THE FATE OF OSSEOINTEGRATED IMPLANTS IN PATIENTS FOLLOWING ORAL CANCER SURGERY AND MANDIBULAR RECONSTRUCTION

Adorján F. Kovács, MD, DMD

Klinik für Kiefer- und Plastische Gesichtschirurgie, Uniklinikum Haus 21, Theodor-Stern-Kai 7, D - 60590 Frankfurt am Main, Germany. E-mail: A. Koacs@em.uni.frankfurt.de

Accepted 11 May 1999

Abstract: *Background.* The feasibility of implant treatment in patients after oral ablative tumor surgery and defect reconstruction has not yet been investigated in terms of the requisite high standards of success assessment. A report on this topic must address not only implant survival but implant health, bone response, soft tissue health, failure pattern, and time of failure, as well.

Methods. From June 1990 through December 1997, 90 patients received 320 dental implants after oral tumor resection and immediate soft tissue reconstruction. Included in the study were 45 patients with 162 implants loaded for at least 1 year. Regular follow-up for 6 years consisted of detailed medical history and evaluation of periodontal parameters. Out of this population, 10 vascularized iliac bone grafts for mandibular reconstruction containing loaded implants were selectively evaluated for bone loss.

Results. The assessment of pocket probing depths, plaque accumulation, bleeding disposition, implant mobility by means of the Periotest method applied to the restoration type, horizontal and vertical (peri-implant) bone loss according to x-ray findings, causes and time of implant loss, and subjective statements offered results comparable to those found in healthy subjects examined with periodontal success parameters.

Conclusion. Prosthetic restoration of patients after oral ablative tumor surgery followed by hard and soft tissue reconstruction can be achieved with dental implants with similar long-term efficacy as found in healthy subjects adhering to internationally established requirements. © 2000 John Wiley & Sons, Inc. *Head Neck* **22:** 111–119, 2000.

Keywords: dental implants; oral cavity cancer; peri-implant soft tissue; iliac bone graft; mandibular defect

Correspondence to: A. F. Kovács

Patients after surgical treatment of oral cancer and immediate reconstruction often need prosthetic restoration for full chewing, speech, and social rehabilitation. In many cases, this can be achieved only by placement of dental implants. As a result of surgery, the anatomy in these situations is no longer amenable to conservative dentistry; grafting with myocutaneous and intestinal flaps alters the oral cavity as mandibular rim resections do.[1] In case of bone continuity defects and mandibular reconstructions with vascularized bone grafts, substitution of the teeth lost due to the resection is mandatory.[2,3] High implant survival rates in vascularized bone containing flaps are known;[4,5] however, implant *survival* is confused with implant *success*; the studies mentioned do not report thorough follow-up, or they consist of mere input–output analyses without peri-implant examinations. Furthermore, it should be noted that vascularized bone containing flaps offer a very favorable environment for concealing problems oral cancer patients frequently have concerning dental implants. On the other hand, radiation further complicates implant healing[5,6] and, therefore, should be examined separately.

Oral cancer patients frequently require careful dental implant treatment[7] and follow-up, because they often have histories of poor oral hygiene, which could endanger long-term success. In addition, postoperative changes of oral physiology (eg, dryness) must be addressed. The functional value of prosthetic rehabilitation with the help of implants is not questioned, but it still has the taint of being provisional and empirical. Because of the dubious prognosis of oral malignancies, the standards of acceptability of implant treatment have been lowered to improve life quality according to the concept of days of life lost.[8,9] But even a functioning prosthesis can be retained by implants that show severe peri-implant bone loss or chronic soft tissue inflammation and, therefore, cannot be counted as success. A study of recall over longer periods of time covering a large population of patients postmalignancy that considers these facts remains yet to be reported.

Moreover, such a study should assess the peculiarities and differences of implant treatment in patients with typical alterations after ablative oral tumor surgery, as compared to implant treatment in healthy subjects. To be scientifically sufficient, implant treatment must be followed up using internationally accepted periodontol standards. To satisfy these standards, examination of the peri-implant status of a given individual must include clinical assessments of inflammation in the peri-implant tissues, registration of probing depths, radiographic assessments of supporting alveolar bone, and specification of failure pattern.[10,11]

Since 1990, we have regularly treated patients in our facility with implants after ablative oral surgery and reconstruction. In a thorough recall regime, these implant patients were followed up over a period of up to 6 years, with special attention on peri-implant health.

