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Review Article

Sinus floor elevation techniques- A review

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ABSTRACT

Long term edentulism in the maxillary posterior region presents with complications that compromise the quality and quantity of the residual ridge, making the implant placement impossible. Despite of these challenges, prosthetically driven dental implants tend to restore function using various sinus membrane elevation and augmentation techniques. Over the past few years, these techniques have undergone several advancements aiming to overcome the short comings of the conventional techniques and assuring a successful outcome.

1. Introduction

Dental Implants have emerged as an excellent treatment modality since their inception in the modern era of dentistry. They are considered to be a viable treatment option when there is sufficient quantity and quality of bone. However, when placed in compromised conditions with deficient alveolar ridges, it could jeopardize their success.[1] The edentulous maxillary posterior region presents several unique and demanding anatomical features that make it a challenging area to deal with. Long-term edentulism in this region has several consequences including residual ridge resorption and pneumatisation of sinus.[2,3] To overcome this, sinus membrane elevation with subsequent bone graft and implant placement has become an established pre-prosthetic procedure. Different types of biomaterials have been used for maxillary sinus floor augmentation including autograft, allograft, xenograft, alloplasts, and growth factors, and the selection of the ideal graft material has been a subject of controversy over the years.[4] The sinus lift procedures involve a) Lateral window approach b) Trans-alveolar approach.

The lateral approach was first introduced by *Tatum* in the late 1970s and was first published in literature by *Boyne & James* in 1980.[5,6] Later in 1994, the novel transalveolar technique was introduced by *Summer* using a set of osteotomes with varying diameters.[7] However, both the lateral and crestal approaches for sinus elevation have a few shortcomings. The most commonly involved complication is sinus membrane perforation that further results in postoperative pain, increased morbidity, delayed healing and sometimes vertigo in few cases. To overcome these limitations, several modifications were done to the conventional technique over the past few years. Therefore, this review article highlights various sinus floor elevation techniques, their indications and the recent advancements.

2. Techniques for Sinus Floor Elevation

2.1. Lateral approach technique

A technique in which the Schneiderian membrane is raised through a window created on the lateral bone wall of the maxillary sinus with (one –stage) or without (two- stage)

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simultaneous implant placement. The advantage of a single-stage procedure is the reduced healing time. However, the main disadvantage is the difficulty in attaining primary stability due to the minimal bone heights. Therefore, it is recommended to provide a healing period of 6–9 months prior to the implant placement.[8,9]

2.2. Transalveolar technique

A small osteotomy is performed through the crest of the edentulous alveolar ridge, and the sinus membrane is elevated, thus creating a space for graft placement and blood clot formation. This technique was further modified by including the graft material into the osteotomy and is known as bone-added osteotome sinus floor elevation (BAOSFE) or "Summers technique".[10] This technique is considered more conservative and invasive than the lateral approach.[8,9] (Figure 1 a,b)

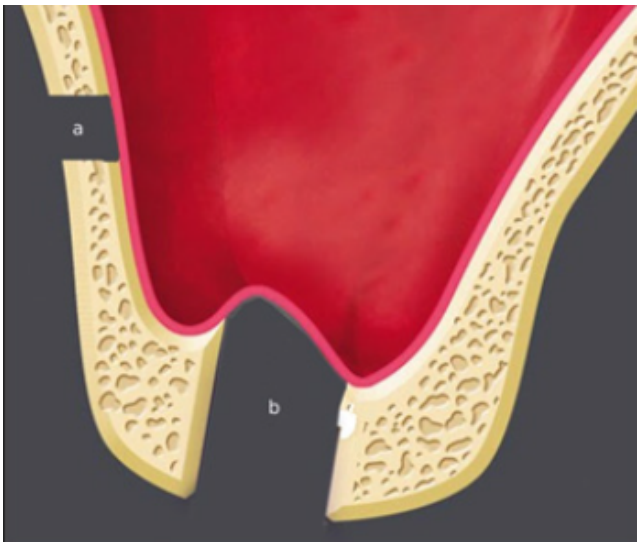

Fig. 1: a. Lateral approach 1b. Transalveolar approach

2.3. Direct and indirect methods of sinus floor elevation (SFE)

Lateral antrostomy as a one or two step procedure is described as direct method and osteotome technique with a crestal approach as indirect method.[11,12]

