The Effect of Different Transplanted Soft Tissues on Bone Resorption Around Loaded Endosseous Implants in Patients After Oral Tumor Surgery

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One hundred eighty-five dental implants loaded for at least 1 year in 49 patients treated with ablative tumor and reconstructive surgery in the oral cavity were examined to ascertain peri-implant bone resorption. While 96 implants penetrated local mucosa and served as the control group, 27 implants were associated with split-thickness skin grafts, 9 in mucosal grafts, 18 in myocutaneous flaps, 30 in jejunal grafts, and 5 in a vastus lateralis and a temporalis muscle flap. Restoration type was similar in all groups (overdentures) except for implants placed in the jejunal grafts (fixed implant-supported prostheses). Regular follow-up was done over an observation period of 3 to 5 years after implant placement. Overall survival rate of the 89 implants surrounded by transplanted soft tissues was 94.1%. Bone loss under the various transplanted soft tissues was similar to or less than that under local mucosa. Over time, only horizontal bone resorption under jejunal grafts and vertical bone resorption under mucosal grafts showed higher values. Mean values of all measurements for split-thickness skin grafts were higher than for local mucosa for the horizontal as well as for the vertical resorption pattern. It can be concluded that transplanted tissues foreign to the oral cavity have no detrimental effect on bone resorption around loaded dental implants and do not endanger their long-term stability. Of all the transplants used, split-thickness skin grafts are least recommended as peri-implant soft tissue.
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Key words: dental implants, jejunal graft, long-term results, myocutaneous flaps, peri-implant bone loss, soft tissue

Tumor surgery in the head and neck usually creates a need for immediate reconstruction, especially in the oral cavity. There are many grafts that may be used, depending on the type of defect. For smaller soft tissue defects, split-thickness skin grafts[1] or mucosal grafts can be used. In patients with larger defects, intestinal microvascular grafts[2] show good results; the myocutaneous platysma flap[3] has similar indications. If intraoral ablative tumor surgery required sacrifice of more structures, the pectoralis major myocutaneous flap[4] often serves as an effective reconstruction modality. The oral rehabilitation of these patients is usually insufficient without prosthodontic restorations supported by endosseous implants. As a result of surgery, the anatomy in these situations was no longer favorable for conservative dentistry; thus dental implants have proved to be indispensable.

Initially, the aim of treatment was simple improvement of life quality without particular concern for esthetic or prosthetic quality. Rationale included poor prognosis of oral malignancies and the presumption that postoperative changes of oral physiology (eg, dryness) would endanger long-term success of implants. In recent years, the use of endosseous implants in tumor patients has become routine,[5] and large patient populations have been followed for several years to demonstrate the success of prosthetic restorations supported by endosseous implants.[6] Actual clinical research has concentrated on the comparison of implants in healthy and tumor patients and the possibility of implant survival in irradiated jaws. Various transplanted soft tissues have primarily been defined

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Table 1 Numbers of Implants Surrounded by Various Soft Tissues (0–3 Months) and Examined During the Observation Period

	Type of soft tissue					
Months	Local mucosa	Split skin graft	Mucosal graft	Myocutaneous flap	Intestinal flap	Others
0–3	96	27	9	18	30	5
4–9	16	3	2	5	9	4
10–15	49	16	7	12	21	4
16–21	30	10	5	5	15	0
22–27	26	11	4	9	11	0
28–33	16	3	2	7	7	0
34–39	9	4	0	0	5	0
40–45	12	4	0	0	5	0
> 45	22	8	0	0	6	0

as simply not adapted to the oral cavity. Recommendations for thinning grafts, which seemed too thick for implant-retained restorations such as the pectoralis major or the intestinal flap, have been the specific treatment or care suggested.[7] Very seldom has the reaction of these soft tissues around the implants been examined in strictly periodontologic terms.[8]

The important question of what effects the various tissues foreign to the oral cavity have on the bone they cover, especially in combination with endosseous implants, remains unanswered. But minimal bone resorption is the key to long-term success of osseointegrated implants. Since 1990, the present authors have treated patients after ablative surgery for oral malignancies with Bone-Lock implants for prosthetic rehabilitation. Since immediate reconstruction involving the use of the aforementioned grafts has been used, the possibility of providing an answer to that question was envisioned.

