IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 15, Issue 1 Ver. IV (Jan. 2016), PP 29-33
www.iosrjournals.org

Maxillary Sinus Floor Elevation: Review of Anatomy and Lateral Sinus Lift Technique

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Abstract: *A review of maxillary sinus floor elevation as a fundamental part of restoring the posterior maxilla is discussed. The related anatomy of the area and the lateral sinus lift technique is reviewed. This classic lateral antrostomy pioneered by Tatum appears to be the most common sinus lift procedure. There is importance of Lateral Sinus Lift in current implantology. After comparing it with alternative procedures, it is inferred that Lateral Sinus Lift, despite having some disadvantages, is the most effective method for implantation into dorsal parts of the maxilla.*

Keywords: *Dental implants, posterior maxilla, lateral antrostomy, crestal approach, pneumatized maxillary sinuses.*

I. Introduction

Implant dentistry has become an excellent treatment modality since its inception into the modern era of dentistry. It not only allows for a conservative and esthetic alternative to treating partial edentulism, but also provides a stable foundation for treating complete edentulism. Dental implants are a viable treatment option when there is sufficient quantity and quality of bone. However, when patients present with deficient alveolar ridges, it could jeopardize the application of implant dentistry. This problem is especially magnified in the posterior maxilla where ridge resorption and sinus pneumatization, compounded with a poor quality of bone, are often encountered. The procedure of choice to restore this anatomic deficiency is maxillary sinus floor elevation (sinus lift).

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Endosseous implants are frequently used for prosthetic reconstruction in the edentulous patient. Sufficient volume and density of the alveolar bone for implant integration and load bearing are prerequisites for good clinical outcome. A Lateral Sinus Lift is one of the most widely used augmentation procedures. It enables to make an implant in the dorsal parts of the maxilla, where the bone is often poor. When considering that the minimum safe length of the implant is 10 mm, the bone at the site of the first premolar is very low in one-fourth (25%) of patients.[2]

The objective of this article is to review, and summarize, the relevant anatomy and lateral sinus lift technique of this procedure. Lateral Sinus Lift is one of the most widely used augmentation procedures. It enables to place an implant in the dorsal parts of the maxilla, where the bone often has poor quality and is reduced by the extended maxillary sinus.

II. Historic Background

Maxillary sinus floor elevation was initially described by Tatum at an Alabama implant conference in 1976 and subsequently published by Boyne in 1980.[1,3] Its need stemmed from the indispensability to restore the posterior maxilla using implants. The procedure is one of the most common preprosthetic surgeries performed in dentistry today. Since its first description, numerous articles[4–7] have been published in this field regarding different grafting materials, modifications to the classic technique, and parity between different techniques. Pneumatization of maxillary sinus causes insufficient vertical bone volume on posterior maxilla. So the restoration of edentulous posterior maxilla with dental implants is challenging due to a deficient posterior alveolar ridge, unfavorable bone quality and increased pneumatization of the maxillary sinus.[1] For maxillary sinus augmentation, the crestal approach and the lateral window approach have been used. In this article, sinus augmentation using lateral window approach with/without bone graft is described.

III. Anatomy Of The Maxillary Sinus

The maxillary sinus is a pyramid- shaped cavity with its base adjacent to the nasal wall and apex pointing to the zygoma. The size of the sinus is insignificant until the eruption of permanent dentition. The average dimensions of the adult sinus are 2.5 to 3.5 cm wide, 3.6 to 4.5 cm in height and 3.8 to 4.5 cm deep.[8] It has an estimated volume of approximately 12 to 15 cm^3.[3,9] Anteriorly, it extends to the canine and premolar area. The sinus floor usually has its most inferior point near the first molar region. The size of the sinus will increase with age if the area is edentulous. The extent of pneumatization varies from person to person and from side to side.[8] Nonetheless, this process often leaves the bony lateral and occlusal alveolus paper thin in the posterior maxilla. The maxillary sinus bony cavity is lined with the sinus membrane, also known as the schneiderian membrane. This membrane consists of ciliated epithelium like the rest of the respiratory tract. It is continuous with, and connects to, the nasal epithelium through the ostium in the middle meatus. The membrane has a thickness of approximately 0.8 mm. Antral mucosa is thinner and less vascular than nasal mucosa.[8] The blood supply to the maxillary sinus is principally derived from the posterior superior alveolar artery and the infraorbital artery, both being branches of the maxillary artery. There are significant anastomoses between these two arteries in the lateral antral wall. The greater palatine artery also supplies the inferior portion of the sinus.[10] However, because the blood supplies to the maxillary sinus are from terminal branches of peripheral vessels, significant hemorrhage during the sinus lift procedure is rare. Nerve supply to the sinus is derived from the superior alveolar branch of the maxillary (V2) division of the trigeminal nerve.

