Osteotome-Assisted Sinus Augmentation Procedure for Single Implant Placement in the Atrophic Posterior Maxilla

Case Series
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Written for dentists, hygienists and assistants
ABSTRACT

There are a number of techniques available for performing sinus augmentation surgery, which has been reported to be a highly predictable procedure. The osteotome-assisted sinus augmentation procedure is a technique that enables simultaneous placement of implants in the atrophic maxilla. Carefully following specific steps as described in this article results in clinical success. Using the OASA technique, the size of the incision and reflection of the periosteal flap are minimized and the lateral window is reduced, thereby decreasing the removal of bone from the lateral sinus wall and the potential for postoperative complications, such as swelling and pain.

EDUCATIONAL OBJECTIVES

The overall objective of this article is to provide the reader with information on the osteotome-assisted sinus augmentation procedure.

On completing this article, the reader will be able to do the following:

1. List some of the procedures available for sinus augmentation.
2. Review the steps required for an osteotome-assisted sinus augmentation procedure.
3. Describe the medications that are required post-surgery following an osteotome-assisted sinus augmentation procedure.
4. Review the procedure required for a bone-added osteotome sinus floor elevation and its limitations.
5. Compare and contrast the hybrid technique with the osteotome-assisted sinus augmentation procedure.

ABOUT THE AUTHORS

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Introduction

Sinus augmentation surgery (SAS) has been reported to be a highly predictable procedure for creating bone in the atrophic posterior maxilla to allow implant placement.1-4 There are several methods of accomplishing this. One of the most widely used procedures for SAS is the Lateral Window Sinus Floor Elevation (LWSFE), whereby an osteotomy “window” in the lateral wall of the sinus is made for access. An advantage of the LWSFE is that it allows direct view of the sinus cavity, direct access to the Schneiderian membrane for elevation and easy addition of an appropriate graft material. However, this procedure has the disadvantages of prolonged time, additional cost, and increased morbidity.5

Elevation of the sinus membrane can also be accomplished with a transcrestal approach to the maxillary sinus, known as the Bone Added Osteotome Sinus Floor Elevation (BAOSFE). The transcrestal approach has been advocated as “minimally invasive” because of minimal flap reflection and less postoperative morbidity.6-7 However, limitations of this procedure include diminished accessibility, limited visibility for elevation of the sinus membrane, an inability to diagnose and treat membrane perforations, and potential paroxysmal positional vertigo.6-9 In order to avoid these complications, other approaches have been proposed, including the hybrid technique,10 the balloon-lift control system,11 use of hydraullic pressure,12-13 use of negative pressure14 and piezo-surgical sinus floor elevation.15

Since a crestal osteotome approach involves blind elevation of the sinus floor, the extent to which the sinus floor can be safely elevated prior to membrane perforation is not readily known with this technique. Using a transcrestal sinus elevation technique, perforation rates have been reported to range between 2.2% and 25%.15-20 In a cadaver study, Reiser et al19 reported a 24% membrane perforation rate using the osteotome technique when associated with proximity to either antral septae or the collateral wall of the nose. Toffler, using a Valsalva maneuver, reported a 4.3% clinically detectable perforation rate.16 The reason for this difference in prevalence may be due to the difficulty in detecting small membrane perforations clinically. Moreover, with the limited access utilizing the transcrestal approach, there is little possibility to repair the membrane perforation without changing to an LWSFE approach.19-22

The purpose of this case series was to evaluate the clinical success of simultaneously placing single implants in the atrophic maxilla and augmenting the available native bone using a new surgical approach: the osteotome-assisted sinus augmentation (OASA) procedure. Implant survival, morbidity and complications with this technique were documented and will be reported. Case selection criteria will be discussed, as well the advantages and disadvantages of this technique.

