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Sinus Lifting Procedures - A Review

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Abstract

The use of dental implants for the prosthetic rehabilitation of an edentulous area has gained much popularity. But, the presence of the maxillary sinus poses difficulties in placing implants in the posterior maxilla. Sinus lifting is a procedure which can be used to augment and increase the height of the available bone in the posterior maxilla. Sinus lifting techniques require a thorough understanding of the maxillary sinus and related anatomy. This article throws light on the various techniques used to elevate the maxillary sinus and augment the available bone.

Key words: maxillary sinus, dental implant, sinus floor augmentation.

Introduction

The use of implants has become one of the most sought out options for tooth replacement. However, implant placement in the posterior maxillary region is often hampered significantly by anatomic limitations such as,

- presence of maxillary sinus
- inadequate vertical dimension
- poor bone quality
- thinning or missing cortex

The loss of maxillary posterior teeth results in an initial decrease in bone width at the expense of the labial bony plate. The width of the posterior maxilla decreases at a more rapid rate than in any other region of the jaw. The fine trabecular bone type and the loss of vascularization hastens the resorption phenomenon.[(1)] For implant placement in the posterior maxillary region, the maxillary sinus is one of the most important anatomic structures. Following tooth extraction, the periosteum of the maxillary sinus can exhibit an increase in osteoclastic

activity, resulting in reduced bone height due to pneumatization of the maxillary sinus which influences the length and location of implants.

Many reports have also concluded that the success rate of shorter implants (<10 mm) is less in comparison with longer implants. Thus, procedures such as sinus floor elevation (SFE), which facilitate the placement of longer implants in the posterior maxilla, have become the topic of interest in recent years.

Maxillary SFE was first described by Dr. Hilt Tatum at an Alabama implant conference in 1976. Sinus lift procedure is a surgical intervention aimed at increasing the height of the residual bone in the posterior maxilla by repositioning the floor of maxillary sinus in an upward direction, creating an appropriate bone height that can accommodate the placement of dental implants. Sinus lift surgery is usually followed by bone grafting in order to fill the compartment created between the osseous floor of the maxillary sinus and the Schneiderian membrane.[2]

Anatomy Of Maxillary Sinus

- Maxillary sinus is the largest paranasal sinus**.**
- It is pyramidal in shape with base towards the lateral wall of nose and apex towards the zygomatic process of maxilla.
- The average volume of the maxillary sinus is 15 ml.[3]
- Ostium serves as the main channel for drainage of secretions (*fig 1*).

Fig 1: Structure and location of the maxillary sinus

- superior wall is formed by the floor of the orbit
- anterior wall is constituted by facial portion of maxillary bone,
- posterolateral wall is constituted by zygomatic bone and greater wing of sphenoid
- floor is constituted by the alveolar process and the palatal process of maxilla

The inner lining of the maxillary sinus is lined by pseudostratified ciliated epithelium known as Schneiderian membrane with an average thickness of 0.8mm[4] and is continuous with nasal epithelium through the ostium in the middle meatus. It also extends between adjacent teeth or individual roots, creating elevations of the antral surface, commonly referred to as `hillocks'**.** Inside the maxillary sinus, bony septa known as Underwood's septa originating in the sinus floor are often found.[5]

Extraosseous vascular anastomosis is usually present around 23–26 mm from the ridge. It may cause hemorrhage during flap preparation. Intraosseous vascular anastomosis is around 16–19 mm from the ridge. When examining cross-sections of a CBCT scan, presence of radiolucency in the buccal plate suggests the presence of an intraosseous blood vessel.[6] Thus, to prevent complications it may need to be managed during a lateral window preparation for sinus elevation.

Indications for sinus lifting

- Inadequate residual bone height (<10 mm of vertical bone height)
- Atrophic posterior maxillary ridge**.**

Contraindications

- Acute active sinus infection
- Recurrent chronic sinusitis
- Neoplasm or large cyst of the sinus
- Previous sinus surgery like the Caldwell–Luc operation

- History of radiation therapy to maxilla
- Presence of Underwood's septa/severe sinus floor convolutions
- Uncontrolled diabetes mellitus
- Alcoholics and heavy smokers
- Psychosis

Classification For Treatment Approach

In 1987, Misch developed a classification for the treatment of edentulous posterior maxilla based on the amount of bone available below the antrum *(fig 2)*.

- **SA1:** It has an adequate vertical bone for implants, that is, 12 mm. No manipulation of sinus is required.
- **SA2:** It has 0-2 mm less than the ideal height of bone and may require surgical correction.
- **SA3:** It has just 5-10 mm of bone below sinus.
- **SA4:** It has less than 5 mm of bone below sinus.

