A Clinical Study of the Outcomes and Complications Associated with Maxillary Sinus Augmentation

Antonio Barone, DDS, PhD[1]/Stefano Santini, DDS, MD[1]/Ludovico Sbordone, DDS, MD[2]/
Roberto Crespi, MD[3]/Ugo Covani, DDS, MD[4]

Purpose: *The aim of this study was to evaluate the rate of complications in maxillary sinus augmentation surgery and the impact of complications on subsequent implant treatment in a patient population with severe maxillary atrophy scheduled for treatment under general anesthesia.* ***Materials and Methods:*** *The study population consisted of 70 patients (124 sinuses) with severe maxillary atrophy who underwent maxillary sinus augmentation. Sixteen patients were scheduled to have a unilateral procedure and 54 patients a bilateral procedure. Sinus augmentation was performed with autogenous bone alone in 93 sinuses; in 31 sinuses, a 1:1 mixture of autogenous bone and corticocancellous pig bone particles was used. Twenty-six of 124 procedures involved both sinus augmentation and autogenous block grafting for the treatment of severely atrophic maxillae.* ***Results:*** *The most common intraoperative complication was the perforation of the sinus membrane, which was observed in 31 sinuses (25%). Seven (5.6%) sinuses in 7 patients exhibited suppuration of the maxillary sinus. Five of the 7 patients with sinus infection were smokers, showing a prevalence of complications significantly greater in smokers compared to nonsmokers. Moreover, the use of an onlay bone graft in conjunction with sinus augmentation appeared to significantly increase the rate of infective complications. Infections were treated by drainage and the administration of systemic antibiotics. Two clinical cases showing persistent signs of infection required an endoscopic inspection of the maxillary sinus.* ***Discussion and Conclusion:*** *In the present study sinus membrane perforation was not shown to be a significant factor in the rate of implant complications. However, the combination of smoking and onlay bone grafting could significantly increase the rate of postoperative infection following sinus grafting.* Int J Oral Maxillofac Implants 2006;21:81–85

Key words: *maxillary sinus complications, maxillary sinus grafts, maxillary sinus surgery*

The placement of dental implants requires a sufficient quality and quantity of alveolar bone to support implantation. Furthermore, proximity of the maxillary sinus often poses a clinical problem for the placement of implants in the posterior area of the maxilla. Sinus augmentation surgery has had to be evaluated[1] and subsequently modified[2,3] to overcome this problem. Maxillary sinus grafting has become routine treatment over the last 10 years. It allows the placement of dental implants using simultaneous or staged procedures in sites in the posterior maxilla that were previously considered unsuitable for implant placement because of insufficient bone volume.

Several studies have reported excellent long-term survival rates for implants placed into augmented maxillary sinuses.[4–6] Most of these studies have shown a correlation between the success of the bone graft and the success of dental implants; the assumption made was that implant integration was possible because the grafted bone remained viable. The sinus lift is generally considered to be a safe surgical procedure with a low prevalence of complications.[7] However, all surgical procedures have the potential to develop complications, leading to addi-

[1]Assistant Professor, Department of Biophysical, Medical and Dental Sciences and Technologies, Medical School, University of Genova, Italy.
[2]Professor and Chairman of Periodontology and Implantology, Department of Surgery, University of Pisa, Italy.
[3]Assistant Professor, Department of Biophysical, Medical and Dental Sciences and Technologies, Medical School, University of Genova, Italy; Private Practice, Busto Garolfo, Italy.
[4]Chairman of Oral Pathology, Department of Biophysical, Medical and Dental Sciences and Technologies, Medical School, University of Genova, Italy;Private Practice, Camaiore, Italy.

