ASSESSMENT OF PROSTHETIC RESTORATIONS ON BONE-LOCK IMPLANTS IN PATIENTS AFTER ORAL TUMOR RESECTION

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KEY WORDS

Dental implants
Prosthetic dentistry
Follow-up examination
Rehabilitation
Head and neck neoplasms

The feasibility of implant treatment in patients after oral ablative tumor surgery has not yet been investigated with consideration of the requisite high periodontal standards. A report on this topic has to deal not only with implant survival but also with implant health, bone response, soft tissue health, failure pattern, time of failure, and ease of restoration. For the assessment of an implant system, an overview must be accomplished that takes into account the different restorations used and their interaction with the implant system that was used. This study presents the Bone-Lock implant system (Howmedica Leibinger GmbH, Freiburg, Germany) in a retrospective investigation after 5 years of follow-up with special emphasis on the prosthetic restorations used following resection of oral malignancies. From early in 1990 through June 1996, we inserted 210 dental endosteal Bone-Lock implants (58 patients) after oral tumor resectioning. Included in the study were 45 patients with 162 implants and prosthetic restorations that had been loaded for 1 year (dentures retained by telescopic or bar-clip or ball attachments, implant-supported prostheses, tooth-to-implant connected bridges). Regular follow-up consisted of evaluation of the Plaque Index (Silness and Löe) and of the Sulcus Bleeding Index (Löe), measurements of pocket probing depth, implant mobility (by means of the Periotest method), bone resorption (according to X-ray findings), and a questionnaire that registered patient satisfaction. The results were evaluated for each restoration and were compared with baseline standards. The overall 5-year survival rate was 83.2%. For implants that had been in place for over 365 days, the survival rate was 93%. The investigation showed that after resection of oral malignancies, patients could be treated with dental implants and superstructures with long-term efficacy similar to that found in healthy subjects considering internationally accepted standards. Implant treatment in tumor patients appeared to offer the most positive periodontic results when use of bar-clip or telescope-retained overdentures was involved. The patient satisfaction level with the described prosthodontic treatment was satisfactory.

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INTRODUCTION

The prosthetic rehabilitation of tumor patients with the help of dental implants still carries the taint of being a provisional treatment. Because of the dubious prognosis of oral malignancies, the standards of acceptability for implant treatment are often lowered to raise life quality, and recall over long periods of time has not been reported.[1] Moreover, there are objective problems, such as

dry or thick skin grafts around the implants, dryness of the oral mucosa secondary to extirpation of salivary glands or radiotherapy, or mouth opening limitations. Nevertheless, it has been shown that implant treatment is possible in patients after radiotherapy.[2] The Bone-Lock endosteal implant system (Howmedica Leibinger GmbH, Freiburg, Germany; Fig 1) was developed as a system consisting of only a few parts that can be used individually to cope with a wide divergence of situations. A very helpful component is the transgingival abutment, which is available in three different lengths: 5, 7, and 9 mm. Therefore, the implant system can be used in cases involving very thick soft tissues, such as those cases involving restoration with jejunal grafts. After this new implant system was found to be satisfactory through clinical research,[3] investigations focused on more specific problems. Considerations of the different restorations used and of their interactions with the implant system were made. Evaluations must deal not only with implant survival (at the earliest, 5 years postimplantation) but with implant health, soft tissue health, bone response, failure pattern, time of failure, and ease of restoration in order to satisfy the high standards required.[4]

This study presents the Bone-Lock implant system in a retrospective investigation after 5 years of follow-up with special emphasis on prosthetic restorations used following resection of oral malignancies. It reviews the feasibility of implant treatment in this patient population, searching for the prosthodontic solutions and evaluations of patient satisfaction best suited to this population.

MATERIALS AND METHODS

From early in 1990 through June 1996, we inserted 210 dental endosteal Bone-Lock implants in 58 patients following oral tumor resection. Included in the study were 45 patients with 162 implants that had been loaded for at least 1 year (dentures retained by bar-clip or ball or telescopic attachments, implant-supported prostheses, or tooth-to-implant connected bridges: Table 1). Fifteen of the loaded implants were placed in the maxilla; the remainder were placed in the mandible. Regular follow-up was carried out for a period of 5 years; follow-up consisted of completing a detailed medical history and clinical and radiologic examinations.