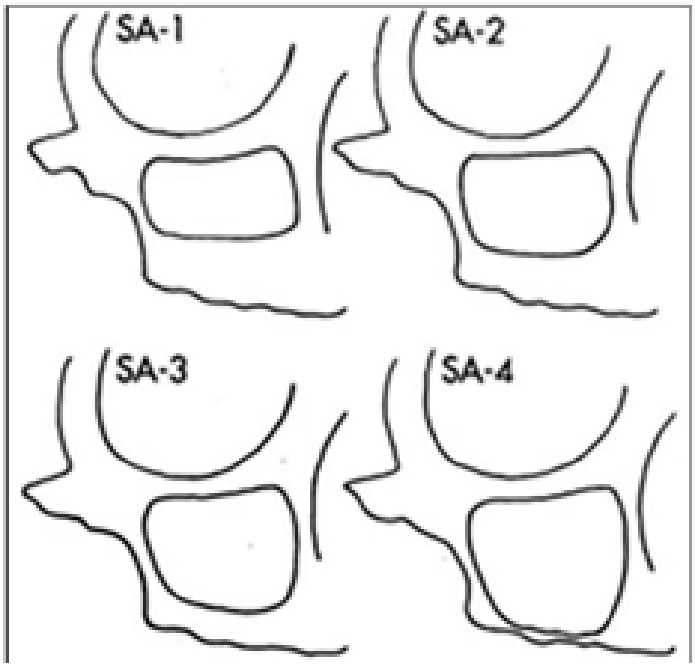

Fig 2: Misch's classification for treatment approach

Different Techniques For Maxillary Sinus Elevation

The selection of sinus elevation technique depends on the surgeon's preference as well as patient anatomy. Anatomical factors include the residual bone height and amount of lift desired. There are two main approaches for maxillary sinus floor elevation: Direct(lateral) and Indirect (transcrestal) approach. The two main techniques of SFE for dental implant placement are:

- ❖ A two-stage technique with a lateral window approach, followed by implant placement after a healing period;
- ❖ A one-stage technique using either a lateral or a transalveolar approach.

The decision to use one or two-stage techniques is based on the amount of residual bone available and the possibility of achieving primary stability for the inserted implants.[7]

Direct/Lateral Window Technique

It was originally developed by Tatum[8] and later described by Boyne and James.[9] Steps involved are as follows:

- Local or general anesthesia can be used. Sedation can be given if the patient is apprehensive.
- Infraorbital, PSA, greater palatine nerve blocks are preferred.
- Horizontal incision is made (at 1–2 mm palatal to the alveolar crest and at least 4–6 mm away from the estimated border of the bony window)
- Buccal vertical releasing incisions are placed at the mesial and distal extension of the horizontal incision with 15C blade *(fig 3)*.
- Full-thickness buccal flap is reflected from the crestal side all the way to 4–6 mm apically beyond the upper portion of the bony window outline.

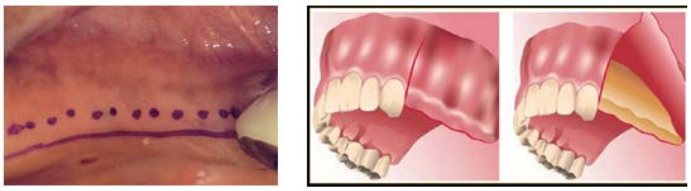

Fig 3: site for horizontal and vertical incision

- A sinus retractor is positioned to retract the mucoperiosteal flap and cheek to fully visualize the surgical site. Once the lateral surface is exposed, a malleable millimeter ruler and bone calipers *(fig 4)* can be used to evaluate the bone dimensions.

Fig 4: bone caliper used to determine the available bone thickness

Lateral window/antrostomy preparation

The position of the antral window on the lateral aspect of the maxilla is outlined.

- Coronal outline- depends on the height of the graft, length of the implant to be placed and location of PSA.
- Apical outline - approximately 3 mm above the sinus floor
- Mesial outline - as close to the anterior wall
- Distal outline- depends on the number of implants to be placed.

High-speed handpiece with no. 6 or 8 diamond bur is used to outline the window until bluish hue is visible with gentle brushing or paintbrush stroke *(fig 5)*. Bone tampers are used to in-fracture the bony access window *(fig 6)*.

Fig 5: bony window preparation using diamond bur

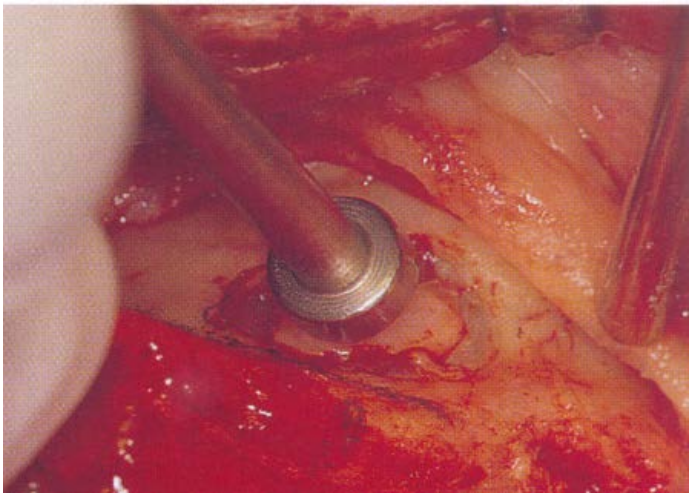

Fig 6: in-fracturing of the bony window with bone tampers

Methods For Handling The Buccal Cortical Bone Plate

Generally, after preparing the lateral window, the buccal cortical bone plate can be handled in 3 ways.[10] i) the lateral antrostomy can be done in a trap-door fashion *(fig 7)*, which can then be repositioned after the sinus floor elevation. ii) it can completely be thinned and removed, later replaced by graft *(fig 8)*. iii) it can be rotated inward and upward after sinus floor elevation, such that it forms the roof of the newly created compartment *(fig 9)*.

