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Maxillary Sinus Lift: Review Article

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Abstract

Replacement of teeth with dental implants have taken a great run but it creates a problem when we encounter insufficient bone volume in the edentulous posterior maxillae. So to overcome such problems after the pneumatization of sinus we have sinus lift procedure with the help of which we can easily augment the sinus floor and gain the lost height. Various sinus augmentation techniques have been used with successful result, aimed at developing these sites for implant placement. The aim of this review article is to provide an update about the basic techniques, namely, direct and indirect techniques used for maxillary sinus elevation and augmentation, followed with various indication, contraindication and treatment aspect of the maxillary sinus and the complications which we can encounter during and after the procedure.

Keywords: Maxillary sinus lift, sinus lift technique, sinus augmentation.

Introduction

For more than 30 years the maxillary sinus augmentation graft has been a mainstay of implant-directed maxillary reconstruction[1].

The history of the maxillary sinus, its discovery and early description is of considerable interest. There is reliable evidence in the medical writings of the ancient Egyptians, between 3700 and 1550 B.C., that the structure of the superior maxilla was known to them. Maxillary antrum as illustrated by Highmore 1613-1685 who dissected and practiced in Rome and whose writings provided the basis

for anatomical studies for the next thousand years. It was, however, the quite remarkable Italian genius **Leonardo da Vinci**[2] who first accurately described and beautifully illustrated that antrum named after Highmore.

Sinus augmentation has become a standard procedure to increase bone height in the posterior maxilla, allowing placement of long dental implants. In general, the implants are inserted after a healing time of 4 to 6 months.[3]

The sinus lift techniques had a lot of modifications through the years. **Boyene**[4] published sinus lift with lateral access.

There are various surgical techniques available for this procedure. On the one hand septa can hamper the preparation and elevation of the bony window in the anterior-lateral antral wall in the procedure explained by **Tatum**[5], on the other hand the minimal invasive approach can also be compromised. Septa can make the complete preservation of the sinus membrane more difficult. Maxillary sinus operations also demand exact anatomical knowledge to decide whether a transnasal or transoral approach is preferable. Septa can harm the endoscopic view when transnasal approach is chosen.

Monje et al[6] stated the anatomical description of the maxillary sinuses who was pursuing to allocate 'the cavities that nourished the roots of the teeth.

Anatomy of Maxillary Sinus

Having knowledge of sinus anatomy is a prerequisite for understanding the principle involved in making proper incisions and designing and managing the sinus elevation. Clinicians should also be familiar with other anatomic structures before performing sinus elevation. We all know that maxillary sinus is a pyramid shaped cavity.

The pyramid has three main processes or projections:

1. The alveolar process inferiorly (bounded by the alveolar ridge).
2. The zygomatic recess (bounded by the zygomatic bone).
3. The infraorbital process pointing superiorly (bounded by the bony floor of the orbit, and below it, the canine fossa). (Fig.1).

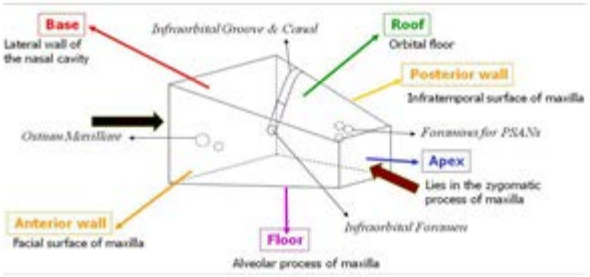

Fig.1. Anatomy of sinus

Lateral wall forms the buccal aspect of the sinus and contributes to the posterior maxillary and zygomatic process; this wall provides access for the lateral wall sinus graft procedure.[7]

Sinus dimensions

When we talk about the average dimension of the maxillary sinus it is 36–45 mm in height, 23–25 mm in width, and 38–45 mm in length (anteroposterior axis). The average volume of the maxillary sinus is 15 ml.[8]

Maxillary sinus septa

Maxillary sinus septa were first mentioned by Underwood in 1910.[9] Septa can easily be subdivided into:

1. Primary septa, formed during maxillary development and tooth growth

2. Secondary septa which is acquired during the pneumatization of the maxillary sinus after tooth loss.

If there is a full partition of the sinus by a septum, more than one lateral window is created as part of the sinus opening to circumvent the septa.[10]

Schneiderian membrane

This membrane is a pseudostratified columnar respiratory membrane ciliated epithelium formed by the basal cells, columnar cells, and goblet cells fixed to the basal membrane.

