Implant Marginal Bone Loss in Maxillary Sinus Grafts

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Purpose: *The marginal bone loss (MBL) around implants placed in maxillary sinus grafts was evaluated.* ***Materials and Methods:*** *The study consisted of 70 patients who had undergone 81 sinus-graft procedures (total 212 screw-type implants). Complete radiographic records were available for 160 implants, which were used to calculate MBL (follow-up 6 to 56.5 months). Habits (smoking, bruxism), surgical phase parameters (preoperative residual bone, grafting material, implant characteristics, and complications), and prosthetic parameters (crown-implant ratio, marginal fit, and opposite-arch restoration) were recorded for each patient and statistically analyzed regarding MBL.* ***Results:*** *Cumulative survival and overall radiographic success rates were 95.5% and 83.7% for 4.5 years, respectively. Smoking, small implant surface area, and a delayed implantation approach were related to enhanced MBL, with mean MBL values of 0.24 mm/y (*$P < .011$*), 0.21 mm/y (*$P < .031$*), and 0.31 mm/y (*$P = .052$*), respectively. In residual bone of ≤ 4 mm, the relation to enhanced MBL was stronger (*$P < .018$*) for delayed implantation.* ***Discussion:*** *Survival and radiographic success rates compare well with other reports. However, most studies modify success criteria regarding MBL. Smoking may be a primary risk factor regarding implant success. Implants with greater surface area values could compensate for problematic bone characteristics (eg, in grafted maxillary sinuses). The effect of delayed implantation on MBL was surprising and may prompt simultaneous implantation whenever primary stability can be achieved.* ***Conclusions:*** *Smoking and implant surface area affected MBL in this patient population. Criteria for long-term implant success should be revised to a standard.* INT J ORAL MAXILLOFAC IMPLANTS 2006;21:103–110

Key words: *implant success, implant survival, marginal bone loss, radiographic success, sinus graft*

The maxillary sinus graft is a predictable procedure with an implant survival rate of over 90% for 3 to 5 years.[1–5] Implant survival commonly defines a successful procedure. Ongoing marginal bone loss (MBL) around implants could jeopardize implant longevity and the supported prosthesis. It is currently agreed that most implants demonstrate initial bone loss "to the first thread," which is attributed to etiologic factors, including biologic width formation, implant crest module, and implant-abutment microgap.[6] However, this "standard MBL" does not present a risk to implant longevity because of its tendency to stabilize at a certain level after approximately 12 months.[6] MBL apical to the level of the first thread could present a problem. Until recently, MBL has been described as associated with occlusal overload, plaque accumulation,[6] smoking,[7] biocompatibility of transmucosal components, abutment loosening, and biomechanical factors.[8]

The purpose of this study was to evaluate marginal bone loss around implants placed in maxillary sinus grafts.

MATERIALS AND METHODS

From 1995 through 2000, 70 healthy patients (25 men and 45 women) ranging in age from 32 to 75 years (mean 52 years) with no limiting disease underwent 81 sinus-graft procedures (40 on the right side, 41 on the left side) performed by an experienced surgeon (DSA). A total of 212 screw-type implants were placed in the grafted sinuses (mean 2.61 implants/sinus).

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Table 1 Filling Material and Survival

Grafting material	No. of sinuses	No. of implants	
		Placed	Failed to integrate
Bio-Oss	5	13	0
Autogenous bone	17	48	4
Autogenous bone + Bio-Oss	54	133	0
Autogenous bone + DFDBA	4	15	5
Autogenous bone + Laddec	1	3	0
Total	81	212	9

DFDBA = demineralized freeze-dried bone allograft;
NA = not applicable.
MBL was not related to grafting material.

Habits (smoking, bruxism), surgical phase parameters (preoperative residual bone, grafting material, implant characteristics, and complications), and prosthetic parameters (crown-implant ratio, marginal fit, and opposite arch restoration) were recorded for each patient. Radiographs were obtained immediately before implant exposure and at least once a year to measure the marginal bone level.