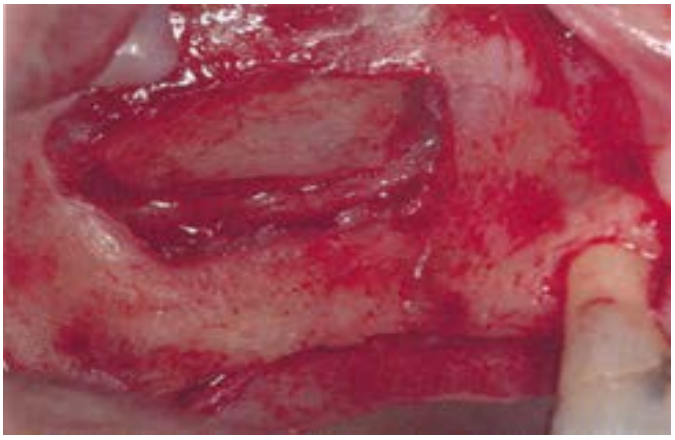

Fig 7: Trap-door' type of fracture

Fig 8: Thinning and complete removal of the lateral bony plate

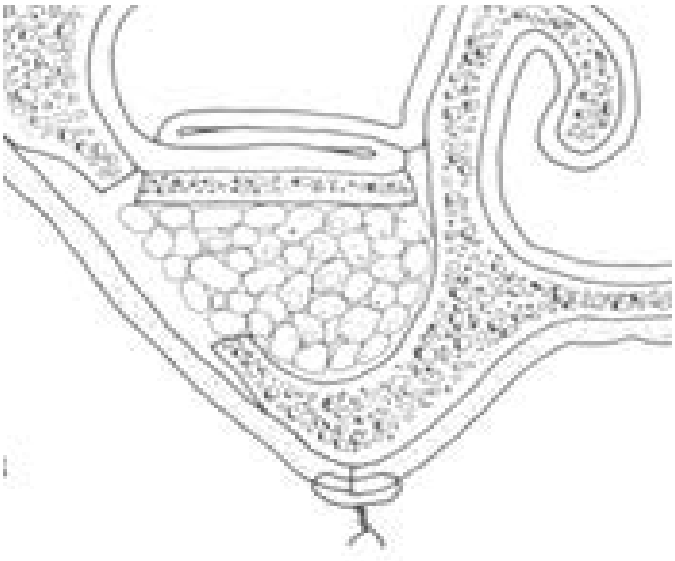

Fig 9: the lateral bony plate can serve as a roof for the newly created compartment

Sinus membrane elevation

Before attempting to elevate the sinus membrane, it has to first be detached from the underlying bone by using special curettes *(fig 10)*. Membrane should be elevated carefully starting on the sinus floor and then extending to the anterior and posterior walls with the help of sinus curettes. Elevation is done up to the medial wall and expected graft height.

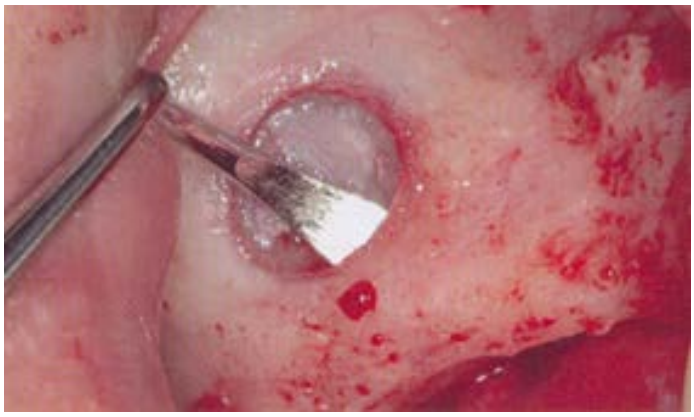

Fig 10: Relieving the sinus membrane from the underlying bone

Preparation of implant site

If there is minimum of 3-4mm of residual crestal bone of good quality, it is possible to place implants simultaneously or else they can be placed after 4–6 months. Since the maxillary bone is a low-density bone, the implant osteotomy site is undersized. The sinus membrane should be protected with periosteal elevator to avoid damaging with drills during osteotomy preparation.

Graft placement

Sinus membrane should be protected with collagen membrane. Bone grafts are placed in the least accessible area first. Compacting the bone graft too tightly reduces vascularization. A synthetic membrane can be used to cover the window or the lateral wall of the graft, later the mucoperiosteal flap is repositioned and sutured.