Materials and Methods

From June 1990 to December 1996, 210 Bone-Lock implants (Howmedica Leibinger GmbH, Freiburg, Germany) were placed in the jaws of 58 patients after resection of oral malignancies. Bone-Lock implants were used exclusively because it is a modern system with a specific coating, and handling is simple since it has few components.[5,6] The endosseous titanium screw has a conical angle of 2.5 degrees and an osteophilic coating of titanium-zircon-oxide. Furthermore, the system has transgingival abutments that are long enough (up to 9 mm) to penetrate the thick grafts that are sometimes necessary. These abutments have two different coatings: in the subgingival area, it is titanium-zircon-oxide, while in the supragingival area, it is titanium-niobium-oxinitride, which is very hard and makes cleaning by scaling easy.

In this study, 185 implants in 49 patients were reviewed because the implants had been loaded and functioning for at least 1 year. Maximum observation time was 5 years after placement, and the minimum time was 3 years. To avoid complicating the study, patients with bony grafts were not included. All patients in this study suffered from squamous cell carcinomas, mainly of the anterior or lateral floor of the mouth. Surgery comprised radical resection of altered soft tissue in healthy margins. Eighteen of the patients underwent rim resections of the mandible with preservation of the inferior alveolar nerve. At least 15 to 20 mm of residual bone was present in these patients. Soft tissue defects were covered with a jejunal graft in 7 patients, with a myocutaneous flap (either pectoralis major or platysma flap) in 11 patients, and with either a split-thickness skin graft or a mucosal graft in 8 patients.

Table 1 shows the exact numbers of examined implants during the 0 to 3 month period. The implants penetrated normal local mucosa in 51.9% of the sites (96 implants), split-thickness skin grafts in 14.6% (27 implants), mucosal grafts in 4.9% (9 implants), myocutaneous flaps in 9.7% (18 implants), intestinal flaps in 16.2% (30 implants), and various other grafts in 2.7% (5 implants) of the sites. It must be pointed out that the implants concerned were not only adjacent to these transplants, but actually penetrated and were completely surrounded by them. The grafts were left to physiologic healing and atrophy and were not thinned. (The 5 implants under the heading "others" were standing in a vastus lateralis and a temporalis muscle flap and were too few to be considered for comparison.)

The implants surrounded by normal local mucosa served as a control group. As a consequence of the distribution of patients and implants, the patients with transplants had implants surrounded by local

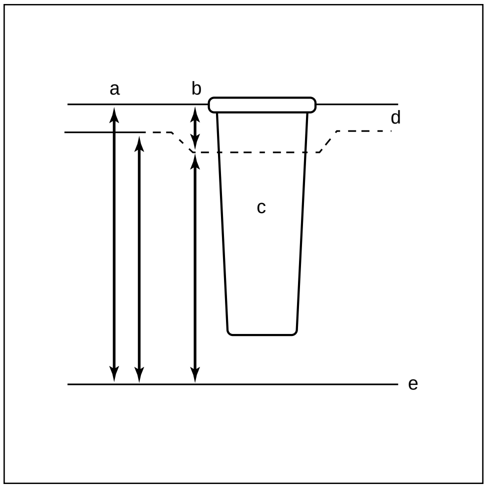

Fig 1 Diagram of the measuring points used in the study: *(a)* horizontal bone loss measured either in the center of the space between two implants or 1 cm lateral to the most lateral implants; *(b)* vertical bone loss measured directly beside the implant shoulder mesially and distally; *(c)* implant with reference point at shoulder; *(d)* bone margin at the implant shoulder (superior margin of the mandible or lower margin of the maxilla); *(e)* bone margin at the apex of the implant (inferior margin of the mandible or nasal and sinus floor in the maxilla).

mucosa as well. Since all implants were placed in the mandible (except 8 screws that were placed in the maxilla with local gingiva), the groups seem to be comparable. The implants were 4.5 × 17 mm (61%) or 4.5 × 15 mm (34.7%) in the majority of cases. The others (4.3%) have a length of 13 mm and are identical to the 8 screws in the maxilla.

