Bone Resorption Around Dental Implants Placed in Grafted Sinuses: Clinical and Radiologic Follow-up After up to 4 Years

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Purpose: *The long-term results of endosseous implants depend on the maintenance of bone support. The aim of this study was to evaluate radiologically bone resorption around dental implants placed in grafted sinuses after up to 4 years of function.* ***Materials and Methods:*** *Between 1997 and 2001, augmentation of the maxillary sinus floor with alloplastic (Biostite) or xenogenic (Bio-Oss) materials was performed in 34 patients.* ***Results:*** *Eighteen patients participated in the study. Twenty-six sinus augmentations were performed on these 18 patients, and they received 37 implants. The change in marginal bone level around the implants at the mesial side was 1 mm during the first year after the abutment connection, followed by an annual loss of 0.1 mm. The change in marginal bone level around the implants at the distal side was 1.1 mm during the first year after the abutment connection followed by an annual loss of 0.2 mm.* ***Discussion:*** *The implant survival rate observed in this study is in line with data previously reported for patients treated with implants in the posterior maxilla without bone atrophy. The results for implants placed into sinuses grafted with Bio-Oss were similar to the results for implants placed in sinuses grafted with Biostite.* ***Conclusion:*** *Although this study involved a limited number of procedures, it confirmed that alloplastic and xenogenic materials can be reliable for bone regeneration in subantral cavities. The angular defects present both at the distal and mesial sides of the implants were comparable to those observed at implants placed in native bone.* Int J Oral Maxillofac Implants 2005;20:261–266

Key words: *bone resorption, bovine bone, dental implants, maxillary sinus*

The long-term results of endosseous implants depend on the maintenance of bone support.[1] Maintenance of osseointegration and stability of marginal bone levels are of fundamental importance for successful implant therapy.[2]

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In successful treatment, low amounts of plaque and low levels of marginal inflammation have been identified at the implants.[3,4] It has been well documented that during the first year dental implants are in function, some bone loss occurs because of the healing and remodeling period.[5] Several studies have provided data concerning marginal bone loss during the first year of implant function.[6–8] One long-term study reported a mean bone loss of 0.9 mm (range, 0.4 to 1.6 mm) during the first year, with a mean bone loss in subsequent years of 0.1 mm (range, 0 to 0.2 mm).[9] An implant may function over a certain period of time, but if the surrounding marginal bone demonstrates progressive resorption, it will eventually fail.[10] For this reason, implants should be evaluated in conjunction with the time-dependent bone height resorption, which reflects implant prognosis.[11]

Generally, the mandible has higher bone density than the maxilla, and in some cases, the maxillary

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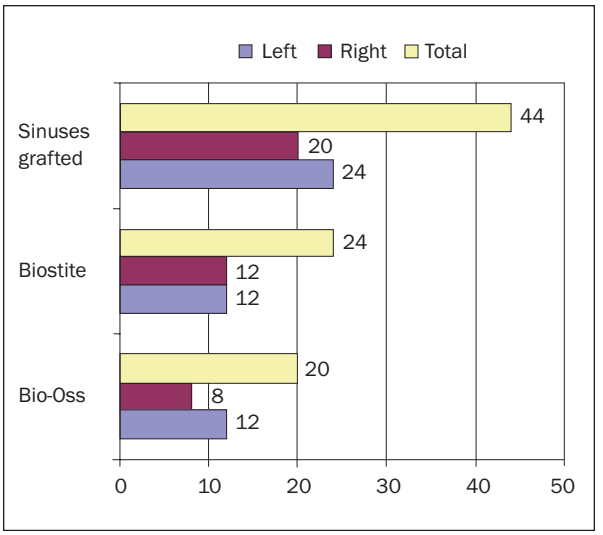

Fig 1 Distribution of grafting materials.

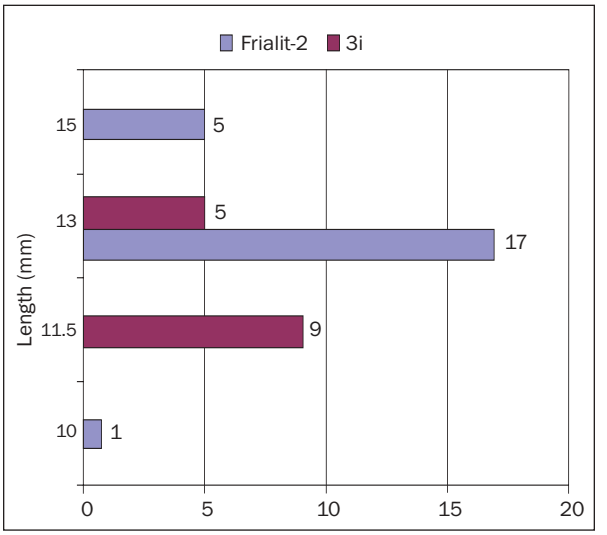

Fig 2 Distribution of implants according to length. A total of 37 implants were placed.

sinus restricts the available bone volume in the posterior areas, necessitating grafting procedures.[12–14] Jawbone vascularity and healing may be compromised in aging patients. All of these parameters can have an impact on crestal bone evaluation.[15]

The aim of this study was to evaluate radiologically bone resorption around dental implants placed in grafted sinuses after up to 4 years of function.

