Retrospective Assessment of the Peri-implant Mucosa of Implants Inserted in Reanastomosed or Free Bone Grafts from the Fibula or Iliac Crest

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Purpose: *To investigate the susceptibility of implants to inflammation following autogenous bone transplantation and to evaluate whether various factors affect outcomes.* ***Materials and Methods:*** *This retrospective cross-sectional clinical investigation involved patients who were treated between the years 1994 and 1996. The donor site, mode of transplantation, primary disease, gender, smoking habits, and age were evaluated with respect to outcomes. Clinical and radiologic assessments were the basis for the classification into 3 categories: (1) no inflammation, (2) mucositis, and (3) peri-implantitis. Lost implants were also noted. The data were evaluated statistically to determine whether significant differences existed.* ***Results:*** *Forty-three patients (23 men and 20 women) were involved in this retrospective study. These patients received a total of 216 oral implants over a follow-up time of 8 to 10 years. Depending on the type of reconstruction, rates of peri-implant inflammation between 9% and 38% were observed. For mucositis, rates of 16.3% to 24.1% were seen, and 30% to 70.9% of sites showed no inflammation.* ***Conclusion:*** *High rates of soft tissue inflammation adjacent to implants were observed. The choice of donor site in conjunction with the mode of transplantation seemed to influence the development of peri-implant inflammation. The microsurgically reanastomosed fibula seemed most resistant to inflammatory processes, followed by the microsurgically reanastomosed iliac crest, free iliac crest, and free fibula. No significant differences could be observed for primary disease. These findings should be taken into consideration prior to surgery and when establishing individual recall systems.* Int J Oral Maxillofac Implants 2008;23:1102–1108

Key words: *free bone transplantation, jaw reconstruction, microsurgical transplantation, oral implants, peri-implantitis*

Large defects of the jaws following ablative surgery are often accompanied by a loss of function and unacceptable appearance, making jaw reconstruction desirable. With the improvement of surgical procedures, especially free flaps and the advent of oral implants,[1] alternatives exist for the rehabilitation of masticatory function. Especially in the treatment of patients following segmental jaw resection with microsurgically revascularized bone transplants and subsequent insertion of oral implants, these measures often result in a restoration of form and function that is close to normal.[2] Oral implants play an integral role in this concept, allowing fixation of prosthetics and protecting existing bone by providing an approximation of physiologic bone loading.[3]

Analysis of the connective tissues has shown that the peri-implant mucosa contains markedly more collagen (85% versus 60%) and fewer fibroblasts (1% to 3% versus 5% to 15%) when compared to normal, healthy gingiva.[4] Hence, the supra-alveolar region of the peri-implant mucosa resembles scar tissue and is thus poorly perfused.[4] Furthermore, in patients with transplanted bone, this is further compounded by certain accompanying factors:

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- Recipient site acceptance of the bone transplant during the healing and remodeling period, involving the development of its vascular supply, influences the bone healing capacity and subsequently the osseointegration of oral implants.
- Following radiation therapy, fibrosis, radioxerostomia, and the risk of developing infection increase as a result of the diminished perfusion of the site. The summation of these factors leads to an alteration of the oral environment that is conducive for the development of inflammation.
- The tissue associated with implants inserted in osseous flaps is not comparable to normal gingiva. Microsurgical transplantation demands that muscle is typically left on the donor bone to facilitate the perfusion of the grafted bone.[5] This results in thick soft tissue coverage. Hence, examination methods such as probing depths are not comparable since, in the absence of inflammation, probing depths exceeding 5 mm can often be observed.

Following osseointegration, an important factor in late failure is thought to be peri-implant infection,[6] highlighting the need for more research in this field. Although numerous reports exist concerning the development of peri-implantitis or the suitability of bone substitutes in implant dentistry,[7] little emphasis has been placed on implants inserted in autogenous transplanted bone and whether a given donor site is more suitable from a long-term point of view. The purpose of this study is to evaluate an association between soft tissue response and different types of autogenous bone and soft tissue grafting. With the obtained information, a relationship between the type of osseous reconstruction and the incidence of peri-implant inflammation is presented. The findings should aid clinicians in selecting the bone flap most suitable for oral rehabilitation and in defining patient-specific recall intervals.