All 212 implants were used to calculate the cumulative survival rate. For marginal bone level measurements, 52 implants were excluded from the study because of inadequate radiographic follow-up. Consequently, 160 implants placed in 70 sinuses (35 on each side) of 60 patients (22 men and 38 women; mean age 52.8 years) were used to analyze the annual MBL. Radiographic follow-up for all implants ranged from 6 to 56.5 months (mean 21.7 months). All implants were restored by fixed ceramometal prostheses.

Preoperative Evaluation

Patients were thoroughly examined extra- and intraorally and evaluated for parafunctional and smoking habits before surgery. Of the 60 patients evaluated, 21 (56/160 implants, 35%) smoked between 5 and 40 cigarettes per day for a period ranging between 5 and 30 years (mean 16.3 years). Parafunctional habits were diagnosed in 15 patients (39/160 implants, 24.3%). Preoperative residual crest bone at the implantation sites was evaluated using orthopantographs in conjunction with computerized tomographic (CT) scans/radial tomography. The amount of residual crestal bone was recorded in millimeters for each future implant site. Of the 160 implants, 74 (46%) were placed in ridges that had residual bone of 4 mm or less prior to grafting.

Surgical Technique

Prophylactic oral premedication was routinely used. The preferred regimen comprised amoxicillin (1 g) and dexamethasone (8 mg) given 1 hour preoperatively and local application of 0.5% chlorhexidine for 2 minutes. Clindamycin (600 mg) was the drug of choice for patients with penicillin allergies. The lateral wall approach was used for sinus grafting. Local anesthesia was administered using a maxillary nerve block via a greater palatine approach. A window was cut using a slow-speed round bone bur. The sinus membrane was carefully reflected from the sinus floor and medial sinus wall. Once there was sufficient exposure, the membrane was examined for perforations. If no visible perforations were observed, the space was filled with saline and the patient was asked to gently perform the Valsalva maneuver. Air bubbles indicated the presence of a perforation. An overlapping collagen resorbable membrane (Bio-Gide; Geistlich, Wolhusen, Switzerland) was used to repair perforations. All implants were placed using a surgical guide based on prewaxed casts. One of 5 grafting materials (Table 1) was condensed into the compartment. The fenestrated lateral wall of the maxillary sinus was covered with a resorbable collagen membrane (Bio-Gide), and the mucoperiosteal flap repositioned and sutured with a 3/0 Vicryl suture (Johnson & Johnson/Ethicon, Somerville, NJ).

Implant Characteristics

A surface area larger than 260 mm^2 was characteristic for 81 implants; the remaining 79 had a surface area of 260 mm^2 or less. One hundred twenty-four implants were hydroxyapatite (HA) -coated; 30 were not.

Timing of Implantation

Simultaneous implant placement was performed only when primary implant stability could be achieved. When primary implant stability could not be achieved, a delayed 2-stage protocol was used, and implant placement was performed 6 months later. A total of 117 implants (73%) were placed simultaneously with the grafting procedure (Tables 2 and 3).

Timing of Implantation and Preoperative Residual Bone

Of the 74 implants placed in residual bone with ≤ 4 mm, 47 (63%) were placed simultaneously with the grafting procedure, and 27 (37%) were placed in a delayed stage (Table 2). Eighty-six implants were placed in residual bone > 4 mm, 70 (81%) simultaneously with the grafting procedure.

Table 2 MBL Around Implants with Preoperative Residual Bone ≤ 4 mm

	No. of implants			
	MBL ≤ 0.2 mm/y	MBL > 0.2 mm/y	Total	Successful implants
Simultaneous implantation	44	3	47	94% (44/47)*
Delayed implantation	20	7	27	74% (20/27)*
Total	64	10	74	86% (64/74)

*$P < .018$.