IV. Surgical Techniques

Lateral Sinus Lift is usually carried out under general or local anesthesia, or under analgesia. After lifting the mucoperiostium from the front wall of the maxilla, a round bur is used to create a window in the thin bone demarcating the maxillary sinus (Fig.1). Antral mucosa must remain intact. Then the mucosa is lifted away from the bone using a special raspatorium to the extent of the alveolar recession and dislocates the same cranially (Fig.2). A space will be created at the base of the maxillary sinus that is filled with an appropriate augmentation material.[11]

Currently, two main approaches to the maxillary sinus floor elevation procedure are found in the literature. The first approach, lateral antrostomy, is the classic and the more commonly performed technique originally described by Tatum. More recently, Summers advocated a second approach: the crestal approach, using osteotomes.[12] The crestal approach is considered to be a more conservative method for sinus floor elevation. Lateral antrostomy is started with a crestal incision made on the alveolar ridge. Sometimes, this incision is made moderately palatal to the crest to preserve a wider band of keratinized attached gingiva for a more solid wound closure and to avoid wound dehiscence.

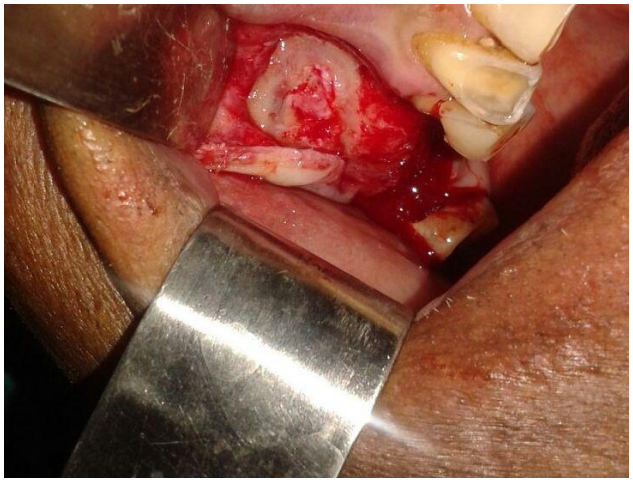

Fig. 1: Window in the front wall of the maxilla. The mucosa of the maxillary sinus remains undamaged

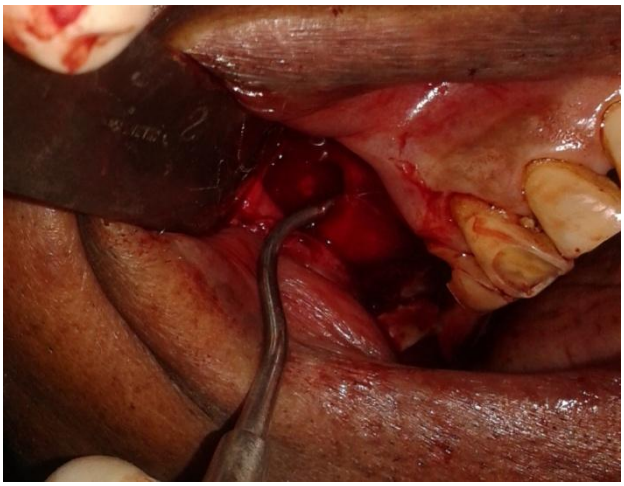

Fig. 2: Preparation of the mucosa of the maxillary sinus using the special raspatorium