Lateral Window Technique Without A Graft Material

This method for simultaneous implant placement was introduced by Lundgren et al. in 2004.[11] In this technique immediate implant installation is necessary to preserve and support the elevated Schneiderian membrane. It involves allowing coagulum formation around the exposed implant surface in the sinus cavity *(fig 11)*. Long-term studies are scarce.

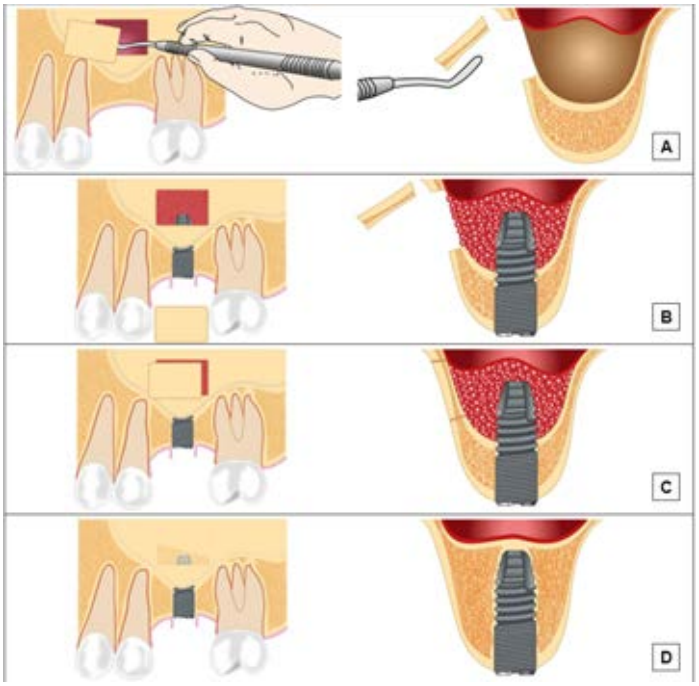

Fig 11: Technique proposed by Lundgren et al

Drawbacks of lateral window approach

- it requires the raising of a large flap for surgical access.
- more technique sensitive
- time-consuming.
- exposure of the collagen membrane.

Advantages of lateral window approach

- sinus membrane is directly visualized
- easy access
- can be used when minimal bone height is present

Transcrestal/Indirect Technique

Also known as transalveolar approach, crestal or osteotome technique. Transcrestal sinus lift approach was given by Tatum in 1986.[8] Schneiderian membrane and the maxillary sinus floor are elevated from a transcrestal approach using osteotomes creating a compartment for graft placement and/ or blood clot formation, without the preparation of a lateral window. Implants are inserted immediately to support the elevated floor of the maxillary sinus with the Schneiderian membrane. In 1994 Summers introduced set of tapered osteotomes with increasing diameters to increase the density of the soft bone and create an up-fracture of the maxillary sinus floor[12] *(fig 12)*.

Fig 12: Osteotomes designed for transcrestal approach by Summer's

Indication

- Flat sinus floor with a residual bone height of at least 5 mm and adequate crestal bone width for implant placement.

Contraindications

- Similar to those previously described for the lateral approach.
- Patients with a history of inner ear complications and positional vertigo are not suitable for the osteotome technique.
- An oblique sinus floor (>45° inclination) is not suitable for the osteotome technique.

Technique

- Anesthesia followed by crestal incision extended distally in some cases, to the tuberosity area where autologous bone needs to be harvested.
- Full-thickness mucoperiosteal flap is elevated.
- Start the osteotomy preparation with pilot drill of 2 mm diameter keeping it 2 mm short of the sinus floor *(fig 13)***.**
- Either the widened drills or set of osteotomes of varying dimensions can be sequentially used to widen the osteotomy site to the same level.
    - With light malleting, the osteotome is pushed towards the compact bone of the sinus floor.

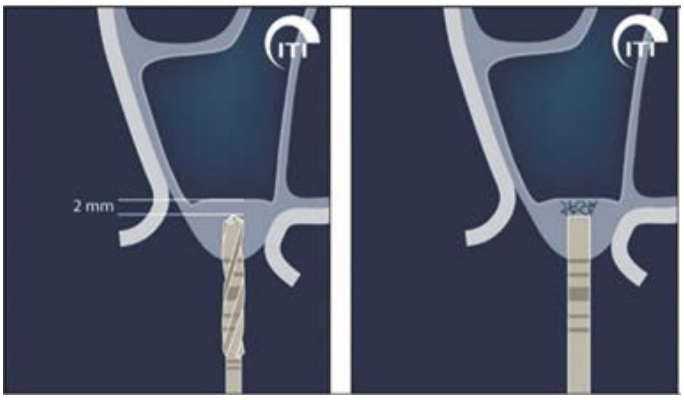

Fig 13: osteotomy preparation done 2mm short of the sinus floor

The first osteotome used in the implant site is a small diameter tapered osteotome to minimize the force. The second tapered osteotome, is slightly larger to increase the fracture area of the sinus floor. The third osteotome used is with a diameter about 1-1.5 mm smaller than the implant to be placed.