Chances of sinus membrane perforation depend on the angle between the lateral and the medial wall of the sinus. Greater than 60º angle has 0% chances of perforation; 30º–60º angle has 28.6% chances of perforation.[11]

Vascularization

Blood supply occurs by the branches of maxillary artery. So, these are namely as follow:

1. Infraorbital artery
2. Posterior lateral nasal artery
3. posterior superior alveolar artery

When examining cross-sections of a CBCT scan, detection of radiolucency in the buccal plate denotes the presence of an intraosseous blood vessel. Thus, it may need to be managed during a lateral window preparation.[12]

Microscopic Anatomy

The microscopic anatomy of the sinuses reveals four basic cell types: namely, pseudostratified ciliated columnar epithelium, non-ciliated columnar cells, goblet cells, and basal cells. The maxillary sinus has the greatest concentration of goblet cells, although all of the sinuses have a paucity of goblet cells and submucosal cells compared to the nasal cavity.[13]

Function of maxillary sinus

- Reduction of weight of the facial skeleton
- Phonetic resonance and auditory feedback
- Insulation: the sinuses may insulate the orbits from intranasal temperature variations.
- Air conditioning: the maxillary sinus contains some serous gland whose watery secretion evaporates to humidify the contained air.
- Water conservation: sinus may act as accessory heat exchanges, warming inspired air to increase its moisture content.
- Olfaction: pneumatization may have involve to increase the area of olfactory mucosa there by improving the sense of smell.

History

1. Tatum (1970) augmented the posterior maxilla with autogenous rib.
2. George Caldwell (1893) and Henry Luc (1897) introduced Caldwell-Luc
3. Tatum (1974) developed a modified Caldwell–Luc.
4. Tatum modified his own procedure to lift the membrane via a lateral approach.
5. Summers (1994) gave an internal approach to lift the membrane via the osteotomy.
6. Summers (1994) introduced a less invasive procedure
7. Chen (1996) gave the hydraulic sinus condensing technique.

A Caldwell-Luc antrostomy is a procedure often used to remove a damaged mucosal lining from the maxillary sinus. The Caldwell-Luc operation indications are usually when sinusitis in the area has not responded to antibiotic treatment, sinus rinses, and other non-invasive treatments. However, the procedure may also be used in cases of malignancy, dental cysts, sinus polyps, fractures in the bone surrounding the maxillary sinus, or the removal of foreign bodies, but in case of modified Caldwell Luc procedure elevation of sinus membrane is done then augmentation or implant placement is performed.

Indications

1. Insufficient bone height.
2. No history of sinus pathosis.
3. Severely atrophic maxilla.
4. Poor bone quality and quantity in the posterior maxilla.

Contraindications

1. Recent radiation therapy in maxilla.
2. Heavy smokers.
3. Alcohol abuse.

Apart from the general contraindications for implant surgery, there are a number of absolute and relative contraindications for sinus lifting.[14]

Absolute Contraindications

1. Previous sinus surgery like the Caldwell Luc operation. This type of surgery often leaves scar tissue instead of the normal ciliated mucosa lining of the maxillary sinus.

2.Medical patient history.

3.Maxillary sinus diseases such as tumors or chronic polypous sinusitis or strong allergic conditions.

Relative Contraindications

1.Presence of Underwood's septa or severe sinus floor convolutions.

2.Extremely narrow sinus.