In nearly all cases (except for those of five patients suffering from ameloblastoma, one patient with a keratocyst, and one patient with an ossifying fibroma, all in the mandible), the tumor diagnosis was squamous cell carcinoma of the oral cavity. In 21 patients, a rim resection of the mandible was necessary. In these cases, at least 15–20 mm of residual inferior border bone was present. Covering of the defects was carried out with microsurgically reanastomized free flaps in 9 cases (jejunal flaps, vastus lateralis and latissimus dorsi muscle flaps, arterialized venous forearm flaps) and with myocutaneous flaps (pectoralis and platysma flaps) in 11 cases. On 15 occasions, split thickness skin or mucosa grafts were transplanted. Bony reconstruction was carried out with free iliac bone in 5 cases and with pedicled iliac bone in 12 cases; once, the alveolar ridge was augmented with external tabula. Fifteen of the patients received chemotherapy with carboplatin and 5-Fluorouracil in three cycles. Accompanying operations, completed prior to implant placement (in 30 cases), included vestibuloplasties, old hardware removal, freeing of adherent tongues, and temporary repositioning of the inferior alveolar nerve.

In a strict recall regimen, the patients were clinically controlled immediately after placement of the prosthodontic restorations and then 3, 6, and 12 months later, and annually thereafter. Because this time division seemed to be too idealistic in practice and may have led to misinterpretation, we took the actual date of examination and set it in relation to the subsequent dates. By doing this, it became necessary to summarize the results semiannually after the first 3 months. The examinations were all carried out by one person. Examinations consisted of the following:

- The Plaque Index[5] was measured at the mesial, facial, distal, and oral surfaces of the transgingival abutments. The maximum of the measured values was ascertained for every implant and the course of these values over time was recorded for dynamic comparison.
- The Sulcus Bleeding Index[6] was measured at the same surfaces and in similar timely intervals.
- The pocket probing depth was measured with a Hu-Friedy probe (3 mm calibration) at the same surfaces, to the millimeter. For every implant, the mean value of the four measured values was calculated and averaged.
- Mobility was ascertained with the Periotest instrument.[7] Superstructures were removed for this purpose. The measurements were carried out supragingivally at the facial surfaces of the abutments. After five measurements, the median was used. The values for each implant at a specific date were applied to the restoration type and to the implants' dimensional characteristics and locations.
- Orthopantomograms were taken directly after implant placement (to provide base findings), directly after placement of the superstructure, and then at 6 and 12 months postimplantation, and annually thereafter. In addition to the usual examinations, bone resorption was ascertained at three positions per implant 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 thus describes the general bone resorption of the whole portion of bone containing the implants. The vertical bone height between the su-

FIGURE 1. Schematic representation of the Bone-Lock dental implant system (implant screw, abutment, screw fixing abutment to implant, conical superstructure, screw fixing superstructure to abutment).

perior 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.

TABLE 1

Numbers and percentages of patients with various types of restorations

Restoration	Implants (%)	Patients (%)
Bar-clip attachment	38 (23.5)	12 (26.7)
Ball attachment	15 (9.3)	6 (13.3)
Interconnected bridge (tooth-to-implant)	13 (8.0)	6 (13.3)
Implant-supported prosthesis	40 (24.7)	9 (20.0)
Telescopic attachment	56 (34.6)	12 (26.7)
Total	162 (100)	45 (100)

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 were used. Horizontal and vertical bone resorption levels were ascertained for every implant and were categorized by type of restoration. After the first 3 months, results were summarized semiannually. Per period of time, the levels of bone resorption were calculated as the difference between those recorded on the first date of orthopantomography.

- Questionnaires were used to determine the ease of restoration, subjective satisfaction of patient (1 = poor; 2 = average; 3 = good), ease of care (1 = difficult; 2 = average; 3 = easy), acceptability of chewing and talking functions (1 = good; 2 = average; 3 = good), acceptability of masticatory capabilities, and absence of pain or discomfort.

RESULTS

The mean values of all measurements are presented in Table 2. The comparison of the several prosthetic restorations shows the following results: bar-clip attachments were not rated best, but were the second best in all examination parameters except for pocket probing depth. Ball attachments had the best values for pocket probing depth and for the Periotest, but had the worst values for Plaque Index, Sulcus Bleeding Index, and vertical bone resorption. Fixed tooth-to-implant connected bridges presented no best values, and showed the worst values for horizontal bone resorption. The purely implant-supported prostheses demonstrated the best values for Plaque Index and horizontal bone resorption, but the lowest values for pocket probing depth and for the Periotest. Finally, the telescopic attachments showed the best values for Sulcus Bleeding Index and vertical bone resorption and the second best values for pocket probing depth.