MATERIALS AND METHODS

The medical charts of patients who had been treated between the years 1994 and 1996 were reviewed. Criteria for eligibility were: (*1*) osseous reconstruction with either of 2 donor sites, with or without microvascular reanastomosis, (*2*) primary disease either malignant tumor or jaw atrophy, (*3*) subsequent implantation with one implant system and similar prosthetic suprastructures, (*4*) information available on smoking habits, age, and gender. All patients who fit the requirements were asked to participate in this retrospective study, either by telephone or letter. At the time of investigation, standardized panoramic radiographs were obtained in conjunction with the clinical investigation.

The evaluation focused only on the implants that were present at the time of examination in 2004. Any lost implants were also recorded and documented based on the medical charts. The examination of the inflammatory process affecting the implants followed the guidelines adopted in the evaluation of periodontitis, with one exception: probing depths were omitted. For the systematic evaluation of the cases, the modified Sulcus Bleeding Index according to Mühlemann[8] (grades 0 to 5) and the degree of bone resorption were recorded. For this purpose, the vertical distance from the neck of the implant to the crest of the surrounding bone tissue was measured on standardized panoramic radiographs. Only reference points that were reproducible in all follow-up panoramic radiographs were included in the evaluation, whereby the length of the implants served as an internal standard. The panoramic radiograph that had been obtained immediately after implant placement served as a reference, and all follow-up radiographs were compared to these images. The evaluation allowed assessment of mucositis and peri-implantitis in comparison to no inflammation. The evaluation was carried out by one person who was not involved in the surgical treatment. A diagnosis of mucositis was given when the peri-implant mucosa showed signs of inflammation without marked bone resorption (according to Smith et al[9]; < 1.5 mm in the first year, < 0.1 mm in following years), and a diagnosis of peri-implantitis always involved loss of the supporting bone.[4,10]

All data were statistically evaluated with the help of SPSS 12.0 (SPSS Inc, Chicago, IL, USA) to determine whether significant differences were present according to univariate analyses for the possible outcomes: (*1*) no problem on any implant (ie, the number of sites with no inflammation equaled the number of implants; thus, no problems were seen on any implant), (*2*) no peri-implantitis on any implant, and (*3*) no problems with more than half of the implants. *P* values were calculated using the Fisher exact test.

RESULTS

This retrospective cross-sectional clinical investigation involved 43 patients (23 men, 20 women) who were treated in the years 1994 to 1996, providing a follow- up of 8 to 10 years. A total of 53 patients proved eligible, and 10 patients were lost to follow-up.

A total of 216 implants were included in the investigation; all were titanium plasma–coated cylindric

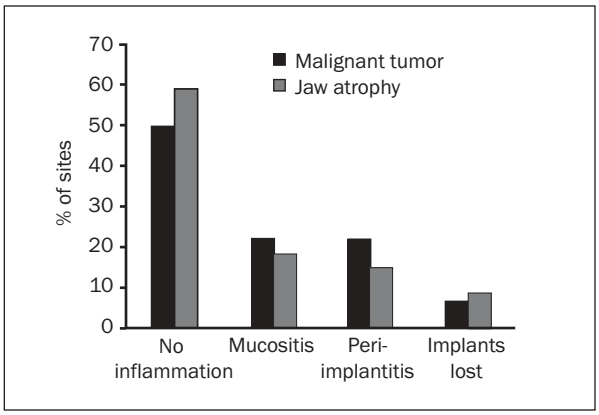

Fig 1 Distribution of site outcomes (%) according to primary disease.

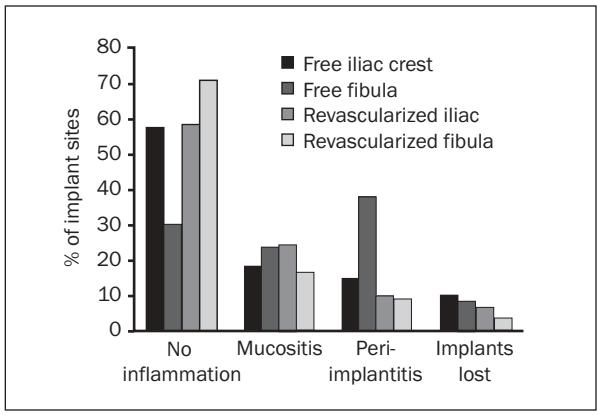

Fig 2 Distribution of site outcomes (%) with respect to type of bone transplant.