Pal et al. compared these two different ways of SFE techniques and they found that direct procedure through lateral antrostomy (mean 8.5 mm) revealed a significantly greater rise in the bone height than in indirect method through crestal approach by osteotome technique (mean 4.4 mm). They concluded that osteotome technique can be recommended when residual bone height is more than 6 mm and an increase of 3–4 mm can be expected. In case of advanced resorption, direct method through lateral antrostomy is indicated. The implant success rate was not effected by either techniques.[13]

2.4. Criteria for case selection

Based on the amount of bone available below the antrum and the ridge width, Misch in the year 1987, proposed a classification for the treatment of edentulous posterior maxilla.[14,15]

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

3. Indications and Contraindications For Sinus Augmentation

3.1. The following are indications for sinus augmentation:[16]

1. Patients with no history of sinus pathosis
2. Inadequate residual bone height (<10 mm of bone height)
3. Severely atrophic maxillary arch
4. Poor quality and quantity of bone in the maxillary posterior region.

3.2. Sinus augmentation is contra-indicated in patients with:[16]

1. Recent history of radiation therapy in maxilla
2. Uncontrolled systemic diseases such as diabetes mellitus
3. Acute/chronic maxillary sinusitis
4. Heavy smoking habit
5. Alcohol abuse
6. Psychosis
7. Severe allergic rhinitis
8. Tumour or large cyst in the maxillary sinus
9. Oro-antral fistula.

4. Minimally Invasive Techniques For Sinus Floor Elevation

To overcome the drawbacks of conventional sinus lift procedures and minimize the risk of membrane perforations, various minimally invasive techniques were introduced. They include: Balloon elevation, Hydraulic pressure, Gel pressure, Piezoelectric system, Reamer mediators, Using CPS putty, Using osseodensification burs and CAD- CAM.

Minimally invasive antral membrane balloon elevation technique (MIAMBE) was introduced by *Kfir et. al.* to overcome certain disadvantages like buccal window preparation and larger incisions and used a crestal osteotomy through conventional drills and osteotomes. The

membrane elevation is achieved using barometric balloon inflator.[17,18] (Figure 2)

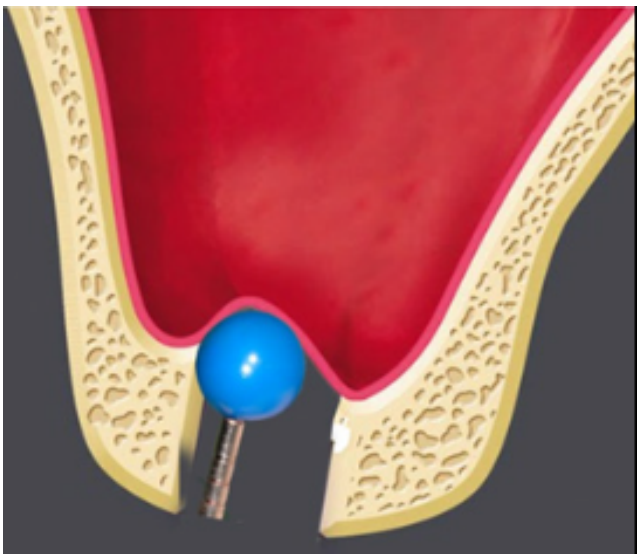

Fig. 2: Minimally invasive antral membrane balloon elevation technique

Hydraulic pressure to elevate sinus membrane was introduced by *Chen & Cha* in the year 2005. A 2mm of round bur is used to create a pinhole on the sinus floor & membrane separation is achieved through hydraulic pressure delivered by the high speed hand piece.[19] *Sotirakis & Gonshor* in the same year, suggested the use of a syringe filled with saline adjusted at an airtight interface to the osteotomy site and membrane elevation was obtained through hydraulic pressure created by depression of the plunger of the syringe.[20] (Figure 3)

