The Effect of Sinus Membrane Perforation and Repair with Lambone on the Outcome of Maxillary Sinus Floor Augmentation: A Radiographic Assessment

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Purpose: *The present study compared the regenerative outcome of sinus graft procedures in a group of patients who underwent the repair of an intraoperatively diagnosed sinus membrane perforation to that of a group of patients without sinus membrane perforations.* ***Materials and Methods:*** *A sinus floor augmentation procedure was performed in 73 sinuses in 63 patients. In 28% of these sinuses a significant (> 5 mm) membrane perforation was observed intraoperatively. In these cases, the perforation was sealed with a freeze-dried human lamellar bone sheet, and the grafting procedure was carried out as planned. The following parameters were measured on panoramic radiographs immediately postoperatively and at the 6- and 24-month follow-up examinations: (1) the distance between the occlusal edge of the implant and the preoperative sinus floor, (2) the distance between the occlusal edge of the implant and the postoperative sinus floor, and (3) the distance between the occlusal edge of the implant and the alveolar crest.* ***Results:*** *The patients whose sinus membranes were perforated experienced no complications. No statistically significant differences were found between the 2 groups in the parameters measured.* ***Discussion:*** *Lambone was used in all cases in the present study. In no case did the sinus augmentation procedure have to be abandoned.* ***Conclusion:*** *It can be concluded that membrane elevation must be carefully executed to avoid membrane perforation, but that if it occurs, it is still possible to continue the procedure safely after repair.* INT J ORAL MAXILLOFAC IMPLANTS 2004;19:559–562

Key words: *grafts, membranes, sinus floor perforation*

Sinus membrane perforation is the most prevalent complication of the sinus floor elevation procedure. It occurs in 10% to 35% of sinus floor elevation procedures.[1–3] Infection, bacterial invasion, loss of the graft material, and disruption of normal sinus physiologic function have been attributed to intraoperative sinus membrane perforation.[1,4,5] Unless it is chronically inflamed and thus thickened, the schneiderian membrane is thin, friable, and easily perforated.[2] Anatomic as well as technical factors have been implicated in membrane perforation. The shape of the osteotomy and whether the lateral bony window is wholly detached or hinged in both can have a direct effect on the risk and severity of a membrane perforation.[6] The presence of antral septa can complicate membrane elevation and increase the risk of perforation during the procedure.[5,7]

Several attempts have been made to classify membrane perforations. Vlassis and Fugazzotto[6] proposed 5 classes based on location and difficulty to repair. Pikos[1] referred to small (5 to 10 mm wide) and large (greater than 10 mm wide) perforations.

Repair of sinus membrane perforations intraoperatively may be performed using a variety of techniques and materials, including sutures, collagen membranes, fibrin glue, and freeze-dried lamellar bone sheets. Special care and delicacy are required to avoid enlarging the perforation.[1,6] Various grafting materials have been used during sinus augmentation procedures, including autogenous bone, freeze-dried

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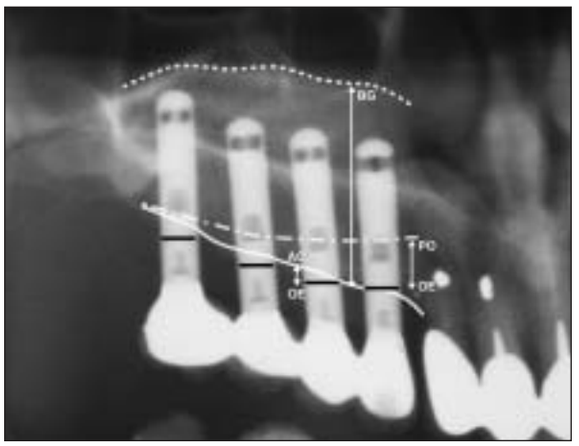

Fig 1 Postoperative panoramic radiograph demonstrating the measured parameters. OE = occlusal edge of the implant; PO = the preoperative sinus floor; BG = the postoperative sinus floor with bone graft; AC = the alveolar crest.

bone allografts, xenografts, hydroxyapatite (HA), tricalcium phosphate, and combinations of these materials.[8–21]

The significance of sinus perforation is debatable. While some researchers have hypothesized that the antral membrane does not play a role in the containment of the bone graft, assuming that bone-like structures form to support endosseous implants placed in either corticocancellous or cancellous bone,[3] others have stated that it appears to be preferable to avoid intraoperative membrane perforations.[1,4,6] Several authors[2,6] assume that the regenerative result of the bone grafting procedure is inferior following sinus membrane perforations and recommend that simultaneous implant placement not be carried out following repair of severe perforations (class 3 or 4 perforations according to Vlassis and Fugazzotto[6]). To the best of the present authors' knowledge, there are no quantitative data to support either of these hypotheses.