There is a classification with the help of which we can easily appreciate the density of the jaw bone. (Fig.2) [15]

BONE DENSITY	DESCRIPTION	TACTILE ANALOG	TYPICAL ANATOMICAL LOCATION
D1	Dense cortical	Oak or maple wood	Anterior mandible
D2	Porous cortical and coarse trabecular	White pine or spruce wood	Anterior mandible Posterior mandible Anterior maxilla
D3	Porous cortical (thin) and fine trabecular	Balsa wood	Anterior maxilla Posterior maxilla Posterior mandible
D4	Fine trabecular	Styrofoam	Posterior maxilla

Fig.2: Bone density classification

In 1987, Misch classified the subantral (SA) region of the posterior: as SA-1 through SA-4.

SA-1 >12mm, no sinus lift required, SA-2 has 10 to 2 mm, indirect sinus lift with immediate implant placement, SA-3 has 5 to 10 mm, direct sinus lift with immediate implant placement, SA-4 has <5 mm, direct sinus lift with delayed implant placement.[16]

Different Techniques for Maxillary Sinus Elevation

1. Direct/lateral window technique

Armamenterium

Below are the basic instruments required for membrane elevation. Fig 3.

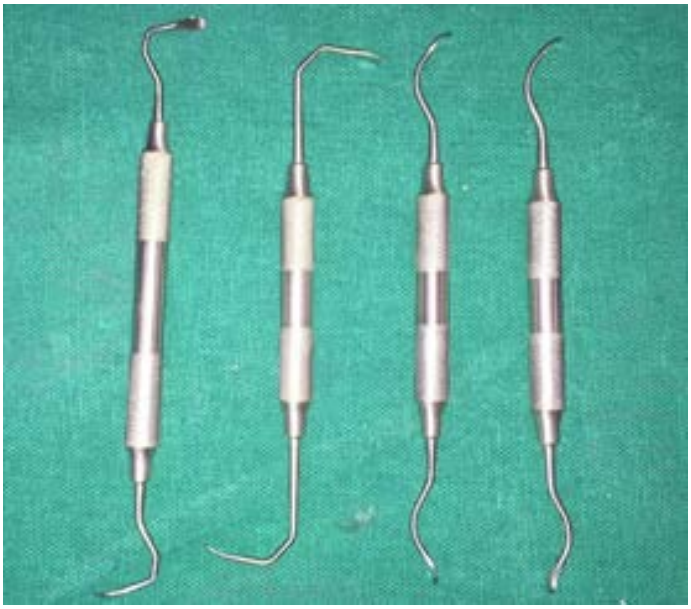

Fig.3: Direct Sinus lift instruments

Picture Courtesy: Dr. Mayur Kaushik, Prof. and Head Department of Periodontology and Implantology, Subharti Dental College and Hospital, Meerut, U.P

These are the following steps which are performed for the surgery.[17]

1- **Anesthesia**

2- **Incision** – Soft-tissue incisions for creation of the lateral window

3-**Lateral window/antrostomy** – After flap elevation, a sterile number 2 pencil is used to demarcate the outline of the lateral wall window on the buccal plate of bone. High-speed handpiece with number 8 diamond bur is used to outline the window until bluish hue is visible with gentle brushing or paintbrush stroke. The shape of the window is usually oval and should not have sharp edges that may cause perforation of the membrane. Fig.4.

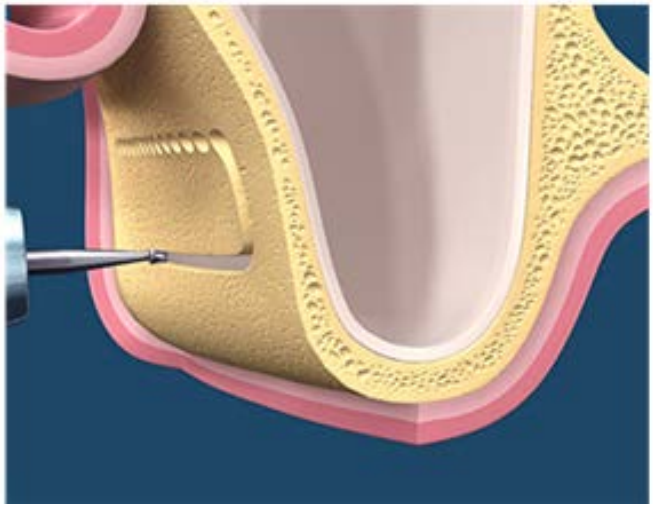

Fig.4. Lateral window preparation

4- **Sinus membrane elevation** – Detach the sinus membrane with blunt instrument.