Table 1 Summary of Results

	No inflammation	Mucositis	Peri-implantitis	Implants lost
Graft type				
Free iliac crest	47/82 (57.3%)	15/82 (18.2%)	12/82 (14.6%)	8/82 (9.7%)
Free fibula	15/50 (30%)	12/50 (24%)	19/50 (38%)	4/50 (8%)
Revascularized iliac crest	17/29 (58.6%)	7/29 (24.1%)	3/29 (10.3%)	2/29 (6.8%)
Revascularized fibula	39/55 (70.9%)	9/55 (16.3%)	5/55 (9%)	2/55 (3.6%)
Gender				
Male	60/123 (48.7%)	26/123 (21.1%)	25/123 (20.3%)	12/123 (9.7%)
Female	58/93 (62.2%)	17/93 (18.2%)	14/93 (15%)	4/93 (4.3%)
Primary disease				
Malignant tumor	53/106 (50%)	23/106 (21.6%)	23/106 (21.6%)	7/106 (6.6%)
Jaw atrophy	65/110 (59%)	20/110 (18.1%)	16/110 (14.5%)	9/110 (8.1%)
Smoking status				
Nonsmokers	67/101 (66.3%)	14/101 (13.8%)	13/101 (12.8%)	7/101 (6.9%)
Smokers	51/115 (44.3%)	29/115 (25.2%)	26/115 (22.6%)	9/115 (7.8%)

implants. At the time of implant placement, the patients' ages ranged from 28 to 82 years of age (mean: 61, median: 62). All patients had undergone jaw reconstruction with autogenous bone transplantation. None of the microsurgically reanastomosed flaps were osseocutaneous flaps, but rather only osseous flaps. Following introduction of implants into the transplanted bone, the prosthetics entailed splinted bar reconstructions and bar-clip overdentures, whereby no differences were made according to the type of reconstruction.

The disorders that had led to jaw augmentation were malignant tumors (21 patients) (all were squamous cell carcinoma and all had received radiation) and severe atrophy (22 patients) (Fig 1). None of the patients had received hyperbaric oxygen therapy.

The methods of bone transplantation were microsurgically reanastomosed iliac crest (6 patients) or fibula (11 patients) without skin paddles, free iliac crest (16 patients) or fibula (10 patients) (Fig 2). The prosthetic rehabilitation involved splinted bar suprastructures with bar-clip overdentures.

In the presentation of the results, the incidence of inflammation is correlated to different factors (type of bone transplant, gender, primary disease, and smoking status). A summary of the results is shown in Table 1.

The microsurgically reanastomosed fibula proved most resistant to inflammation, followed by the revascularized iliac crest, free iliac crest, and free fibula (Tables 2 to 4); low levels of significance were observed by this small sample size (see Tables 2 to 4). Concerning the primary disease, patients who suffered from malignant tumors showed a higher incidence of inflammation; interestingly, more implants were lost in the group with atrophy of the jaw (not statistically significant). In smokers as well as in male patients a higher rate of inflammation was noted and more implants were lost during the follow-up time (Figs 3 and 4).

With a *P* value of .05 indicating significance, only 2 analyses showed significance. In the analysis for "No problem on any implant," gender was correlated with a statistically significant difference ($P = .039$), and in the analysis "No problems with more than half

Table 2 Univariate Analysis of the Outcome "No Problem on Any Implant"

Variable	No problem at any implants	At least 1 implant presents problems	P*
Total	4	39	
Gender			
Female	4	16	
Male	0	23	.039
Age at implant placement			
Under 55	4	24	
55 and older	0	15	.166
Smoking status (at surgery)			
Nonsmoker (neither at implantation nor at examination in 2004)	3	10	
Smoker	1	29	.075
Primary disease			
Atrophy	3	19	
SCC	1	20	.607
Donor site			
Fibula	3	18	
Iliac	1	21	.345
Type of surgery			
Free graft	1	25	
Microsurgical graft	3	14	.284

*Fisher exact test.
SCC = squamous cell carcinoma.

Table 3 Univariate Analysis of the Outcome "No Problems with More Than Half of the Implants"

Variable	No problem with more than half implants	Problems with at least half implants	P*
Total	21	22	
Gender			
Female	12	8	
Male	9	14	.227
Age (at surgery)			
Under 55	15	13	
55 and older	6	9	.526
Smoking status (at surgery)			
Nonsmoker (neither at implantation nor at examination in 2004)	10	3	
Smoker	11	19	.022
Primary disease			
Atrophy	13	9	
SCC	8	13	.227
Donor site			
Fibula	11	10	
Iliac crest	10	12	.763
Type of surgery			
Free graft	10	16	
Microsurgical graft	11	6	.124

*Fisher exact test.
SCC = squamous cell carcinoma.

of the implants," smoking showed a statistically significant difference ($P = .022$).