Materials and Methods

Clinical data in this study was obtained from Implant Database (ID). This data set was extracted as de-identified information from the routine treatment of patients at the Ashman Department of Periodontology and Implant Dentistry at New York University College of Dentistry (NYUCD). The ID was certified by the Office of Quality Assurance at NYUCD. This study was in compliance of the Health Insurance Portability and Accountability Act (HIPAA) requirements.
Study Subjects
Fifteen consecutive posterior partially edentulous patients with posterior maxillary atrophy who underwent single implant placement using the OASA procedure from August 2009 to August 2011 were chosen from the ID and were included in this study. The population consisted of 6 male and 9 female patients with a mean age of 52 years (range: 44 to 62). Each subject selected from the database for this study had to have conformed to the following criteria prior to undergoing the OASA procedure:

Inclusion Criteria:
All subjects were required to have:
1. A panoramic radiograph and reformatted computed tomography (CT) scans.
2. A posterior maxillary partially edentulous area with limited vertical bone height, 4-7 mm, and requiring single implant placement. (Figs. 1-2)
3. A healed ridge at least 3 months following tooth extraction.
4. The final implant restoration in function for a minimum of 6 months.

Exclusion Criteria:
1. Presence of uncontrolled diabetes, immunological diseases or other systemic conditions that contraindicated surgery.
2. Radiation therapy to the head and neck region in the 12 months prior to the proposed therapy.
3. Chemotherapy within a 12-month period prior to the proposed therapy.
4. Periodontal disease, or an unwillingness to undergo needed periodontal therapy, around the remaining teeth.
5. Active sinus infection, or a history of persistent sinus infection.
6. Smoking habit of one pack or more per day and an unwillingness to enter a smoking cessation protocol.
7. Psychological problems that, in the opinion of the surgeons, would have rendered the delivery of comprehensive therapy untenable.
8. Unwillingness to commit to a long-term post-therapy maintenance program.

Prior to OASA surgery, a complete examination of oral hard and soft tissues was conducted for each patient, and a dental treatment plan was formulated in conjunction with the treating restorative dentist. Diagnostic casts, wax-ups and surgical templates were also prepared prior to surgery.

In conjunction with the OASA procedure, single rough-surface implants were placed and submerged. The time between stage 1 and stage 2, abutment placement surgery, ranged from 3 to 6 months. All implants were restored as

Figure 1. Preoperative X-ray of the missing maxillary 2nd premolar tooth with < 7 mm of native bone remapping
Figure 2. Clinical preoperative view of edentulous premolar area
single-tooth restorations. Patients were recalled every 3 months for supportive care and evaluation.

The criteria for determining survival required that the implant be in function for at least 6 months. In addition, the implant had to meet the following conditions (modifications of Albrektsson success criteria) to be considered a success:
1. The individual, unattached implant be immobile when tested clinically.
2. Postsurgical periapical radiographs that demonstrated no evidence of peri-implant radiolucency.
3. Vertical bone loss, as measured on a nonstandardized radiograph, using the implant platform as the reference point, be less than 0.1 mm semiannually following the implant being placed in function. Periapical radiographs were taken at follow-up visits and compared with the radiographs taken after implant placement (baseline). Radiographic bone loss was computed using magnification and measurements determined by comparison of actual and radiographic implant length.
4. The implant was characterized by an absence of persistent and/or irreversible signs of complications such as pain, infection, neuropathy or paresthesia/anesthesia.