5- **Preparation of implant site** – If there is minimum of 3–4 mm of residual crestal bone of good quality, it is possible to place implants simultaneously or else place the implant after 4–6 months.

6- **Graft placement** – After membrane elevation bone graft is placed, Fig.5.

7- **Membrane placement** – Resorbable membrane is placed over the window

8- **Suturing/incision closure**

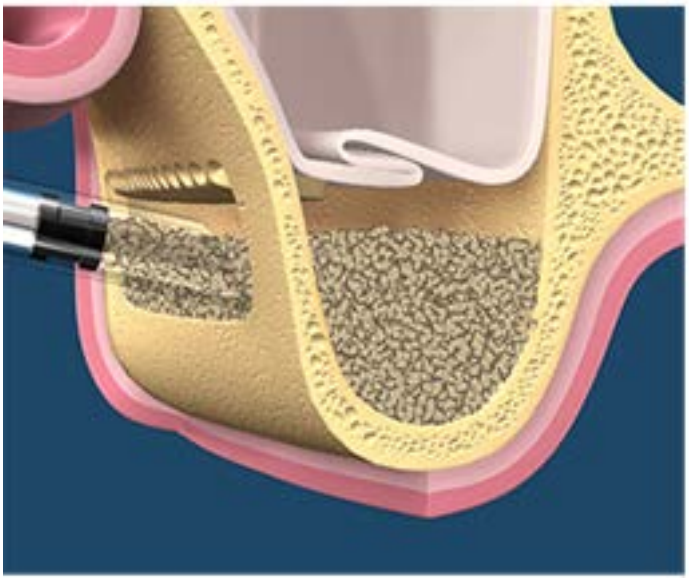

Fig.5. Membrane elevation and Bone Graft placement

Indirect/osteotome technique/crestal approach/transalveolar approach

These are the steps of osteotome technique.[18]

Armamenterium

Below is the picture of basic instruments used for Indirect Sinus lift.Fig.6.

Fig.6. Indirect Sinus Lift instruments

Picture Courtesy: Dr. Mayur Kaushik, Prof. and Head Department of Periodontology and Implantology, Subharti Dental College and Hospital, Meerut, U.P

1. Anesthesia
2. Incision – crestal incision should be extended distally in some cases, to the tuberosity area where autologous bone needs to be harvested
3. Flap – to expose ridge crest, full-thickness mucoperiosteal flap is elevated
4. Drilling – Osteotomy preparation with pilot drill of 2 mm. Here, confirmatory radiograph should be taken by inserting pilot drill.
5. Grafting– once the largest osteotome has expanded the implant site, particulated bone substitutes (mixed with autogenous bone) are added to the osteotomy as the grafting material. Composite bone graft composed of

25% autogenous and 75% hydroxyapatite graft should be preferred.

6. Fracture – an osteotome of lesser diameter than the implant body is inserted in the prepared osteotomy site and tapped gently to fracture up the sinus floor.
7. Sinus floor elevation– This is done by reinserting the largest osteotome in the implant site with the graft material in place. Fig.7.