The purpose of the present study was to compare both radiographically and clinically the regenerative outcome of sinus graft procedures in a group of patients who underwent repair of an intraoperatively diagnosed sinus membrane perforation to the outcome in a group of patients who underwent a sinus graft procedure without sinus membrane perforation.

MATERIALS AND METHODS

A sinus floor augmentation procedure was performed in 73 sinuses in 63 patients, 37 men and 26 women aged 23 to 72 years old (mean 48 years) with class IV, V, or VI maxillary atrophy according to the classification of Cawood and Howell.[22] Prior to treatment all patients were examined clinically and radiographically (by panoramic radiography and computerized tomography [CT]) for available bone volume, bone quality, anatomy, and any existing sinus pathology.

In 8 patients in need of bilateral sinus augmentation, the grafts were obtained from the iliac crest. In 53 patients who needed unilateral sinus augmentation, the bone grafts were obtained from the symphysis of the mandible and mixed with an equal volume of bovine bone mineral (Bio-Oss; Geistlich Biomaterials, Wolhusen, Switzerland). In 2 patients who needed unilateral sinus augmentation, the bone graft was obtained from the iliac crest because of their concern that an unesthetic outcome could result from chin graft harvesting.

Criteria for simultaneous implant placement were defined preoperatively and were based on the initial available patient bone. The patient had to have $>$ 4 mm of bone at the implant site. A 2-stage procedure (sinus graft followed by implant placement) was performed when the height of the posterior maxillary alveolar bone was less than 5 mm.

Sinus Floor Augmentation Technique

When the bone graft was taken from the iliac crest, the operation was performed under general anesthesia. When the grafts were obtained from the chin, the operation was accomplished under local anesthesia. In the first procedure, a midalveolar ridge incision was made, followed by a vertical releasing incision, and a mucoperiosteal flap was raised to expose the lateral aspect of the maxilla. A round bur was used with copious sterile saline irrigation to fenestrate the lateral wall of the maxillary sinus. The window technique for gaining access to the maxillary sinus was used. The bony window was rotated medially and superiorly; care was taken not to perforate the sinus membrane. Intraoperative membrane perforations were sealed with a demineralized freeze-dried human lamellar bone sheet (Lambone; Pacific Coast Tissue Bank, Los Angeles, CA), which functioned as a mechanical barrier.

The bone graft was then placed in the new compartment made by elevation of the sinus membrane. Fifty-three patients received a composite autogenous bone graft consisting of a volumetric combination of 50% symphyseal bone graft and 50% Bio-Oss. The graft material was introduced using a plastic syringe and was meticulously condensed in the newly formed cavity. The bone window was covered with a resorbable collagen membrane (Bio-Gide; Geistlich Biomaterials). The mucoperiosteal flap was closed primarily over the graft using 3/0

Table 1 Summary of Radiographic Measurements in 73 Consecutive Grafted Sinuses

	Minimum (mm)		Maximum (mm)		Range (mm)		Mean (mm)	
	Control	Study	Control	Study	Control	Study	Control	Study
Implant length	13	13	18	18	5	5	NA	NA
Alveolar ridge height								
Prior to augmentation	2.0	2.0	8.3	7.2	6.3	5.2	5.2	4.9
Immediately after implantation	14.5	14.7	21.5	20.3	7.0	5.6	17.4	17.2
6 mo after implantation	14.0	14.0	21.5	20.0	7.5	6.0	17.3	17.0
24 mo after implantation	13.5	13.2	21.0	20.0	7.5	6.8	17.4	17.2
Crestal bone loss								
At 6 mo	0.0	0.0	1.5	1.5	1.5	1.5	0.2	0.4
At 24 mo	0.0	0.0	2.0	2.0	2.0	2.0	0.8	0.7

vicryl continuous sutures. In the 2-stage procedure, implant placement was carried out 4 to 6 months after the sinus was grafted. Either HA-coated cylindric or screw-type implants (Zimmer Dental, Carlsbad, CA) were used. The results were evaluated by repeated clinical and radiographic examinations, including clinical postoperative examinations 1, 2, and 4 weeks after placement and subsequently every month until surgical exposure of the implants. Panoramic radiographs were taken immediately postsurgery, 6 months after implant placement, and 24 months after implant placement.

