REVIEW ARTICLE

Maxillary Sinus Floor Elevation Surgeries: An Overview

Riddhi Katara,[1] D. Gopalakrishnan,[2] Tuhina Tyagi,[1] Disha Kataria,[1] Gurbani Kaur,[1] Archana Singh[3]

ABSTRACT

Maxillary sinus floor elevation surgeries were developed to increase the height of bone in the subsinus region of the posterior maxilla. This height is required for implant placement in the posterior maxillary region. These surgeries have developed in due course of time from being highly invasive to minimally invasive procedures. The basic procedure involves making a window in the lateral maxillary wall and then a direct sinus lift surgery is performed. The indirect method is crestal and is more conservative. Implants can be placed immediately at the time of the surgery or after a healing of 6 to 9 months. This article provides an overview of the surgical techniques with their advantages and disadvantes as well as their complications.

Key words: Anatomy; Crestal approach; Lateral approach; Sinus augmentation; Sinus floor elevation; Sinus grafting.

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[1,3,4,5] Post graduate student, [2]Professor and Head of Department, [3]Professor, Department of Periodontology and Oral Implantology, Dr. D. Y. Patil Dental College & Hospital, Dr. D. Y. Patil Vidyapeeth, Pimpri, Pune, India.

Corresponding author: Dr. Riddhi D. Katara, Post graduate student, Department of Periodontology and Oral Implantology, Dr. D. Y. Patil Dental College & Hospital, Dr. D. Y. Patil Vidyapeeth, Pimpri, Pune, Maharashtra, India.

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INTRODUCTION

The successful placement of a dental implant in the edentulous posterior maxilla is compromised by the lack of adequate vertical dimension of alveolar bone present between the alveolar crest and the maxillary sinus floor. The proximity of the maxillary sinus to the alveolar crest is enhanced by sinus pneumatization, and resorption of the alveolar ridge owing to tooth extraction, trauma, or pathology. This, prevents placement of the implant of adequate length.[1,2] A minimum of 10 mm of vertical bone height is usually required for predictable implant success.[3] Also a decreased implant success rate is seen due to the poor bone density of posterior maxilla. To increase the height of bone in the posterior maxilla, maxillary sinus floor elevation surgeries were developed. Sinus elevation surgery for implant placement was initially described by Boyne and James and by Tatum.[4, 5]

ANATOMY OF THE MAXILLARY SINUS

The maxillary sinus is an air cavity located in the maxilla. It is pyramidal in shape and is frequently reinforced with internal vertical septa, creating intrasinus cavities. The base of the pyramid is the medial wall of the sinus, which is also the lateral wall of the nasal cavity, and its apex is pointed toward the zygomatic bone. The roof of the sinus is also the floor of the orbit. The maxillary sinus begins to develop in early childhood and continues to increase in size. The average volume of a fully developed sinus is 15 ml. In the adult the mean width is 35 mm at the base and the mean height is 25 mm.[6] The maxillary sinus is lined with respiratory epithelium (pseudostratified columnar epithelium), covering a loose and highly vascular connective tissue. The sinus epithelium, connective tissue, and periosteum which lies immediately next to the bony walls of the sinus is referred to as the schneiderian membrane. The ostium, positioned in the superior medial aspect of the sinus, and opening into the nasal cavity between the middle and lower nasal conchae helps drain the sinus. The grafting done in sinus lift surgeries does not interfere with the sinus function since the sinus drains through the

superior aspect. Maxillary sinus derives its blood supply from the maxillary artery and from the anterior ethmoidal and superior labial arteries. The nerve supply is from the maxillary division of the trigeminal nerve by means of the anterior, middle, and posterior superior alveolar nerves. Warming of the aspirated air, reduction in the weight of the craniofacial complex, and provision of resonance to the voice are the different functions of the maxillary sinus.[7, 8]

CLASSIFICATION OF BONE PRESENT IN THE SUBSINUS REGION

A useful classification that assesses the volume of bone in the subsinus area in 3 dimensions has been presented by Davarpanah et al.[9] The subsinus bone loss classification includes 4 categories:

1. Vertical bone loss from within the sinus: This bone loss results from significant pneumatisation of the sinus. The residual distance from the floor of the sinus to the crest of the ridge is reduced. However, the interocclusal distance is not altered. Methods to increase the intrasinus volume of bone such as sinus elevation and graft are used in these cases.
2. Vertical bone loss (apicocoronal) of the alveolar ridge: This is loss of the alveolar ridge below the sinus. The interocclusal distance is increased. This type of loss can compromise placement of implants, restrict the length of the implants being used, and result in an unfavorable crown implant ratio. The volume of the crestal bone needs to be increased in these cases by use of techniques such as onlay graft and guided bone regeneration (GBR).
3. Horizontal bone loss (buccopalatal) of the alveolar ridge: This is a centripetal type of resorption that could lead to an unsatisfactory emergence profile of the implant. The surgical correction of this situation should restore the buccopalatal volume of bone by use of appositional bone grafts or by GBR.
4. Combination subsinus bone loss: This type of bone loss, both vertical and horizontal, is the most frequent. Saddle-shaped bone grafts are used to correct the bone loss in these situations. If this bone loss is combined with intrasinus loss of bone volume, sinus grafts should also be combined with the previously mentioned surgical technique.