Before placing the graft material, the integrity of the sinus membrane should be checked by the Valsalva maneuver *(fig 14)*. If air leaks out of the implant site**,** it implies that the sinus membrane is perforated, and no grafting material should be placed in the sinus cavity.

Fig 14: Valsalva maneuver performed to check sinus integrity

Graft is inserted into the osteotome site. Osteotome of lesser diameter than the implant body is inserted in the prepared osteotomy site and tapped gently to up- fracture the sinus floor by exerting pressure onto the sinus membrane which elevates it further *(fig 15)*. A slightly larger diameter implant than the osteotomy created by the final osteotome is preferred for placement.

Fig 15: Graft is placed, then osteotome of a lesser diameter than the implant size is inserted and gently tapped, followed by implant placement.

Advantages

- ❖ more conservative procedure
- ❖ localized augmentation possible
- ❖ postoperative morbidity relatively less
- ❖ a shorter time to implant loading than with the direct technique

Disadvantages

- ❖ grafts are placed blindly into the space below the sinus membrane.

- possibilities of perforating the Schneiderian membrane.

Modifications of Transcrestal Approach

The Modified Summers' Osteotomes

Original concave, cutting osteotomes were replaced by convex and rounded ones *(fig 16)***.** The main difference of the modified osteotome technique is that there is no fracture of a fragment in the sinus floor. The rounded osteotomes permit safe handling of the bone after preparing the pilot osteotomy. It also expands the osteotomy and extrudes the graft into the sinus cavity.[13]

Fig 16: Modified summers' osteotomes

Cosci's Technique

This technique is a crestal approach technique given by Cosci and Luccioli in 1994**.** It is a one-stage crestal SFE approach using a specific sequence of atraumatic drills of varying lengths *(fig 17)*.[14] The shape of the drill tip prevents perforation of the sinus membrane and permits gentle abrasive removal of the cortical bone of the sinus floor without fracture. The drills have a cutting edge of 30 degrees and a built in water flow system

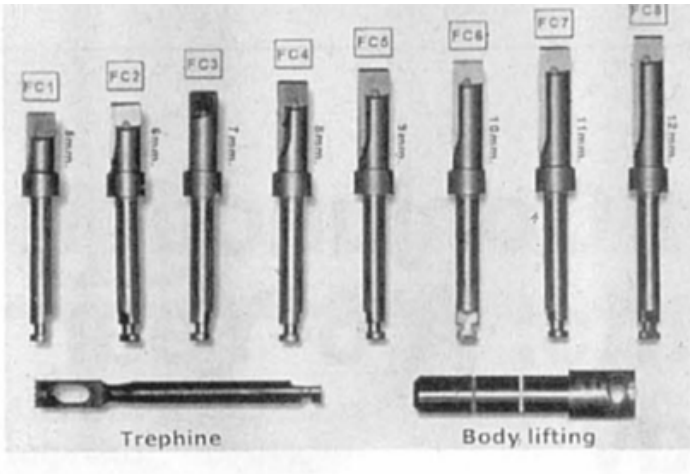

Fig 17: Drill set for Cosci's technique

Sinus Floor Elevation Using A Connective Tissue Graft

This technique was introduced by Davarpanah et al in 1996. In this technique implant site is drilled up to 1mm below the sinus floor and connective tissue graft is placed into the surgical site before using the osteotomes *(fig 18)*. It acts as a cushion and aids in up fracture of the cortical bone.[15]

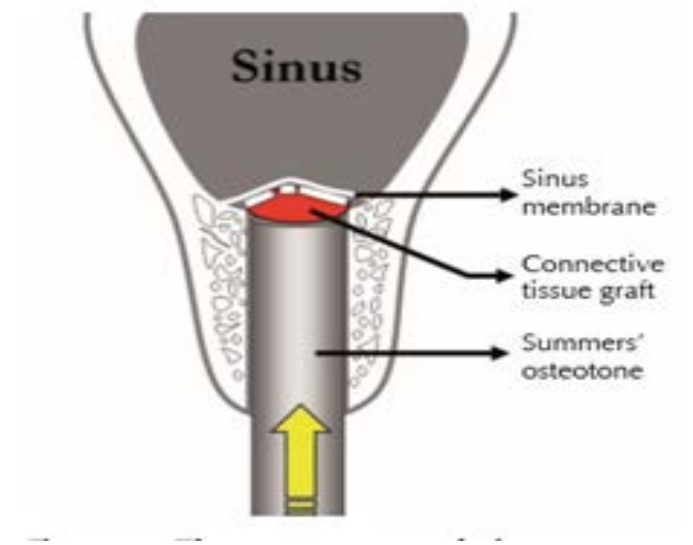

Fig 18: placement of connective tissue graft below the sinus floor

Minimally Invasive Transcrestal-Guided Sinus Lift Technique

This technique was given by Pozzi and Moy in 2013. This new technique is a computer-guided planning and a

guided surgical approach to elevate the maxillary sinus. The use of CAD/CAM generated surgical template in combination with expander-condensing osteotomes, make this surgical technique minimally invasive.[16]

Three dimensional planning and virtual implant placement is done *(fig 19)*. Periapical radiographs are used to assess the actual bone height preoperatively *(fig 20)*. A surgical guide is fabricated by keeping the working length 1mm short of the actual bone height. After osteotomy preparation up to 1mm short of the sinus floor, grafting material reshaped as a root form and introduced into each implant site *(fig 21)*. Then, the osteotome is gently tapped through the sleeve *(fig 22)*. Elevation of the sinus membrane occurs due to the hydraulic pressure created by the graft material. This is followed by implant placement *(fig 23)*.