Three parameters were measured in each panoramic radiograph[20]: *(1)* the distance between the occlusal edge of the implant and the preoperative sinus floor, *(2)* the distance between the occlusal edge of the implant and the postoperative sinus floor, and *(3)* the distance between the occlusal edge of the implant and the alveolar crest (Fig 1). The magnification factor was calculated by the ratio of the predetermined implant length to the length measured on the panoramic radiograph. In 2-stage procedures, the original sinus floor height was taken from the patient's preoperative CT scans. All implants were uncovered at 6 months after placement, and all the patients were rehabilitated using fixed prostheses.

RESULTS

A significant perforation (> 5 mm) was observed intraoperatively in 20 sinuses (28%). The perforation was sealed with a freeze-dried human lamellar bone sheet (Lambone), and the grafting procedure was carried out as planned. Those cases served as the study group. The sinuses that were not perforated served as the control group. No unfavorable sequelae were noted in any patient with a membrane perforation.

Table 2 Implant Survival Rate in View of Sinus Membrane Perforations at 24 Months

	Control	Study
No. of implants placed	185	68
No. of failed implants	16	7
Survival rate (%)	91	90

Radiographic measurements for both groups are summarized in Table 1. No statistically significant differences were found between the groups regarding implant length, ridge height prior to augmentation, ridge height immediately after augmentation, or ridge height or crestal bone loss at 6 or 24 months postoperatively.

Seven of 68 implants failed in the study group; 16 of 185 implants failed in the control group. The survival rates for the 2 groups (90% for the study group versus 91% for the control group) were similar (Table 2).

DISCUSSION

Sinus grafting is well recognized as a predictable procedure for rehabilitation of the atrophic posterior maxilla with dental implants. The success rate for the bone augmentation procedure (100%) and the survival rate of the implants placed in grafted bone (91%) in the present study concur with other published reports.[12,20,23,24] The implant survival rate was higher than that reported for maxillary implants placed in the posterior maxilla without sinus grafting.[25,26]

The most commonly reported intraoperative complication of sinus augmentation is membrane perforation.[1–3] In the present study, a membrane perforation was observed in 28% of the sinuses. Preferred management of membrane perforations is not clearly defined in the literature. Small perforations usually do

not need treatment because the membrane folds on itself during the elevation. Large perforations are usually managed by use of a membrane, by use of a block graft instead of a cancellous graft, or by abandonment of the procedure. The technique of using a relatively rigid membrane, specifically a demineralized human lamellar bone membrane such as Lambone, that is also slow to resorb was suggested by Vlassis and Fugazzotto[6] for the management of more severe perforations (as defined by their classification system). In the present study, Lambone was used for all cases in which a significant perforation was diagnosed. In no case was the procedure abandoned or the choice of graft material changed, and in no case was membrane perforation followed by complications.

SUMMARY

In this short-term retrospective study, no significant differences in grafting procedure outcome or implant success rate were seen between those patients whose sinus membrane was perforated and those whose sinus membrane remained intact. The overall success rate coincides with other well-documented data regarding sinus bone grafts and implant placement. No serious infections have occurred, and bone level at the 2-year follow-up, as determined radiographically, was adequate. Therefore, it can be concluded that membrane elevation must be carefully executed, but that if membrane perforation occurs, it is still possible to continue the procedure safely after adequate repair. Additional clinical and histologic long-term follow-up studies are recommended to confirm these conclusions.