A full-thickness flap is then raised to allow access to the lateral antral wall. Once the flap has been raised to a desired level, antrostomy is performed with a round bur to create a U-shaped trapdoor on the lateral buttress of the maxilla (Fig. 2). The height of this trapdoor should not exceed the width of the sinus to allow for a final horizontal position of the new floor. The sinus membrane is then gently lifted from the bony floor by means of an antral curette. Marx and Garg suggested using a cottonoid soaked with a carpule of 2% lidocaine with 1:100,000 epinephrine and left in the space created for 5 minutes so as to limit bleeding and allow for better visualization for further dissection.[13] It is important to free up the sinus membrane in all directions (anteriorly, posteriorly and medially) before attempting to intrude the trapdoor medially. A space is created after the sinus membrane has been elevated by the intruded trapdoor. This space is then grafted with different materials to provide the platform for implant placement. Numerous research projects have been published to evaluate the prognosis of implants under different grafting materials.[14,15] Autogenous bone remains the gold standard in bone grafting.[16] Iliac crest, chin, anterior ramus, and tuberosity have all been mentioned as common autogenous donor sites in maxillary sinus lift. Hydroxyapatite mixed with autogenous bone or used alone are also viable alternatives.[17] Care should be taken not to overfill the recipient site, because it will cause membrane necrosis. Implants are placed either simultaneously with the graft (one-stage lateral antrostomy) or after a delayed period of up to 12 months to allow for graft maturation (two-stage lateral antrostomy). The initial bone thickness at the alveolar ridge seems to be a reliable indicator in deciding between these two methods. If the bone thickness is 4 mm or less, initial implant stability would be jeopardized. Therefore, a two-stage lateral antrostomy should be carried out. The reverse holds true for a one-stage procedure.[18] A one-stage procedure is less time-consuming for both the clinician and the patient. However, it is more technique-sensitive and its success relies heavily on the amount of residual bone.

V. Sinus Augmentation Using Lateral Window Approach

Lateral window approach using various bone substitutes have been performed to overcome deficient bone volume on posterior maxillary ridge for decades.[17-19] However some studies reported new bone formation in animal and human's sinus with membrane elevation alone, resorbable gelatin sponge alone, venous blood alone and autologous fibrin gel with concentrated growth factors alone as alternatives to bone materials.[20-27] According to these studies, bone substitutes may not be a prerequisite for sinus augmentation. The function of elevated sinus membrane is controversial, but some studies reported that sinus membrane acted as periosteum and showed osteoinductive potetnial.[28, 29] Sohn et al reported that significantly higher new bone formation was demonstrated in the sinus without bone graft than inorganic bovine bone grafted sinus.[25] According to this study, bone reformation in the new compartment under the elevated sinus membrane started from elevated sinus membrane and repositioned bony window. Osteoinductive function of sinus membrane seems to be similar to periosteum. Grafted bovine bone acted as only space maker and scaffolding effect in this study. The key for bone reformation in the sinus is not grafting materials but space making under the elevated sinus membrane. Therefore simultaneous implant placement is required to maintain blood clot in the new compartment under the elevated sinus membrane when bone materials are not used.

VI. Drawback Of Lateral Sinus Approach

One of the drawbacks of the lateral antrostomy is that it requires the raising of a large flap for surgical access. Summers proposed a conservative crestal approach using osteotomes for maxillary sinus floor elevation in 1994.[12] This technique begins with a crestal incision. A full-thickness flap is raised to expose the alveolar ridge. An osteotome of the smallest size is then tapped into place by a mallet or drill into the bone. Preoperative bone height underneath the sinus is measured to determine the desired depth for osteotome extension. The goal is to extend the instruments just shy of the sinus membrane. Osteotomes of increasing sizes are introduced sequentially to expand the alveolus. With each insertion of a larger osteotome, bone is compressed, pushed laterally and apically Summers stated that the very nature of this technique improves the bone density of the posterior maxilla where type IV bone is normally found.[19] The disadvantage of the crestal approach is that the initial implant stability is unproven if the residual bone height is less than 6 mm. The chances of achieving a sufficiently high elevation with the osteotome technique are limited.[18] With this approach, there could also be a higher chance of misaligning the long axis of the osteotome during the sequential osteotomy. Restoring edentulism with dental implants requires careful treatment planning. This is especially true with the posterior maxilla when pneumatized maxillary sinuses could limit the amount of alveolar bone for implant placement. Maxillary sinus floor elevation offers one of the most common preprosthetic procedures to solve this problem. Two technique procedures, the classic lateral antrostomy and the more conservative crestal approach, were discussed in this article. Lateral antrostomy allows for a greater amount of bone augmentation to the atrophic maxilla but requires a larger surgical access. The crestal approach is minimally invasive but permits only a limited amount of augmentation. Therefore, practitioners should select the type of procedure appropriate to the particular clinical needs. In addition, all relevant anatomic structures in the vicinity should be respected to minimize surgical complications.