PATIENTS AND METHODS

From early in 1990 to December 1997 we inserted 320 dental implants in 90 patients. Included in the study were 45 patients with 162 implants that were loaded for at least 1 year. This was done to meet the long-term standard and because only loaded implants can be examined periodontally. The bone–lock endosseous implant system (Howmedica Leibinger, Freiburg) was used exclusively, because it was found to be satisfactory in clinical research.[12,13]

The tumor diagnosis was squamous cell carcinoma of the oral cavity in nearly all cases (except for five patients suffering from ameloblastoma, one patient with a keratocyst, and one patient with an ossifying fibroma, all in the mandible). In 21 patients, a rim resection of the mandible was necessary. In these cases, at least 15 to 20 mm of residual inferior border bone had been left. Covering the defects was performed with microsurgically reanastomized free flaps in nine cases (jejunal flaps, vastus lateralis and latissimus dorsi muscle flaps, and arterialized venous forearm flaps), and in 11 cases, with myocutaneous flaps (pectoralis and platysma flaps). On 15 occasions, split thickness skin or mucosa grafts were transplanted. Bony reconstruction was performed with free iliac bone graft in five cases and with vascularized iliac bone graft in 10 cases; once, the alveolar ridge was augmented with external tabula. The vascularized bicorticocancellous grafts for mandibular reconstruction were elevated from the side of the ilium contralateral to the defect side. They measured between 4 × 4 × 3 cm and 14 × 4 × 3 cm. In general, implant placement was performed 6 months after the soft or hard tissue reconstruction (Table 1).

Fifteen patients received adjuvant chemotherapy with carboplatin and 5-fluorouracil in three cycles. Accompanying operations before implant placement (in 30 cases) included vestibuloplasties, old hardware removal, freeing of adherent tongues, and temporary repositioning of the inferior alveolar nerve.

Figure 1 shows a case with several of the typical difficulties caused by hard and soft tissue transfer after ablative surgery: bony and oral reconstruction with vascularized iliac bone graft and an intestinal graft creating complicated surroundings for the penetrating implants.

The patients were controlled clinically directly after fabrication of the prosthetic restorations, then 3, 6, and 12 months later and annually thereafter over the 6-year strict follow-up regimen. Results were summarized semiannually after the first 3 months. All examinations were done by the author. They comprise detailed medical history and clinical and radiological examina-

Table 1. Synopsis of prosthetic restorations on mandibular reconstructions with vascularized iliac bone.

Sex	Indication	Classification of defect	Implants	Superconstruction in site
Woman	Ameloblastoma	Right CRB	2	Telescope retained total prosthesis/6 years
Woman	Keratocyst	Left CRB	1	Interconnected tooth-to implant bridge/5 years
Man	Ameloblastoma	BSB	9	Implant-supported prosthesis/5 years
Man	Squamous cell carcinoma	BSB	3	Bar-clip retained total prosthesis/4 years
Man	Squamous cell carcinoma	Right BS	2	Bar-clip retained total prosthesis/4 years
Woman	Squamous cell carcinoma	BSB	6	Implant-supported prosthesis/4 years
Woman	Ameloblastoma	Left RB	3	Implant-supported prosthesis/4 years
Man	Squamous cell carcinoma	Right BS	5	Implant-supported prosthesis/2 years
Woman	Squamous cell carcinoma	Right B	2	Bar-clip retained total prosthesis/2 years
Woman	Ameloblastoma	Right RB	4	Implant-supported prosthesis/1 year
$\Sigma = 10$			$\Sigma = 37$	

Abbreviations: C, collum; R, ramus; B, body; S, symphysis of the mandible.

tions (see Table 2). Plaque Index[14] was found taking the maximum of the values measured (0–3) was ascertained for every implant, and their changes over the course of time were recorded as difference to the first measurement. Sulcus Bleeding Index[15] is measured at the same surfaces and at similar time intervals. Pocket Probing Depth for every implant is the mean value of the four measured values which was calculated and averaged, then using the same procedure as for the above mentioned parameters. Mobility was ascertained with the Periotest Instrument. In the present study, superstructures were removed for the measurements, which were carried out supragingivally at the facial surfaces of the abutments. After five measurements, the most frequent value was used. The values for each implant, at a specific date, were applied to the restoration type. Orthopantomograms were made directly after implant placement (as base findings), directly after placement of the superstructure, then 6 months, 12 months, and annually thereafter. In addition to the usual examinations, bone resorption was ascertained at every follow-up date. Horizontal bone resorption was evaluated either in the center of the space between two implants, or 1 cm posterior to the most distal implant. The horizontal component describes the general bone resorption of the whole part of bone containing the implants. The vertical bone height between the superior and inferior margins of the mandible (or in the maxilla, the oral margin of the maxilla to the nasal or sinus floor) was measured directly beside each implant shoulder mesially and distally and correlated with the bony pocket around the implant. Measurements were accurate to the millimeter, which is reasonable in orthopantomograms. The peri-implant bone height was corrected according to the enlargement factor (1.25). Templates on transparent sheets and magnifiers