MATERIALS AND METHODS

Patients

Between 1997 and 2001, augmentations of the maxillary sinus floor with alloplastic or xenogenic materials were performed in 34 nonsmoking and generally healthy patients (17 men and 17 women). However, only 18 patients participated in the study (10 men and 8 women ranging in age from 25 to 66 years; mean 52 years). They attended annual clinical and radiographic examinations. The mean follow-up time after implantation was 29 months (range, 12 to 48 months). All patients received oral hygiene instructions before entering the study.

Treatment Planning

Orthopantomograms and computerized tomographic (CT) scans were performed to evaluate the residual height of the maxillary alveolar bone. The radiographs were also screened for sinus pathology. Residual alveolar height was measured on the orthopantomogram. The mean vertical height of the alveolar bone between the most caudal part of the sinus and the oral cavity was an average of 7 mm (range, 5 to 9.5 mm). Since all patients were partially edentulous, a diagnostic tooth setup for each prosthesis was made and converted to a surgical template.

Bone Augmentation Materials and Implants

Two different grafting materials were used: anorganic bovine bone (Bio-Oss; Geistlich, Wolhusen, Switzerland) and hydroxyapatite plus collagen (Biostite; Vebas, Milan, Italy). In 22 of the 26 sinus floor elevations performed, the implants were placed simultaneously; in the remaining 4 cases, a 2-stage procedure was performed, with implant placement after 8 months (Fig 1).

A total of 37 implants were placed: 23 conical rough-surfaced Frialit-2 implants (Dentsply Friadent Ceramed, Lakewood, CO) and 14 3i Osseotite screw-type implants (3i/Implant Innovations, Palm Beach Gardens, FL) (Fig 2).

Surgery

The day before surgery, general therapy was provided as follows: 1 g amoxicillin (Pharmacia Italia, Milan, Italy) every 8 hours for 6 days, 50 mg dexketoprofen (Desketo; Malesci, Milan, Italy) every 12 hours for 3 days, and a ½ vial of mucolytic antibiotic (Fluimucil; Zambon Italia, Milan, Italy) every 12 hours for 6 days. On the day of surgery each patient received medication with diazepam (1 drop/2 kg body weight; Valium 2; Roche, Basel, Switzerland) half an hour before the operation.

Local anesthesia was achieved with 1:50,000 epinephrine (2% Ecocain; Molteni Dental, Milan, Italy). Surgical procedures were performed by specialists in oral and maxillofacial surgery. In 4 patients where the

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height of the residual alveolar crest was less than 5 mm (4 sinuses and 8 implants), a 2-stage procedure (bone grafting in the first stage and implant placement 8 months later) was used. Otherwise, a 1-stage approach, with bone grafting and implant placement in the same surgery, was performed (14 patients, 22 sinuses, 29 implants).

Sinus augmentation was performed according to the Tatum technique.[16,17] A midcrestal incision was made distally from the maxillary first premolar to the tuberosity, and 2 vertical releasing incisions were made mesially and distally in the buccal mucosa to elevate a mucoperiosteal flap. The lateral wall of the maxillary sinus was fenestrated with a round diamond bur used with saline solution irrigation to mark the limits of a square area. Care was taken to preserve the mucosal lining. The sinus membrane was exposed, an infracture was done, the membrane was raised, and the mobilized part of the lateral sinus wall, together with the raised sinus membrane, was rotated medially and upward to create a subsinus cavity into which the graft material could be placed. Perforation of the sinus membrane was not treated, as these defects were closed off by folding the lifted membrane. In the case of a 1-stage procedure, the implant sites were drilled in the desired positions. A resorbable membrane (Geistlich) was used to cover the lateral wall defect after the bone graft was placed.

Postoperatively the patients received a 0.2% chlorhexidine mouth rinse once daily for 2 weeks.

Prosthodontics

Eight months after implant placement surgical reentry was performed. The prosthetic rehabilitation was performed by several different prosthodontists. Thirty-six fixed ceramometal partial prostheses were fabricated.