VII. Contraindications

Disorders and conditions that contraindicate the sinus lift have not been fully defined yet. The following are the generally known and recognized rules:

1. Purulent exudate in the maxillary sinus is the most frequently occurring contraindication of sinus lift. Empyema, whether a symptomatic or not, is an absolute, though temporary, contraindication.
2. Situation after Caldwell-Luc operation usually makes the Sinus Lift highly difficult or impossible. Scar tissue cannot be treated as physiological mucosal lining.
3. If the patient reports a history of acute sinusitis and the cause has not been eliminated, the augmentation may increase the proneness to further attacks of inflammation. The patient must be informed to this respect.
4. Chronic sinusitis does not complicate the Sinus Lift. On the contrary hyperplastic antral mucosa is increased mechanical resistance, which facilitates the preparation.
5. Mild osteoporosis is not considered to be contraindication, while moderate forms of this disease require prolongation of the healing period up to twelve months. Surgery is never performed in case of severe osteoporosis.
6. Concurrent treatment with anti-aggregation drugs causes no life-threatening bleeding. Nevertheless it is recommended to discontinue such treatment subject to an agreement with the treating physician. Dose reduction is required in case of concurrent treatment with anticoagulants (the borderline level is INR 1.8). If not realistic, the patient should be transferred to low-molecular heparin.
7. Inhalation or superficial application of corticosteroids has no influence on the effects of surgery, as the absorbed dose of the medication is low.
8. Age itself is not a contraindication.
9. Controlled diabetes mellitus is not considered to be a contraindication, independently of the type of treatment.
10. Heavy smokers frequently have a thin mucous lining of the maxillary sinus, which is highly prone to perforation during the surgery.[11]

VIII. Complications

The following list contains notes on the most significant complication of Sinus Lift.

Serious complications are very rare, while the occurrence of the other complications corresponds to the character of the procedure and is acceptable for both the patient and the surgeon.

1. By far the most frequently occurring complication is perforation of mucosa of the maxillary sinus during the surgery. If not closed spontaneously, oxycellulose mesh can be used for coverage. This original procedure is fast, cheap and reliable, and was repeatedly published by the authors In emergency, the mesh can be used to reconstruct the entire ceiling of the augmented space.
2. Acute sinusitis is the most serious complication. It is most frequently caused by infection of the augmentation material during the surgery. It has dramatic manifestations and requires revision surgery of the maxillary sinus

under general anesthesia with the removal of all foreign bodies. It is a quite rarely occurring episode that had the occurrence of 0.1% in the presented group of patients.
3. Mild purulent exudate from a dehiscent mucosal wound accompanied by swelling, pain and subfebrile conditions, is not a big threat. It can be usually managed by irrigations and antibiotic therapy.
4. From time to time, healing by second intention is seen and it is not a big risk for the effectiveness of the procedure. If the bone window is situated too close to the mucosal incision, or if the augmentation material is too much compressed, the augmentation material can be liberated from the wound. In this case, it is recommended to use antibiotic treatment and try to apply a secondary suture.
5. Postoperative hematoma is observed mostly in older females. It has annoying effects in esthetic terms but usually resorbs within two weeks.
6. Primary failure (non-osseointegration) of the implant remains a very rare event in hydroxyapatite-coated fixtures Long-term success is not significantly different from that of usual implantations.[2]

IX. Conclusion

Restoring edentulism with dental implants requires careful treatment planning. This is especially true with the posterior maxilla when pneumatized maxillary sinuses could limit the amount of alveolar bone for implant placement. Maxillary sinus floor elevation offers one of the most common preprosthetic procedures to solve this problem. the classic lateral antrostomy and the more conservative crestal approach, was discussed in this article. Lateral sinus lift, despite having some disadvantages, such as in particular high demands on both surgeon and the patient and longer healing period, is in most cases the best available solution for insufficient quantity of the alveolar bone during the implantation into the dorsal parts of the maxilla. Its role in current dental implantology is still non-replaceable. The invasiveness of the procedure can be substantially reduced when performed by an experienced surgeon using the presented surgical protocol. The risk of complications remains low.

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