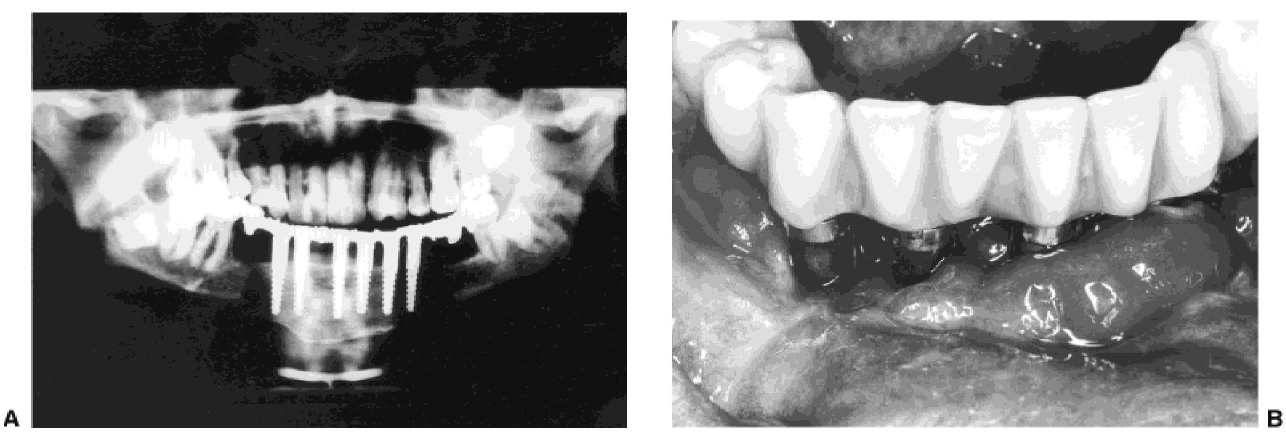

FIGURE 1. a: Orthopantomogram of a 54-year-old woman showing complete anterior mandibular reconstruction with vascularized iliac bone graft, the implant-supported cantilever bridge functioning for 3 years. No peri-implant bony pockets visible. b: Close view of the same restoration shows abutments penetrating a thick and movable jejunal graft, while the most lateral one penetrates scar tissue. No inflammatory signs are present.

Table 2. Definition of periodontal examinations.

Plaque Index	A method for scoring plaque deposits in a scale from 0 to 3, according to which absence of plaque deposits is scored as 0, plaque disclosed after running a periodontal probe along the gingival margin as 1, visible plaque as 2, and abundant plaque as 3; measured at the mesial, facial, distal, and oral surface of the transgingival abutments
Sulcus Bleeding Index	A parallel method for recording presence of inflammation by means of probing assessments. According to this system, entire absence of visual signs of inflammation in the peri-implant unit is scored as 0, and a slight change in color and texture is scored as 1. Visual inflammation and bleeding tendency from the peri-implant margin right after a periodontal probe is briefly run along the peri-implant margin is scored as 2, and overt inflammation with tendency to spontaneous bleeding is scored as 3
Pocket Probing Depth	Defined as the distance from the peri-implant margin to the location of the tip of a periodontal probe inserted in the pocket with moderate probing force; method assesses soft tissue swelling and bone resorption clinically; was measured with a Hu-Friedy probe (3-mm calibration) at the same surfaces to the millimeter
Periotest Instrument	Periotest was developed as a method to measure the periodontal and peri-implant function objectively. An electronically controlled rod percusses the tooth or implant four times per second. The rod is decelerated when it impinges on the tooth or implant. The higher the solidity, the faster is the deceleration; ie, the higher is the damping effect of the periodontium or peri-implant tissue. After hitting the tooth or implant, the rod recoils. Again, the higher the periodontal or peri-implant damping, the faster is the recoil. The contact time per impact between rod and tooth or implant lies roughly in the range of a millisecond. This contact time represents the measuring parameter proper. Periodontal or peri-implant structural changes in bones and/or soft tissue influence the contact time, because it is longer by fractions of a millisecond, as compared with that of a peridontally healthy tooth or an osseointegrated implant. This difference can be recorded by the microcomputer of the Periotest unit. It calculates the mean contact time from roughly 16 percussion signals per tooth or implant. The result obtained represents the Periotest value of the tooth or implant. Clinically firm teeth have values between −8 (very firm) and +9 (elastically firm)

were used. After the first 3 months, results were summarized semiannually. For each period of time, the bone resorption was calculated as the difference since the first date of orthopantomography. The values were added up, and the mean was recorded. Radiological measurements for the patients with implant-bearing microsurgical mandibular reconstructions were calculated separately. No additional stratification was performed, because oral cancer surgery always comprises soft tissue reconstruction.

RESULTS

At the date of investigation, the loading time of the prosthetic restorations of the 45 patients lasted 1 year in 13 patients, 2 years in 11 patients, 3 years in eight patients, 4 years in eight patients, and 5 years in five patients. The mean age was 53.57 years (men) and 49.14 years (women).

Implant placement was carried out in nearly all single sites of the jaws (in the maxilla from region 16 to 27, in the mandible from region 37 to 47. Seven times as many implants were placed in the mandible than in the maxilla. Although distribution was symmetrical in the maxilla, the interforaminal area was preferred in the mandible.

Most prosthetic indications were edentulous mandibles (41.8%) and reduced dentition (37.3%), followed by tooth gaps (20.9%). Accordingly, bar-clip and, especially, telescope retained total prostheses were used mainly (58.1%) in this patient population. A high percentage of the examined implants (24.7%) were provided with completely implant-supported bridges. The remainder were ball-clip restorations (9.3%) and interconnected tooth-to-implant bridges (8%).