DISCUSSION

Although a multitude of long-term results exist concerning implant survival, the number of reports focusing solely on peri-implantitis are rare and have increased only in the last few years.[11] Overall incidences of peri-implant inflammation have been stated as 0.8%,[12] 5.8%,[11] and 14%.[13] The comparatively high incidence (up to 38%) in this study is likely the result of the patient population chosen for this evaluation, being a highly preselected group (ie, a population with severe atrophy or large defects) in comparison to the aforementioned studies.

It is well known that poor oral hygiene contributes to the development of peri-implantitis and that microbiologic colonization plays a decisive role.[4,10,14] Biomechanical overloading and cigarette smoking have also been identified as promotive agents.[15–17] Noteworthy according to Klinge et al[11] is that there are apparently no data available to support specific treatment protocols that will prevent peri-implantitis. Zitzmann et al[14] pointed out that even when the stimulus or the cause of the inflam-

Table 4 Univariate Analysis of the Outcome "No Peri-implantitis on Any Implant"

Variable	No peri-implantitis at any implant	At least 1 implant with peri-implantitis	P*
Total	17	26	
Gender			
Female	10	10	
Male	7	16	.225
Age at implantation			
Under 55	13	15	
55 and older	4	11	.327
Smoking status			
Nonsmoker (neither at implantation nor at examination in 2004)	8	5	
Smoker	9	21	.089
Primary disease			
Atrophy	11	11	
SCC	6	15	.215
Donor site			
Fibula	8	13	
Iliac crest	9	13	1.000
Type of surgery			
Free graft	8	18	
Microsurgical graft	9	8	.205

*Fisher exact test.
SCC = squamous cell carcinoma.

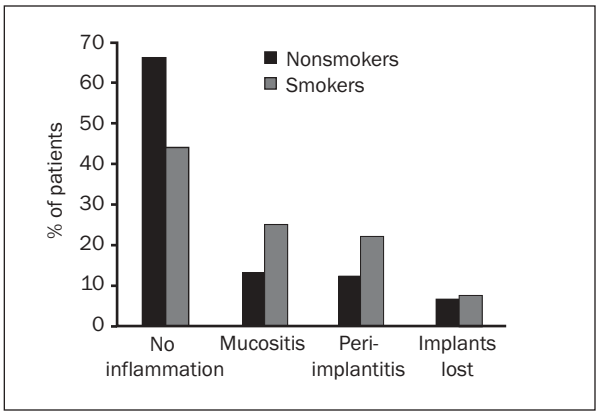

Fig 3 Distribution of site outcomes with respect to smoking habit.

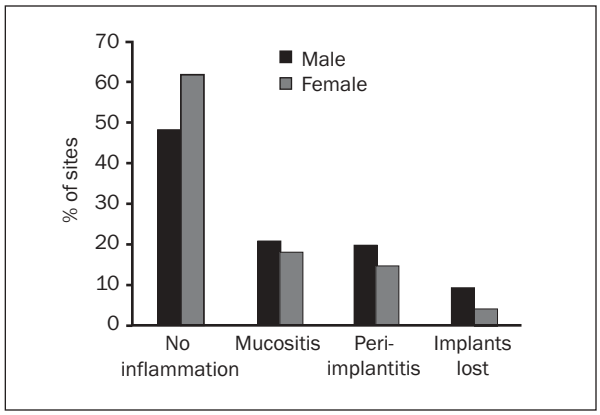

Fig 4 Distribution of outcomes (%) with respect to gender.

mation is eliminated, in some cases it progresses; this makes its prevention even more important. With regard to patients who underwent reconstructive surgery involving bone transplantation, the etiology and perpetuation of the inflammation seem to be affected by other factors as well. The majority of the patients in this study were 59 years or older. Older patients' manual ability, ie, handling of toothbrushing, is diminished; thus, older patients tend to have greater plaque accumulation on oral surfaces.

The adjunctive therapy of patients who suffered from squamous cell carcinoma promotes the development of periodontitis, ie, peri-implant inflammation.[18] Radiation therapy can also lead to early onset and late-onset tissue reactions.[19,20] As a result, mucositis is a commonly seen sequela. The late reactions are the typical radiation-induced fibrosis and demineralization of osseous structures, in conjunction with a decreased ability to ward off infection. With the subsequent xerostomia, salivary production decreases and becomes more viscous. This effect is not transient, as the salivary glands are permanently damaged. The effect on the irradiated bone is also not temporary; rather, the bone remains more prone to infection because of the decreased perfusion. However, the implants in this study were all placed in bone segments that had been transplanted after radiotherapy, so the direct effects of radiotherapy should have played a minor role.