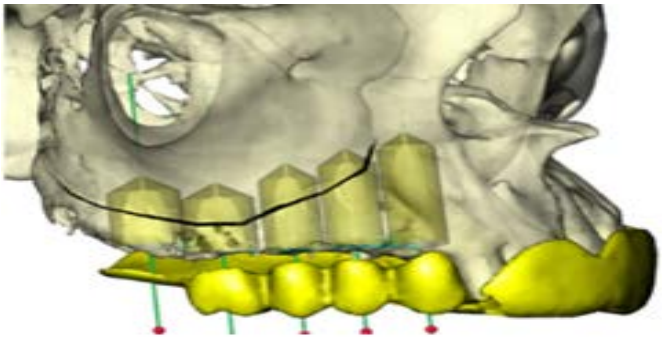

Fig 19: Preoperative three-dimensional planning and virtual implant placement

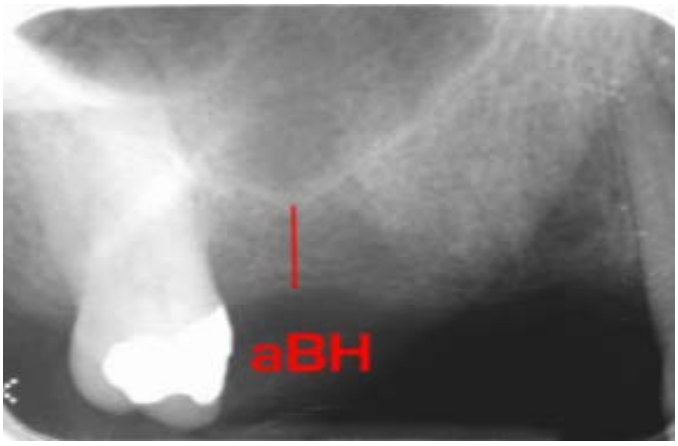

Fig 20: Periapical radiograph for measuring the actual bone height

Fig 21: Graft material placed into the osteotomy site

Fig 22: Gentle tapping with osteotome after placement of graft material

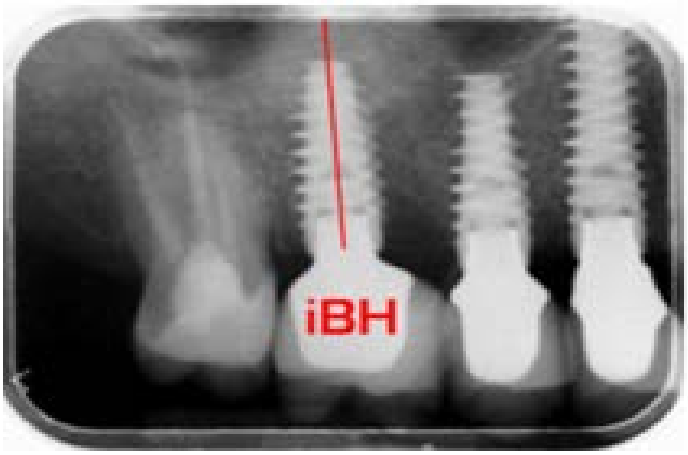

Fig 23: Postoperative radiograph with implant placement showing the increased bone height

Piezoelectric Surgery

It is less traumatic and the risk of perforation of the Schneiderian membrane is reduced, and a better view is achieved during surgery.[17] This is due to the cessation of the surgical action when the piezo surgery tips come in contact with nonmineralized tissue. The ultrasonic vibrations of the piezoelectric elevator working on the internal wall of the sinus walls and the hydro-pneumatic pressure of a physiologic solution also aids in non-invasive detachment of the periosteum *(fig 24)*. Osteotomies are done in a frequency range of 25-30 kHz.

