Lateral antrostomy technique for maxillary sinus augmentation

Authors_Hussam Batal, DDS, DMD, and Olena Norris, DDS

Implant dentistry has become an integral treatment modality in dentistry and is to be considered a viable option in the restoration of partially edentulous maxillary arches. However, when presented with a deficient maxillary alveolar ridge, placement and/or longevity could be jeopardized without proper treatment. Maxillary sinus augmentation has shown to be a successful treatment option for restoration of anatomic deficiency in the posterior maxilla; this article will review the lateral antrostomy technique.

History

Lateral antrostomy technique was first described by Tatum in 1976, first published by Boyne and James in 1980, and is commonly referred to as lateral antrostomy approach to the maxillary sinus floor. Currently, this method has become a common surgical technique, as it allows regeneration of bone in the posterior maxilla.

The primary procedural approach involves surgical access through the lateral wall of the zygomatic buttress of the maxilla followed by elevation of the sinus membrane and placement of bone-grafting material.

An alternative approach, advocated by Summers, is the crestal or "osteotome" technique. This procedure is less invasive, with reduced healing and overall treatment time; however, it is site specific and allows for only limited augmentation.

Anatomy

The maxillary sinus is a pyramidal-shaped cavity with four walls with the base facing the lateral nasal wall, the apex extending to the zygomatic buttress and the anterior extending to canine and premolar area. The average dimension of an adult sinus is 2.5-3.5 cm in width, 3.6-4.5 cm in height and 3.8-4.5 cm in depth; with an approximate volume of 12-15 cubic cm. Blood supply to the maxillary sinus is derived from the posterior superior alveolar, infraorbital, greater palatine arteries and terminal branches of the internal maxillary artery. The extent of pneumatization varies from person to person and increases with age.

The maxillary sinus is lined with the sinus membrane, also known as Schneiderian membrane, which, like the rest of the respiratory tract, consists of thin pseudo stratified ciliated columnar epithelium. The membrane is continuous with the nasal epithelium through the ostium of the middle meatus with a thickness of approximately 0.8 mm. Antral mucosa is thinner and less vascular than the respiratory mucosa. Nerve supply to the sinus is derived from the superior alveolar branch of the maxillary (V2) division of the trigeminal nerve.
Proper function of the maxillary sinus depends on the balance of mucous production, transport via ciliated epithelium and adequate drainage through the ostium. There are local conditions that affect sinus function; they might be reversible or irreversible. Irreversible conditions include malignant or benign tumors of the naso-maxillary region; these are contraindications for sinus augmentation. Reversible conditions can be treated prior to sinus augmentation, one example being the narrowing of the osteomeatal complex that could compromise sinus drainage.

Additional reversible conditions include sinus disease, such as polyps or mucous retention cysts. Bacterial sinusitis with air fluid level should always be treated prior to sinus augmentation. The majority of these conditions are treated with medical or endoscopic sinus surgical procedures. Cone-beam computerized tomography (CBCT) scan prior to sinus augmentation is strongly recommended but not considered mandatory. A CT scan yields information regarding pathology in the sinus or chronic sinusitis and is used for precise location of the lateral approach to the maxillary sinus cavity. A common finding on CT scan, especially in smokers, is mucosal thickening; this condition is not considered contraindication to sinus augmentation.

Patient evaluation

Patients referred for posterior maxilla implant placement with concomitant sinus surgery should be assessed for possible general risk factors such as allergic rhinitis, history of chronic or recurrent sinusitis (multiple infections lasting more than four weeks or four episodes of acute sinusitis in the previous 12 months). Chronic use of nasal steroids or vasoconstrictors, chronic nasal obstruction or rhinorrhea, chronic hyposmia or hypogeusia are also to be assessed. Previous treatment of head and neck neoplasms, radiotherapy to head and neck region and other co-morbidities, including immune-deficiencies, active bone disease (fibrous dysplasia, Paget’s disease, osteomyelitis), cystic fibrosis, asthma and chronic pulmonary disease should all be included in overall assessment. CT scans can aid in determination of sinus anatomy and pathology. A thorough intraoral exam should be performed to evaluate general dental pathology, inter-ridge space and alveolar ridge contour/width.

