effect a tolerance dosage of 30 to 40 Gy is quoted.[14–16] Dosages over 65 Gy are associated with additional reduced resistance against general infections and trauma, and the danger of an avascular necrosis.[2,15] In addition, the risk of irradiation-induced bone damage is increased by chemotherapy or hyperfractionation.[13,15] In this study, 59 (22.5%) implants were placed in patients who underwent radiation as well as chemotherapy. Five of these implants were lost (8.5%).

The highest implant failure rate following irradiation was reported in implants inserted into the craniofacial bone (up to 50% in 5 years),[10] followed by implants in the maxilla (approximately 25% in 5 years),[1,10] and the mandible (approximately 5–20%).[10] It could be proven that, following radiation therapy of cancer of the oro- and hypopharynx, the interforaminal area is exhibited to lower radiation damage than other regions of the mandible.[13] This is attributed to an additional periosteal vascular supply by the facial artery in the area of the mandibular symphysis, thus the higher resistance to radiation-induced vascular damage.[15,17] In the present study, after radiotherapy, 95 of 127 implants were inserted in the interforaminal area (within the range between the first premolars) of the lower jaw. Osteoradionecrosis was not observed in this study. The risk of osteoradionecrosis has been estimated at 4%,[10,15,18,19] with the mandible as the most susceptible location.[10] Because of the diffuse blood supply, the risk for necrosis in the maxilla is negligible in comparison.[5]

To enhance osseointegration of implants after radiotherapy, hyperbaric oxygen (HBO) is controversially discussed.[15,20,21] The main effect of HBO is the hyperoxygenation of irradiated ischemic bone, resulting

in an increased oxygen tension that provokes capillary angiogenesis and bone formation[22] in previously ischemic and hypoxic sites. The high effectiveness of HBO in therapy and prophylaxis of osteoradionecrosis has been consistently demonstrated. Further, HBO in combination with implant insertion in craniofacial bone is recommended because of the high implant failure rate,[20,21] whereas, HBO therapy in the mandible and maxilla is still judged controversially because of the above-mentioned anatomic characteristics.[13] In this study, preventive hyperbaric oxygen was not applied, as there is no consensus about its indication.

Recommendations regarding timing of implant placement in relation to the end of radiotherapy vary and range from 6 weeks to 24 months.[23] A clinical treatment protocol with an interval of at least 12 months has been reported in the literature.[12,15] Extension of this interval was associated with a gradual progressive endarteritis and continuous loss of capillaries without the tendency of spontaneous revascularization resulting in poorer implant prognosis.[2,15]

Implants in Grafted Bone

The reported survival rate of implants in grafted bone is lower than that of implants inserted in residual bone.[4,19,25] Implant stability, particularly in avascular bone grafts, is endangered by poorer bone quality, lower bone density, less vascularisation and a higher bone resorption rate.[4] In this study, no statistically significant influence of transplanted/residual bone on implant survival was observed (Figure 2). This result might be attributed to the two-stage procedure: patients underwent non-vascularized iliac bone graft reconstruction for 1 to 27 months following mandibular discontinuity resection, and secondary implant insertion was performed on an average of 22 months (range, 6–101 months) later.

Implants in Grafted Soft Tissue

Loss of attached and keratinized gingival and its replacement by mobile, peri-implant soft tissue grafts, in particular jejunal grafts, may result in inflammation and peri-marginal bone loss.[4] Diminished oral hygiene further contributes to this unfavorable situation.[4] In this study, 31 implants showed increased inflammatory processes. Because of contemporary conservative therapy, no peri-marginal bone loss was measured in the following intraoral radiographs.

Location of Implants (Maxilla/Mandible)

Implants inserted in the maxilla showed higher success rates than implants inserted in the mandible (Figure 3). Similar results were reported by Mericske-Stern and colleagues[18] In agreement with their report, we suspect that the higher success rates were due to the higher number of implants inserted in the mandible, as well as the higher number of these implants inserted into the irradiation field and/or in tissue transplants (bone, mucosal flap, or jejunal grafts). These finding are in contrast to those of Kovacs,[23] who reported a much higher implant loss in the maxilla (80%) compared with the mandible (11.6%; 279 implants, observation period 6 years). Seventy-six percent of all maxillary implant losses were primary losses (before prosthetic rehabilitation), which may be attributed to a higher number of implants placed into grafted sites (17 out of 65, 26%, implant losses). In this study, likewise, no predictive factor for implant loss could be detected.