Implantation always took place secondarily, usually 6 months after tumor surgery. The implants were generally loaded 3 to 4 months after placement. The prosthetic treatment consisted of telescopic or bar-retained overdentures for the majority of patients. For the patients with intestinal grafts (7 of 49), entirely implant-supported fixed prostheses were fabricated to protect the soft and vulnerable grafts. Similarity of prosthetic treatment also enhanced the comparability of the groups.

The regular follow-up consisted of periodontologic measurements (pocket probing depth, Plaque Index according to Silness and Löe,[9] Sulcus Bleeding Index according to Löe,[10] Periotest value) and radiologic measurements using orthopantomograms. In this study, bone response was the most important parameter for the effect of transplanted soft tissues in combination with endosseous implants. Orthopantomography took place directly after implant placement (baseline), directly after placement of the prosthodontic restoration, at 6 and 12 months afterward, and annually thereafter. Bone resorption was ascertained at three positions per implant at each date. Resorption was measured either in the center of the space between two implants, or 1 cm lateral to the most lateral implants, as evaluation of the vertical bone height between the superior and the inferior margins of the mandible. The horizontal component thus describes the general bone resorption of the whole part of bone containing the implants. Vertical bone resorption was measured directly beside the implant shoulder mesially and distally and correlates with the bony pocket around the implant. The measurement process is illustrated in Fig 1. Measurement was accurate to the millimeter only, 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 was ascertained for every implant surrounded by a particular soft tissue. After the first 3 months, the results were summarized every 6 months. For each period of time, the bone resorption was calculated as the difference since the first date of orthopantomography. Table 1 shows the number of implants examined in the different periods of time.

Results

The values of the periodontologic parameters are reported summarily[11] to allow better analysis of the actual results of this study. After the beginning of loading, specific adaptation phenomena of tumor patients could be detected. Despite constant plaque accumulation (mean 1.79, range 1.5 to 2.0), the bleeding disposition (mean 1.42) diminished from 1.83 to 0.71. Corresponding to this finding, the pocket probing depths (mean 5.25 mm) decreased from 5.75 mm to 4.57 mm. The implant mobility (Periotest method: mean 2.25, range –3.0 to +8.5) showed a decrease in the first 2 years, and then the values increased. The mobility seemed to depend on the type of supraconstruction: telescopic or bar attachments had the lowest values, and implant-supported prostheses had the highest values.

Figures 2 to 4 show the results of the investigations over time. Concerning the horizontal bone loss (Fig 2), there was little difference between grafts such as split-thickness skin or pectoralis major flaps. The curves are similar for the resorption rate of bone covered by local mucosa, which show a gentle increase until they reach 1.94 mm after 2 years. Then the values oscillate around the 2-mm level. Only the course of values for bone resorption under jejunal