Radiologic Evaluation

According to the adopted protocol, panoramic radiologic evaluations were obtained as follows:

- Before surgery
- At implant placement in the 2-stage procedure
- At 6 to 12 months
- At 24, 36, and 48 months

Two panoramic radiographs were used for measurement for the purposes of this study. The t1 radiograph was taken either before surgery (in cases where a 1-stage approach was used) or at implant placement (in cases where a 2-stage approach was used). The t2 radiograph was taken at the patient's last follow-up visit 2, 3, or 4 years postoperatively.

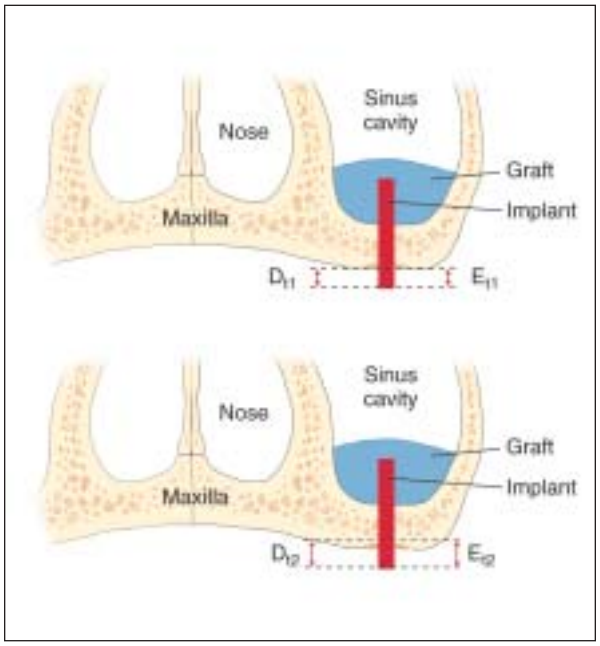

Fig 3 Radiologic measurement.

The following measurements were made on the t1 radiograph:

- D_{t1}: The distance between the coronal margin of the implant and the ridge crest on the mesial side
- E_{t1}: The distance between the coronal margin of the implant and the ridge crest on the distal side

The following measurements were made on the t2 radiograph:

- D_{t2}: The distance between the coronal margin of the implant and the most coronal point of bone contact on that side
- E_{t2}: The distance between the coronal margin of the implant and the most coronal point of bone contact on that side

The measurements were made by 4 operators, a senior dental student and 3 dentists. By calculating D_{t1}, E_{t1}, D_{t2}, and E_{t2}, the mesial and distal angular defects for each implant after 2, 3, or 4 years were evaluated (Fig 3). Each investigator recorded the measurements for each implant by putting the radiograph on a negatoscope and measuring with a millimetric ruler at 4× magnification. All measurements were made separately by each investigator and later compiled in a single table.

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Table 1 Life Table Analysis

Interval (mo)	Implants at risk	Failed implants	Survival rate (%)	Cumulative survival rate (%)
12	37	0	100	100
24	36	1	97	97
36	11	0	100	97
48	6	0	100	97

Table 2 Bone Level Change Between First and Last Measurements at the Mesial and Distal of the Implants

Bone level change (mm)*	Mesial n (%)	Distal n (%)
0 to 0.5	15 (41.66)	16 (44.44)
0.5 to 1.0	12 (33.33)	8 (22.22)
1.0 to 1.5	4 (11.11)	6 (16.66)
1.5 to 2.0	3 (8.33)	5 (13.88)
2.0 to 3.0	2 (5.55)	1 (2.77)

*Mean bone level change was 1.04 mm on the mesial side and 1.05 mm on the distal side.

Table 3 Bone Level Changes Between First and Last Measurements of Implants Placed into Sinuses Grafted with Bio-Oss

Bone level change (mm)*	Mesial n (%)	Distal n (%)
0 to 0.5	8 (40.00)	6 (30.00)
0.5 to 1.0	7 (35.00)	7 (35.00)
1.0 to 1.5	3 (15.00)	5 (25.00)
1.5 to 2.0	2 (10.00)	2 (10.00)

*Mean bone level change was 0.98 mm on the mesial side and 1.07 mm on the distal side.

Table 4 Bone Level Changes Between First and Last Measurements of Implants Placed into Sinuses Grafted with Biostite

Bone level change (mm)*	Mesial n (%)	Distal n (%)
0 to 0.5	6 (37.50)	8 (50.00)
0.5 to 1.0	4 (25.00)	2 (12.50)
1.0 to 1.5	3 (18.75)	1 (6.25)
1.5 to 2.0	3 (18.75)	5 (31.25)

*Mean bone level change was 1.09 mm on both the mesial and distal sides.

RESULTS

A total of 26 sinus elevation procedures were performed, 13 with Bio-Oss and 13 with Biostite in 18 patients with 37 implants. No infections of the grafts were observed.

