Sinus Augmentation Bone Grafts for the Provision of Dental Implants: Report of Clinical Outcome

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Purpose: *The aim of this study was to report the outcome of sinus augmentation surgery with autogenous bone grafting in routine dental implant practice.* ***Materials and Methods:*** *Twenty-seven sinus augmentation procedures were undertaken on 18 consecutive patients (mean age 43.7 years). The mandibular symphysis was used as the donor site for 11 patients. The iliac crest was used as a donor site for 7 bilateral cases.* ***Results:*** *Six patients had implants placed at the time of grafting; the other 13 had a mean bone graft consolidation period of 24.7 weeks (range 9 to 39 weeks) before implants were placed. One patient who had a repeat procedure had both immediate and delayed techniques. A total of 79 Brånemark System Mk II implants were placed in grafted bone (and 2 Mk IV implants were placed in a patient who had to have a repeat procedure) and proceeded to occlusal loading. After a mean follow-up period of 162 weeks (range 76 to 288 weeks), 16 implants failed to integrate in grafted bone, representing an 80.25% survival rate. Fourteen patients proceeded to the planned prosthesis, 3 patients had a compromised treatment plan, and 1 patient was restored conventionally. This represents 94% of patients who were rehabilitated.* ***Discussion and Conclusion:*** *The sinus augmentation procedure using autogenous bone grafting can increase bone volume to allow implant placement where there is insufficient bone. The survival of implants in the grafted bone, as measured by integration and successful loading, was reduced compared to implants placed in normal maxillary bone. Infection during the healing of the grafted site reduces the success of subsequent implant osseointegration.* (Int J Oral Maxillofac Implants 2003;18:377–382)

Key words: *bone grafts, endosseous dental implants, maxillary sinus, osseointegration, sinus augmentation*

The success of osseointegrated implants has been well established by means of long-term clinical trials on ideal patients.[1–3] With success and patient satisfaction has come increasing demand for implants by patients with less-than-ideal conditions for successful osseointegration. The requirements for successful osseointegration have been outlined by many authors[4,5] and include appropriate implant material and design, surgical technique, host site, and loading conditions. The bone quality and quantity at the host site are important variables affecting the success of osseointegration. This varies throughout the jaws and between individuals. The posterior maxilla is known to have poor-quality bone and reduced volume because of pneumatization by the maxillary sinuses.[6] This has been reflected in long-term success rates for maxillary implants of 81% to 89%,[1,2,7] compared with 91% to 99% for mandibular implants.[1–3]

Research is continuing into methods of identifying the quality of alveolar bone and improving it with regard to osseointegration.[8] Ridge augmentation in the maxilla has been shown to improve the bone volume to allow implant rehabilitation.[9–11] Onlay techniques can be used to increase ridge width or height.[11,12] But if used for the latter, there

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Table 1 Summary of Patient Data