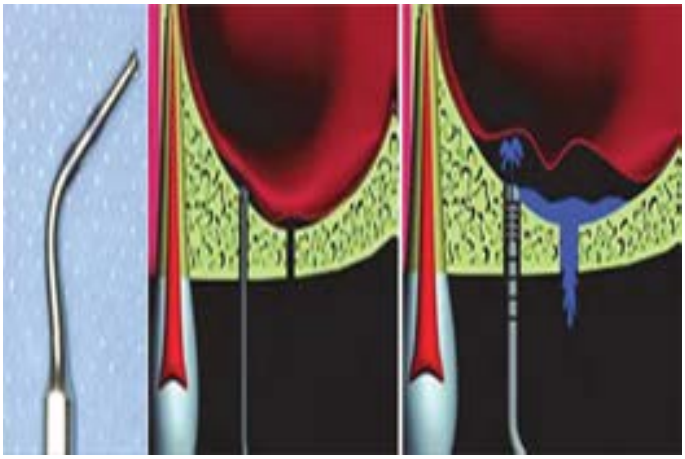

Fig 24: Elevation of the sinus membrane using piezo tips

Hydropneumatic Sinus Lift

It is a crestal access technique, introduced in 2008 by Troedhan et al**.** It is a minimally invasive technique for lifting the maxillary sinus floor using piezoelectric surgery based on a specific set of tips for the application of ultrasound. It operates in four power modes, D1 to D4, corresponding to the classification of bone quality (1 = Dense bone, 4 = Very spongy bone). A nondiamond tip known as “trumpet” is used, which is a noncutting tip that sprays sterile irrigation, causing internal sinus membrane elevation by micro cavitation *(fig 25)*.[13]

Fig 25: Set of tips for hydropneumatic sinus lift

Antral Membrane Balloon Elevation

It is a modification of the traditional method of SFE as the antral membrane elevation is performed using a specially designed balloon *(fig 26)*. Originally described by Soltan and Smiler in 2005.[18] It is designed to lift the Schneiderian membrane gently and uniformly. It is helpful in areas that are difficult to reach and also if there is teeth adjacent to edentulous area.

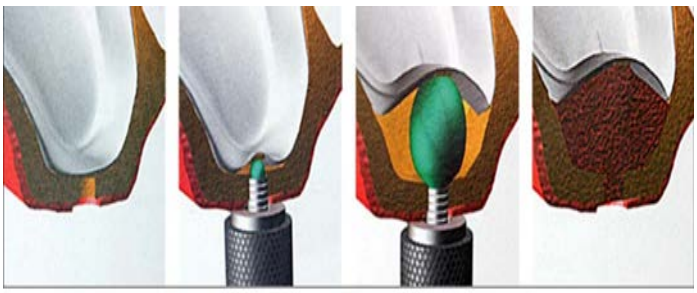

Fig 26: Sinus membrane elevation using balloon elevation technique

The angled design can be used in the lateral window/Caldwell-luc approach,[19] the straight design can be used in the crestal/summers approach and the micro-mini design can be also used in the crestal/summers approach with a small diameter opening *(fig 27)*.

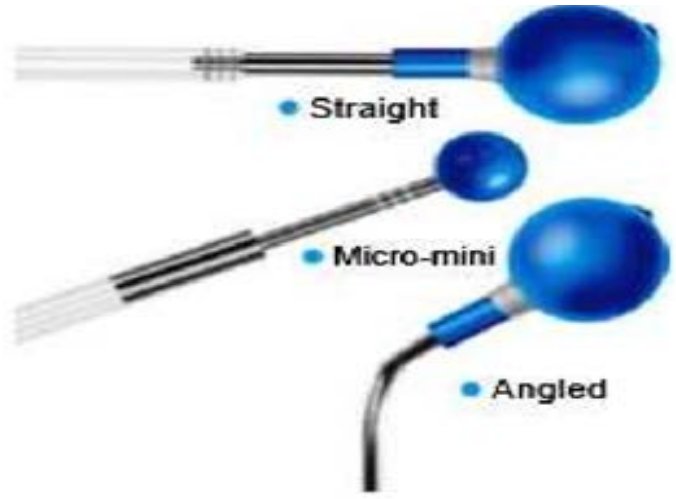

Fig 27: Various designs of the antral balloon used for sinus elevation

It consists of a balloon-harboring device which is a tube, that has a specially designed inflation syringe in the proximal end, and has an embedded single use silicone balloon in the distal end. The balloon is inflated with diluted contrast fluid that pushes up the Schneiderian membrane creating the desired height for implant placement. *(fig 28)*,

Fig 28: Balloon harbouring device, consisting of a syringe for inflation and a silicone balloon for sinus elevation

Osteotomy is done up to 1-2 mm below the sinus floor, the balloon is slowly inflated with a progressively higher volume of contrast fluid. After the desired elevation has been obtained, the balloon remains inflated in the sinus for five minutes to reduce the sinus membrane elasticity. The balloon is then deflated and removed. A mixture of grafting material is placed, followed by implant placement into the osteotomy. On average, with 1 cc of saline, the sinus lift balloon may elevate sinus membrane up to 6 mm and consequently 1cc of graft material.[20]

Advantages

- Minimal risk of membrane tear.[21]
- Reduces postoperative pain, bleeding, possibilities of infection, and the other possible risks associated with sinus lift procedures.
- Less time consuming.
- Useful in areas with little access and when adjacent teeth are present next to the edentulous area.