In the examined tumor patients, only 52% of the fixtures are standing in fixed gingiva apart

Table 3. Periodontal parameters of 45 examined tumor patients.

Months	0–3	4–9	10–15	16–21	22–27
Pocket depth (mm)	0.00 ± 0.00	−0.08 ± 0.95	−0.07 ± 1.13	0.26 ± 1.45	−0.83 ± 1.01
Plaque Index	0.00 ± 0.00	0.64 ± 1.23	0.61 ± 0.83	1.06 ± 1.18	0.48 ± 1.34
Sulcus Bleeding Index	0.00 ± 0.00	0.49 ± 0.91	0.65 ± 1.05	0.81 ± 1.05	0.35 ± 1.27

Mean values (and standard deviations) for the differences of measurements, as compared to the first measurement. Using this statistical procedure tendencies can be shown.

from the resection and grafting area. Nearly half of the implants penetrate such soft tissue grafts as split thickness skin, mucosa, myocutaneous flaps, and intestinal flaps.

The Plaque Index had an over-all mean value of 1.79 ± 1.07 (range between 1.50 and 2.00). For each period of time, the value differences compared to the first measurement did not show a clear-cut trend (Table 3). The level remained the same. For the Sulcus Bleeding Index, there was a strong decrease of bleeding disposition after reaching its highest value at the end of the first year. After 3 years, there was practically no clinical sign of inflammation, compared to the base line (Table 3). The over-all mean value was 1.42 ± 0.99 and varied between 1.83 and 0.71. The mean values of the probing depths per implant varied in their course between 5.75 mm in the beginning and 4.57 mm at the end, having an over-all mean value of 5.25 ± 1.81 mm. The differences to the first recall examination show a decrease of 1 mm during the period of 3 years, having a tendency to decrease further (Table 3).

Periotest values (Figure 2) ranged between −3 and +8.5, with a mean value of 2.25 ± 3.82. The mean values for the different prosthetic restoration types were: ball attachments 0.53 ± 2.95; bar-clip retained prostheses 1.62 ± 3.71; telescope retained restorations 2.27 ± 3.62; interconnected tooth-to-implant bridges 2.61 ± 3.88; implant-supported bridges 3.69 ± 4.12.

The mean value of all measurements of horizontal bone resorption over 5 years was 1.04 ± 1.58 mm. The vertical bone loss could be divided into a mesial (1.24 ± 1.59 mm) and a distal value (1.43 ± 1.95 mm). This means that general horizontal bone loss constituted 73% to 84% of the peri-implant bony pocket. Both kinds of bone loss reached a steady state of about 2.5 mm after 2 years of increase. The curves were in the same range over the third, fourth, and fifth year of observation (Figure 3).

All 320 implants were included for assessment of survival. By means of the Kaplan—Meier statistical analysis, the probability of implant loss was calculated, beginning with the date of implant placement, for a period of 6 years. All losses were counted (including those in the healing time or caused by tumor recurrences). The probability of holding a placed implant after 6 years is 83.5%. Looking at implants in place for more than 1 year (after the critical healing time), the survival probability is 93%. Causes of loss were lacking osseointegration during the healing time (28.3%) and tumor recurrences (28.3%), the last factor being independent from the implants. Other causes were inflammatory reactions, bone resorption, and biomechanical overloading. Most implants were lost early (76%) before fabrication of the prosthesis. After restoration, there was a nearly 100% probability of function, if the prosthesis was well implanted.

Only one implant was lost among those inserted into vascularized iliac bone graft. It had to be removed during the second-stage operation (uncovering and fixation of abutments) because of failing osseointegration. Prosthetic restoration could be performed, nevertheless. After 6 years of follow-up, the survival rate of these implants was 97.6%. Bone loss showed a similar course for the horizontal and for the vertical (peri-implant) portion in the cases with mandibular reconstruction (Table 4). After 1 year, horizontal bone loss was 0.9 mm in the microvascular graft. After 2 years 2 mm were resorbed; then the height of the graft identical with the height of the neomandible remained stable. The values for the vertical bone loss (the bony pocket) were almost the same as those for the horizontal bone loss. No implant in function caused any pain or other persistent damage.

DISCUSSION

The peri-implant health of tumor patients (post-malignancy) rarely has been examined; moreover, those studies that exist cover small populations.[17,18] A larger population of 32 patients was examined by Betz et al,[12] but without using the necessary periodontal parameters, and results are based on a 3-year observation period only.

Table 3. (continued)

Months	28–33	34–39	40–45	46–51	>51
Pocket depth (mm)	−1.00 ± 1.08	−1.12 ± 1.53	−3.13 ± 1.00	−3.15 ± 0.97	−3.54 ± 1.50
Plaque Index	0.53 ± 1.26	1.09 ± 0.97	0.25 ± 2.06	0.20 ± 0.45	−0.80 ± 1.10
Sulcus Bleeding Index	0.21 ± 1.08	0.23 ± 0.97	0.00 ± 1.41	0.00 ± 0.00	−0.60 ± 1.34

Mean values (and standard deviations) for the differences of measurements, as compared to the first measurement. Using this statistical procedure tendencies can be shown.