Technique

Lateral antrostomy technique is performed superior to the residual alveolar bone. Treatment initiates with the administration of a single preoperative dose of systemic antibiotic (Amoxicillin, clindamycin or levaquin) and Chlorhexidine 0.12 percent rinse. Local anesthesia is achieved by maxillary vestibular infiltration and middle/posterior superior alveolar nerve block (V2). Ideally, a mid-crestal or a slightly palatal incision performed, leaving at least 3 mm of attached tissue on the facial aspect of the incision.
with anterior and posterior vertical release. These vertical incisions should be at least 5 mm away from the planned osteotomy (Fig. 1). Full-thickness mucoperiosteal flap is then raised and the lateral aspect of the maxillary sinus is exposed.

The design of the antrostomy is based on the outline of the sinus on the CT scan, which also aids in determining the thickness of the lateral wall of the antrum, position of the antral floor from the crest of the ridge, relationships to the teeth (if present) and the presence of septa. Palatal transillumination can also aid in establishing the outline of the maxillary sinus (Fig. 2). Osteotomy can be performed using conventional rotary instruments at 800–50,000 rpm with irrigation for cooling. However, ultrasonic hand-pieces are preferred to conventional rotary instruments in order to decrease the risk of membrane perforation. Bone thinning is accomplished utilizing light pressure under copious cooling irrigation. Regardless of the instrumentation used to create the osteotomy, there are generally two techniques to create the lateral window: the “trap door” approach and the “access hole” approach (Figs. 3, 4).

Osteotomy should follow the outline of the sinus and should not be more than 3 mm away from the floor (Fig. 5); greater distances decrease the ability of hand-eye coordination and increase the chance of membrane perforation. The corners of the access window are usually round rather than at right or acute angles, as sharp corners increase the risk of membrane perforation when a trap-door approach is used.

The window should be large enough to allow access for instrumentation. If a trap-door approach is used, the height of the osteotomy should not exceed the width of the sinus, allowing for final horizontal positioning of the new floor. Upon thinning of the bone, a bluish hue of the membrane should be noted. Curettes are used to carefully elevate the sinus membrane and should always be maintained on the bony floor or sinus walls to avoid membrane perforation. The sequence of membrane elevation is from the sinus floor, toward the posterior wall, then superior wall and finally to the anterior wall (Fig. 6a).

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The membrane should be elevated from the medial sinus wall to allow for optima graft placement (Fig. 6b); use of an iodophor gauze strip soaked in 2 percent Lidocaine with 1:100,000 epinephrine left in the space for five minutes minimizes bleeding and allows for better visualization before further dissection (Fig. 7).
The space created after sinus membrane elevation is grafted with optional materials (Fig. 8a). A collagen resorbable membrane is used to cover the window (Fig. 8b) and the mucoperiosteal flap is then repositioned and sutured. The presence of antral septa can create additional difficulty at the time of surgery; incidence of septa is approximately 30 percent and configuration is variable.

The use of CT scans prior to sinus graft surgery allows for additional information regarding the configuration of the septa and potential modification of the procedure depending on the location of the septa. Double window antrostomy approach is preferred in the presence of septa, with one window anterior to the septa and one posterior, elevating the sinus membrane from the lateral walls and above the septa (Fig. 9).

Post-operatively, patients are given a seven-day course of antibiotic (500 mg Amoxicillin three times per day, 500 mg Levaquin per day or 300 mg Clindamycin four times per day), Chlorhexidine 0.12 percent rinse (twice daily) and sinus precautions for a week, especially if sinus perforation was noted. Patients with history of chronic sinusitis could benefit from the use of nasal decongestants (Oxymetazoline 0.05 percent and sodium chloride 0.65 percent). The graft should be left to heal for a minimum of four to nine months, dependent on the type of grafting material used. In cases of simultaneous implants and sinus augmentation, the sinus membrane should be elevated prior to starting the implant osteotomy.

Prior to placement of the implant, the medial and anterior aspect of the sinus should be grafted (Fig. 10).

**Success rate**

Variables that affect success rate of implants in combination with sinus floor elevation include implant surface, type of bone graft, residual height of

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**Fig. 7** Use of iodophor gauze strip to minimize bleeding and improve visualization.

**Fig. 8a** Bone graft placed after membrane elevation.

**Fig. 8b** Collagen membrane placed over the lateral window.

**Fig. 9** 'Double window' technique for sinus augmentation in presence of septum.
bone, sinus membrane perforation and placement of collagen membrane over the lateral window.