**Description of the OASA Procedure**
The clinical procedures were standardized and followed the protocol as described below:
1. Patients were prescribed 2 g of amoxicillin 1 hour prior to surgery or if allergic, 600 mg of clindamycin 1 hour prior to surgery.
2. Local infiltration anesthesia of lidocaine 2% containing epinephrine at a concentration of 1:100,000 was used, or Carbocaine 3% administered in cases where a vasoconstrictor was contraindicated.
3. A midcrestal incision, between the two adjacent teeth, was performed, followed by a single vertical releasing incision from the distal aspect of the adjacent anterior tooth to the mucogingival junction. (Fig. 3) A full-thickness mucoperiosteal flap was raised, exposing the lateral sinus wall. (Fig. 4a)
4. A small round-shaped osteotomy consisting of a 2 to 3 mm diameter window was prepared in the lateral wall, using a high-speed round #6-#8 diamond bur with copious irrigation, followed by use of a piezo-surgical tip. This window was created at the height of the apex of the planned implant. (Figs. 4b, c)
5. The integrity of the Schneiderian membrane was assessed visually.
6. The following algorithm was followed:
   a. Intact membrane – continue procedure according to the technique.
   b. Perforated membrane – modification of the osteotomy in which a wider lateral window was prepared to allow increased access to repair the membrane. The membrane was repaired using an absorbable collagen wound dressing (CollaTape, Zimmer Dental Inc, Carlsbad, CA) to completely cover the perforation, allowing the graft material to be placed in the contained space.
7. The round-shaped osteotomy made previously in the lateral wall was expanded in an apico-coronal direction, creating a vertical slot of 5-7 mm, to allow access for atraumatic elevation of the membrane from the floor of the sinus. (Figs. 5a, b)
8. The sinus membrane was fully elevated mesiodistally and medially over the drilling site, using a sinus membrane elevator (SSC1, EBI Implant, Kyungsan, South Korea)
inserted through the access slot on the lateral wall. (Fig. 5c)

9. Depth drilling for implant placement with irrigation was performed according to the manufacturer’s instructions in a serial sequence to the final diameter drill while the membrane was elevated and protected with a periosteal elevator.

10. The bone graft material (Anorganic Bovine Bone Matrix, Bio-Oss, Osteohealth, Shirley, NY) 1:1 mixture of 0.25-1.0 mm particle size and 1.0-2.0 mm particle size) was placed and condensed from both the lateral and crestal directions prior to implant placement. (Fig. 6a)

11. The implant was then placed according to the manufac-
turer’s instructions and the cover screw was inserted. If needed, an additional amount of bone graft material was then added from the lateral window to completely surround the implants. (Figs. 6b, c)

12. To obtain tension-free closure, interrupted resorbable sutures were placed using 4.0 Vicryl (Ethicon Inc, Somerville, NJ) for the midcrestal closure and 5.0 chromic gut for vertical incision closure. (Fig. 7) A radiograph was taken immediately following implant placement. (Fig. 8)

13. Postoperative medications consisted of antibiotics (amoxicillin 500 mg or clindamycin 150 mg) prescribed for 7 days (tid). 0.2% chlorhexidine was also prescribed starting 24 hours after surgery and was used twice a day for 2 weeks. Analgesics as needed for pain were prescribed (ibuprofen 600 mg q 4-6 h.).

14. Postoperative care instructions, including a soft diet and oral hygiene procedures, were given to the patient.

15. Follow-up examination with periapical radiographs was performed 7-14 days post-operative.

16. Stage 2 surgery (abutment placement) was performed 4 months following implant placement, at which time implant mobility was assessed. Final restorations were placed 1-2 months after stage 2 surgery. (Figs. 9-10)

17. Patients were recalled at 3, 6, 12, 18 and 24 months following final restorations for follow-up examination and periapical radiographs.

All patients were monitored with routine follow-up for all surgical and restorative implant procedures. Radiographic parameters measured included preoperative crestal bone height, postoperative augmented bone height and crestal bone loss around the implant from time of implant placement to the final follow-up visit. A comparison of these measurements was performed and recorded.

**Results**

Fifteen single implants were placed in 15 patients following the protocol of the OASA technique. All 15 implants were successful at the 6 to 24 month post-loading time period.