Table 3 MBL Around Implants with Preoperative Residual Bone > 4 mm

	No. of implants			
	MBL ≤ 0.2 mm/y	MBL > 0.2 mm/y	Total	Successful implants
Simultaneous implantation	58	12	70	83% (58/70)
Delayed implantation	12	4	16	75% (12/16)
Total	70	16	86	81% (70/86)

Postoperative Management

Patients were given amoxicillin (500 mg 3 times daily) or clindamycin (300 mg 3 times daily) for 10 days, dexamethasone (4 mg for 2 days), 0.2% chlorhexidine mouthwash (twice daily for 10 days), and instructions to avoid physical stress and blowing the nose or sneezing with the mouth closed for 2 weeks. Routine clinical examinations were scheduled 2 weeks postoperatively, then monthly until implant exposure (usually 9 months postplacement). Postoperative complications were carefully recorded.

Prosthetic Evaluation

Crown-implant ratio was radiographically evaluated for each implant using the implant-abutment interface as the reference point. Twenty-two implants were restored with an unfavorable crown-implant ratio > 1. The marginal fit of the restoration was also radiographically evaluated. No abutment-implant misfits were recorded. However, 66 implants demonstrated poor marginal restoration fit. Furthermore, opposite-arch characteristics were clinically recorded: 142 implants were restored opposing natural dentition, 16 opposing an implant-supported fixed prosthesis, and 2 opposing a removable partial denture.

Bone Level Measurements

MBL was measured on radiographs (orthopantographs or intraoral) using the implant threads as the internal standard, a technique formerly suggested by Haas and associates.[9] The number of threads unsupported by bone at both the mesial and distal sides of each implant was counted, and the higher number was used to calculate bone loss. The number of threads unsupported by bone at implant exposure was subtracted from the number of threads unsupported by bone at the most recent follow-up. This result was multiplied by the implant pitch (in mm) to determine the amount of bone loss (in mm).

A modification of the criteria suggested by Albrektsson and colleagues,[10] Smith and Zarb,[11] and Albrektsson and Zarb[12] was used to evaluate implant radiographic success. An implant was considered successful radiographically when bone loss apical to the implant neck was less than 0.2 mm/year (starting from the first year).

Statistical Methods

Pearson chi-square analysis was used to test the significance of differences between groups according to the radiographic success criteria. A Kaplan-Meier survival analysis was used to calculate the cumulative survival rate. A nonparametric Mann-Whitney analysis was used to test significance of differences between groups according to mean MBL values. Although multiple implants in the same patient are not statistically independent, these statistical methods were nevertheless used so as not to lose data concerning implant characteristics and individual implantation sites.

RESULTS

During the first year prior to loading, 9 failures in integration were recorded (Table 4). No failures in integration were later recorded, and the cumulative survival rate was 95.5% for 4.5 years (Table 5). Of the 160 implants used for bone level measurements, 26 demonstrated MBL > 0.2 mm/y. The overall radiographic success rate was 83.7% (134/160).

Smoking and Bruxism

The association between smoking and MBL > 0.2 mm/y was statistically significant ($P < .011$). This result was not affected by the amount of cigarettes smoked per day. Smokers demonstrated a mean MBL of more than twice that compared to nonsmokers (Table 6). No association between bruxism and MBL was evident.

Table 4 Non-surviving Implants

Patient	Years of smoking	Graft material	Complications		Implant				
			Intraoperative	Postoperative	No.	Residual crestal bone (mm) around	Coating	Timing of placement	Diameter × length (mm)
1	0	Autogenous bone + DFDBA	None	None	1	8	CPT[3]	Simultaneous	4.7 × 16
					2	Irrelevant*	CPT[3]	Delayed	3.7 × 13
					3	4	CPT[3]	Simultaneous	4.7 × 16
					4	Irrelevant*	CPT[3]	Delayed	4.7 × 13
2	20	Autogenous bone	Membrane perforation	Swelling	5	3	CPT[3]	Delayed	3.7 × 13
					6	2	CPT[3]	Delayed	3.7 × 13
3	10	Autogenous bone + DFDBA	Membrane perforation	Swelling	7	4	CPT[3]	Simultaneous	3.7 × 15
4	20	Autogenous bone	None	None	8	4	CPT[3]	Simultaneous	3.7 × 16
					9	Irrelevant*	HA[4]	Delayed	3.7 × 13

*Cases of recurrent implantation at the sites of previous implant failures; implants 2, 4, and 9 replaced failing implants 1, 3, and 8.
CPT = commercially pure titanium.