Figures 2 through 8 show graphs of the measurements per periods of time. For all restoration types, the values for pocket probing depth reflected decreasing values of between 4 and 6 mm during the first 3 years. The values for the implant-supported prostheses in-

TABLE 2

Mean values of all prosthetic restoration measurements

Restoration	Pocket Probing Depth (mm)	Periotest	Plaque Index	Sulcus Bleeding Index	Horizontal Bone Loss (mm)	Vertical Bone Loss (mm)
Bar-clip	5.41 ± 1.72	1.62 ± 3.71	1.14 ± 1.11	0.90 ± 0.91	0.84 ± 1.12	1.06 ± 1.46
Ball	4.64 ± 1.72	0.53 ± 2.95	2.38 ± 0.70	1.44 ± 0.99	1.09 ± 1.65	2.11 ± 2.24
Interconnected	5.62 ± 1.72	2.61 ± 3.88	1.47 ± 1.08	0.98 ± 0.94	1.53 ± 1.49	1.61 ± 2.35
Implant Supported	5.83 ± 2.64	3.69 ± 4.12	1.01 ± 0.96	1.12 ± 1.08	0.66 ± 1.03	1.20 ± 1.86
Telescopic	4.84 ± 1.22	2.27 ± 3.62	1.23 ± 1.09	0.88 ± 0.90	1.08 ± 1.65	1.01 ± 1.25
Mean	5.29 ± 1.87	2.25 ± 3.82	1.30 ± 1.10	1.00 ± 0.96	0.97 ± 1.40	1.25 ± 1.75

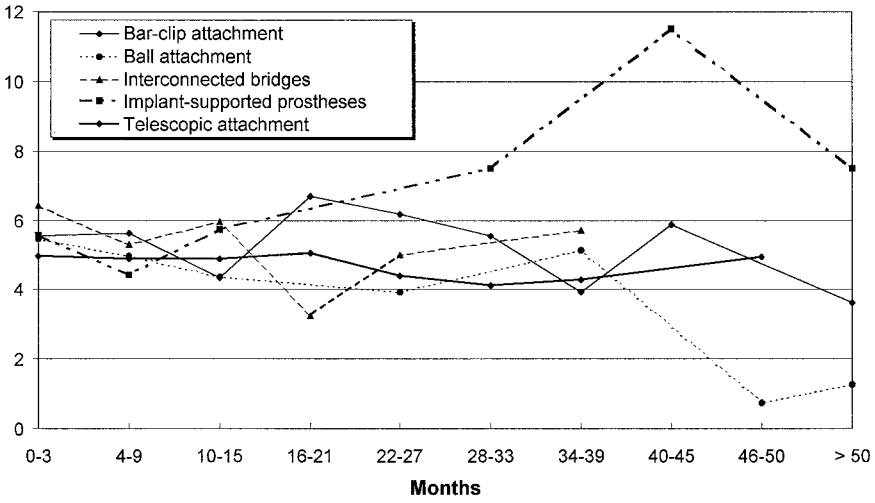

FIGURE 2. Courses of pocket probing depth values over time for each restoration.

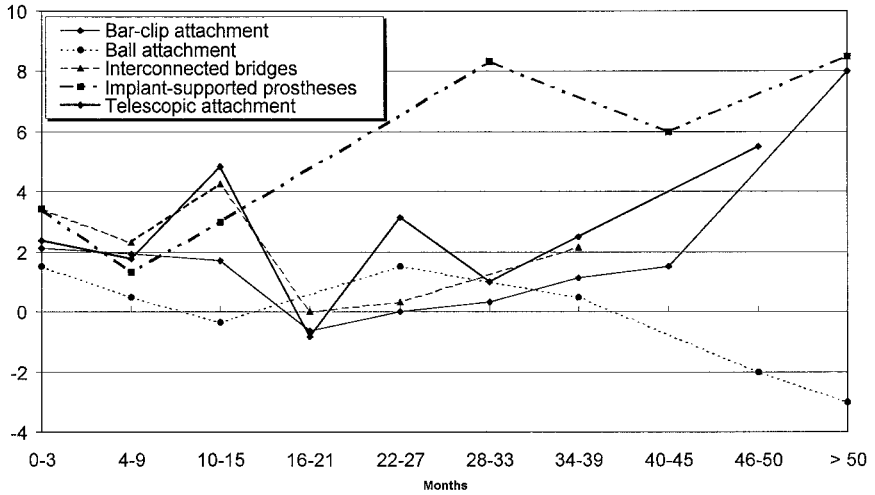

FIGURE 3. Courses of Periotest values over time for each restoration.