PREOPERATIVE PATIENT EVALUATION

Contraindications to this surgery include all medical conditions and medications that preclude implant placement. In addition, the patient should be questioned regarding sinus problems or diseases and destructive former sinus surgery (such as the Caldwell-Luc surgery), which could complicate or contraindicate the procedure. The presence of sinus pathology including acute sinusitis, antral polyps, cysts, or tumors could certainly compromise the success of the procedure.[10] Also the interarch distance should be measured. If this distance is < 5 mm, there is not enough space for the prosthetic components. Sometimes an increased interarch distance is also observed due to resorption of the alveolar ridge. This could lead to the fabrication of long abutments and crowns, which result in compromised esthetics, an unfavorable crown-to-root ratio, and increased mechanical forces on the implants. The interarch relationship is best determined by a diagnostic wax-up. This information is then combined with a two-dimensional or three-dimensional radiographic evaluation. The two-dimensional radiographic evaluation helps to determine the height of the residual alveolar ridge, the location of the maxillary sinus floor, the height of the maxillary sinus, and the presence of sinus pathology or septa. The most frequently used two-dimensional radiograph is the panoramic film, although this radiograph can cause enlargement of measurements by up to 25%. Three-dimensional radiography (computed tomography [CT]) is more accurate than conventional two-dimensional radiography and can also provide information about the widths of the alveolar ridge and the maxillary sinus and the thickness of the lateral wall of the sinus. Additionally, it accurately identifies the presence of septa and sinus pathology. A radiographic tempelate can be made with the help of this diagnostic wax up to

determine the position of the future prosthetic restoration in relation to the alveolar ridge and sinus.[11]

SURGICAL TECHNIQUE

In 1960, Boyen published sinus lift technique with a lateral access, which was initially used for achieving an optimal intercrestal distance needed for denture making. But in 1980 Boyen and James[4] started to place implants in the newly created bone. Since this procedure was more invasive, in pursuit of a less invasive method, Summers[12] in 1994 made the easier surgical protocol .

LATERAL WINDOW TECHNIQUES

Tatum[5] was the first one who reported the penetration of the maxillary sinus using a modified Caldwell-Luc approach. He made use of an unfinished fenestration osteotomy in the external face of the maxilla to raise the sinus membrane. This area is then filled with different grafting materials. However, perforation of the schneiderian membrane while separating it or while making the osseous window for reaching the sinus is a common complication.[13] To avoid the complications of perforation, Torella et al.[14] have proposed using an ultrasonic ostectomy to obtain access to the sinus. The method is similar to the original technique proposed by Tatum.[5] After elevation of a full-thickness flap, an ultrasonic ostectomy provides access to the cavity with the tip of the generator placed perpendicular to the osseous level and with abundant sterile irrigation. A complete ostectomy along the perimeter of the osseous window is initiated and deepened until tactile sensation of the schneiderian membrane, which is resected by the ultrasonic tip, is obtained. Once the fenestration is completed, the osseous window is dislocated with an instrument.

The schneiderian membrane in the sinus floor is separated until the membrane, together with the osseous window, is raised, and in this way empty space is obtained to place an implant. This space is then filled with a bone graft. The authors report the advantages of this technique as follows-

1. Reduced risk of perforating the schneiderian membrane.
2. Better view and hygiene of the operative area during ostectomy because of the mechanical cleaning effect of the irrigation liquid under the action of the ultrasound.
3. A thinner and more conservative osseous incision.

Advances

Vercellotti et al.[15] have advocated a piezoelectric bony window osteotomy and piezoelectric sinus membrane elevation (PSME). After flap elevation, the procedure involves making a bony window with the No. 1 piezoelectric scalpel. Thereafter, the PSME is done using an overturned cone compressor tip. The compressor is inserted into the frame of the window, separating the borders by approximately 2 mm. The second phase of the PSME involves using the elevator tip with which membrane elevation is achieved, beginning first at the apical position, then in the mesial and distal aspects. Once the membrane is elevated on 3 sides, it is possible to separate it from the floor of the sinus, where adhesions are very common, therefore avoiding the risk of perforation. Autogenous bone graft mixed with autogenous platelet-rich plasma gel was used for the elevation of the sinus floor. A success rate of 95% was reported for this technique. The insufficient power of the ultrasonic instruments makes it difficult to make a linear cut like that when using piezo surgical instruments.

A novel approach to the lateral wall method has been proposed by Emtiaz et al.[16] An incision, either a midline or palatal crestal incision, is made along the alveolar ridge, starting from the tuberosity area to the anterior border of the sinus. After the crestal incision, a buccal vertical incision anterior to the planned osteotomy is made to ease tissue release. A mucoperiosteal flap is elevated. The location of the osteotomy is decided based on the anatomic variations in the sinus and the number and length of implants to be placed. The most coronal aspect of the crestal bone to a position at least 2 to 4 mm higher than the planned implant position/height is measured. A round bone cut is made 4 to 5 mm above the

crest of the alveolar ridge using a trephine on a straight handpiece. Copius irrigation must be done to avoid overheating of the surrounding bone. The trephine is positioned perpendicular to the lateral wall. The outer bony cortex is removed gently to avoid tearing the membrane.