Correspondence to: Dr Antonio Barone, Piazza Diaz 10, 55041 Camaiore (Lu), Italy. Fax: +39 0584 985334. E-mail: barosurg@libero.it

COPYRIGHT © 2005 BY QUINTESSENCE PUBLISHING CO, INC.
PRINTING OF THIS DOCUMENT IS RESTRICTED TO PERSONAL USE ONLY.
NO PART OF THIS ARTICLE MAY BE REPRODUCED OR TRANSMITTED IN ANY FORM
WITHOUT WRITTEN PERMISSION FROM THE PUBLISHER.

tional surgery, prolonged hospital recovery, fatigue, and nutritional disorders, which markedly compromise quality of life.[8–10]

The occurrence of complications with maxillary sinus augmentation procedures may in fact jeopardize the final outcomes of bone grafting and implant placement. The most common intraoperative complication seems to be schneiderian membrane perforation, which occurs in 7% to 44% of procedures.[11,12] Less common complications can also occur in the postoperative phase, for example, sinus infection and barrier membrane or graft exposure.[7,13]

The aim of the present study was to evaluate the surgical complication rate of maxillary sinus augmentations performed under general anesthesia and the impact on subsequent implant treatment in a patient population diagnosed with a severe maxillary atrophy.

MATERIALS AND METHODS

Patient Selection

The study sample comprised 70 patients (32 men and 38 women) ranging in age from 35 to 68 years (median age 51.2 years). Forty-two of the patients were partially edentulous in the posterior maxilla, and 28 were completely edentulous. All patients were selected as suitable candidates for maxillary sinus augmentation prior to implant surgery. All patients were healthy and had previously undergone a complete intraoral and radiographic examination. Preoperative radiographic assessment included careful evaluation of any pathologic conditions of the sinus using orthopantomograms and computed tomography.

The inclusion criteria were as follows: the need for sinus lifting and grafting; the presence of severe maxillary bone atrophy rated class V according to the Cawood and Howell classification[14]; a residual maxillary sinus floor less than 3 mm high, and healthy systemic conditions, including the absence of any disease that would contraindicate surgery under general anesthesia.

The exclusion criteria were as follows: severe illness, unstable diabetes, uncontrolled periodontal disease, a history of head and neck radiation, chemotherapy, and a history of drug abuse. In addition, patients smoking more than 10 cigarettes per day were excluded from the study; patients smoking less than 10 cigarettes per day were advised to refrain from smoking. However, there was no monitoring of patient compliance.

A total of 21 patients were smokers; 49 were nonsmokers.

The patients were informed of the surgical technique, and oral and written consent were obtained.

A total of 124 maxillary sinus augmentation procedures were performed: 16 patients were planned for a unilateral procedure and 54 patients for a bilateral procedure.

Surgical Technique

Maxillary sinus floor lifting and grafting were performed under general anesthesia in all clinical cases. The preoperative treatment regime consisted of intravenous antibiotic (2 g cephalosporine) and corticosteroids (8 mg dexamethasone). A local anesthetic agent with vasoconstrictor (2% xylocaine, 1:50,000) was injected into the vestibule and into the palate. First, a crestal incision was made. A mucoperiosteal flap was raised, and an osteotomy was then performed on the lateral wall of the maxillary sinus using a round steel bur under cooling with sterile saline solution to prepare a bony window. The sinus mucosa was carefully dissected and elevated using mucosal sinus elevators, and the bony wall was gently pushed inside the sinus cavity forming the roof for the bone transplant. If small perforations appeared in the sinus membrane they were repaired with a collagen membrane. The donor sites for bone harvesting included the mandibular symphysis or the antero-superior border of the iliac crest.[15,16] Sinus augmentation was performed in 93 sinuses with autogenous bone alone and in 31 sinuses with a 1:1 mixture of autogenous bone and corticocancellous pig bone particles (Osteobiol; Tecnoss, Coazze, Italy) (Table 1). The particles were about 600 μm wide. The bony sinus windows were covered with a resorbable collagen membrane. Finally, the mucoperiosteal flap was replaced and sutured using vertical interrupted mattress sutures.