Table 5 Cumulative Survival Rate

Year	No. of implants		CSR (%)
	Placed	Failed	
0–1	212	9	95.5
1–2	203	0	95.5
2–3	203	0	95.5
3–4	203	0	95.5
4–4.5	203	0	95.5

Table 6 Factors Most Affecting MBL and Average MBL in mm/y

Factors affecting MBL	Average MBL (mm/y)	SD	No. of implants
Smokers*	0.24	0.49	56
Nonsmokers*	0.09	0.32	104
Simultaneous implantation†	0.08	0.24	117
Delayed implantation†	0.31	0.62	43
Surface area > 260 mm^2‡	0.07	0.23	81
Surface area < 260 mm^2‡	0.21	0.49	79
Postoperative complications	0.18	0.33	47
No postoperative complications	0.13	0.41	113

MBL results for grafting material and implant coating are not included since they were not statistically significant using logistic regression analysis.
*$P < .011$.
†$P = .052$.
‡$P < .031$.

Surgical Phase

Preoperative Residual Bone. MBL was not statistically related to the amount of preoperative residual bone.

Intraoperative Complications. Fixable membrane perforations were observed in 30 of the 70 sinuses (43%). Membrane perforations were not associated with MBL but were strongly related to the manifestation of postoperative complications ($P < .001$).

Grafting Material. Mean MBL values were 0.38 mm/y for Bio-Oss, 0.09 mm/y for autogenous bone, 0.11 mm/y for autogenous bone + Bio-Oss, 0.16 mm/y for autogenous bone + DFDBA, and 0.74 mm/y for autogenous bone + Laddec. There was no association between grafting material and MBL > 0.2 mm/y (results for autogenous bone + Laddec were not included in the statistical analysis because of the small number of implants).

Simultaneous vs Delayed Implantation. Although an association was found between the delayed approach and MBL > 0.2 mm/y, and delayed implantation resulted in a mean MBL 3 times greater than that of simultaneous implantation, the difference was not statistically significant ($P = .052$) (Table 6). An association between delayed implantation in residual bone of ≤ 4 mm and MBL > 0.2 mm/y was found ($P < .018$) (Table 2).

Implant Characteristics. An association was found between small implant surface area and MBL > 0.2 mm/y ($P < .031$). A significantly higher radiographic success rate (MBL < 0.2 mm/y) and a lower mean MBL were related to implants with a surface area greater than 260 mm^2 (Table 6). The mean MBL values for HA and non-HA implants were 0.17 mm/y and 0.19 mm/y, respectively. Implant coating (HA versus non-HA) and MBL were not statistically related.

Postoperative Complications. Swelling, hematoma, purulent secretion, hemoptysis, adjacent tooth sensitivity, sinus congestion, cyst formation, hemorrhage, graft-induced sinusitis, apical implant inflammation, or systemic fever were found in 18 (30%) of the 60 patients. Mean MBL values were not distinctly different compared to uncomplicated implants (Table 6).

Prosthetic Phase. No association between any of the prosthetic factors and MBL > 0.2 mm/y was found.

Factors Most Affecting MBL. A logistic regression analysis was conducted to define the factors most affecting MBL: timing of implantation (simultaneous rather than late), smoking, and implant surface area (large rather than small).

DISCUSSION

The ultimate goal of the sinus graft procedure is to allow rehabilitation of the posterior atrophied maxilla with a functional implant-supported prosthesis. This objective is at risk where there is ongoing MBL around the implants. The purpose of this study was to evaluate MBL around implants placed in maxillary sinus grafts.