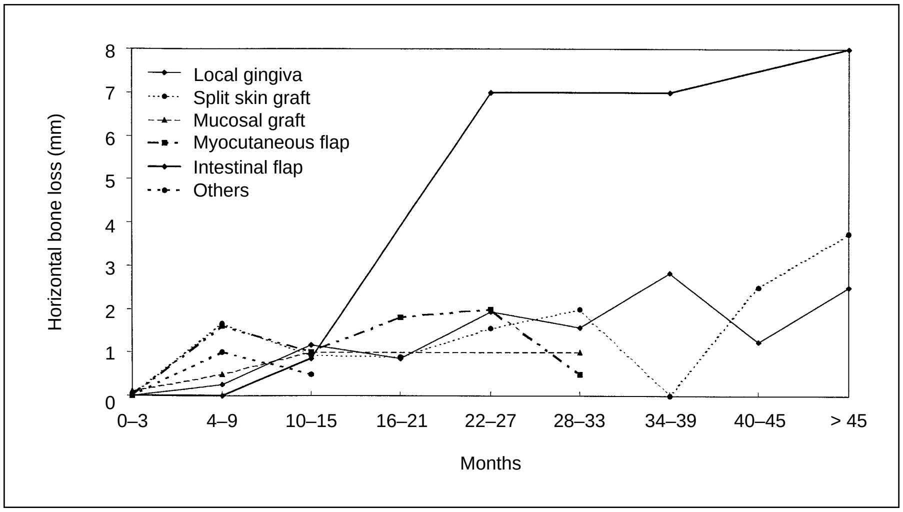

Fig 2 Horizontal bone loss related to different soft tissues.

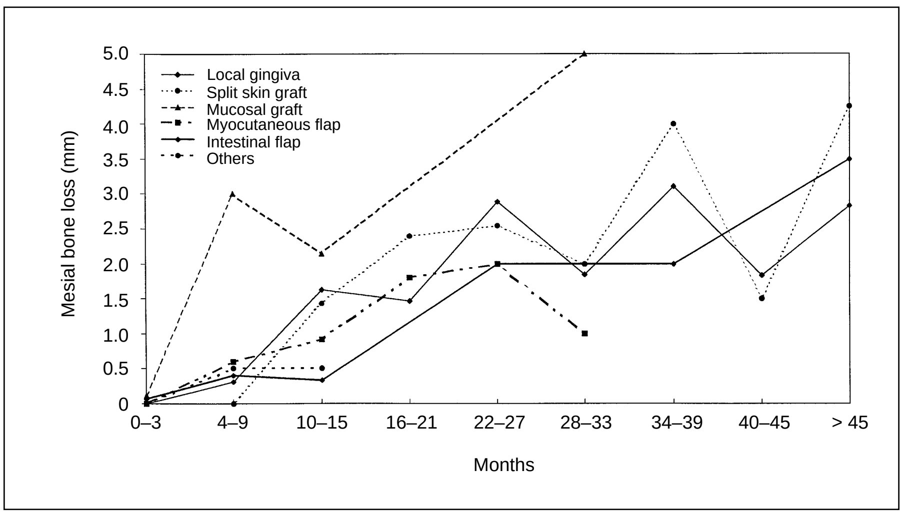

Fig 3 Mesial bone loss related to different soft tissues.

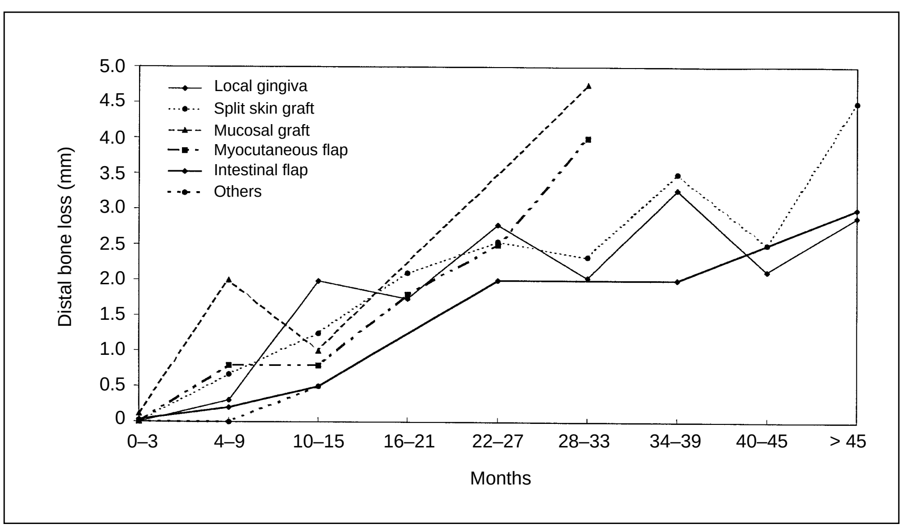

Fig 4 Distal bone loss related to different soft tissues.