Postoperative Management

All patients received antibiotics (cephalosporine 2g/day) for 5 days following surgery, a corticosteroid (dexamethasone 4 mg/day) for 2 days following surgery, and chlorhexidine mouthwash twice daily for 21 days following surgery. All patients were advised to avoid physical stress, blowing their noses, or sneezing for a period of 3 weeks.

The sutures were removed after 10 days. Dentures were not allowed to be worn until they had been adjusted and refitted not sooner than 2 weeks after surgery.

During the postoperative healing period the occurrence of clinical complications such as acute or chronic sinus infection, bleeding, and onlay bone graft exposure or mobility were recorded.

COPYRIGHT © 2005 BY QUINTESSENCE PUBLISHING CO, INC.
PRINTING OF THIS DOCUMENT IS RESTRICTED TO PERSONAL USE ONLY.
NO PART OF THIS ARTICLE MAY BE REPRODUCED OR TRANSMITTED IN ANY FORM
WITHOUT WRITTEN PERMISSION FROM THE PUBLISHER.

Implant Therapy

A healing period ranging from 4 to 6 months was allowed before dental implant placement. The implantation procedure took into account the implant manufacturer's recommendations (Sweden & Martina, Padova, Italy). The implants were allowed to heal over a period of 6 months before prosthetic loading. The implants placed ranged from 11 to 15 mm in length and from 3.75 to 5 mm in diameter.

Statistical Methods

The comparison between the different groups was performed with the chi square test with a contingency table analysis (statistically significant at a level of $P = .05$).

RESULTS

A total of 124 sinus lift procedures were performed in 70 patients. Twenty-six of 124 procedures included both sinus augmentation and autogenous block graft to treat severely atrophic maxillae (Table 1).

The most common intraoperative complication observed was the tearing or perforation of the sinus membrane. Membrane perforation was observed in 31 sinuses (25%). In these clinical cases, a resorbable collagen membrane was trimmed and used to overlap the site of perforation prior to insertion of the graft material.

Seven (5.6%) maxillary sinus augmentation procedures performed in 7 patients exhibited suppuration 3 to 5 weeks after surgical treatment (Table 2). Five of these 7 patients were smokers. The prevalence of acute infection following the sinus lift operation was significantly greater in smokers (14.2%), compared to nonsmokers (2.2%). Moreover, 4 of the 7 patients showing acute sinus infection were treated with an additional onlay bone graft. Acute infection was observed in 15.3% of patients treated with onlay bone grafts compared to 3% of patients treated without onlay bone grafts. The use of onlay bone grafts in conjunction with maxillary sinus augmentation produced a significantly greater rate of infective complications ($P < .05$). Complications following maxillary sinus augmentation were significantly greater in patients who smoked and received onlay bone grafts (50%) compared to patients who did not smoke and did not receive onlay bone grafts (2.5%) ($P < .05$).

Once the infection was confirmed by clinical and radiographic examination, the sinuses were drained, and systemic antibiotics were administered. Two clinical cases showed persistent signs of infection despite drainage and required an endoscopic inspection through the nasal cavity to enlarge and to liberate the maxillary osteum. Five of 7 patients with suppurated sinuses received additional sinus augmentation using corticocancellous pig bone particles 4 to 6 months subsequent to the sinus suppuration. No further complications were observed. Implants were placed at a later stage according to the initial treatment planning. Two of 7 patients who developed sinus infections refused any additional surgical treatment.

Absence of adequate bone volume was observed in 1 patient with a bilateral sinus augmentation; the patient was a smoker. Additional surgery was performed by elevating the schneiderian membrane while simultaneously placing the implants. Once satisfactory clinical stability of the implants had been achieved, the sinuses were subsequently filled with deproteinized pig bone particles.

A total of 287 implants were placed in the augmented areas.