Age/ gender	Date of grafting	Date loaded	Smoker	Graft donor site	Graft site	Graft type	Adjuncts used	No. of implants placed	Complications	Failed implants/ date	Definitive prostheses	Opposing occlusion
75/F	03-94	07-95	No	Chin	Bi sinus	Particulate	BGM	4 I	Exposure BGM	2/03-95	Removable	ND
44/M	09-94	06-95	No	Chin	R sinus	Block	—	1 I	—	1/05-95	1 crown	ND
35/M	10-94	05-96	Yes	Hip	Bi sinus	Particulate	—	6 D 03-95	—	—	Removable	ND
65/F	08-95	09-96	No	Hip	Bi sinus	Block	—	6 I	—	1/06-96	Removable	Implants FP
50/M*	11-95	06-96	No	Chin	R sinus	Block	—	3 I	—	1/06-96	Temp fixed	Implants FP
	11-98	12-99	No	Chin	R sinus	Particulate	—	2 D 04-99	Infection	—	Fixed	
58/M	02-96	01-97	Yes	Chin	R sinus	Particulate	PRP, GM	4 I	Infection; GM removed 04-96	1/10-96	Removable	ND
43/F	12-96	03-99	No	Chin	R sinus	Particulate	—	3 D 09-97	—	—	Fixed	Implants FP
18/F	02-97	11-98	No	Chin	L sinus	Particulate	50% BO	3 D 09-97	—	—	Fixed	ND
32/F	02-97	05-98	No	Chin	L sinus	Particulate	PRP	5 D 07-97	—	2/06-98	3 crowns	ND
58/F	02-97	07-98	Yes	Chin	R sinus	Particulate	50% BO	2 D 07-97	—	—	Fixed	ND
20/F	02-97	11-98	No	Hip	Bi sinus	Particulate	PRP, BGM	7 D 10-97	—	1/04-98	Fixed	ND
39/F	03-97	08-98	No	Chin	R sinus	Particulate	PRP, GM	2 D 09-97	—	—	Removable	ND/FP
30/F	04-97	06-98	No	Chin	R sinus	Particulate	PRP	4 D 11-97	—	—	Fixed	ND/FP
48/M	05-97	02-98	No	Chin	R sinus	Block	—	3 I	—	—	Fixed	ND/FP
53/M	10-97	—	No	Hip	Bi sinus	Block	—	6 I	—	6/10-98	None	Implants RP
31/F	11-97	08-99	No	Hip	Bi sinus	Block	—	6 D 04-98	—	—	Removable	Implants FP
54/F	03-98	03-99	Yes	Hip	Bi sinus	Block	—	4 D 07-98	—	—	Removable	Implants FP
34/F	07-98	12-99	Yes	Hip	Bi sinus	Particulate	—	10 D 10-98	—	1/03-00	Fixed	ND/Implants

PRP = platelet-rich plasma; GM = gore-tex membrane; BGM = Bio-Gide membrane; BO = Bio-Oss added to expand graft ~50:50; I = immediate; D = delayed; ND = natural dentition; RP = removable prosthesis; FP = fixed prosthesis.
*Patient had 2 additional implants placed to enable restoration. Four Brånemark System implants were used in the second procedure.

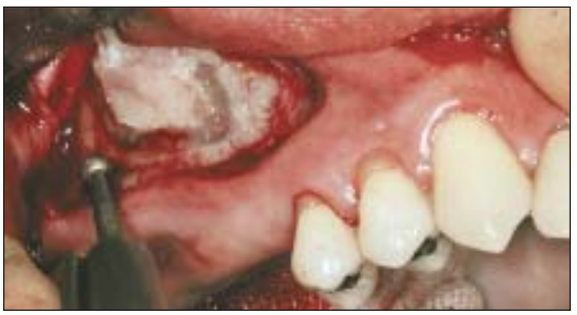

Fig 1 Cutting of a trap door flap in the wall of the sinus with a slow-speed diamond bur.

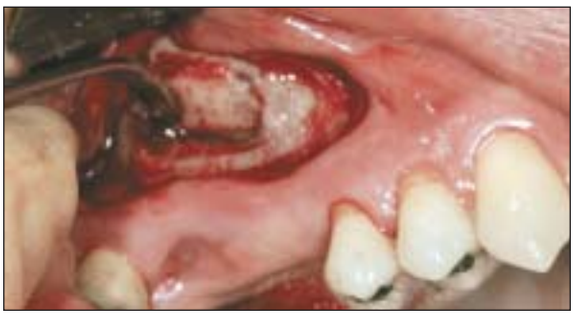

Fig 2 Infracture of the sinus wall is performed, taking care not to tear the sinus membrane.

may be reduced interarch space for prosthetic restoration. Therefore, sinus augmentation procedures have been established[13] and modified to overcome such problems.[14–16] The aim of this study was to analyze the survival of osseointegrated implants in grafted bone following the sinus augmentation.

MATERIALS AND METHODS

Twenty-seven consecutive sinus augmentation procedures were carried out on 18 patients for the provision of dental implants. All patients included in this study had proceeded to occlusal loading of their implants (Table 1).

Patients requiring implants in the posterior maxilla with poor bone volume (insufficient to accommodate a 3.75×7-mm implant) were examined radiographically by Scanora tomography (Soredex, Helsinki, Finland) to visualize the cross-section of the proposed site prior to performing a sinus augmentation procedure. In general, for patients in whom a unilateral procedure was planned, the mandibular symphysis was used as the donor site. Where a bilateral procedure was planned, the iliac crest was used as the donor site. All procedures were carried out under general anesthesia using standard techniques of bone harvest. The graft site was exposed and visualized following careful soft tissue reflection.