Because of the extensive resections and subsequent reconstructions in this population, the mucosal lining covering the bone varied from that in healthy patients. Often in such cases, no attached gingiva is present and the thickness of the mucosa exceeds that of healthy gums, predisposing the patient to the development of periodontal pockets or nonhygienic niches. For this reason, the often recommended probing depth, which should normally be an integral part of any implant assessment,[6] could not be used in the evaluation of this patient population. The distance between the bone surface and the oral cavity can easily exceed 5 mm, since the microsurgically reanastomosed flaps need the muscle layer for the perfusion of the bone.[5] Introduced into the oral cavity, these flaps may or may not be covered with oral mucosa, should it be present. The muscle then epithelializes. Subsequently, in these flaps, probing depths of more than 5 mm can be expected in the absence of inflammation. Also in some microvascularly reanastomosed flaps, a skin paddle can be elevated in conjunction with the osseous flaps.[5] If this skin paddle is used for the oral lining, then its morphology also varies greatly from the natural gingiva. In contrast to this, in free flaps, the bone is stripped of its soft tissue and covered only by the oral mucosa. Here, mucosal thickness that is closer to physiologic norms can be expected. These facts do not permit comparison of probing depths between groups, and this measurement was excluded in this investigation.

The unfavorable environment following jaw reconstruction is further demonstrated by the number of implants that were lost in this patient population. Berglundh et al[10] reported that in a meta-analysis of 51 studies, an implant loss rate of 2% to 5% in the first 5 years can be expected (late failures). Although the follow-up in the present study was 8 to 10 years, 7.4% of the implants were lost—close to twice the usual rate.

A point of criticism must be the chosen prosthetic suprastructures that all the patients received in this study. In the mid-1990s, splinted bar constructions with clip overdentures found great acceptance at the investigating institution. Today, with a stronger emphasis on hygienic accessibility, telescopic crowns that facilitate circumferential cleaning are preferred.

The type of bone transplantation seems to play a role in the prognosis of implants. The vitality of the

recipient bone is dependent on the nature of the transplantation, ie, whether a microsurgically reanastomosed flap or a free flap was used. The revascularized flap retains the perfusion of the bone at all times, whereas higher rates of resorption occur in free flaps.[21] The results with the fibular transplants were surprising. Although the microsurgically reanastomosed fibula proved most resistant to inflammation in this investigation, the free fibular graft seemed least suitable and showed the highest rates of inflammation. This seems contradictory. It would seem more likely that the results of the fibular flaps would be more similar. The reperfusion seems of utmost importance, likely as a result of the high cortical bone content. However, this needs to be substantiated by other investigations and remains a subject of speculation.

In cigarette smokers, an increased prevalence of peri-implant infections was observed. According to Heasman et al,[15] smoking increases the risk of periodontal disease by 2 to 6 times. Tobacco reduces the phagocytic response to periodontal pathogenic agents, reduces the perfusion of the tissue, and delays wound healing.[22] In periodontitis, this is associated with increased periodontal attachment loss.[23] Controlled transverse and longitudinal studies have verified that tobacco smoking leads to increased bone loss, marked pocket development, attachment loss, and calculus development by equal plaque levels as compared to results in nonsmoking individuals, and the success rate of periodontal treatment is lower than in nonsmokers.[15] The results of this study revealed that in light of the multitude of cofactors examined in this analysis, only the differences between smokers and nonsmokers and men and women proved significant (.022 and .039, respectively). It is noteworthy, although without scientific bearing, that of the 30 smokers who were treated, 23 continued to smoke in 2004 and did not succumb to recurrent tumors or other malignancies. This raises the question of whether the presented procedures remain fruitless in the fight against smoking.

Concerning the choice and mode of transplantation, the microsurgically reanastomosed fibula flap followed by the microsurgically reanastomosed iliac crest seemed most suited for oral reconstruction in terms of long term incidence of per-iimplantitis. Nonetheless, the likelihood of developing a periimplant inflammation can be kept low if certain behavioral patterns are followed by emphasizing the need for individual maintenance care, especially in this patient population. The inauguration of a so-called cumulative interceptive supportive therapy, as proposed by Lang et al,[6] seems to be a step in the right direction.

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