Table 1 Overview of the Procedures Performed in 70 Patients

Filling material	No. of sinus floor elevations	Onlay bone graft		
		H	V	H+V
Iliac bone	93	17	1	
Iliac bone and Osteobiol	31	6	1	1
Total	124	23	2	1

H = horizontal; V = vertical.

Table 2 Postoperative Complications

Patient	Membrane perforation	Complication	Grafting material	Smoking	Associated onlay bone graft	Treatment
1	No	Infection	Autogenous	Yes	Horizontal	Drainage and antibiotics
2	Yes	Infection	Autogenous	No	—	Drainage and antibiotics
3	No	Infection	Mix*	Yes	Horizontal	Drainage and antibiotics
4	No	Infection	Autogenous	Yes	—	Drainage and antibiotics
5	Yes	Infection	Autogenous	No	Horizontal	Drainage and antibiotics
6	No	Infection	Mix*	Yes	Horizontal	Drainage and antibiotics + EI†
7	No	Infection	Autogenous	Yes	—	Drainage and antibiotics + EI†

*Mix was a 1:1 mixture of autogenous bone and deproteinized pig bone particles (Osteobiol).
†Additional treatment was necessary by an endoscopic inspection (EI) of the sinus.

COPYRIGHT © 2005 BY QUINTESSENCE PUBLISHING CO, INC.
PRINTING OF THIS DOCUMENT IS RESTRICTED TO PERSONAL USE ONLY.
NO PART OF THIS ARTICLE MAY BE REPRODUCED OR TRANSMITTED IN ANY FORM
WITHOUT WRITTEN PERMISSION FROM THE PUBLISHER.

DISCUSSION

The sinus lift procedure is an internal augmentation of the maxillary sinus; the aim of this procedure is to increase the bone volume in the lateral maxilla to make use of dental implants possible. The dental implants can either be placed simultaneously when there is sufficient bone height, or be placed in a second procedure postaugmentation.

The principle and technique of sinus elevation is relatively straightforward; however, the possibility of postoperative complications exists and should be considered.

The aim of this study was to evaluate in a population of patients with severe maxillary atrophy the prevalence of complications associated with maxillary sinus augmentation. This study was carried out within a patient population scheduled to be treated under general anesthesia. All the patients selected for this study showed severe maxillary atrophy (class V using the Cawood and Howell classification). Twenty-six sinus lift procedures needed additional bone augmentation by autogenous onlay graft to obtain better sagittal and/or vertical relationships and create more favorable conditions for the implant-prosthetic rehabilitation. In 93 surgical procedures, sinus augmentation was performed with autogenous bone alone; in the remaining 31 procedures, a 1:1 mixture of autogenous bone and corticocancellous pig bone particles was used.

Perforation of the sinus membrane has often been reported as the most common intraoperative complication in case studies.[12,17,18] Although the membrane perforation could represent a window for bacterial penetration and invasion into the grafted area, the authors did not find any correlation between the treatment outcome and the subsequent implant failure rate. More recently, other authors[19] have suggested that a sinus membrane perforation larger than 2 mm could be associated with reduced bone formation and implant success compared to sites where the sinus membrane was not perforated. On the contrary, within the limits of this study population, the 31 sinuses with membrane perforation did not show any significant complications during the healing period or at the time of implant placement. It should be taken into consideration that the current study was based on a radiographic evaluation and prevalence of complications. No comparative analysis was performed on the basis of histologic evaluation and implant survival rate.