Table 2 Mean Values of all Bone Loss Measurements for the Various Soft Tissues

Mean bone loss (mm)	Type of soft tissue					
	Local mucosa	Split skin graft	Mucosal graft	Myocutaneous flap	Intestinal flap	Others
Horizontal	0.93 ± 1.23	1.06 ± 1.49	0.55 ± 0.76	0.77 ± 0.86	1.12 ± 1.18	0.46 ± 0.78
Mesial	1.24 ± 1.78	1.54 ± 1.93	1.6 ± 1.73	0.66 ± 0.89	0.38 ± 0.86	0.31 ± 0.48
Distal	1.36 ± 2.11	1.54 ± 1.79	1.08 ± 1.67	0.81 ± 1.17	0.33 ± 0.8	0.15 ± 0.38

$P < .05$.

grafts is clearly different, as already after 1 year it increased to 7 and 8 mm. The mean values of all measurements for each group in Table 2 demonstrate the results even more exactly (significance of between-group comparisons, $P < .05$): whereas the values for horizontal bone loss under split-thickness skin grafts and jejunal flaps are slightly higher than those for local mucosa, the values for bone loss under mucosal grafts and myocutaneous flaps are lower than those for local mucosa.

Figures 3 and 4 show the marginal bone loss. The curves illustrate that there was no major difference in peri-implant bone loss among the different groups. Only the values for mucosal grafts, especially at the mesial site of the implants, are slightly larger. The mean values in Table 2 confirm the supposition that peri-implant bone loss under split-thickness skin and mucosal grafts is comparable to that under local mucosa (although split-thickness skin grafts show slightly higher values as well), while myocutaneous and jejunal flaps seem to induce far less resorption. The mean values for mesial and distal bone loss were generally higher than were those for horizontal bone resorption, indicating the development of a bony pocket around the implants and showing that vertical bone loss has a large portion of general horizontal resorption (Table 2). Only the bone covered by an intestinal flap showed contrary reaction. Because of the function of an implant-supported prosthesis,[12] peri-implant bone suffers less resorption than the bone between the implants. Although the number of implants surrounded by the vastus lateralis and the temporalis muscle flap were too few to be significant, their results were similar to those for the myocutaneous flaps.

For all 210 implants, a probability of 83.2% survival rate after 5 years from the date of placement was found using the Kaplan-Meier statistical analysis (including all losses by tumor recurrency). For implants in place for over 365 days, the survival rate was 93%. For the 89 implants surrounded by the various soft tissue grafts, the survival rate was 94.1% from the date of placement. Implant losses in the tissue graft group were all the result of failing osseointegration and occurred during the period of abutment connection 3 to 5 months after placement. None of the implants in situ caused any severe, persistent, or irreversible signs or symptoms.

Discussion

Normally, a certain width of attached masticatory mucosa is considered desirable as a condition for a healthy peri-implant seal. It was shown that the soft tissue barrier around teeth (gingiva) and implants (peri-implant mucosa) has a similar guarding potential.[13] Although this may be an optimal environment, it cannot always be achieved. As the indications for dental implantation have become broader, new opportunities have been created to examine peri-implant soft tissues under these more unfavorable conditions. Nevertheless, discussion continues as to whether attached mucosa really is essential for a healthy peri-implant seal.[14] The lack of attached mucosa may not be as critical as originally supposed.[15] Peri-implantitis has been treated with free gingival or mucosal grafts[16] among other things, which meant surgical alteration of the peri-implant region. But these grafts have been relatively small and did not cover larger parts of the jaws. The effect of larger soft tissue transplants on the covered bone in combination with endosseous implants has not yet been examined in detail.