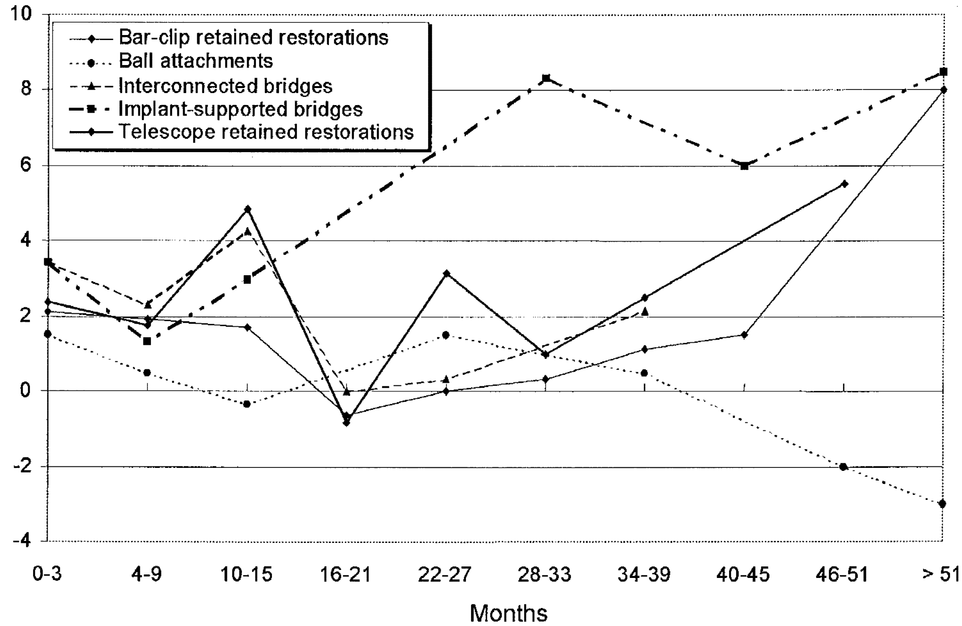

FIGURE 2. Courses of Periotest values over time of examined tumor patients. General decrease during the first 2 years, then increase. Exceptions: early increase of values for implant-supported constructions, values for ball attachments decrease to negative ones.

Such genuine periodontal parameters as Plaque and Sulcus Bleeding Indices indicate accurately the hygiene behavior of a patient or ease of care and health of the soft tissue margins around an implant. In our study, the mean value of the Plaque Index (1.79) confirmed the well-known bad mouth hygiene of tumor patients, which cannot be attributed solely to a lack of willingness. Another reason was the complicated local conditions compared to healthy patients. Betz et al[12] found a value of 69 in tumor patients as against 19.8 in nontumor patients over a 3-year period, using the hygiene index according to O'Leary. The study of Flemming and Höltje[19] over 5.5 years used the same method as the present one and found in healthy patients a slightly better value of the Plaque Index (1.56 ± 0.15). The bleeding disposition following probing decreased in the present study parallel to a smaller probing depth over time. The mean value of 5.25 mm is rela-

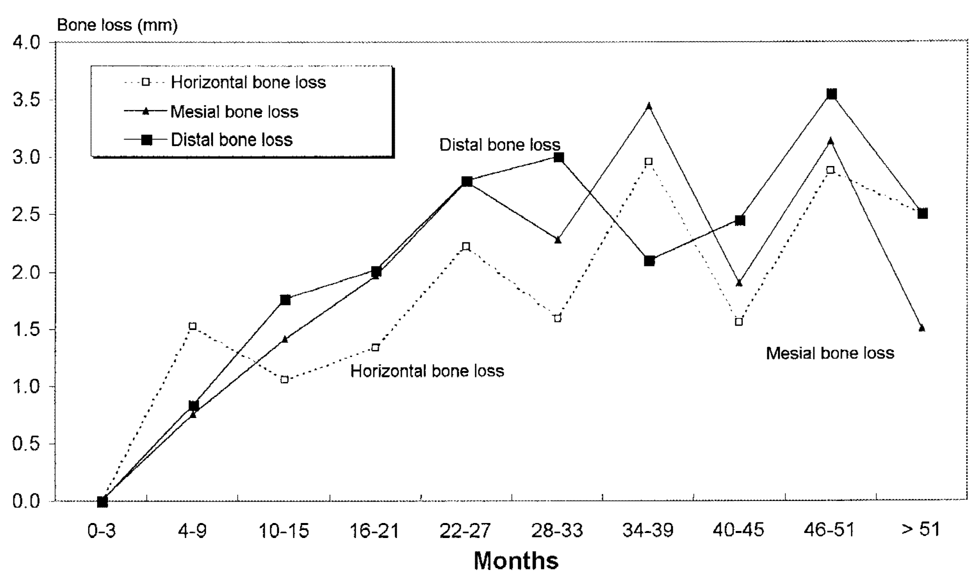

FIGURE 3. Courses of horizontal and vertical (mesial and distal) bone loss values of examined tumor patients.