In the present study, an overall cumulative survival rate of 95.5% for 4.5 years compared favorably with other reports.[1–5] However, success rate largely depends on how success is defined.[13,14] Most investigators relate success to definitions formerly suggested by Albrektsson and associates,[10] Smith and Zarb,[11] and Albrektsson and Zarb[12] but choose to modify the criteria regarding MBL, ie, radiographic success criteria (Table 7). Therefore, it is not possible to compare the present data with the literature until radiographic success criteria are modified to a standard.

Smoking and Bruxism

Smoking is well known to be associated with implant loss,[1,17–20] including the loss of implants situated in sinus graft areas.[1,13,21] The present data suggested that smoking greatly affected MBL, which is in agreement with Carlsson and associates.[7] This finding may also explain the relatively low total radiographic success rate compared to the cumulative survival rate (35% of the implants were placed in smokers). The present results indicated that smoking could be a primary risk factor regarding implant survival and MBL.

Another possible risk factor regarding implant survival is parafunctional habits, such as tooth grinding and clenching. Such habits should be considered during treatment planning.[1,19,22,23] Occlusal overload may also induce MBL.[6,24] Nevertheless, Carlsson and colleagues[7] did not find MBL to be related to grinding habits, TMJ symptoms, or maximal biting force. In the present study, all patients diagnosed with parafunctional habits were asked to wear an acrylic resin custom-made bite guard. Although bruxism did not have a demonstrated effect on MBL, it remains a subject for further research.

Table 7 Criteria for Marginal Bone Loss in Several Studies

Study	MBL allowed	Success rate (%)	Follow-up
Khoury[4]	Up to 3 mm; not related to time	94	2–6 y (49 mo mean)
Hurzeler et al[5]	1.5 mm first year; 0.2 mm/y next (± 0.5 mm error)	90	1–5 y (34 mo mean)
Widmark et al[13]	1 mm first year; 0.2 mm/y next	74	3–5 y
Watzek et al[14]	Up to 2 mm; not related to time	74	15–76 mo
Present study	0.2 mm/y not including implant neck	83	6–56.5 mo (21.7 mo mean)

Surgical Phase

Preoperative Residual Bone. At the Sinus Consensus Conference of 1996[1] it was suggested that preoperative residual bone may be a crucial factor in the ability to achieve and maintain osseointegration. A statistical relationship was reported between preoperative residual bone of less than 4 mm and implant loss. Therefore, it was suggested that the amount of preoperative residual bone should help determine the timing of implantation, choice of filling material, and implant to be used.[1] More recent studies have shown primary implant stability to be a precondition for osseointegration.[14,19,25–27] It has been shown that primary stability can be securely achieved with a minimum of 25% to 35% vital bone in the filling volume.[28] Thus, preoperative residual bone is important. However, some reports did not find a relation between implant survival and preoperative residual bone.[3,29,30] In the present study, MBL was not related to the amount of preoperative residual bone. Preoperative residual bone is a helpful guideline for treatment planning, but it may be secondary to the achievement of primary implant stability.

Complications. Membrane perforations could lead to infiltration of particulate graft material inside the sinus and to subsequent inflammation and are therefore considered a complication.

Sinus membrane perforations are common, occurring in up to 43% of the procedures,[1,3,21,31,32] and may be related to implant loss.[4,33] Schwartz-Arad and coworkers,[32] however, disagree that there is a relationship. In the present study, sinus membrane perforations were not associated with MBL.

Graft and implant loss subsequent to sinus infection has been reported.[3,34] Furthermore, postoperative complications have been related to MBL.[35] The present data suggested that postoperative complications could be related to MBL. The inflammatory

reaction associated with postoperative complications may affect wound healing and, this in turn, may affect surrounding tissues to induce bone absorption, both in the short- and long-term. However, this cannot been established until absolute understanding of the biologic course of action is achieved.