Günay et al[8] showed that the thickness of intestinal grafts had no detrimental effect on the periodontologic parameters (such as hygiene index) of Brånemark implants. This was explained by the persistent mucus secretion of the graft, which had a cleansing effect on the abutments. Today, rehabilitation of patients suffering from significant alterations of oral anatomy and physiology caused by ablative tumor surgery is routine and frequently involves hard and soft tissue reconstruction of defects and prosthetic restoration using endosseous dental implants. The environment that soft tissue transplants create is not optimal for the peri-implant situation; the split-thickness skin is dry, the intestinal graft is movable and thick, and the myocutaneous grafts are dry, rigid, and thick. In this patient series, no thinning of the voluminous transplants or changing of the grafts was done by any operation not necessary for implant placement and abutment connection, since the region had already suffered multiple trauma. The data of periodontologic parameters in tumor patients with implant treatment show that, despite some peculiarities, the values nearly reach the acknowledged international standards.[6,11,17] The decrease of bleeding disposition and pocket probing depth indicate an accommodation of the thick and vulnerable tissues. Yet it is difficult to extrapolate all of the success criteria for implants in healthy patients to those in tumor patients. Regarding newer protocols,[17] however, defined criteria are becoming more applicable to clinical treatment and can be differentiated according to the examined object.

This study shows that the effects of transplanted soft tissues, such as split-thickness skin grafts, mucosal grafts, and myocutaneous and jejunal flaps, on the underlying bone are surprisingly similar to those of normal local mucosa. This result is even more reliable since it was obtained in patients carrying implants surrounded by normal mucosa as well as implants surrounded by foreign soft tissues. Although the existing differences of mean values should not be overrated because of relatively high standard deviations, split-thickness skin grafts do not seem to be suited as peri-implant tissue. Associated horizontal and vertical bone loss was higher than the values for local mucosa. In the case of the jejunal graft, a possible explanation for the high horizontal bone resorption over time may be the clinical fact that there is no development of an attached interface between bone and mesenterial tissue,[2] and the graft always retains a motility on the bony surface and can be easily removed. All other grafts developed a strong connection to the underlying bone, which may protect it.

There are two points of possible criticism. First, measurement using orthopantomograms is not as exact as using standardized periapical radiographs. The use of dental periapical films is generally impossible in patients after ablative and reconstructive tumor surgery. Orthopantomography was considered to be precise enough for the requirements of this study (precision to the millimeter).[18] Second, the prosthetic treatment was not identical for all patients examined. Providing all patients with implant-supported restorations was financially unfeasible.

Furthermore, because of the vulnerable base, the prosthetic concept of telescopic and bar-retained overdentures could not be used in the patients with jejunal grafts. This obstacle can be overcome by cautious interpretation of results. Thus, the very low mean values for vertical bone loss under jejunal flaps are probably the result of the recognized bone-protecting quality of fixed implant-supported prostheses.

Conclusion

This study attempts to ascertain the reaction of peri-implant bone to different transplanted soft tissues. Generally, transplanted soft tissues such as split-thickness skin grafts, mucosal grafts, myocutaneous flaps, and jejunal grafts had no detrimental effect on bone resorption around functioning dental implants in this patient population. There were no obvious signs that these tissues endangered the long-term stability of the implants, as was demonstrated by the favorable survival rate for the implants surrounded by foreign soft tissue. Of all transplants, split-thickness skin grafts can least be recommended as peri-implant soft tissue. This study confirms the authors' conviction that implant treatment can be equally effective for tumor patients as for healthy individuals. Future investigations should include observation of periodontologic and microbiologic parameters of the transplanted tissues.

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