The mean gain in bone height was 7.18 mm (range of 4.72-8.77 mm). The crestal bone loss around the implants from time of placement to the final follow-up averaged 0.82
mm (range of 0.31-1.43 mm). One out of 15 (6.7%) membranes had a detectable perforation, which was repaired during surgery. (Table 1)

Discussion

The Bone Added Osteotome Sinus Floor Elevation (BAOSFE) procedure is considered to be a less traumatic technique than the Lateral Wall Sinus Floor Elevation (LWSFE) procedure, with reported similar success rates.16,22-26

The results of the present study utilizing the OASA procedure showed a 100% implant survival rate in the atrophic posterior maxilla, which is comparable with results re-
ported in systematic reviews for the crestal approach, which documented implant survival rates between 93.5% and 96.4%,22,23 and between 91.5% and 92.6% for the lateral window technique.2,3

However, limited accessibility and visibility for elevating the sinus membrane is one of the major limitations of the BAOSFE approach. The most common complication that occurs with the BAOSFE technique is the iatrogenic perforation of the Schneiderian membrane during elevation.23,27 Membrane perforation, according to the literature, is strongly associated with the appearance of postoperative complications that include acute or chronic sinus infection, bacterial invasion, swelling, bleeding, wound dehiscence, loss of the graft material, and a disruption of normal sinus physiologic function.8,17,21,28-35 When transcrestal “minimally invasive” sinus augmentation techniques are applied, BAOSFE, perforation of the Schneiderian membrane may not be detected unless an intraoperative antroscopy is carried out.7 In the present study the perforation rate was 6.7%.

The primary purpose for modifying the BAOSFE with a 2-3 mm lateral window osteotomy (OASA technique) was to provide good visual access for reflecting the Schneiderian membrane at the inferior border of the sinus floor, avoid perforation of membrane and have better control of bone graft placement. Drilling with direct vision and the protection of the elevated membrane with a periosteal elevator avoided the risk of an osteotome touching the membrane, which also decreased the chance of perforation related to the preparation of the osteotomy.21,24 In addition, eliminating the osteotome tapping results in reduced patient discomfort and avoids paroxysmal positional vertigo that has been reported to be induced by head trauma with vibratory and percussive pressures on the upper maxilla.10,11 Another drawback with the BAOSFE technique is that it has been

### Table 1. Data of case series with the OASA procedure

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<th>Postoperative bone height (mm)</th>
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reported to be less predictable with 4 mm or less of preexisting alveolar bone height beneath the sinus.\textsuperscript{24} When the membrane is lifted more than 3 mm, use of an endoscope is recommended due to the risk of membrane perforation, thus increasing the cost and time of the procedure.\textsuperscript{21} An average of 2-3.5 mm gain of bone height has been reported with the BAOSFE.\textsuperscript{35-36} Thus, in cases when crestal height is 4-7 mm and an implant length of 10-13 mm is desired, the BAOSFE may not achieve sufficient bone height and the risk of membrane perforation may be increased. With the OASA technique, the operator has more control of the bone grafting placement. Using a conventional LWSFE, bone removal may be excessive when used for single implant placement. Utilizing the OASA technique, direct addition of the graft materials through the drilling site results in an even distribution in all directions and creates a dome-shaped elevation around the implant apex. The ability to add additional bone through the window allows the graft material to surround the entire body of the implant and improves graft to bone contact.

Using the OASA technique, the size of the incision and reflection of the periosteal flap are minimized with respect to the conventional LWSFE. The lateral window is reduced, thereby decreasing the removal of bone from the lateral

Figure 15. Osteotomy window on lateral wall of sinus

Figure 16. Bone graft and implants in place

Figure 17. Tension-free closure achieved

Figure 18. X-ray at time of implant placement and 4 months post-op

Figure 19. Final restorations in place, lateral view

Figure 20. X-ray of final restorations
sinus wall and allowing more cells from the intact sinus wall to contribute to the healing. Reduced bone removal decreases potential postoperative complications, such as swelling and pain. The limited-size lateral wall osteotomy also reduces the potential for disruption of vascular intraosseous anastomoses in the lateral sinus wall.