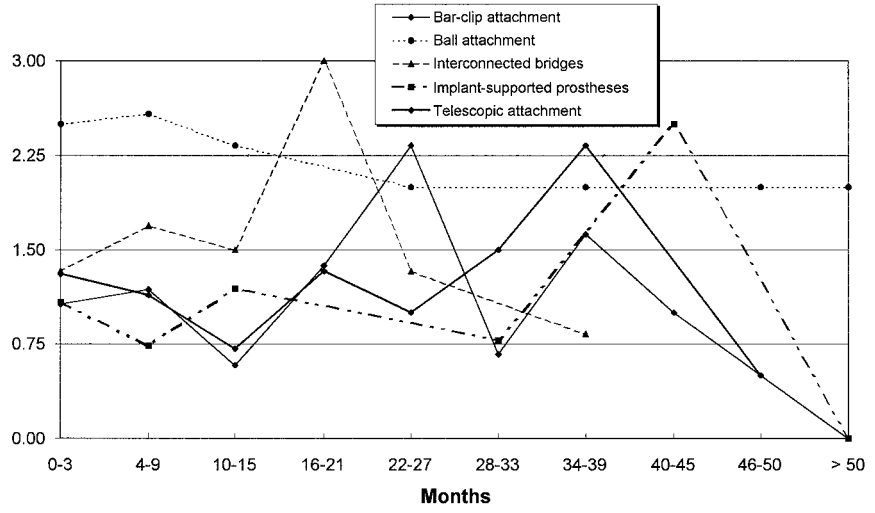

FIGURE 4. Courses of Plaque Index values over time for each restoration.

dicated increasing values of up to 11.5 mm. Values correlated to the other prostheses, especially those of the ball attachments, indicated decreases in pocket probing depth (Fig 2). In Fig 3, corresponding to Periotest measures, values show an ascent during the first year; then, after a baseline during the 16–21 month period, the values increased again. There were two exceptions: the implant-supported prostheses had very high values beginning in the second year, and the values for the ball attachments became negative. The Plaque Index was relatively stable for two restoration types: the implant-supported prostheses, which lay between values of 0.73 and 1.19 during the first 3 years, and the ball attachments, which showed constantly high values of between 2.0 and 2.5 (Fig 4). For the Sulcus Bleeding Index there was no identifiable individual course (Fig 5). In Fig 6, we list the values for the horizontal bone loss, which indicate an ascent for all restoration types. Once again, there was no emphatic difference between values associated with the various restoration types. In Fig 7, however, the telescopic attachments had the lowest course for vertical bone loss. Figure 8 shows the summarized values for horizontal and vertical (mesial and distal) bone loss: after 2 years, an unchanging status at 2.5 mm can be seen.

The 5-year survival rate for the 210 implants was calculated using the Kaplan-Meier statistical method and indicated a survival rate of 83.2% (Fig 9). Calculation began at the time of implant placement. (For implants in position for more than 365 days, the survival rate was 93%.) Losses due to tumor recurrence (13 implants) were not excluded so that the statistics of this special patient population would not be skewed. The majority of implant-related losses (26 implants) occurred during the first year and most were due to loss of osseointegration (5 implants), inflammation (16 implants), and possibly iatrogenic errors (2 implants). These implants were removed

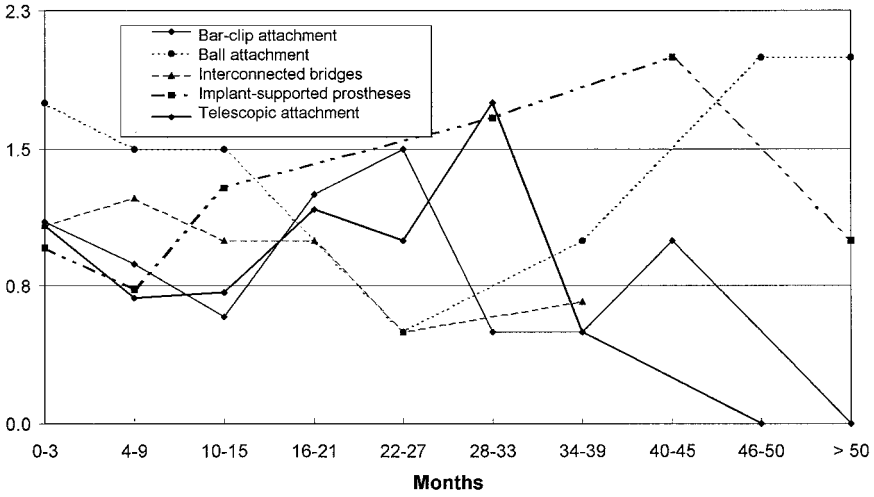

FIGURE 5, Courses of Sulcus Bleeding Index values over time for each restoration.