Table 4. Mean values (and standard deviations) of horizontal and vertical bone loss in 10 vascularized iliac bone grafts containing loaded dental implants. In the first 3 years, difference between the values for horizontal and vertical bone loss indicate bony pockets not reaching depth of 1 mm. After the third year, peri-implant bone height surpasses level of the neighboring bone.

Months	0–3	4–9	10–15	16–21	22–27
Horizontal bone loss (mm)	0.03 ± 0.17	1.50 ± 0.84	0.94 ± 1.00	2.00 ± 1.15	2.00 ± 0.96
Vertical bone loss (mm)	0.03 ± 0.17	0.67 ± 0.75	1.64 ± 2.08	2.20 ± 1.57	2.89 ± 2.40

tively high compared to other studies.[17,20] Probing depth data are associated with a large range of factors causing such measurement errors as pocket access, reaction of the patient, form of the probe, and probing force.[21] However, it must be pointed out that all measurements in this study were made by one person (the author) to minimize errors. The relatively high values for the pocket probing depth can be explained by the relatively thick transplanted soft tissues that surround about half of the implants and hinder peri-implant hygiene.[17] Over time, the values reached the level of under 4 mm demanded by investigators who use this parameter as a success criterion.[22] Betz et al[12] reported a mean probing depth of 5.1 mm in tumor patients, as against 3.4 mm in nontumor patients. The decrease of these values (Sulcus Bleeding Index, probing depth) is contrary to the courses found in healthy populations.[12,19,23] These investigations state that the incidence of peri-implant soft tissue inflammations and pocket depths increases over time. Betz et al[12] do not give particulars for tumor patients. From the present study, it can be concluded that an adaptive rebuilding takes place in an operated area with transplanted soft tissues, despite constant moderate plaque accumulation. This rebuilding leads to a decrease of peri-implant inflammation over time, which is contrary to healthy, or at least normal, gingiva. This is remarkable, because nearly half of the implant measurement surfaces were surrounded by movable (nonpassive) soft tissue. Neither this fact nor the transplanted soft tissues surrounding the implant posts have a detrimental effect on peri-implant bone or endanger long-term survival.[1]

The range of the Periotest values (−3 through +8,5) is comparable to those found in different implant systems.[24] The decrease of values can be interpreted as consolidation of deeper bony levels around an implant, because the cortical bone around the implant shoulder, which chiefly stabilizes an implant, is reduced early after loading start. However, vertical bone resorption of a high degree is not detected by these measurements, and, therefore, the prognostic value of the Periotest is low.[25] For the same reason, the elevation of values does not necessarily mean host site deterioration. Especially in the case of completely implant-supported prostheses, the possibility of elastic adaptation must be kept in mind. It is possible that implant motility comes to resemble that of teeth. In general, it can be noticed that the development of values depends on the chosen superstructures. Ball-clip attachments lead to ankylotic values.

Bone loss was assessed with a maximum of 1.43 mm on average for a 5-year period. That does not mean too much, because there have been far more measurements after 3 months than after 5 years. The very high portion of horizontal bone loss (73% to 84%) in the peri-implant area shows that bone loss in tumor patients is independent of the used implant system. Multiple operations traumatizing the bone are responsible. On average, the course of the vertical (peri-implant) bone loss is only half a millimeter higher. The steady state after 2 years (with the value of 2.5 mm in the present study) can be found in other studies as well.[20, 26] There is no divergence between the two curves of horizontal and vertical bone loss that might indicate an isolated increase of peri-implant bone loss. Adell et al[20] found only 1-mm bone loss during the first 3 years. Betz et al[12] reported 2.1 mm for the same period of time. Compared to the healthy patient population of Betz et al,[12] the values for bone loss in tumor patients do not show substantial differences. One reason might be the good prognosis of implants in transplanted bone as shown below.

The survival rate of all 320 implants placed during the period of investigation is 83.5% after 6 years. Survival does not necessarily equal success. The criteria for implant success are variously defined in the literature. All use the methods described in the present study. But these are in some cases defined as specific to a particular study,[27] or alternatively, criteria are claimed to be universal.[10,11] Both proposals have draw-

Table 4. (continued)

Months	28–33	34–39	40–45	46–51	>51
Horizontal bone loss (mm)	2.33 ± 1.53	1.50 ± 0.71	2.50 ± 0.71	2.25 ± 0.76	2.00 ± 0.82
Vertical bone loss (mm)	2.83 ± 2.52	1.00 ± 0.00	2.00 ± 0.71	1.75 ± 0.80	1.50 ± 0.71