Cigarette smoking can now be strongly linked to several oral pathologies such as oral cancer, periodontal disease, leukoplakia, and stomatitis.[20–22] Smoking has been shown not only to represent a significant risk factor for periodontal disease[23] but also to be a negative influence on healing following periodontal and dental implant procedures.[24,25] Until recently, the toxic effects of smoking were largely assigned to nicotine. However, some studies have suggested that other major components of cigarette smoke might play a more important role than nicotine in mediating the deleterious effects of smoking on marginal bone loss and, consequently, on periodontal health.[26,27] In spite of the number of studies showing the link between smoking and oral pathologies, the biologic mechanisms by which cigarette use influences the pathogenesis of oral disease and the healing process are not yet fully understood. The findings of the present study reaffirm that cigarette smoking is a deleterious factor in oral surgery, since a greater rate of complications following maxillary sinus lifting was observed in smokers compared to nonsmokers. In addition, it was also observed that the onlay bone graft procedure combined with the sinus lift operation significantly increased the rate of postoperative infective complications in the present population. Moreover, smoking and onlay bone graft treatment together were associated with a significantly increased rate ($P < .05$) of complications following maxillary sinus augmentation. The present study does not provide any analysis of the mechanisms related to complications in patients who smoke or receive onlay bone grafts; however, it could be speculated that factors such as systemic vasoconstriction, reduced blood flow, and polymorphonuclear leukocyte dysfunction are involved.

The present research showed no significant correlations between the occurrence of complications and the type of filling material adopted in the maxillary sinus augmentation. Furthermore, it was observed that new bone formation took place within 6 months of the sinus lift operation. No radiographic discrepancies in the amount of bone regenerated were observed between sinuses where only autogenous bone was used and those where a 1:1 mixture of autogenous bone and corticocancellous pig bone particles was used.

Cases of acute sinus infection were treated using drainage through the bony window and administration systemic antibiotics. In the 2 clinical cases where signs of infection persisted despite this treatment, the patients subsequently underwent an endoscopic inspection via the nasal cavity, which indicated a maxillary osteum obstruction. The obstruction was cleared with endoscopy, and a drainage was obtained. As a result of this treatment, both patients made a full recovery.

The sinus lift operation has been generally considered to be a safe treatment with a low rate of complications. Indeed, data from this study have shown a

COPYRIGHT © 2005 BY QUINTESSENCE PUBLISHING CO, INC.
PRINTING OF THIS DOCUMENT IS RESTRICTED TO PERSONAL USE ONLY.
NO PART OF THIS ARTICLE MAY BE REPRODUCED OR TRANSMITTED IN ANY FORM
WITHOUT WRITTEN PERMISSION FROM THE PUBLISHER.

survival rate of 94.3%. Of the 7 patients with infected sinuses, 5 underwent subsequent sinus augmentation, and implant placement proceeded as planned. The remaining 2 clinical patients declined any further treatment.

In conclusion, longer-term clinical studies are needed to identify the potential factors involved in the occurrence of complications. Preselection of suitable candidates for maxillary sinus augmentation will undoubtedly help reduce the incidence rate. Finally, the validity of new procedures specifically designed to treat these complications must be fully evaluated.