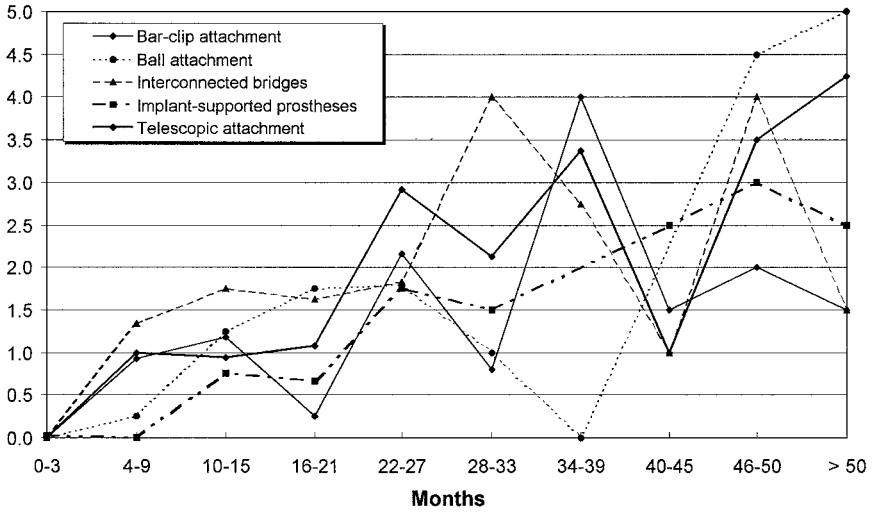

FIGURE 6. Courses of horizontal bone loss values over time for each restoration.

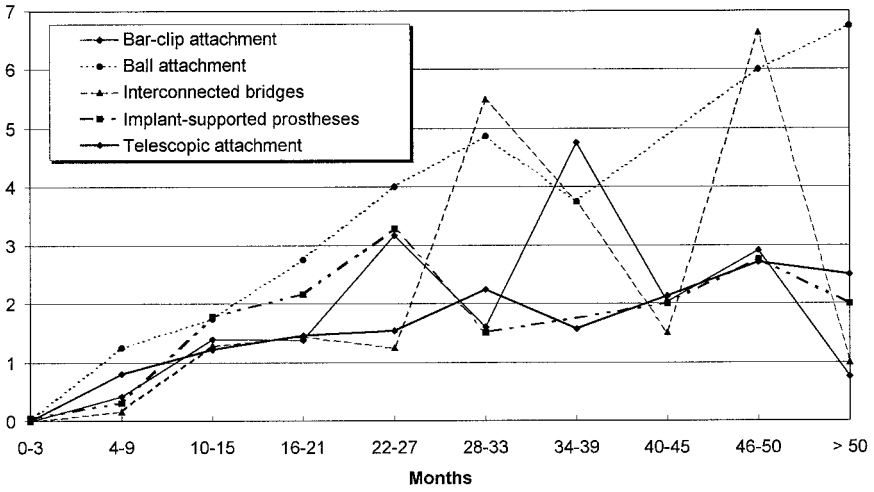

FIGURE 7. Courses of vertical bone loss values over time for each restoration.

at the second-stage operation (abutment connection). Restorations could be fabricated despite disparate implant loss in all cases concerned. Three implants in the maxilla of one patient were lost at a later date due to masticatory overload (prosthetic imbalance). The denture, retained by telescopic attachments, had to be changed into a conventional prosthesis.

The answers to the satisfaction questionnaire showed a high level of contentment among the 45 patients who were restored (mean score, 2.8). There were no patients who failed to wear their dentures. Ease of care was judged with a score of 2.5. Many patients showed an overestimation of their abilities to clean their superstructures when this questionnaire item score was compared to Plaque Index values for the same patients. Statistically, the implant-supported prostheses were cleaned most efficiently (see Table 2 and Fig 4). Scores for chewing function were 2.5 and for speaking function, 2.4. The patients with implant-supported prostheses complained of lack of sensitivity during biting and mastication. Transport and swallowing of the bolus was difficult. However, in these cases, no prosthetic fault could be found. The patients, however, did suffer from the usual postoperative difficulties. (The distinction between function of the prostheses and postoperative problems of the patients was often difficult or impossible to differentiate.) Over time, these patients reported a learning effect. Three of the six patients with interconnected bridges first reported that they were chewing on the contralateral side only. One year later, all reported normal masticatory habits. Implant function did not cause any pain in any case.