backs. For example, the suggested rate of annual bone loss acceptable for the Brånemark group was very low (less than 0.2 mm[10]), because they excluded bone loss occurring in the first year and selected certain data, or they reported very high standard deviations[29] without accounting for theem.[30] Thus, there is a growing number of authors who reject an annual bone level of less than 0.2 mm as a success criterion.[22,31] Because the orthopantomograms are not as accurate as dental films, which cannot be used in patients after tumor resection, different criteria had to be established. Spiekermann et al[30] reported a mean annual bone loss ranging between 0.07 and 0.54 mm per year for 130 IMZ and 132 TPS implants (with maximum of 6 mm after 9 years). This study was performed in healthy patients. These results report about 2.5 mm of bone loss after 5 years, which coincides with the results of this study, given that our values ranged between 2 and 3.5 mm in the third to fifth year of observation (Figure 2). As with this parameter, the others, such as the pocket probing depth and Periotest values may be criticized, as already suggested. Nevertheless, using these parameters might show that implant treatment is scientifically justified when compared with healthy subjects and is far from being provisional. The proposal of success criteria by Jahn and d'Hoedt[22] is useful, because it does not require measurement precision of tenths of millimeters for the bone loss, which does not seem to be realistic, especially in tumor patients. Accepting this recommendation for success criteria, which includes mobility and pain in addition to the periodontal criteria previously mentioned, the success rate would be nearly the same as the survival rate. A different statistical method and presentation would be needed, because the exact dates of failure, according to the definition of Jahn and d'Hoedt (eg, pain), are not known in the way that the dates of implant loss are known. Some investigators try to reach statistical independence by considering only one implant per patient. This procedure is not acceptable, because of the possible unrealistic positive or negative consequences of random choice.

Most losses occur during the first year after placement, a fact known from other systems.[10] For implants in place for more than 1 year, the survival rate was 93%. The survival rate of 83.5% after 6 years is comparable to other implant systems[10] and exceeds the requirements of the latest evaluations of implant success by others.[11] To rate implant success from the date of placement seems to be appropriate.[28] The long-term success rate was especially high considering that implant losses by tumor recurrence compromised the result and that most losses occurred during the first year after placement. A relatively high number of implants were lost because of inflammation. This almost always occurred immediately after the second stage operation of abutment connection and may be a specific problem of tumor patients with their relatively poor oral hygiene and the irritable soft tissues frequently found after grafting. However, it could be shown that the efficacy of implant-assisted and -borne prosthetic treatment is limited only by the lifetime of patients postmalignancy and not by the oral alterations following tumor treatment.

Dielert and Zangrando[33] reported as early as 1989 that vascularized bone grafts had a high volume constancy. Neukam et al,[34] in an investigation concerning the resorption rate of bone containing loaded endosteal implants, found that after 2 years, the mean annual resorption in vascularized bone grafts was 0.2 mm. For implants in vascularized bone used for mandibular reconstruction, the survival rate was nearly 100%.[35] Primary placement of implants during the reconstruction phase is possible when only overdentures are the target. Rapid rehabilitation is desirable in tumor patients,[9] but a waiting period is indicated in cases of mandibular reconstruction. If no recurrence occurrs within 1 year, reconstruction can be performed. For the restoration modalities that we used (eg, implant-supported bridges), secondary placement of implants is necessary. Moreover, this time for placement seems to be the best, especially with regard to healing and bone protection.[36]