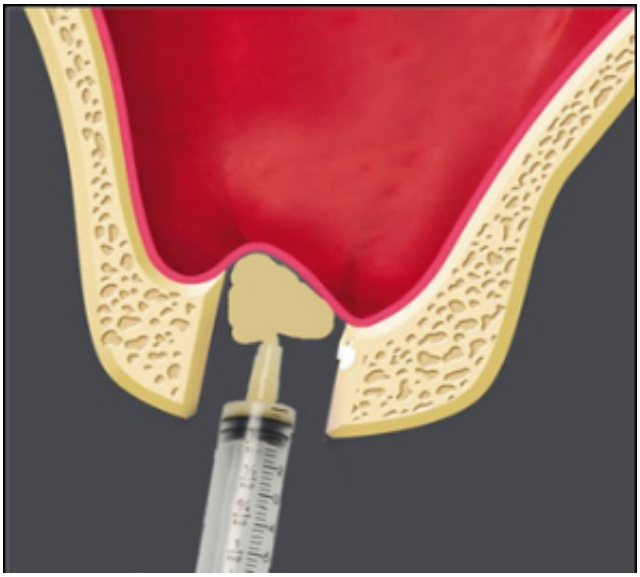

Fig. 3: Hydraulic pressure to elevate sinus membrane

Gel pressure elevation was introduced by Pommer & Watsek in 2009. In this technique a surgical template, a soft tissue punch of 4.1mm diameter, cannon drills of 3.3mm diameter with internal irrigation and custom made drill stops along with a specially designed injection nozzle with a radiopaque gel composed of 2% Hydroxy propyl methyl cellulose (HPMC), a viscoelastic agent, 37% iopamidol, a radio opaque marker mixed at a ratio of 3:1, were used to elevate the sinus membrane.[21]

Piezoelectric minimally invasive system was introduced by *Vercelloti et. al.*[22] and *Troedhan et. al.*[23] have developed the Intralift System for crestal osteotomy site preparation. Four power modes are available D-1 to D-4, which correspond to bone quality. Initially D-1, D-2 modes are used corresponding to the cortical bone density followed by D3-D4. The separation of the periosteum is achieved by ultrasonic vibrations and hydro-pneumatic pressure of saline solution, created by the mechanism of piezoelectric cavitation. (Figure 4)

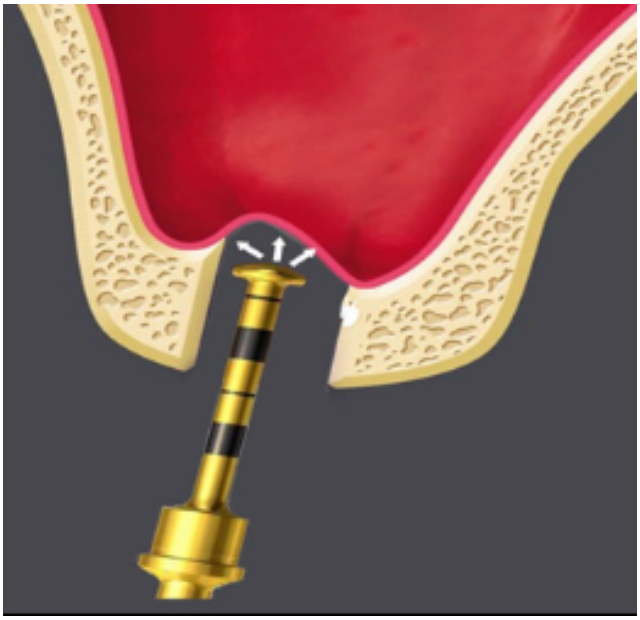

Fig. 4: Piezoelectric minimally invasive system

Reamer mediated sinus floor elevation was introduced by *Ahn & co workers.* They used specially designed reamers with one cutting edge (CE) at 85 degree cutting angle to prepare the osteotomy site and at a lower speed of 30-50 rmp along with bone graft material to elevate the sinus membrane. The flat end of the RE provides a light vertical pushing action on the sinus floor during the reaming that enables separation and elevation of sinus membrane.[24] (Figure 5)

Transcrestal approach with CPS putty was introduced by *Kher & co workers* in 2014. They used calcium phosphosilicate (CPS) putty for hydraulic sinus membrane elevation. Initially, 0.2cm of Calcium silicophosphate putty