At second-stage surgery all the implants were rigidly anchored, except for 1 Frialit-2 implant, which was removed. No implants were lost during follow-up. As success criteria, the permanence of implants under function in regard to 3 of the criteria for success described by Albrektsson and associates[1] in 1986 were considered:

- Absolute implant immobility when individually tested
- Absence of peri-implant radiolucency
- Absence of pain, swelling, and paresthesia

A 100% prosthetic success rate for 36 implants placed into grafted sinuses was achieved. The cumulative implant success rate after 48 months was 97% (Table 1).

For each implant it was possible to evaluate the mesial angular defect (D) and the distal angular defect (E) after 2, 3, and 4 years. Since all radiographs were obtained with the same machine, whose magnification degree was 25% of the actual, this percentage was deducted from each measurement.

In this study, the mean loss of marginal bone for all implants equaled 1 mm (range, 0.8 to 1.2 mm) during the first year after abutment connection, followed by a mean annual loss of 0.1 mm. In this study, the average change in marginal bone level around the implant at the mesial side was 1 mm (range, 0.8 to 1.1 mm) during the first year after abutment connection, followed by an annual loss of 0.1 mm during following 3 years. The average change in marginal bone level around the implant at the distal side was 1.1 mm (range, 0.9 to 1.2 mm) during the first year after abutment connection, followed by an annual loss of 0.2 mm during the following 3 years.

Table 2 provides data on marginal bone level changes for at the mesial and distal aspects of the implants between the first and last measurements.

The average changes in marginal bone levels, at both the mesial and distal sides, after up to 4 years of function, were very similar (mean of 1.04 mm for the mesial side and 1.05 mm for the mesial and distal side).

The average bone loss around the implants placed into sinuses grafted with Bio-Oss (0.97 mm/year) 12 months after abutment connection was

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similar to that obtained for the implants placed into sinuses grafted with Biostite (1 mm/year). Tables 3 and 4 show the marginal bone level changes at both the mesial and distal aspects of implants placed into sinuses grafted with Bio-Oss and Biostite, respectively. After up to 4 years of function, there were no great differences in the results obtained; mean resorption was 1.02 mm for Bio-Oss and 1.09 mm for Biostite.

DISCUSSION

The aim of this clinical and radiologic study was to evaluate the marginal bone level changes at both the mesial and distal aspects of implants placed into sinuses grafted with 2 different bone substitutes, Bio-Oss and Biostite. Although autogenous bone is the "gold standard" for grafting material for the oral cavity because of its osteoinductive and osteoconductive properties,[18] Bio-Oss and Biostite appear useful as human bone substitute materials where sinus augmentation procedures are required.[19]

The implant success observed in this study is in line with the data from patients treated with implants in the posterior maxilla without bone atrophy. In a recent study with a 16-year follow-up, Naert and colleagues[20] reported a success rate of 96.6% for implants supporting fixed partial prostheses, which approximates the 97% reported in the present study of 37 implants. Only 1 implant was lost after the first surgical stage, and no implants were lost after the placement of prostheses.

Generally, even if an implant has been functioning well for some years, the implant will eventually fail if the surrounding marginal bone level demonstrates progressive resorption.[11] For this reason, the clinical aspects of the implant-supported restoration should be evaluated in conjunction with time-dependent bone height measurements, which reflect implant prognosis.[8] The decrease in marginal bone height around implants has been estimated to be 1 mm/year (range between 0.8 and 1.2 mm) during the first year after abutment connection, followed by a mean annual loss of 0.1 mm up to 4 years.[5] In the present study, 1 mm of bone resorption was registered mesially and 1.1 mm distally in the first year after function; 0.1 mm/year of bone resorption was registered mesially and 0.2 mm/year distally after the first year. The magnitude of bone alteration observed in the patients of the present study was within the range of bone loss reported in the literature with regard to implant-supported fixed partial prostheses.[21–23] At the 4-year follow-up examinations, there were no major differences in the peri-implant bone level between the mesial and distal aspects. No differences were found between implants placed in sinus grafted with Bio-Oss and those placed in sinuses grafted with Biostite. Thus the use of bone substitutes for sinus grafting procedures does not appear to influence bone resorption around osseointegrated implants after a medium-term follow-up. No differences in the results for the 2 implant systems used in this study were observed.

CONCLUSIONS

Osseointegrated implants represent a reliable method for the restoration of the posterior maxilla, and their predictability may not be influenced by their placement in areas augmented with bone substitutes after sinus elevation. This study suggested that alloplastic and xenogenic materials are reliable for bone regeneration in the subantral cavities. They showed low resorption in the medium term and provided optimal primary stability to the implants placed in this limited patient population.

The angular defects present at both the distal and mesial sides of the implants were comparable to those observed for implants placed in native bone without associated reconstructive or regenerative procedures.

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