REFERENCES

1. Kovács A. The effect of different transplanted soft tissues on bone resorption around loaded endosseous implants in patients after oral tumor surgery. Int J Oral Maxillofacial Implants 1998;13:554–560.
2. Riediger, D. Restoration of masticatory function by microsurgically revascularized iliac crest bone grafts using endosseous implants. Plast Reconstr Surg 1988;81: 861–877.
3. Urken ML, Buchbinder D, Weinberg H, et al. Primary placement of osseointegrated implants in microvascular mandibular reconstruction. Otolaryngol Head Neck Surg 1989;10:56–73.
4. Gürlek A, Miller MJ, Jacob RF, et al. Functional results of dental restoration with osseointegrated implants after mandible reconstruction. Plast Reconstr Surg 1998;101: 650–655.
5. Urken ML, Buchbinder D, Costantino PD, et al. Oromandibular reconstruction using microvascular composite flaps: report of 210 cases. Arch Otolaryngol Head Neck Surg 1998;124:46–55.
6. Lukash FN, Sachs SA. Functional mandibular reconstruction: prevention of the oral invalid. Plast Reconstr Surg 1989;84:227–233.
7. McGhee MA, Stern SJ, Callan D, et al. Osseointegrated implants in the head and neck cancer patient. Head Neck 1997;19:659–665.
8. Urken ML. Discussion of "functional results of dental restoration with osseointegrated implants after mandible reconstruction," Plast Reconstr Surg 1998;101:656–659.
9. Mulholland RS, Boyd JB, Gullane PJ, et al. Mandibular reconstruction: bone versus plate. Plast Surg Forum 1992; 15:37.
10. Albrektsson T, Zarb G, Worthington P, et al. The long-term efficacy of currently used dental implants: a review and proposed criteria of success. Int J Oral Maxillofacial Implants 1986;1:11–25.
11. Roos J, Sennerby L, Lekholm U, et al. A qualitative and quantitative method for evaluating implant success: a 5-year retrospective analysis of the Brånemark implant. Int J Oral Maxillofac Implants 1997;12:504–514.
12. Betz, T, Reuther, JF, Bill, J. Klinische Nachuntersuchung enossaler Bone–Lock Implantate unter besonderer Berücksichtigung der periimplantären Gewebe. Eine Studie über 5 Jahre. Dtsch Z Mund Kiefer Gesichts Chir 1995;19:35–40.
13. Kovács A. Rehabilitation of tumor patients with the endosseous Bone–Lock dental implant system: a 5-year study. Mund Kiefer Gesichts Chir 1998;2:20–25.
14. Silness J, Löe H. Periodontal disease in pregnancy. II. correlation between oral hygiene and periodontal condition. Acta Odontol Scand 1964;24:747–759.
15. Löe H. The gingival index, the Plaque Index, and the retention index system. J Periodontol 1967;38:610–616.
16. Lucas D, Schulte W. Periotest —a dynamic procedure for the diagnosis of the human periodontium. Clin Phys Physiol Meas 1990;1:65–75.
17. Günay H, Blunck U, Neukam FW. Periimplantäre Befunde bei Branemark—Implantaten. Z Zahnärztl Implantol 1990;6:120–125.
18. Weischer T, von Recklinghausen G, Dermoumi H, et al. Periimplantäre Mikroflora bestrahlter und nicht bestrahlter Tumorpatienten. Z Zahnärztl Implantol 1996; 12:164–168.
19. Flemming TF, Höltje W- J. Periimplantäre Mukosa und Knochen bei Titanimplantaten. Z Zahnärztl Implantol 1988;4:158–164.
20. Adell R, Lekholm U, Rockler B, et al. Marginal tissue reactions at osseointegrated titanium fixtures. (I). A 3-year longitudinal prospective study. Int J Oral Maxillofacial Surg 1986;15:39–52.
21. Quirynen M, van Steenberghe D, Jacobs R, et al. The reliability of pocket probing around screw-type implants. Clin Oral Impl Res 1991;2:186–192.
22. Jahn M, d'Hoedt B. Zur Definition des Erfolges bei dentalen Implantaten. Ein Vergleich verschiedener Kriterien. Z Zahnärztl Implantol 1992;8:221–226.
23. Spörlein E, Schramm-Scherer B, Tetsch P. Recall bei Implantatpatienten—Bedeutung und Umfang des Recalls sowie Untersuchungsergebnisse. ZWR 1987;96:128–135.
24. Buchmann R, Khoury F, Heßling R, et al. Measurements of the damping capacity of implant abutments and natural teeth. Dtsch Zahnärztl Z 1993;48:184–187.
25. van Scotter DE, Wilson CJ. The Periotest method for determining implant success. J Oral Implantol 199;17: 410–413.
26. Lindquist LW, Rockler B, Carlsson GE. Bone resorption around fixtures in edentulous patients treated with mandibular fixed tissue-integrated prostheses. J Prosth Dent 1988;59:59–63.
27. Sullivan DY, Sherwood RL, Mai TN. Preliminary results of a multicenter study evaluating a chemically enhanced surface for machined commercially pure titanium implants. J Prosthet Dent 1997;78:379–386.
28. James RA, Altman AF, Clem DC, et al. A critical review of the "osseointegrated" literature. Branemark "fixtures" fail to meet recommendations of Harvard implant consensus conference. J Oral Implantol 1986;14:35–41.
29. Adell R, Lekholm U, Rockler B, et al. A 15-year study of osseointegrated implants in the treatment of the edentulous jaw. Int J Oral Surg 1981;10:387–416.
30. Spiekermann H, Jansen VK, Richter E- J. A 10-year follow-up study of IMZ and TPS implants in the edentulous mandible using bar-retained overdentures. Int J Oral Maxillofacial Implants 1995;10:231–243.
31. Chaytor DV. Clinical criteria for determining implant success: bone. Int J Prosthodont 1993:6:145–152.
32. Haas R, Mensdorff-Pouilly N, Mailath G, et al. Survival of 1920 IMZ implants followed up to 100 months. Int J Oral Maxillofacial Implants 1996;11:581–588.
33. Dielert E, Zangrando F. First results on the volumetric behavior of osseous transplants after avascular and reanastomized transfer. Dtsch Zahnärztl Z 1989;44: 678–680.
34. Neukam FW, Scheller H, Günay, et al. International anerkannte Implantationssysteme im klinischen Einsatz. Vorläufige Ergebnisse einer prospektiven Studie. Z Zahnärztl Implantol 1988;4:147–150.
35. Scheller H, Neukam FW, Wichmann M, et al. Prosthetic treatment of mandibular defects following tumor surgery. Dtsch Zahnärztl Z 1993;48:506–509.
36. Bothe KJ, Neukam FW, Schliephake H, et al. Auflagerungsosteoplastik mit simultaner Implantatinsertion zur Behandlung der extremen Alveolarfortsatzatrophie—Erfahrungen aus 7 Jahren klinischer Anwendung, In: Gesellschaft für Orale Implantologie, ed. Jahrbuch für Orale Implantologie, Berlin: Quintessenz; 1994. pp 443–450.