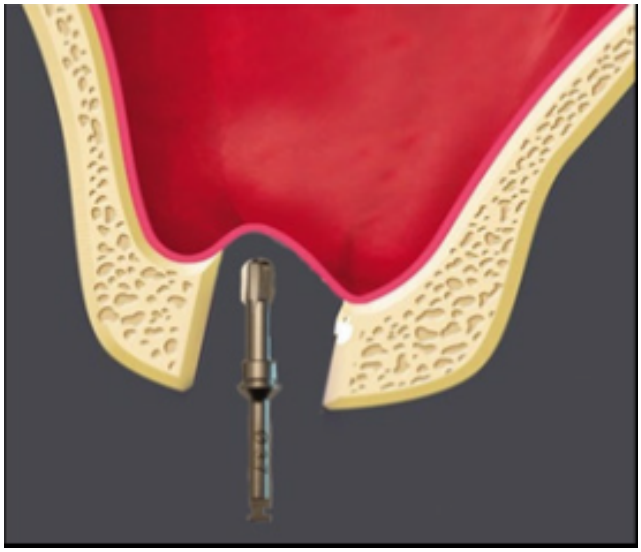

Fig. 5: Reamer mediated sinus floor elevation

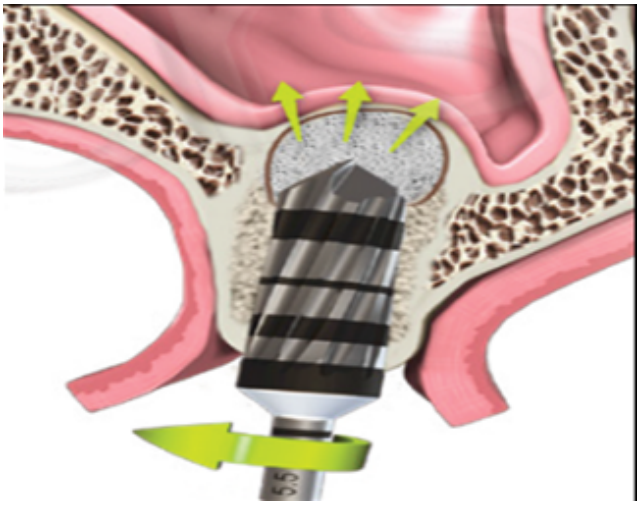

Fig. 6: Indirect sinus elevation with osseodensification

is supplied into the osteotomy site using a catridge and it provides a cushioning effect. Using this, a greenstick fracture on the sinus floor is created. Later, 0.5cm CPS are inserted into the space. According to the authors, this technique possess minimal risk of perforation due to consistency of putty and have shown considerable gain in bone height comparable to lateral approach.[25]

4.1. Indirect sinus elevation with osseodensification

The technique was introduced by Huwais in 2013. They used specially designed bur called Densah bus in counter clockwise direction at a speed of 800-1500 rpm to achieve osseodensification. The tip of these burs is designed to achieve apical condensation of bone enabling an indirect sinus elevation with reduced chances of perforation.[26] (Figure 6)

CAD-CAM approach for Sinus elevation was introduced by Pozzi & Co- workers in 2013. They used a computer-guided planning and a guided surgical approach. A CAD/CAM-generated surgical template along with drills and calibrated expanding condensing osteotomes were used for sinus elevation.[27]

5. Discussion

In this era of prosthetically driven implant dentistry, the sinus lift procedures enabled implant placement even in areas with compromised bone quality and quantity. However, the conventional techniques presented with an increased risk of sinus perforation. *Nolan & co-workers* in their longitudinal study of 359 sinus lift procedures for 3 years observed that 7 out of every 10 failed sinus grafts were accompanied by a perforated Schneiderian membrane during sinus lift surgery.[28] This further increased the risk of incidence of sinusitis and implant failure. However, few other studies did not report any significant differences in implant survival rates between the perforated and non-perforated side. Thus, minimally invasive sinus elevation techniques were introduced to eliminate the risk of perforation. *Kfir et al.* in their multicentre research study in 109 patients treated using balloon elevation technique, reported 95% of implant survival rate with only 3 cases with sinus membrane perforation. They have concluded that, minimally invasive antral membrane balloon elevation technique can be employed as alternative to conventional techniques.[17] *Chen & Cha.* have advocated that cases with sloping sinuses & compartmental sinus septum can be safely treated using hydraulic pressure technique. However, risk of membrane perforation increases as the use of a fluid jet may cause pressure peaks.[19] *Pommer and Watzek* have executed Gel pressure transcrestal sinus lift procedure in 10 atrophic maxillae of human cadavers and they revealed that the gel provides cushioning effect to the sinus membrane by absorbing sudden pressure and transmits forces over greater areas thereby minimizing the risk of membrane perforation.[21] Therefore these advanced techniques are considered to be more accurate, less invasive, assuring faster recovery and higher patient satisfaction with decreased patient morbidity and chair side time. However, a skilled operator with greater precision is required to perform these technique- sensitive procedures and the kits are of a higher cost.

6. Conclusion

In the era of minimally invasive dentistry, these newly advanced sinus floor elevation techniques pose an exciting alternative to the indigenous techniques. The success of the procedure is further determined by the operator skills and the available literature on these techniques is minimal.

Therefore, long term clinical studies are essential.

7. Source of Funding

None.

8. Conflict of Interest

None.

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