Minimally Invasive Transalveolar Sinus Approach (Mitsa)

This technique was given by Kher et al in 2014. In this technique calcium phosphosilicate putty is used for hydraulic sinus membrane elevation. Drilling is done 1 mm short of the sinus floor and osteotomy completed till the last drill. Concave 3 mm osteotome is used to in-fracture the sinus floor. The cannula of the calcium phosphosilicate putty is snugly fitted into the prepared osteotomy and injected. The material gently lifts the sinus membrane due to its consistency. MITSA technique is minimally invasive as this technique uses osteotome only once.[22]

Nasal Suction Technique

Initially described by Stassen et al in 2007.[23] A modified technique was described by Ucer et al in 2008[24]**.** The sinus lining is exposed through a lateral antrostomy. Yankeur suction tube is placed in the nose with tip facing towards the ostium followed by pinching the nose to create negative pressure *(fig 29)*. Thus, the sinus lining is

elevated as a result of the mild negative pressure. In the modified technique, a graduated medical grade vacuum device is used to create the negative pressure.

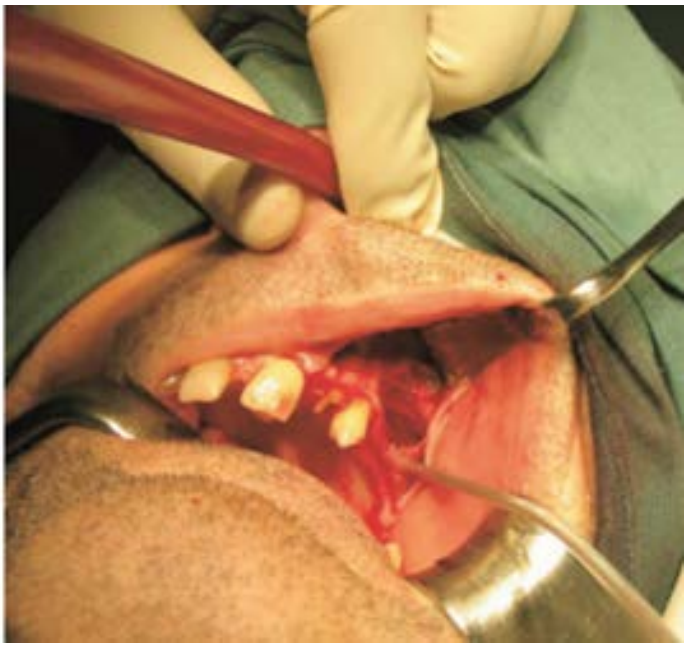

Fig 29: Sinus membrane elevation using the nasal suction technique, by Yankeur suction tube placement and pinching the nose to create negative pressure.

Postoperative Instructions And Care Sinus Lifting Procedure

- On the first night after surgery, head should be elevated on 2 or more pillows
- Liquid diet to be followed for 2 days and then soft diet for 2 weeks .
- Some nasal bleeding may occur during first day.
- Medications – Amoxicillin with clavulanate potassium 625 mg BID for 10 days; ibuprofen 600 mg and acetaminophen 500 mg QID for 3 days; oxymetazoline nasal spray for 7 days; 1.2% chlorhexidine mouth 30 cc BID for 14 days.
- Avoid chewing from the surgical site, blowing the nose for 2 weeks, smoking, balloon blowing, sucking liquid with straw, flying in pressured aircraft or scuba diving, carbonated drinks (minimum 3 days).
- If the patient does sneeze, mouth should be kept open so that the pressure is not exerted within the sinus.
- If slight swelling or bruising is expected underneath the eye, apply ice packs over the face for 10 min on and 10 min off.[25]

Complications OF SINUS LIFTING SURGERY

There may be bleeding either during the procedure or postoperatively. Other intraoperative complications include tear of the buccal flap, injury to infraorbital nerve and sinus membrane perforation. Some of the postoperative complications include, loss or failure of graft material, implant failure or migration, oro-antral fistula, inadequate graft material and barrier membrane exposure.

Some Complications And Its Management

Sinus membrane perforation

It is the most common intraoperative complication, which occurs in 7%–35% of sinus augmentation procedures. If it is <2 mm it can be left to heal by itself but if the perforation is more than 2 mm, it has to be sealed. Various techniques to manage these perforations include suturing, the use of collagen membrane, fibrin sealants, freeze dried human lamellar bone sheets.

Bleeding

It can occur while performing an osteotomy. Bleeding from the sinus membrane can be controlled by placing gauze soaked with anesthetic solution containing 1:80,000 epinephrine directly onto the membrane. Bleeding from the bone requires application of direct pressure with an artery forceps, or it can be managed with a cautery unit. The bone should be compressed with a mosquito hemostat, thereby crushing the bone and obstructing the bleeding blood vessel.

Dislodgement of implant into sinus

Once the displacement is diagnosed and located in computed tomography scan/orthopantomogram, the implant must be removed as soon as possible.

CONCLUSION

Placing implants in atrophic maxillary posterior ridge is a difficult challenge that dentists encounter in their regular implant practice. In the recent years, more research is being done on the sinus lifting procedure and it has been widely practiced with predictable results. Although, it is considered a safe procedure, preoperative evaluations are of prime importance to decide the treatment plan and select the most appropriate technique for the patient.

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