The bony segment is placed in saline solution and is used for repositioning over the graft at the end of the procedure. The exposed membrane is then lifted from the sinus floor. The mucoperiosteal flap is repositioned and sutured. The advantages of this technique are as follows-

1. The time required to prepare the lateral window is decreased.
2. A more precise osteotomy can be performed.
3. Depending on the size and anatomy of the sinus, smaller or larger preparation with the various sizes of trephines available can be made.
4. There is no need for a barrier membrane because the bony segment acts as a barrier.

The angulation of the trephine causes a limitation in some patients and is considered as a disadvantage of the technique.

The antral membrane balloon elevation technique has been proposed by Soltan and Smiler.[17] After elevation of a mucoperiosteal flap at the site, an osteotomy is performed of the buccal bone with copious irrigation. The resulting bony fenestration is pressed inward, carrying the underlying membrane along with it. The dissection of the membrane for the sinus wall should be carried up to the medial wall. At this point, a balloon made out of latex is used. It should be inflated with 3 to 4 mL of sterile saline solution to check for leaks. The balloon is then emptied and placed against the sinus floor midway between the lateral and medial walls. The balloon is gently inflated with 2 to 4 ml of sterile saline solution, and as it expands, the membrane is elevated. After the required amount of elevation of the membrane, the balloon is deflated and removed. A resorbable collagen membrane soaked in platelet rich plasma is placed under the elevated sinus membrane, and the space created by the balloon is grafted with a bone graft material. Loose compaction of the material is carried out until the lateral wall of the sinus is rebuilt. A second GBR membrane is trimmed, moistened with platelet-rich plasma or aqueous antibiotic, and placed over the lateral wall window. The mucoperiosteal flap is repositioned and sutured. The advantages offered by this technique are as follows-

1. The technique is said to offer optimal assurance that the fragile epithelium will be subjected to minimal trauma.
2. Postoperative pain, bleeding, and possibilities of infection are reduced.
3. The technique is said to be completed within 30 minutes.
4. 4. It is beneficial especially in difficult-to-access areas when adjacent teeth are present.

The disadvantages are as follows-

1. Not as conservative as the crestal approach.
2. If the balloon is inflated too quickly or with more than 4 mL of saline solution, it may burst. This could rupture the antral lining.

CRESTAL APPROACH TECHNIQUES

Summers[12] in 1994 developed a surgical technique using osteotomes that is indicated when the subsinus residual bone height is 5 to 6 mm and the bone is of low density. After progressive preparation of the bone, elevation of the floor of the sinus by several millimeters is obtained. In this technique bone is compacted laterally and apically around the implant site by use of osteotomes of progressively increasing diameter. A success rate of 96% over a period of up to 5 years was reported by Summers for 143 implants placed in 46 patients. However, the type of implant and the criteria for success were not described. Robert Horowitz[18] has reported a 97% success rate in a study in which 34 implants were placed in 18 patients using the osteotome technique. However, this study was a short-term study ranging from 2 to 15 months, with a mean of 5 months. In addition, the number of implants placed was small. The modified osteotome technique was proposed by Davarpanah et al.[9] in 2001. This technique is indicated when the height of subsinus bone is greater than 5 mm. Once the site is drilled up to 1 mm below the sinus floor, a

resorbable graft material is introduced into the surgical site. Decreased chairside time, more conservative approach, placement of implants greater than 10 mm in length and immediate placement of implants are the different advantages of this technique.

Advances

Sotirakis and Gonshor[19] proposed an elevation of the maxillary sinus floor with hydraulic pressure. This technique is similar to the technique of Summers[14] in that it uses osteotomes in a specific sequence to both deepen and widen the osteotomy site and in-fracture the sinus floor. Elevation of the sinus floor is achieved by injecting normal saline solution under hydraulic pressure beneath the schneiderian membrane with a suitably fitted syringe. This procedure achieves simultaneous detachment and elevation of the sinus membrane. The technique was first used on hen's eggs, then on human cadavers, and, finally, on patients.

POST OPERATIVE COMPLICATIONS

Commonly encountered complications are perforation of the membrane and haemorrhage. Small membrane perforations are manageable however if large perforations are encountered, the procedure should be stopped. Placement of an absorbable collagen membrane below the perforated sinus membrane and suturing the perforated part of the membrane with absorbable sutures are the different ways of management of small membrane perforations.[10]

IMPLANT PLACEMENT

Implant placement can be done immediately with the sinus lift surgery or after waiting for the healing period of 6 to 9 months to complete. 5 mm of vertical bone is the minimum height of bone that is required for the immediate placement of implants. Although some implants have been successfully placed implants in 2 to 3 mm of bone.[20,21]

CONCLUSION

An exhaustive review of techniques and, where applicable, the success rates have been presented. Several of the techniques presented require more long-term studies with a larger study population.

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