Comparison of the hybrid technique (10) with the OASA procedure shows similar implant survival rates at an average 27.3-month follow-up period. The hybrid technique combines a transcrestal approach with a small (3-5 mm) horizontal slot-shaped osteotomy made along the lower border of the sinus floor. The osteotomy is extended mesiodistally to include the planned implant sites. This technique can be considered a modified LWSFE when more than one implant is planned. However, the authors prefer the conventional LWSFE when more than one implant is required.1-4

Within the limitations of the present study with the small number of patients (15 subjects) and the relatively short follow-up period (24 months), the results showed a 100% implant success rate, a low incidence of membrane perforation (6.7%) and an average increase in bone height of 7.18 mm obtained with the OASA procedure. This technique has many advantages compared to the LWSFE and BAOSFE techniques when used for single implants or when multiple implants are placed but only one implant has deficient native bone < 7 mm that limits implant placement. (Figs. 11-20) However, additional research with more cases and long-term clinical evaluation is required to verify the results achieved in the current investigation.

References
18. Berengo M, Sivolella S, Majzoub Z, Cordioli G. Endoscopic

Webliography
1. Sinus augmentation surgery has been reported to be a highly predictable procedure for __________ in the atrophic posterior maxilla to allow implant placement.
   a. filling in deficiencies of the sinus space
   b. increasing the available sinus
   c. creating bone
   d. a and b

2. An osteotomy “window” is made in the __________ for access, when performing the Lateral Window Sinus Floor Elevation.
   a. apical wall of the sinus
   b. lateral wall of the sinus
   c. nasal passage
   d. all of the above

3. An advantage of the Lateral Window Sinus Floor Elevation is that it allows for __________.
   a. direct view of the sinus cavity
   b. direct access to the Schneiderian membrane
   c. easy addition of an appropriate graft material
   d. all of the above

4. Elevation of the sinus membrane with a transcrestal approach to the maxillary sinus has been advocated as “minimally invasive” because of __________.
   a. less postoperative morbidity
   b. minimal flap reflection
   c. a lower risk of periodontal disease
   d. a and b

5. A crestal osteotome approach involves ______ of the sinus floor.
   a. blind elevation
   b. direct visualization
   c. visible reduction
   d. all of the above

6. Toffler, using a __________ maneuver, reported a 4.3% clinically detectable perforation rate.
   a. Vasalla
   b. Valhalla
   c. Valsalva
   d. none of the above

7. Membrane perforation, according to the literature, is strongly associated with __________.
   a. acute or chronic sinus infection
   b. wound dehiscence
   c. bacterial invasion
   d. all of the above

8. Patients were instructed ______ following the procedure.
   a. to eat a soft diet
   b. on oral hygiene procedures
   c. on suture removal
   d. a and b

9. One of the criteria for determining survival in the current case study was that the implant be in function for at least __________.
   a. 3 months
   b. 6 months
   c. 9 months
   d. 12 months

10. Using a transcrestal sinus elevation technique, perforation rates of up to ______ have been reported.
    a. 5%
    b. 15%
    c. 25%
    d. 35%

11. Radiographic bone loss was computed using magnification and measurements determined by comparison of __________ implant length.
    a. actual and radiographic
    b. actual and envisioned
    c. desired
    d. none of the above

12. In a cadaver study, Reiser et al reported a 24% membrane perforation rate using the osteotome technique when associated with proximity to the __________.
    a. antral septae or the palatal canal
    b. antral septae or the collateral wall of the nose
    c. teeth or antral septae
    d. all of the above

13. The Bone Added Osteotome Sinus Floor Elevation (BAOSFE) procedure is considered to be ______ the Lateral Wall Sinus Floor Elevation (LWSFE) procedure, with reported similar success rates.
    a. a less traumatic technique than
    b. as traumatic as
    c. a more traumatic technique than
    d. none of the above

14. One hour prior to surgery, patients were prescribed 2 g of amoxicillin or if allergic, 600 mg of ________.
    a. fibromycin
    b. clindamycin
    c. erythromycin
    d. any of the above