CASE REPORT

A 52-year-old male suffered from a squamous cell carcinoma of the anterior floor of the mouth. The compromised parts of the oral cavity and the alveolar rim had to be resected. Lymph nodes were dissected on both sides of

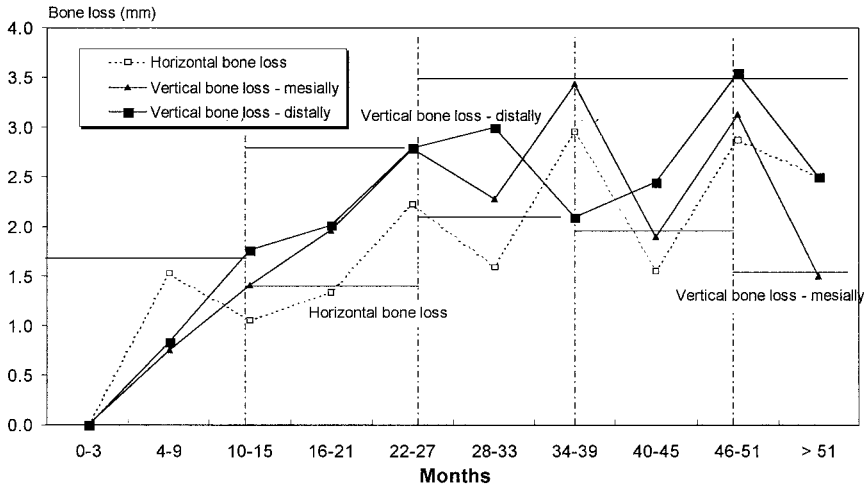

FIGURE 8. Courses of overall horizontal and vertical (mesial and distal) bone loss values. The ranges for vertical bone loss are shown annually.

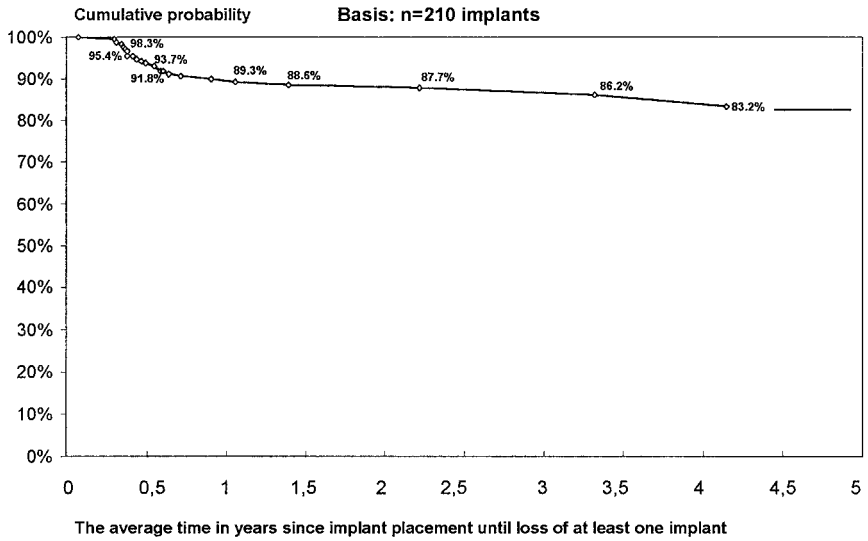

FIGURE 9. Survival rate according to Kaplan-Meier analysis.

the neck in the suprahyoidal region. The defect was reconstructed with an arterialized venous forearm flap. Surgery was followed by adjuvant chemotherapy with cisplatin and 5-Fluorouracil (three cycles). One year later there was no evidence of recurrence, and four Bone-Lock implants (4.5 × 15 mm) were placed in the interforaminal region (Fig 10). After 4 months, the abutments were connected and a bar construction was fabricated (Fig 11). The patient was provided with two new total prostheses and is satisfied with the functional and aesthetic result (Fig 12).

DISCUSSION

On one hand, this investigation attempted to judge an implant system by a survey using the prosthetic restorations incorporated. On the other hand, it tried to judge the restorations in their relationship to this implant system. It took into account a patient population (postmalignancy) not yet examined thoroughly in periodontal-implant terms. Therefore, it presented a more discrete statement of a problem than is usually analyzed in evaluation of dental implants.

