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

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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.


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

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

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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 and, therefore, should be examined separately.

Oral cancer patients frequently require careful dental implant treatment 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 (e.g., 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. 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 periodontal 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.

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.

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 \(4 \times 4 \times 3\) cm and \(14 \times 4 \times 3\) 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-
Plaque Index\textsuperscript{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\textsuperscript{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

<table>
<thead>
<tr>
<th>Sex</th>
<th>Indication</th>
<th>Classification of defect</th>
<th>Implants</th>
<th>Superconstruction in site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Woman</td>
<td>Ameloblastoma</td>
<td>Right CRB</td>
<td>2</td>
<td>Telescope retained total prosthesis/6 years</td>
</tr>
<tr>
<td>Woman</td>
<td>Keratocyst</td>
<td>Left CRB</td>
<td>1</td>
<td>Interconnected tooth-to-implant bridge/5 years</td>
</tr>
<tr>
<td>Man</td>
<td>Ameloblastoma</td>
<td>BSB</td>
<td>9</td>
<td>Implant-supported prosthesis/5 years</td>
</tr>
<tr>
<td>Man</td>
<td>Squamous cell carcinoma</td>
<td>BSB</td>
<td>3</td>
<td>Bar-clip retained total prosthesis/4 years</td>
</tr>
<tr>
<td>Man</td>
<td>Squamous cell carcinoma</td>
<td>Right BS</td>
<td>2</td>
<td>Bar-clip retained total prosthesis/4 years</td>
</tr>
<tr>
<td>Woman</td>
<td>Squamous cell carcinoma</td>
<td>BSB</td>
<td>6</td>
<td>Implant-supported prosthesis/4 years</td>
</tr>
<tr>
<td>Woman</td>
<td>Ameloblastoma</td>
<td>Left RB</td>
<td>3</td>
<td>Implant-supported prosthesis/4 years</td>
</tr>
<tr>
<td>Man</td>
<td>Squamous cell carcinoma</td>
<td>Right BS</td>
<td>5</td>
<td>Implant-supported prosthesis/2 years</td>
</tr>
<tr>
<td>Woman</td>
<td>Squamous cell carcinoma</td>
<td>Right B</td>
<td>2</td>
<td>Bar-clip retained total prosthesis/2 years</td>
</tr>
<tr>
<td>Woman</td>
<td>Ameloblastoma</td>
<td>Right RB</td>
<td>4</td>
<td>Implant-supported prosthesis/1 year</td>
</tr>
</tbody>
</table>

$\Sigma = 10$  

$\Sigma = 37$

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

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.
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

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**Table 1. Definition of periodontal examinations.**

<table>
<thead>
<tr>
<th>Periodontal Examination</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Plaque Index</strong></td>
<td>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.</td>
</tr>
<tr>
<td><strong>Sulcus Bleeding Index</strong></td>
<td>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.</td>
</tr>
<tr>
<td><strong>Pocket Probing Depth</strong></td>
<td>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.</td>
</tr>
<tr>
<td><strong>Periotest Instrument</strong></td>
<td>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 periodontally 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).</td>
</tr>
</tbody>
</table>

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**Table 2. Definition of periodontal examinations.**

| Table 2. Definition of periodontal examinations. |
|-------------------------|-------------------------------------------------|
| **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 ± 1.32** | **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 (postmalignancy) rarely has been examined; moreover, those studies that exist cover small populations. A larger population of 32 patients was examined by Betz et al, but without using the necessary periodontal parameters, and results are based on a 3-year observation period only.

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

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

![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.](image)

![FIGURE 3. Courses of horizontal and vertical (mesial and distal) bone loss values of examined tumor patients.](image)
tively high compared to other studies.\textsuperscript{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.\textsuperscript{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.\textsuperscript{17} Over time, the values reached the level of under 4 mm demanded by investigators who use this parameter as a success criterion.\textsuperscript{22} Betz et al\textsuperscript{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.\textsuperscript{12,19,23} These investigations state that the incidence of peri-implant soft tissue inflammations and pocket depths increases over time. Betz et al\textsuperscript{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.\textsuperscript{1}

The range of the Periotest values (−3 through +8.5) is comparable to those found in different implant systems.\textsuperscript{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.\textsuperscript{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 ankylosis 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.\textsuperscript{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\textsuperscript{20} found only 1-mm bone loss during the first 3 years. Betz et al\textsuperscript{12} reported 2.1 mm for the same period of time. Compared to the healthy patient population of Betz et al,\textsuperscript{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,\textsuperscript{27} or alternatively, criteria are claimed to be universal.\textsuperscript{10,11} Both proposals have draw-

| 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     |
backs. For example, the suggested rate of annual bone loss acceptable for the Brånemark group was very low (less than 0.2 mm\textsuperscript{10}), because they excluded bone loss occurring in the first year and selected certain data, or they reported very high standard deviations\textsuperscript{29} without accounting for them.\textsuperscript{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.\textsuperscript{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\textsuperscript{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\textsuperscript{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.\textsuperscript{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\textsuperscript{10} and exceeds the requirements of the latest evaluations of implant success by others.\textsuperscript{11} To rate implant success from the date of placement seems to be appropriate.\textsuperscript{29} 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 Zangrad\textsuperscript{33} reported as early as 1989 that vascularized bone grafts had a high volume constancy. Neukam et al.\textsuperscript{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 was 0.2 mm. For implants in vascularized bone used for mandibular reconstruction, the survival rate was nearly 100%.\textsuperscript{35} Primary placement of implants during the reconstruction phase is possible when only overdentures are the target. Rapid rehabilitation is desirable in tumor patients,\textsuperscript{9} but a waiting period is indicated in cases of mandibular reconstruction. If no recurrence occurs 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.\textsuperscript{36}

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<tbody>
<tr>
<td>Horizontal bone loss (mm)</td>
<td>2.33 ± 1.53</td>
<td>1.50 ± 0.71</td>
<td>2.50 ± 0.71</td>
<td>2.25 ± 0.76</td>
<td>2.00 ± 0.82</td>
</tr>
<tr>
<td>Vertical bone loss (mm)</td>
<td>2.83 ± 2.52</td>
<td>1.00 ± 0.00</td>
<td>2.00 ± 0.71</td>
<td>1.75 ± 0.80</td>
<td>1.50 ± 0.71</td>
</tr>
</tbody>
</table>
REFERENCES