The sinus augmentation technique has been described in other reports.[13–16] In essence, a modified Caldwell-Luc approach was utilized; a trap door was outlined in the lateral wall of the sinus using a diamond drill[14] (Fig 1). The trap door was then infractured, taking care to avoid perforation of the sinus membrane (Fig 2). This then formed the new, elevated floor of the sinus, and donor bone was then placed beneath it (Fig 3). Harvest of bone at the mandibular symphysis has also been documented previously.[17] In this procedure, the mucosa was reflected following a sulcular incision. Where augmentation of the ridge width was also required, corticocancellous blocks were taken using a drill. Where small volumes of bone were required to fill the sinus floor, particulate grafts were harvested using a trephine and bone mill (Leibinger, Botzinger, Frieburg, Germany). Bone harvested from the iliac crest was obtained from the medial wall of the anterior spine following dissection of the overlying soft tissue.[18]

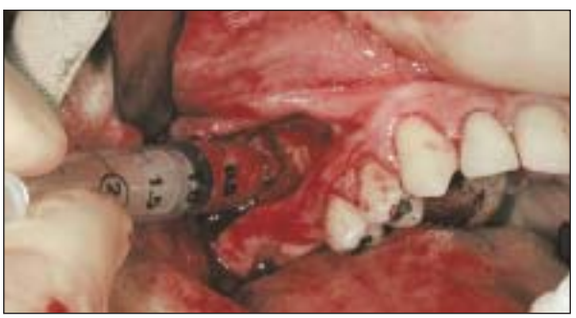

Fig 3 Placement of compressed, milled cortical bone trephined from the chin.

Guided bone regeneration techniques were used in patients having minimal defects of bone, such as exposed implant threads.[19] In some patients, platelet-rich plasma (PRP) was combined with the graft.[20]

Where there was adequate height of bone for primary stability (4 mm or more), the implants were placed immediately at the time of grafting. Where this was not possible, a delayed approach of graft consolidation followed by implant placement was implemented (Figs 4a and 4b). Implant surgery was carried out by operators trained ad modum Brånemark, using machined-surface Mk II implants (Brånemark System, Nobel Biocare, Göteborg, Sweden).

At second-stage surgery, implants were clinically assessed for integration by testing for mobility using percussion following manual tightening of the transmucosal abutment. At subsequent review appointments, the implants were examined for clinical mobility and adverse symptoms. Radiographic examination was not standardized but only executed

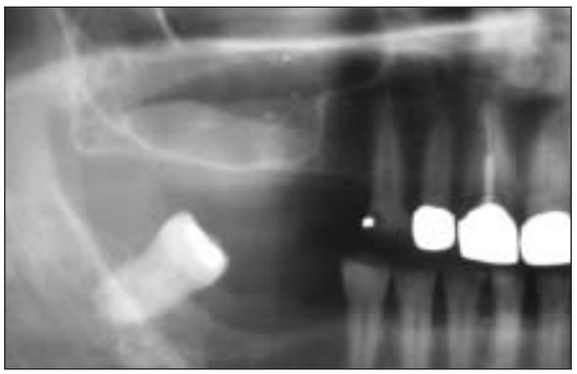

Fig 4a Preoperative radiograph.

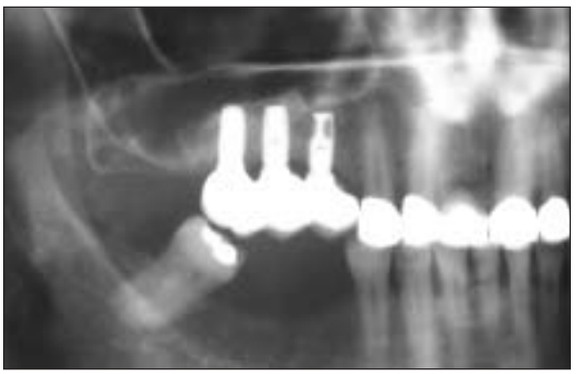

Fig 4b Radiograph 2 years post-loading of implants.

where clinically indicated. Analysis of the survival of the loaded implant was considered to be the main outcome measure and the determinant of the success of bone grafting.