The criteria for implant success are presented controversially in the literature. Either there are criteria individually defined for a study[8] or attempts are made to make criteria universally acceptable.[4,9] These proposals always have drawbacks. For instance, the suggested rate of annual bone loss acceptable for the Brånemark group was very low (less than 0.2 mm[4]) because the authors excluded bone loss occurring in the first year and performed certain data selection,[10] or they reported very high standard deviations[11] without taking them into account.[12] Thus, there is a growing number of authors who reject an annual bone level of less than 0.2 mm as a success criterion.[13,14] Since the orthopantomograms are not as accurate as dental films, which cannot be used in patients after tumor resection, different criteria had to be used. Moreover, Schramm-Scherer *et al*[15] found approximately 0.45 mm bone loss per year for 40 IMZ and 40 TPS implants, and Spiekermann *et al*[12] 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 bone loss after 9 years). Both studies were performed in healthy patients. These results report about 2.5 mm of bone loss after 5 years, which corresponds very well with the results of our study, where the bone loss values ranged between 2.0 and 3.5 mm in the third to fifth years of observation (Fig 8).

As with this parameter, the other values, such as the pocket probing depth and the Periotest measures, may be criticized as well. Probing depth data are associated with a large range of factors that may cause measurement errors, such as pocket access, reaction of the patient, form of the probe, and probing force.[16] But is has to be pointed out that all measurements in this study were performed by one person to minimize certain errors. The relatively high values for the pocket probing depth are explicable due to the relatively thick transplanted soft tissues that surrounded about one-half of the implants. Over time, the values reached

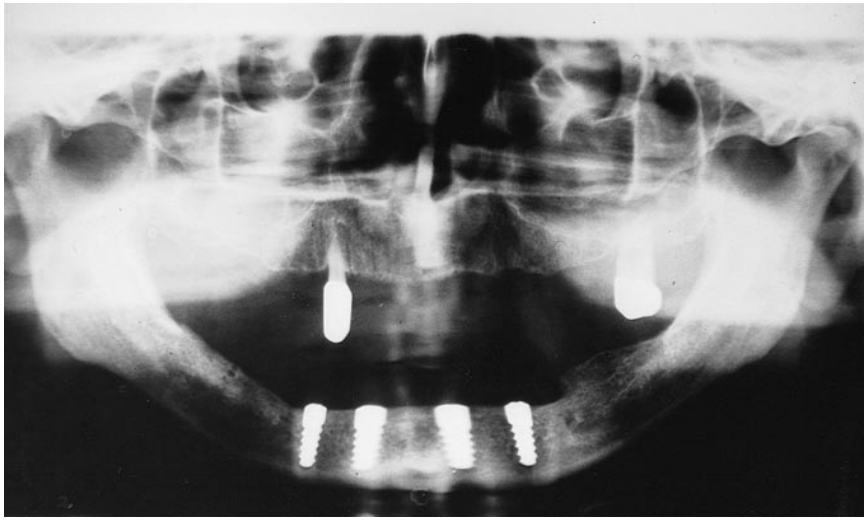

FIGURE 10. Orthopantomogram 1 day after implant placement in the region of extended mandibular rim resection.

FIGURE 11. Oral cavity of the same patient with bar construction on four implants. Note the arterialized venous forearm flap penetrated by the abutments. Hair growth shows good condition, no restriction of tongue mobility.

the level of <4 mm demanded by investigators who use this parameter as a success criterion.[13]

The Periotest device does not seem to be an appropriate instrument for determining changes in the state of the bony interface. Although the decrease of values (Fig 3) can be interpreted to be the consolidation of deeper bony levels around an implant,[17] vertical bone resorption of a high degree is not noticed by these measurements, and, therefore, the prognostic value of the Periotest is low.[18] For the same reason, the elevation of Periotest values does not necessarily indicate host-site deterioration. Especially in the case of entirely implant-supported prostheses, the possibility of elastic adaptation has to be kept in mind.

Genuine periodontal parameters like Plaque and Sulcus Bleeding indices indicate more accurately the hygiene behavior of a patient or the ease of care and the health of the soft tissue margins around an implant. The implant-supported prostheses seemed to offer the best ease of care; they produced the least horizontal bone resorption. This was confirmed by the fact that edentulous mandibles are protected from further atrophy by similar restorations.[19] The other prosthetic alternatives failed to perform in this manner; normal atrophy of the implant-bearing areas continued.