Implants after Resection of Hard and Soft Tissue

A frequent complication following hard and soft tissue resection is a change of the anatomic relation of the jaws, resulting in a decrease of vertical dimension. This alteration in jaw relation[24] is a result of scar formation and/or indurations of closing muscles following irradiation in the sense of radiation-induced trismus.[25] In addition to the number and distribution of the retaining

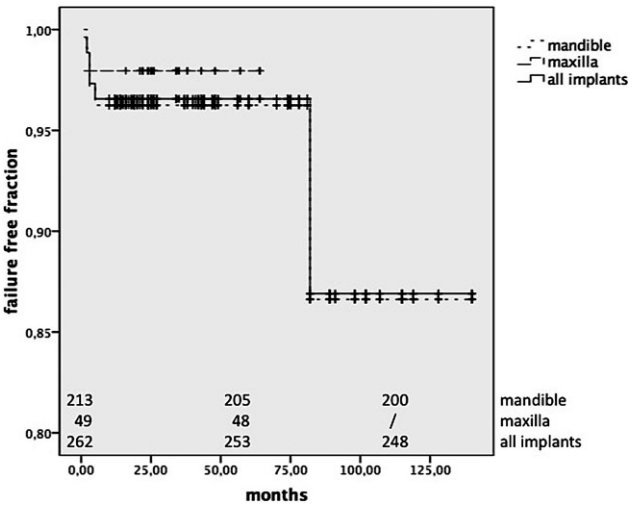

Figure 3 Kaplan-Meier analysis of the implants placed into the mandible or maxilla and overall cumulative survival rate of all implants (logrank: $p = .563$). Number above time axis gives the number of implants still at risk at the respective time point.

elements (teeth, implants), the defect size, height and contour of the residual alveolar ridge, lateral undercuts, and the posterior palatal shelf significantly improved the success of the functional rehabilitation of the maxilla.[3] Excessive lateral torque forces evoked by the obturator may result in an overload of teeth and implants, and thereby in loss of the retaining elements.[3] In the resected mandible, diameter and length of implants may weaken the mandible body, thereby resulting in an increased danger of fracture.[26] Thus, prosthetic rehabilitation is often compromised. An overload of implants due to the masticatory process is not to be expected, because even in healthy jaw areas in healthy patients, voluntary bite force is clearly reduced compared with healthy patients.[27] Maximum voluntary bite force is on average approximately 50% lower in resected jaw areas than in non-resected ones.[27]

Prosthetic Rehabilitation

Survival rate of implant-borne prosthetic appliances is 90% over a period of more than 6 years.[24,28–30] With regard to prosthetic rehabilitation, no standard appliance has been described in literature, which is likely due to the high individuality of prosthetic restorations because of topography and size of defects. In this study, as well as in the study by Kovacs,[23] no specific superstructure was found to be particularly favorable. No prosthetic appliance was needed to be replaced or had caused implant loss by prosthetic overload. Removable appliances were regularly adjusted by relining.

Recall of tumor patients because of diminished oral hygiene is considered to be of fundamental importance for long-term success of implants. Fulfilling the hygienic conditions, implants contribute to considerable improvement of oral function.[26]

CONCLUSIONS

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

1. Radiotherapy has the biggest influence on implant survival. Gender, insertion in transplanted/original bone or soft tissue, and implant site (maxilla/mandible) are of secondary importance. With a 10-year survival percentage of 93.7%, radiotherapy is not generally considered to be a contraindication for implant insertion.
2. Implant insertion resulting in osteoradionecrosis is not common in patients who received appropriate therapy.
3. Implant loss is to be expected primarily during the healing period (lacking primary osseointegration).
4. Endosseous implants enable a more effective oral rehabilitation with regard to improvement of retention, support, and stability of prosthetic devices.
5. No superstructure was found to be particularly favorable.

As a result of specific operative risks and the special quality of the prosthetic planning, treatment and follow-up care, patient selection, and intensive care seems to be crucial.

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