REFERENCES

1. Boyne PJ, James RA. Grafting of the maxillary sinus floor with autogenous marrow and bone. J Oral Surg 1980;38:613–616.
2. Kent JM, Block MS. Simultaneous maxillary sinus floor bone grafting and placement of hydroxyapatite-coated implants. J Oral Maxillofac Surg 1989;47:238–242.
3. Tatum H. Maxillary and sinus implant reconstruction. Dent Clin North Am 1986;30:207–229.
4. Blomqvist JE, Alberius P, Isaksson S. Two stage maxillary sinus reconstruction with endosseous implants: A prospective study. Int J Oral Maxillofac Implants 1998;13:758–766.
5. Valentini P, Abensur DJ. Maxillary sinus grafting with anorganic bovine bone: A clinical report of long-term results. Int J Oral Maxillofac Implants 2003;18:556–560.
6. Tong DC, Drangsholt M, Beirne OR. A review of survival rates for implants placed in grafted maxillary sinuses using meta-analysis. Int J Oral Maxillofac Implants 1998;13:175–182.
7. Ziccardi VB, Bets NJ. Complications of maxillary sinus augmentation. In: Jensen OT (ed). The Sinus Bone Graft. Chicago: Quintessence, 1999:201–208.
8. Cunningham CD, Slattery WH, Luxford WM. Postoperative infection in cochlear implant patients. Otolaryngol Head Neck Surg 2004;131:109–114.
9. Poetker DM, Pytynia KB, Meyer GA, Wackym PA. Complication rate of transtemporal hydroxyapatite cement cranioplasties: A case series review of 76 cranioplasties. Otol Neurotol 2004;25:604–609.
10. Niedergethmann M, Farag Soliman MP, Post S. Postoperative complications of pancreatic cancer surgery. Minerva Chir 2004;59:175–183.
11. Khoury F. Augmentation of the sinus floor with mandibular bone block and simultaneous implantation: A 6-year clinical investigation. Int J Oral Maxillofac Implants 1999;14:557–564.
12. Schwartz-Arad D, Herzberg R, Dolev E. The prevalence of surgical complications of the sinus graft procedure and their impact on implant survival. J Periodontol 2004;75:511–516.
13. Regev E, Smith RA, Perrott DH, Pogrel MA. Maxillary sinus complications related to endosseous implants. Int J Oral Maxillofac Implants 1995;10:451–461.
14. Cawood JI, Howell RA. Reconstructive preprosthetic surgery: I. Anatomical considerations. Int J Oral Maxillofac Surg 1991;20:75–82.
15. Cricchio G, Lundgren S. Donor site morbidity in two different approaches to anterior iliac crest bone harvesting. Clin Implant Dent Relat Res 2003;5:161–169.
16. Smolka W, Iizuka T. Surgical reconstruction of maxilla and midface: Clinical outcome and factors relating to postoperative complications. J Craniomaxillofac Surg 2005;33:1–7.
17. Garg AK. Augmentation grafting of the maxillary sinus for placement of dental implants: Anatomy, physiology and procedures. Implant Dent 1999;8:36–46.
18. Raghoebar GM, Timmega NM, Reinstema H, Boudewijn S, Arjan V. Maxillary bone grafting for the insertion of endosseous implants: Results after 12-124 months. Clin Oral Implants Res 2001;12:279–286.
19. Proussaefs P, Lozada J, Kim J, Rohrer MD. Repair of the perforated sinus membrane with a resorbable collagen membrane: A human study. Int J Oral Maxillofac Implants 2004;19: 413–420.
20. Christen AG. The impact of tobacco use and cessation on oral and dental diseases and conditions. Am J Med 1992;93:25–31.
21. Alabandar JM. Global risk factors and indicators for periodontal diseases. Periodontol 2000 2002;29:177–206.
22. Genco R, Kinane D. Smoking and periodontitis. J Int Acad Periodontol 1999;1:21–33.
23. Tonetti MS. Cigarette smoking and periodontal disease: Etiology and management of the disease. Ann Periodontol 1998;3:88–101.
24. Grossi SG, Skrepcinski FB, De Caro T, Zambon JJ, Cummins D, Genco RJ. Response to periodontal therapy in diabetes and smokers. J Periodontol 1996;67:1094–1102.
25. Schwartz-Arad D, Samet N, Samet N, Mamlider A. Smoking and complications of endosseous dental implants. J Periodontol 2002;73:153–157.
26. Bock KW. Aryl hydrocarbon or dioxine receptor: Biologic and toxic responses. Rev Physiol Biochem Pharmacol 1994;125:1–42.
27. Jansson L, Lavestedt S. Influence of smoking on marginal bone loss and tooth loss. A prospective study over 20 years. J Clin Periodontol 2002;29:750–756.

COPYRIGHT © 2005 BY QUINTESSENCE PUBLISHING CO, INC.
PRINTING OF THIS DOCUMENT IS RESTRICTED TO PERSONAL USE ONLY.
NO PART OF THIS ARTICLE MAY BE REPRODUCED OR TRANSMITTED IN ANY FORM
WITHOUT WRITTEN PERMISSION FROM THE PUBLISHER.