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INDIRECT SINUS LIFT: A REVIEW

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Abstract: The indirect sinus lift, also known as a crest-based approach, is a less invasive procedure aimed at augmenting the maxillary sinus floor to assist with placing dental implants in the back of the upper jaw. It is especially useful when there is an inadequate vertical bone height because of sinus expansion, or bone loss following tooth extraction. The procedure involves using osteotomes or specialized instruments to gently fracture and elevate sinus floor, followed by placing bone graft material to support osseointegration. Compared to the direct sinus lift, the indirect approach results in lower morbidity, shorter surgical, recovery and fewer complications. This article provides a comprehensive review of evolution of surgical methods carried out for indirect sinus lift, detailing their clinical outcomes, potential complications, thereby offering a thorough understanding of its efficacy and safety in modern dental implantology.

Keywords: Indirect sinus lift, Sinus lift, Sinus elevation, Sinus Augmentation.

I. INTRODUCTION

The posterior maxilla presents challenges for implant placement when natural bone height has been diminished due to tooth loss, sinus expansion, or bone resorption. Initially, the loss of maxillary posterior teeth leads to a reduction in bone width, particularly affecting the labial bony plate. The width of the posterior maxilla decreases at a more rapid rate than in other regions of the jaw. This resorption process is accelerated by the loss of alveolar bone vascularization and lack of muscle stimulation, compromising bone quality.[1] When teeth are lost, the sinus can gradually extend downward into the space once occupied by the tooth roots, this pneumatization of the maxillary sinus further reduces available bone height for secure implant placement in maxillary posterior region.[2] To treat insufficient bone quantity problems, various treatment options have been carried out in the posterior maxilla, like the use of short, tilted and zygomatic implants in a position medial or distal to the sinus cavity when adequate bone support exists.[6,7,8,9]

In the past, implants were inserted in the posterior maxilla without modifying maxillary sinus topography. Large endosteal implants were placed behind the maxillary sinus and in the tuberosity and pterygoid plates. This approach requires three or more pontics between the anterior and posterior implants which leads to excessive prosthesis flexibility, increased stress, and potential implant failure. As a result, the long-term success of maxillary sub-periosteal implants remains uncertain.[11,12,13,14,15,16,17]

To address this issue, a surgical procedure known as sinus membrane elevation is used to slightly lift the maxillary sinus membrane, facilitating the placement of implants in the posterior maxilla. This sinus lift technique was pioneered by Tatum Jr. and first documented by Boyne.[19]

The two main procedures of sinus floor elevation for dental implant placement are-
(1) One-stage/ transalveolar approach.
(2) Two-stage/ lateral window approach.

The decision to utilize one- or two-stage technique is based on the amount of residual bone available and the possibility of achieving primary stability of inserted implants.

The general indications include presence of 5 to 6 mm of residual alveolar bone height, ensuring adequate support for the procedure, no existing pathology/ disease in the area.

The general contraindications include the presence of sepsis, uncontrolled systemic disturbances, psychological disorders, substance abuse problems, oral radiotherapy.

Indirect Sinus Lift offers a minimally invasive alternative to the traditional technique, which is a more extensive surgical approach.[20]

Osteotome technique was first detailed in multiple publications by Summers in 1994 where blunt instruments called osteotomes were used for elevation of sinus, followed by dental implant placement simultaneously four to six months later as a two-stage technique. Overtime technique has been modified to increase density of bone, atraumatically widening ostectomy sites. Generally indicated where the residual bone height is equal to or >6 mm.[20,21,22,23,24,25,26]

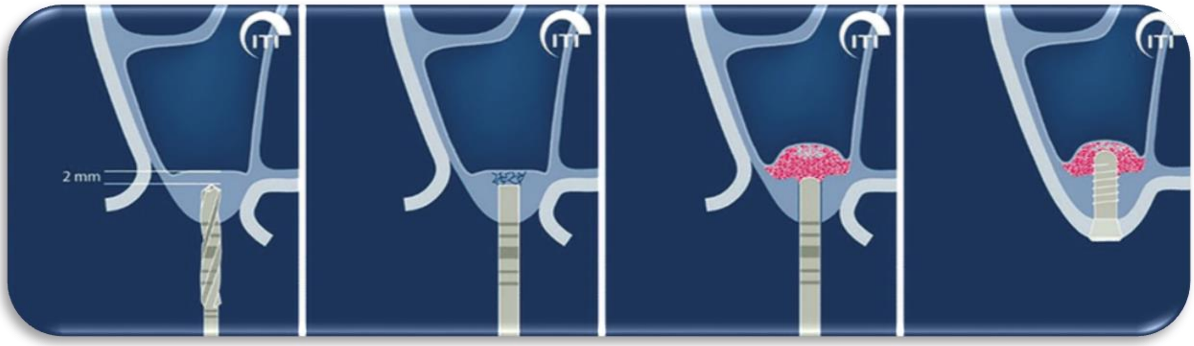

Figure 2. Osteotome sinus floor elevation.[23]