15. During the osteotome-assisted sinus augmentation (OASA) procedure, a ______ incision, between the two adjacent teeth, was performed, followed by ______ releasing incision.
    a. midcrestal; a single horizontal
    b. lateral; a double vertical
    c. midcrestal; a single vertical
    d. lateral; a single vertical
16. Using the OASA technique, the size of the incision and reflection of the periosteal flap are _______ with respect to the conventional LWSFE.
   a. minimized  
   b. maximized  
   c. avoided  
   d. none of the above

17. The integrity of the Schneiderian membrane was assessed _______ during the OASA procedure.
   a. radiographically  
   b. manually  
   c. visually  
   d. all of the above

18. If during the procedure the Schneiderian membrane was found to be perforated, a wider lateral window was prepared to allow increased access to _______.
   a. allow for more infiltration  
   b. repair the membrane  
   c. remove the membrane  
   d. increase the likelihood of spontaneous repair

19. During the OASA procedure, the sinus membrane was fully elevated mesiodistally and medially over the drilling site using a _______.
   a. retractor  
   b. scalpel  
   c. sinus membrane elevator  
   d. a and b

20. The bone graft material was placed and condensed from both the _______ directions during the OASA procedure prior to implant placement.
   a. incisal and midcrestal  
   b. lateral and crestal  
   c. vertical and crestal  
   d. all of the above

21. If an additional amount of bone graft material was required when the implant was being placed, this was added from the _______ to completely surround the implants.
   a. lateral window  
   b. vertical window  
   c. nasal passageway approach  
   d. all of the above

22. Following the OASA procedure, 0.2% chlorhexidine was also prescribed starting _______ after surgery and was used twice a day for _______.
   a. 24 hours; 1 week  
   b. 48 hours; 1 week  
   c. 24 hours; 2 weeks  
   d. 48 hours; 2 weeks

23. To obtain tension-free closure at the end of the OASA procedure, _______ sutures were placed.
   a. resorbable mattress  
   b. nonresorbable mattress  
   c. interrupted resorbable  
   d. interrupted nonresorbable

24. Stage 2 surgery (abutment placement) was performed _______ following implant placement.
   a. 1 month  
   b. 2 months  
   c. 3 months  
   d. 4 months

25. Final restorations were placed _______ after stage 2 surgery.
   a. 1-2 months  
   b. 2-3 months  
   c. 3-4 months  
   d. 4-6 months

26. _______ were made prior to surgery in the current case study.
   a. Wax-ups  
   b. Diagnostic casts  
   c. Surgical templates  
   d. all of the above

27. _______ is the most common complication that occurs with the BAOSFE technique.
   a. Poor implant placement  
   b. Copious bleeding  
   c. Iatrogenic perforation of the Schneiderian membrane during elevation  
   d. all of the above

28. A small round-shaped osteotomy window was prepared in the lateral wall _______.
   a. using a high-speed round #6-#8 diamond bur with copious irrigation  
   b. using a piezo-surgical tip  
   c. at the height of the apex of the planned implant  
   d. all of the above

29. Eliminating osteotome tapping during a sinus augmentation procedure _______.
   a. results in reduced patient discomfort  
   b. reduces bone protruberances  
   c. avoids paroxysmal positional vertigo  
   d. a and c

30. Comparison of the hybrid technique with the OASA procedure shows _______ implant survival rates.
   a. similar  
   b. higher  
   c. lower  
   d. none of the above

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EDUCATIONAL OBJECTIVES
- List some of the procedures available for sinus augmentation.
- Review the steps required for an osteotome-assisted sinus augmentation procedure.
- Describe the medications that are required post-surgery following an osteotome-assisted sinus augmentation procedure.
- Review the procedure required for a bone-added osteotome sinus floor elevation and its limitations.
- Compare and contrast the hybrid technique with the osteotome-assisted sinus augmentation procedure.

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