There are many studies that have attempted comparisons of different implant systems. Such research presents problems because of the absence of predictive parameters in monitoring the status of implants in long-term follow-up studies.[12] Nevertheless, evaluation of implant systems has to be accomplished in order to discover such information. In recent years, besides the Brånemark group, evaluations of the ITI implant,[20] the transmandibular implant,[21] the Bone-Lock implant,[22] and the Osseotite implant[8] were performed. All these studies had the drawback that they did not consider the wide variety of prosthetic restorations that had been used. Either the prosthetic devices were not considered at all[4,8,22] or only two of them were compared.[23] If one restoration type was considered exclusively,[21] comparisons of course values would not have been possible. In the investigation described in this paper, the qualifications of the different prosthetic restorations retained or supported by one implant system were examined by means of the same periodontal parameters. This method presented the advantage that it did not involve several implant systems. As a result, the varying prosthetic options that were utilized were compared without complication. The presence of a relatively homogeneous patient population with comparably poor oral hygiene[3] offered further opportunities to create the requisite strict conditions, which helped in selection of the most suitable restoration type. The results of the investigation demonstrated that bar-clip attachments on

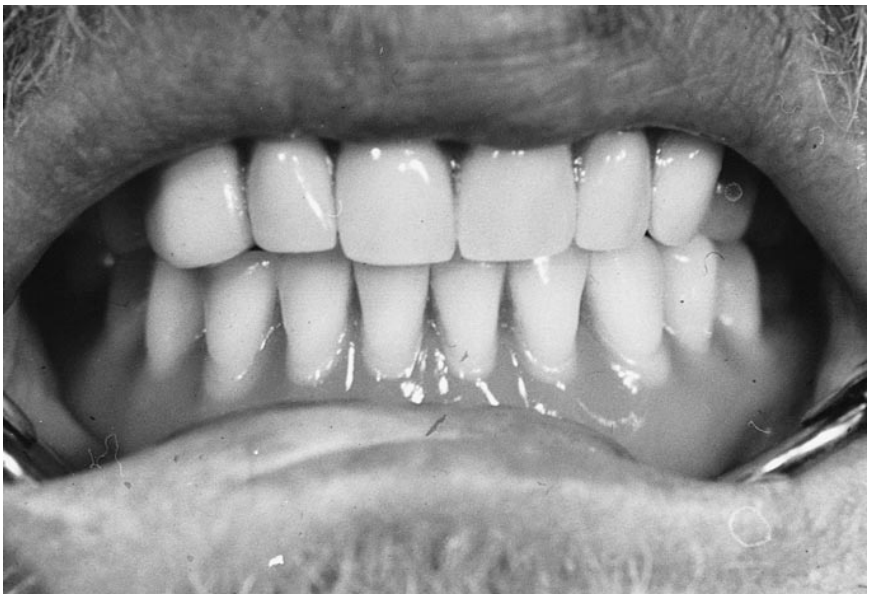

FIGURE 12. View of the total prostheses in full occlusion in the same patient. Good aesthetic result.

two or four implants achieved the most consistent positive values in all of the studied parameters. Seen in relation to the other restorations, there was no negative extreme associated with this restoration type. The telescopic attachments appeared to be almost equally acceptable. Not acceptable were the poorest results, which were the horizontal and vertical bone resorption attributed to ball attachments and to tooth-to-implant bridges. Since the preservation of bone is essential for long-term survival of implants, this research offers evidence regarding the types of superstructures that will best assure such long-term survival. Parallel investigations concerning a similar patient population are lacking. Further studies are required in order to ascertain the reasons for these findings.

The survival rate of 83.2% after 5 years for the restoration types studied is comparable to that of other implant systems[4] and surpasses the results of the latest evaluations of implant success by others.[9] To rate implant success from the date of placement seems to be appropriate.[10] The long-term success rate was especially high when taking into consideration the fact that implant losses due to tumor recurrence compromised the results and that most losses occurred during the first year after placement. For implants in place for more than 1 year, the survival rate was 93%. A relatively high number of implants were lost due to inflammation. This almost always occurred immediately after the second-stage operation of abutment connection and may be a specific problem of tumor patients, due to their relatively poor oral hygiene and to the irritable soft tissues so frequently found after grafting.

Studies concerning patient satisfaction found in the literature[24,25] have dealt with healthy subjects and cannot be cited for comparison with validity. The postoperatively altered anatomical situations created a completely different environment for evaluation of the subjective opinions of the patients. Other studies dealing with the functional outcome of patients after mandibular reconstruction with microvascular flaps have not satisfied the most modest periodontal criteria for implant assessment and have judged success by simple input–output analyses.[26]

CONCLUSIONS

It can be concluded that after resection of oral malignancies, patients can be treated with dental implants and with the superstructures normally used in healthy subjects with similar long-term efficacy, taking into consideration the internationally established requirements and standards. The implant treatment of tumor patients seems to be safest, in periodontal terms, with the use of bar-clip or telescope-retained overdentures (compared with implant-supported prostheses, tooth-to-implant connected bridges, or ball-retained dentures). Patient satisfaction with the described prosthodontic treatment was satisfactory.

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