The procedure starts with a 2 mm pilot drill, stopping 2 mm short of the sinus floor. In low-density bone (D3, D4), osteotomes condense and improve bone density. Particulate bone substitutes like 75% hydroxyapatite mixed with 25% autogenous bone are added as graft material. The final osteotome is reinserted with the graft in place, and the implant fixture selected should be slightly larger than the osteotomy.
Survival rate of 90% for implant sites with 4-5 mm bone height and 100% where bone height was 5mm or more was observed.
Various modifications to indirect sinus lift techniques have been developed, leading to improved clinical outcomes: -

INTRALIFT TECHNIQUE - TORRELLA et al [1998] [27,28,29,30,31]
It is a minimally invasive approach for elevating maxillary sinus floor, utilizing piezoelectric surgery and specialized ultrasound tips to ensure precise application.

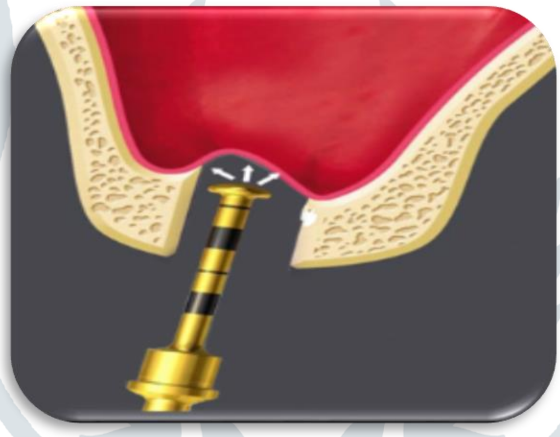

Figure 3. Intralift sinus floor elevation technique.[28]

Preparation of access to the sinus floor involves using Intralift system and Piezotome for controlled vibration and irrigation. Piezotome offers four power modes (D-1 to D-4) based on bone quality. Different diamond tips are used sequentially, with varying diameters, power modes and drilling tasks. A non-cutting tip (Trumpet) aids in sinus membrane elevation through microcavitation. This approach reduces the risk of sinus cavity penetration, minimizes patient discomfort, boasts efficient completion times and eliminates need for osteotome hammering or large flap lifting.

THE MODIFIED TREPHINE/OSTEOTOME SINUS AUGMENTATION TECHNIQUE- FUGAZZOTTO [2001][32,33]
It involves utilizing trephines of increasing outer diameters, succeeded by an osteotome to collapse a bone core before placing regenerative substances, in preparation for implant placement.

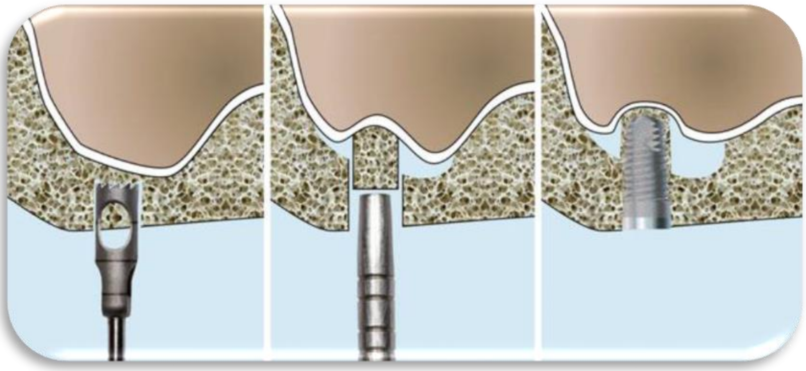

Figure 4. Modified trephine sinus augmentation technique.[33]

Preoperative radiographs and residual ridge morphology guide the use of trephine to prepare site near sinus membrane at a maximum cutting speed of 500 rpm. Offset osteotome, matched to trephine diameter, implodes the bone core gently, leaving a depth approximately 1mm less than prepared site. Site is filled with bone graft material, covered with a collagen membrane, and secured. Flaps are sutured for passive primary closure. This minimizes sinus membrane perforation risk while facilitating controlled bone implosion and sinus floor displacement.

INFLATABLE CATHETER TECHNIQUE - PENARROCHA DIAGO M [2007][34]

Transcrestal sinus lift using sinus balloon technique is based on the osteotome transcrestal procedure described by Summers in 1994. Unlike classical osteotome technique, balloon technique can be used with crestal surface area measuring 3 mm or less, providing up to 10 mm of elevation.

Figure 5. Inflatable catheter technique.[34]

Osteotome tip is gently tapped to fracture sinus cortical layer. Latex balloon is inserted in subantral space and inflated gradually with saline solution not more than 4 ml, while monitoring. Sinus membrane detachment is done till the expected height, followed by bone graft placement, implants are placed if residual maxillary alveolar crestal bone is 3 mm or more.