**Implant surface**

The annual failure rate for machine surface implants is significantly higher (p < 0.0001) than for rough surface implants. Rough surface implants have 1.19 percent annual failure rate with three-year survival of 96.5 percent, as compared to machined surface implants with annual failure rate of 6.86 percent and three-year success rate of 81.4 percent. The healing phase failure rate for machined surface implants is 8.1 percent, compared to 1.1 percent for rough surface implants.

**Bone graft types**

Grafting material can be of human, animal, BMP or synthetic origin. Autogenous bone grafts (iliac crest, calvarial bone, chin, anterior ramus, alveolar ridge, tuberosity) remain the gold standard in bone-augmentation procedures; however, many allografts, xenografts and alloplastic materials have also been used successfully. Regardless of the type of bone graft, there is strong evidence that all grafting materials are effective, differing only in duration of healing time and amount of bone formation.

Studies suggest the best grafting protocol is coagulum with autogenous particulate bone, alone or with DBBM or DFDBA, with an estimated three-year survival rate 96.8-99.8 percent for rough surface implants. Studies have also shown that particulate bone grafts provide better outcomes, as compared to block grafts. Wallace et al reports an implant survival rate for iliac block grafts of 80.40 percent compared to a rate of 94.83 percent for particulate grafts. Testori et al has similar reports that use of particu-
late grafts alone increases implant survival to 92.5 percent as compared to 82.9 percent for autogenous block grafts alone.

It has been demonstrated that grafted sinuses may undergo re-expansion over time, in particular, during the initial two to three years after the procedure. The use of nonresorbable or slowly resorbable grafting materials should prevent this phenomenon. If particulated autogenous bone is used with xenografts or alloplastic materials, such as DBBM or HA, it should reduce the risk of bone resorption and sinus re-pneumatization.

Residual bone height
Sinus grafting and implant placement can be accomplished as a one-stage or two-stage procedure, with the decision often dictated by the amount and quality of the residual alveolar bone. This is attributable to the fact that it is difficult to achieve primary stability with a decrease in residual bone height (RBH). RBH can be measured on the periapical radiograph. In 1996, the Sinus Consensus Conference issued recommendations, dependent on the vertical dimension of the residual bone between the alveolar crest and the maxillary sinus floor. When RBH is greater than 10 mm (Class A), a classical implant procedure should be performed. When RBH is 7 mm to 9 mm (Class B), an osteotome technique should be applied in combination with immediate implant placement.

When the RBH is 4 mm to 6 mm (Class C), a lateral approach involving a grafting material with immediate or delayed implant placement is recommended. Finally, when RBH is 1 mm to 3 mm (Class D), a lateral approach involving bone-grafting material and delayed implant placement should be used.

Fig. 13a Classification of sinus membrane perforation.
Fig. 13b Class II (mesial) perforation of sinus membrane.
Fig. 14a Repair of membrane perforation with collagen membrane.
Fig. 14b Mixture of autogenous grafts, DBBM and PRGF.
general, immediate placement is not indicated when the residual height is less than 4 mm and in cases of poor bone quality. It has been demonstrated that immediate implant placement with less than 5 mm residual bone height noted significantly lower implant survival rates as compared to placement in more than 5 mm residual bone. The implant success rate is 96 percent when RBH is 5 mm or more and 85.7 percent when RBH is 4 mm or less.

Membrane over window
Positive effects of membrane are:
- prevents soft tissue ingrowth,
- contains particulate graft material,
- increases vital bone formation,
- increases implant survival rate
- and promotes positive outcome when used for perforation repairs.

Several studies have shown increased bone formation when membrane is placed over the lateral window.

Membrane perforation
Studies show no difference in success rates in cases with or without sinus membrane perforation. If repair is successful, membrane perforation does not appear to be associated with post-operative complication or reduced implant survival.

Complications of lateral antrostomy
Complications may occur intraoperatively or postoperatively. Common intraoperative complications are perforation of the sinus membrane, bleeding and perforation of the buccal flap (very rarely). Bleeding from the lateral antrostomy is rare and usually temporary in nature. Branches of the posterior superior alveolar artery are present in lateral maxillary sinus wall and could be injured during preparation of the lateral window, especially in cases of extensive maxillary resorption.

Excessive bleeding may occur with elevation of sinus membrane from the medial wall of the antrum, which is a location of the lateral nasal artery (branch of the sphenopalatine artery). The most common intraoperative complication is sinus membrane perforation. Membrane perforations may cause increased risk of short-term complications, such as acute or chronic sinus infections, bacterial invasion of the graft or loss of the graft material into the sinus. Sinus membrane perforation occurs in 11 percent to 56 percent of procedures during preparation of the lateral window, sinus membrane elevation or placement of the bone graft. Several factors affect the rate of perforation.