RESULTS

In the study group of 18 patients, there were 12 women and 6 men with a mean age at surgery of 43.7 years (range, 18 to 75 years). Five were smokers, and 13 were nonsmokers. In addition, 3 patients were taking oral contraceptives (1 of whom was a smoker). One patient had high blood pressure, 1 was an asthmatic, and 1 had Chagas syndrome, a rare parasitic cardiomyopathy necessitating an indwelling cardiac pacemaker.

Twenty-seven sinus augmentations were undertaken; 11 unilateral operations and 8 bilateral procedures (one patient [50/M] required a repeat procedure. The mandibular symphysis was used as the donor site for 11 unilateral and 1 bilateral procedure). The iliac crest was used as a donor site for 14 augmentations in 7 bilateral cases. Block grafts were used in 11 augmentations, and corticocancellous particulate grafts were used in 16. One patient had both particulate and block grafts placed on separate occasions. Of the 16 particulate grafts, autologous PRP was added to 6. Two particulate grafts harvested from the mandible were expanded by 50% with bovine mineralized bone matrix (Bio-Oss, Geistlich Biomaterials, Wolhusen, Switzerland).

A guided bone regeneration (GBR) technique was used to close the buccal wall of the sinus in 4 patients, 2 with nonresorbable Gore-Tex membrane (W. L. Gore, Flagstaff, AZ) and 2 with resorbable Bio-Gide (Geistlich Biomaterials). Ten augmented sinuses received implants immediately. The other 17 had a mean period of bone graft consolidation of 24.7 weeks (range 9 to 39 weeks), and 1 patient had both immediate and delayed implant placement.

Five patients reported paresthesia at or around the donor site immediately following the graft surgery, 1 at the iliac crest and 4 in the mandible. In 1 patient the Gore-Tex membrane became exposed, necessitating premature removal. One male patient experienced a failed implant, requiring a repeat sinus augmentation procedure. This same patient experienced a postoperative infection after the second procedure.

There was a mean time period of 30.1 weeks between implant placement and abutment connection surgery (range, 4 to 52 weeks). A mean period of 35.4 weeks followed prior to occlusal loading (range, 4 to 192 weeks). However, 192 weeks elapsed prior to occlusal loading for the patient who had a repeat bone graft procedure. Excluding this patient, the mean time prior to occlusal loading was 25.6 weeks (range, 4 to 56 weeks). Patients have been followed up for a mean of 162.4 weeks (range, 76 to 288 weeks) from the time of occlusal loading. Figures 4a and 4b illustrate a patient preoperatively and at 2 years after occlusal loading.

A total of 79 machined-surface Brånemark Mk II implants were placed in grafted bone, and 2 machined-surface Mk IV implants were used for the patient who required a repeat procedure. A mean of 4 implants were placed per patient (range, 1 to 10 implants).

Sixteen implants failed to integrate in grafted bone, following 10 procedures in 9 patients. This represents an 80.25% survival rate of implants during the follow-up period. Fourteen patients proceeded to the planned prosthesis. The treatment plan was compromised in 4 patients, including 1 who was restored conventionally. This represents 94% of patients who were successfully rehabilitated. Eight patients were restored with fixed prostheses, 7 with overdentures, and 2 with crowns.

Of the 9 patients with failed implants, 6 patients had received immediate implantation (12 implants) and 3 had received delayed implant placement (4 implants). Of the patients who experienced no failures, 8 were treated with delayed implants and only 1 had immediate implants placed. Three of the patients with failed implants experienced postoperative infection or exposure of membranes, but none of the patients without implant failures experienced postoperative infection.

The mean age of the "failure" group was 48.5 years; the mean age of the "success" group was 39.6 years. There were 2 smokers in the former group and 3 smokers in the latter group. There were similar distributions regarding the donor site, the type of graft, and the use of GBR and bone substitutes. A summary of the patients' details is given in Table 1.