REFERENCES

1. Pikos MA. Maxillary sinus membrane repair: Report of a technique for large perforations. Implant Dent 1999;8:29–34.
2. van den Bergh JP, ten Bruggenkate CM, Disch FJ, Tuinzing DB. Anatomical aspects of sinus floor elevations. Clin Oral Implants Res 2000;11:256–265.
3. Jensen J, Sindet-Pedersen S, Oliver AJ. Varying treatment strategies for reconstruction of maxillary atrophy with implants: Results in 98 patients. J Oral Maxillofac Surg 1994;52:210–216.
4. Aimetti M, Romagnoli R, Ricci G, Massei G. Maxillary sinus elevation: The effect of macrolacerations and microlacerations of the sinus membrane as determined by endoscopy. Int J Periodontics Restorative Dent 2001;21:581–589.
5. Betts NJ, Miloro M. Modification of the sinus lift procedure for septa in the maxillary antrum. J Oral Maxillofac Surg 1994;52:332–333.
6. Vlassis JM, Fugazzotto PA. A classification system for sinus membrane perforations during augmentation procedures with options for repair. J Periodontol 1999;70:692–699.
7. Krennmair G, Ulm C, Lugmayr H. Maxillary sinus septa: Incidence, morphology and clinical implications. J Craniomaxillofac Surg 1997;25:261–265.
8. Boyne P, James RA. Grafting of the maxillary sinus floor with autogenous marrow and bone. J Oral Maxillofac Surg 1980;38:113–116.
9. Tatum H Jr. Maxillary and sinus implant reconstructions. Dent Clin North Am 1986;30:207–229.
10. Smiler DG, Holmes RE. Sinus lift procedure using porous hydroxyapatite: A preliminary report. J Oral Implantol 1987; 13:239–253.
11. Wood RM, Moore DL. Grafting of the maxillary sinus with intraorally harvested autogenous bone prior to implant placement. Int J Oral Maxillofac Implants 1988;3:209–214.
12. Kent JN, Block MS. Simultaneous maxillary sinus floor bone grafting and placement of hydroxylapatite-coated implants. J Oral Maxillofac Surg 1989;47:238–242.
13. Jensen J, Simonsen EK, Sindet-Pedersen S. Reconstruction of the severely resorbed maxilla with bone grafting and osseointegrated implants: A preliminary report. J Oral Maxillofac Surg 1990;48:27–32.
14. Hirsch JM, Ericsson I. Maxillary sinus augmentation using mandibular bone grafts and simultaneous installation of implants. A surgical technique. Clin Oral Implants Res 1991;2:91–96.
15. Jensen J, Sindet-Pedersen S. Autogenous mandibular bone grafts and osseointegrated implants for reconstruction of the severely atrophied maxilla: A preliminary report. J Oral Maxillofac Surg 1991;49:1277–1287.
16. Smiler DJ, Johnson PW, Lozada JL, et al. Sinus lift grafts and endosseous implants: Treatment of atrophic posterior maxilla. Dent Clin North Am 1992;36:151–186.
17. Raghoebar GM, Brouwer TJ, Reintsema H, Van Oort RP. Augmentation of the maxillary sinus floor with autogenous bone for the placement of endosseous implants: A preliminary report. J Oral Maxillofac Surg 1993;51:1198–1203.
18. Misch CM, Misch CE. The repair of localized severe ridge defects for implant placement using mandibular bone grafts. Implant Dent 1995;4:261–267.
19. Block MS, Kent JN. Maxillary sinus grafting for totally and partially edentulous patients. J Am Dent Assoc 1993;124: 139–143.
20. Hurzeler MB, Kirsch A, Ackermann KL, Quinones CR. Reconstruction of the severely resorbed maxilla with dental implants in the augmented maxilla. A 5-year clinical investigation. Int J Oral Maxillofac Implants 1996;11:466–475.
21. Langer B, Langer L. Use of allografts for sinus grafting. In: Jensen OT (ed). The Sinus Bone Graft. Chicago: Quintessence, 1999:69–78.
22. Cawood JI, Howell RA. A classification of the edentulous jaws. Int J Oral Maxillofac Surg 1988;17:232–236.
23. Chanavaz M. Maxillary sinus: Anatomy, physiology, surgery and bone grafting related to implantology—Eleven years of surgical experience (1979–1990). J Oral Implantol 1990;16: 199–209.
24. Peleg M, Mazor Z, Chaushu G, Garg A. Sinus floor augmentation with simultaneous implant placement in the severly atrophic maxilla. J Periodontol 1998;69:1397–1403.
25. Adell R, Eriksson B, Lekholm U, Brånemark P-I, Jemt T. A long-term follow-up study of osseointegrated implants in the treatment of totally edentulous jaws. Int J Oral Maxillofac Implants 1990;5:347–359.
26. Adell R, Lekholm U, Rockler B. A 15-year study of osseointegrated implants in the treatment of edentulous jaw. Int J Oral Surg 1981;10:387–416.