First factor is the thickness of the sinus membrane — rate of perforation of 41 percent reported with sinus membrane of less than 1.5 mm. Second factor is the width of the sinus (Fig. 11), i.e., the angle between the medial and the lateral walls. The narrower the angle, the higher the incidence of perforation — 0 percent incidence in angles greater than 60 degrees and 62 percent with angles less than 30 degrees. The angle is narrower in the anterior portion of the sinus and wider in the posterior aspect of the sinus.

Consequently, we recommend elevation of the floor, posterior wall, superior and anterior walls; such sequencing allows elevation from a wider portion to the narrower portion of the sinus. In addition, placing the window 3 mm above the floor and anterior wall will allow better coordination of eye-hand movement and decrease incidence of perforation. Third factor is the presence of septa; these cases are better approached utilizing a two-window approach with elevation of the membrane around the septum at the last stage (Fig. 12).

Perforation during placement of the graft is usually because of pressure against the membrane; this
can be avoided by packing the graft against the floor and anterior wall (Fig. 13). Utilizing ultrasonic drills also decreases the risk of membrane perforation, with incidence of perforation of 3–7 percent; as compared to 16-46 percent utilizing conventional drills.

**Membrane perforation types**

Membrane perforations are classified based on their location. Class I perforations typically occur along the apical wall of the prepared sinus window. Class II perforations occur along the lateral or crestal aspects of prepared sinus window, and they are subdivided as mesial, distal and crestal. Class III perforations occur at any location within the body of the prepared sinus widow (Fig. 14).

Upon discovery of a perforation, ascertain its size and extend the osteotomy to gain better visualization and access to the sinus window. Intact membrane elevation should proceed in the area away from the site of the perforation and only after obtaining enough reflection of the membrane; the membrane in the area of the perforation should be reflected.

**Membrane perforation repair**

Membrane repair varies and is dependent on the size and location of the perforation. With Class I perforations, sinus membrane elevation proceeds along a normal course and apical to the displacement of the sinus membrane, resulting in it folding over itself and thus sealing the perforation. In cases of Class II perforations, extend the osteotomy mesially or distally to expose intact sinus membrane; if more than 3 mm of perforation is present or the membrane does not fold on itself, place a collagen membrane over the perforation area.

In cases of Class II perforations, when it is not possible to remove additional bone mesial to the prepared sinus window or in Class III cases of extensive sinus perforations, a membrane is shaped and inserted into the sinus window with its ends extruding out of the window. In general, during placement of the bone graft, the membrane will get displaced medially and inferiorly.

Extruding aspects of the membrane can be secured to the external aspect of the alveolar bone with fixation tacks to decrease displacement of the membrane. Curettes are used to mold the membrane to ensure adequate space for augmentation material. In addition to using a membrane, the use of consolidated particulate graft material decreases the incidence of migration of graft material into the sinus.
Common post-operative complications are dehiscence of the incision line, migration of implant into the sinus (Fig. 15), loss of graft material, antral ostium obstruction, oral antral communication, graft infection (Fig. 16) and maxillary sinusitis. Postoperative infection has been reported in 2-5 percent of cases. Symptoms associated with post-op infection include erythema, tenderness, swelling, purulent discharge, nasal congestion and fistula.

Patients with a history of chronic sinus infection or sinus disease are at higher risk for post-operative graft infection or sinusitis. Untreated periapical pathology, extended surgical time and bacterial contamination of the graft may also contribute to infection. The two most common postoperative complications are graft infection or postoperative sinusitis; CT scans help to establish proper diagnosis (Fig. 17).

Antibiotics provide coverage for common sinus microorganisms, such as *S. Pneumonia, H. Influenza* and *M. Catarrhalis*. Appropriate antibiotic therapy is Augmentin in non-penicillin allergic patients and Levaquin in penicillin allergic patients. Treatment of postoperative infection includes antibiotic therapy and incision-drainage with cultures and removal of the graft, if infection does not respond to antibiotic therapy.

References

5) Chen et al. Implant placement immediately after the lateral approach to the trap door window procedure to create a maxillary sinus lift without bone grafting: a two-year retrospective evaluation of 47 implants in 33 patients. JOMS. 2007.