DISCUSSION

The results of this study conducted in routine dental implant practice show the survival of implants in grafted bone of the maxillary sinus to be lower than in similar reports. A report of a series of 50 implants placed immediately into 18 grafted sinuses demonstrated a 100% success rate.[14] A report of delayed graft and implant placement in 50 patients revealed 84% survival with a follow-up period of 9 to 48 months.[16] Both groups used the iliac crest as the donor site.

In the present study, only patients who had implants loaded with a prosthesis were included. This was to enable a categorical outcome measure to evaluate the success or otherwise of the bone graft. To minimize exposure to ionizing radiation, radiographs were taken only when clinically indicated; therefore, the success of the implants according to criteria proposed in the recent literature[21] could not be analyzed.

By associating the success of the bone graft with osseointegration, an assumption was made that integration occurred because the grafted bone remained viable. Since implant hardware was constant, the main variable was bone quality. Research has demonstrated the association between osseointegration and bone quality. Integration of implants tends to be categorical and therefore is not a subjective measure and is less prone to bias. However, the success of prosthetic rehabilitation is subjective. Perhaps one of the shortcomings of this study is that the operator and not the patient determined the success of the prosthesis.

This study reviewed survival of the implants for a mean period of 162.4 weeks from the onset of occlusal loading. Although these data are short-term when compared to some other implant trials, it has been demonstrated that implant failure often occurs in the early loading period.[22]

Certain aspects of the surgery were not standardized, ie, the use of bone substitutes and GBR techniques. Some patients received resorbable membranes, and some received nonresorbable membranes. During the course of the study, observation of exposure and subsequent infection of nonresorbable membranes led to the use of resorbable membranes where GBR was indicated.

Although the numbers involved do not lend themselves to statistical analysis, there are some observations that can be made when comparing the patients in whom all implants integrated to patients in whom failure of integration occurred. There are studies that have shown less resorption of grafts of intramembranous origin as compared to endochondral bone.[23] In this study the bone source did not appear to have an effect, since there was no difference in the proportion of integrated implants in grafts from the iliac crest or the mandibular symphysis. Hip grafts necessitate more invasive and prolonged surgery than chin grafts, yet it is possible to harvest a greater volume of bone from this site. Comparison of possible complications was not evaluated between the 2 methods, in particular with regard to the inconvenience to the patient. In contrast with other reports,[24] smoking did not appear to have a significant effect on the patients in this study group.

The proportion of integrated implants was similar between the block-graft and particulate-graft groups. It has been reported that particulate grafts revascularize faster than block grafts.[25] However, cortical block grafts remain an admixture of viable and necrotic bone. This does not appear to have affected osseointegration significantly in this group of patients. The fact that there is little difference between these 2 groups highlights the need for further controlled trials of bone substitutes and GBR techniques, since more patients in the particulate group had these methods employed than those who had block grafts. The effects of the different bone substitutes are difficult to evaluate from this sample group. This is because there were many variables that needed to be controlled prior to definitive comparison. Factors that were used included GBR in conjunction with PRP and/or bovine bone mineral. Of the 9 patients in whom implants failed to integrate, 3 experienced exposed membranes or a postoperative wound infection, and none of the patients in whom all implants integrated experienced wound or membrane infection. Infection is

known to cause bone resorption because of the presence of inflammatory mediators.

A greater proportion of implants integrated in grafts after a healing period, in comparison to those placed at the time of the graft surgery. Comparisons between these 2 groups are difficult because of the inherent differences between their clinical indications. That is, where there was adequate bone volume to achieve primary stability, implants were placed simultaneously with the graft. Simultaneous procedures are technically demanding and are only possible where there is adequate bone to allow primary fixation. A possible reason for the outcomes in this study could have been the fact that implants were placed into non-viable bone. The delayed approach allows the grafted bone to undergo remodeling and repair, so that the implants can then be placed into viable bone.

CONCLUSION

Augmentation of the sinuses with autogenous bone can enable the placement of implants for rehabilitation. However, the procedure is not predictable. Within the confines of this study, the authors recommend the use of a bone graft healing period prior to implant placement and avoidance of the use of membranes.

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