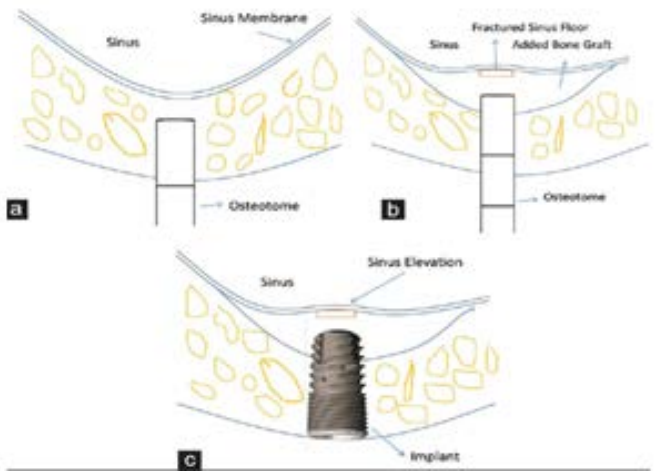

Fig.7. A) Osteotome instrumentation by malletin B) Fractured sinus floor and added bone graft in osteotomy. C) Sinus elevation and Implant placement

8. Implant placement – Implant fixture to be placed should be slightly larger in diameter than the osteotomy created by the final osteotome.

Minimally invasive techniques

A) Modified trephine/osteotome technique

Modified trephine/osteotome technique was described in 1999 The implant site is prepared using a 3 mm exterior diameter trephine bur at a distance of 1–2 mm from the sinus floor.

The final preparation of the implant site is carried out using osteotomes of increasing diameters, always inserting them to the same depth. The implants are inserted at a speed of 30 rpm, causing controlled lateral movement of the bone cylinder inside the space created by the movement of the sinus membrane.[19]

B). Antral membrane balloon elevation procedure

Antral membrane balloon elevation procedure was given by Soltan *et al*. in 2012.This technique uses inflatable balloon to elevate the sinus membrane. This technique has been shown to reduce the chance of sinus membrane perforation. The straight design balloon is used.

Before the balloon is inserted, the osteotomy is enlarged to 5 mm. The sleeve of the balloon is then inserted 1 mm beyond the sinus floor. The saline is injected slowly from the syringe into the balloon so that the balloon would inflate progressively. One cubic centimeter of saline is expected to raise 6 mm of the membrane.[20]

C). Minimally invasive transalveolar sinus approach (MITSA) elevation technique.

Minimally invasive transalveolar sinus approach (MITSA) elevation technique was given by Kher *et al*. 2014. In this procedure, calcium phosphor-silicate putty is used for hydraulic sinus membrane elevation.[21] Drilling is done 1 mm short of the sinus floor and osteotomy completes till the last drill. Concave 3 mm osteotome is used to in-fracture sinus floor. Nova-bone gun cannula fits snugly in prepared osteotomy. The material gently lifts membrane due to its consistency.

D). minimally invasive transcrestal-guided sinus lift technique

Minimally invasive transcrestal-guided sinus lift technique was given by Pozzi and Moy. This is a new procedure with computer-guided planning and a guided surgical approach to elevate the maxillary sinus.

Post Oprative Care and Medications

A) Activity

- Do not blow the nose for 4 weeks.
- Sneeze with mouth open
- Do not spit or drink with straws
- Avoid pressurized areas like aircraft

- Decongestant can be taken to reduce pressure in sinuses

B) Oral hygiene

- 24-h period: Do not spit or rinse.
- After 24-h: Rinse with ½ teaspoon of salt in warm water 4-5 times a day.
- Do not brush teeth near surgical area for 48-h
- Avoid smoking as it leads to implant failure.

C) Post medication:

- Antibiotics
- Analgesics
- Sedatives
- Antibacterial oral rinse

Complications

Intraoperative complications

- The Schneiderian membrane perforation
- Excessive bleeding
- Inadequate primary stability of implant
- Displacement of the implant to the sinus cavity.

Postoperative complication

- Postoperative infection.
- Benign paroxysmal positional vertigo (BPPV).
- Implant loss.
- Graft infection.
- Acute maxillary sinusitis.

Conclusion

Placement of implant in the maxillary reason can be because of the pneumatization of maxillary sinus with secondary to tooth loss in the posterior region. The clinician must be habituated with the anatomy and pathology of the maxillary sinus to evade any nonessential complications following lateral sinus floor augmentation procedure.

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