Grafting Material. The effect of different grafting materials on the progression of ossification, short- and long-term volume stability of the graft, bone-to-implant contact, and implant survival has been discussed with different values.[1–3,27,36–39] However, no statistical difference between different materials and implant survival has been found.[1–3,32] In the present study, there was no relation between grafting material and MBL. A 9-month healing period before implant exposure was mandatory in all cases. Therefore, it could be suggested that a wide range of grafting materials may be successfully applied to augment the maxillary sinus as long as the healing period is sufficient.

Simultaneous vs Delayed Implantation. Standard guidelines support delayed implantation when residual bone is less than 4 mm.[25,27,40] Justification can be found in the requirement to achieve primary implant stability for osseointegration.[1,14,19,25,27,29] Another reason is to allow sufficient support for a functioning loaded implant while ossification of the graft is completed.[23,27] Previous studies report no relation of implantation timing to MBL when residual bone was > 4 mm.[3,29,41] The present data, surprisingly, may imply that simultaneous implantation can be safely implemented when primary stability is achieved regardless of the amount of preoperative residual bone. It was also surprising that timing had a significant effect on MBL, while amount of residual bone and grafting material did not. These results, when combined, could advocate innovative guidelines: simultaneous implantation could be performed when primary stability is achieved. This obviously calls for further research.

Implant Characteristics. Blomqvist and associates[42] recommended the use of implants with a greater surface area in augmented sinuses. Furthermore, a surface area > 230 mm^2 increased implant survival rates in nonaugmented sites in both the maxilla and mandible.[43] The present data also support the use of implants with greater surface area values. It is possible that greater surface area compensates for problematic bone characteristics (eg, in grafted maxillary sinuses).

HA-coated implants have greater affinity to surrounding bone when compared to implants with a pure titanium surface, which results in enhanced bone formation immediately after implantation and shorter healing periods.[1,44,45] Additionally, long- term superiority of HA-coated implants over pure titanium implants for survival and bone loss has been reported.[46] However, higher failure rates of HA-coated implants have been recorded in long-term survival research, mainly because of increased MBL.[47]

Prosthetic Phase

Crown-implant Ratio. Biomechanical overload is a potential risk factor for implant survival.[1,19,22,23,25] Crown-implant ratio >1 is considered a potential risk factor for biomechanical overload via stress concentration. Longer implants have reportedly caused less MBL than shorter ones through improved crown-implant ratio.[27] However, the present data did not support these assumptions, which was surprising when the challenge of the treatment environment was considered. Crown-implant ratio < 1 is a traditional guideline regarding the rehabilitation of natural dentition and may have been adopted for implant treatment. In contrast to conservative rehabilitation guidelines, the use of implants as connected abutments without pontics or cantilevers during fixed prosthesis rehabilitation is well accepted. Further research is required because of the small number of patients with unfavorable crown-implant ratios in the current study.

Opposing arch characteristics, which were not addressed here, also represent a load factor on implants, and the effect of this factor requires further investigation.

Marginal Restoration Fit. Accumulation of dental plaque can increase the MBL rate.[6,24,48,49] Patients with poor dental hygiene are at risk of suffering from enhanced MBL. It is expected that poor marginal restoration fit will have the same result on MBL. The present data did not support this assumption, possibly because of the meticulous hygiene treatment and follow-up and the relatively short follow-up period.

CONCLUSIONS

Within the limitations of this retrospective study, it seems that smoking may be a primary risk factor regarding implant survival and MBL. A greater implant surface area may compensate for problematic bone characteristics. MBL was not related to the amount of preoperative residual bone. Simultaneous implantation may be performed when primary stability is achieved.

It is almost impossible to isolate the numerous factors that affect MBL around implants. A cumulative survival rate of 95.5% for 4.5 years compared favorably with other studies. The overall radiographic success rate of 83.8% strongly emphasizes the differ-

ence between implant survival and implant radiographic success in the long-term and consequently, the impact MBL could have on implant survival. Nevertheless, the criteria for long-term implant radiographic success should be revised to a standard.

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