THE ANTRAL MEMBRANE BALLOON ELEVATION (AMBE) TECHNIQUE - SOLTAN [2012][28,35]

It elevates sinus membrane with minimal trauma reducing postoperative pain, bleeding, possibilities of infection, and morbid symptoms often associated with sinus lift procedures. It is beneficial when access is difficult and teeth are present adjacent to edentulous area.

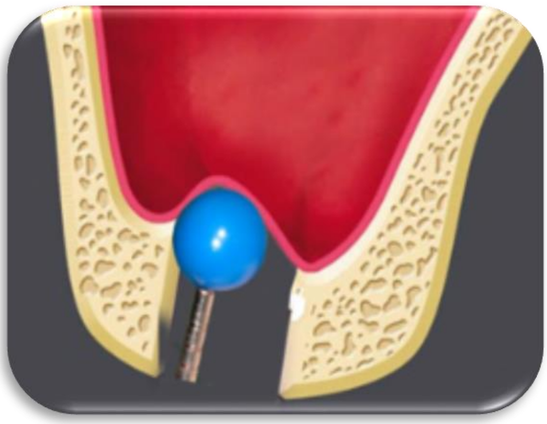

Figure 6. Antral membrane balloon elevation technique.[28]

Osteotomy using 5-mm trephine or a #8 round diamond is performed. Balloon is gently inflated with 2 to 4 ml of sterile saline, elevating the membrane. Resorbable collagen membrane is placed under elevated membrane. Bone graft mixed with PRP is used to fill the space, avoiding overpacking to prevent membrane injury and encourage angiogenesis. Loose compaction continues until the sinus wall is rebuilt.

HYDRAULIC SINUS LIFT TECHNIQUE - M ANDREASI BASSI et al [2013][36,37]

It facilitates hydraulic detachment of the sinus membrane while placing sub-Schneiderian space with graft material. Proposed method involves preliminarily detaching Schneiderian membrane through liquid injection, followed by expulsion, creating space for graft material insertion. Instruments utilized are titanium syringe with a micrometric control piston, threaded surgical steel dispenser, and needle.

Figure 7 The Hydromab kit and system[36]

Figure 8. Sinus lift by hydraulic pressure[37]

Syringes can be pre-loaded with desired amount of graft material. Injection typically takes 5 minutes per ml of material, typically 0.5 to 0.7 ml of material is placed per site. Micrometric screw can be activated manually or, if desired, by contra angle hand piece geared down to a speed of 20 rpm and torque no greater than 45 Ncm. Elevation is checked via x-ray.

MINIMALLY INVASIVE TRANSALVEOLAR SINUS AUGMENTATION (MITSA) - KHER [2014][22,38]

Huwais (2013) developed a non-excavation osteotomy technique, and Kher et al. (2014) introduced MITSA using calcium phosphosilicate (CPS) putty for hydraulic sinus membrane elevation with Osseodensification drills. These drills, used at high speed in an anticlockwise direction with irrigation, create dense bone along the osteotomy walls. About 2mm CPS putty is injected, followed by gentle fracturing of the sinus floor with a 3 mm concave osteotome. Bone substitute is then injected into the sinus cavity, with CPS putty incrementally added until sufficient membrane elevation is achieved. This technique increases bone support and implant stability, with researchers noting a 30% increase in ridge width and bone volume.

TRANSCRESTAL GUIDED SINUS LIFT (TGSL) - POZZI AND MOY [2014][39]

It involves computer-guided planning and guided surgical approach to raise the maxillary sinus. Employing computer-aided design to create surgical templates, along with expander-condensing osteotomes, renders this technique minimally invasive and highly predictable.

Figure 9. TGSL using surgical template.[39]

Radiographic acrylic templates, with radiopaque markers for CT scanning, are created to avoid metal scatter interference. A rigid vinylpolysiloxane occlusion index stabilizes the template during scanning. Virtual implant positions are determined from the template's prosthetic emergence profile, and bone height is calculated using 3D software to adjust drill length. Implant length is confirmed intraoperatively with a periapical radiograph after transcrestal grafting.
The digital treatment plan guides the fabrication of a stereolithographic surgical template that registers planned implant locations, and a surgical occlusion index ensures precise template seating.
On average, bone height increased by 6.4 ± 1.6 mm, ranging from 3.2 to 8.1 mm.

SINU LIFT SYSTEM - PARTHASARADHI.T et al [2015][40]
This minimally invasive two-stage indirect sinus lift procedure uses the Sinu Lift System and beta-tricalcium phosphate (β-TCP) along with platelet-rich plasma (PRP) to evaluate clinical and radiological outcomes as well as postoperative morbidity.

Figure 10. Sinu-Lift system.[40]

The Sinu Lift System kit includes a 3.2 mm starter drill, curettes, and a bone packer. The drill initiates the osteotomy towards the sinus membrane, disengaging on contact to prevent rupture. Color-coded curettes (3 mm yellow and 4.2 mm blue) gently elevate the membrane, minimizing perforation risk. The bone packer fills the space with β-TCP mixed with PRP, and the mucoperiosteal flap is repositioned and sutured.
A mean 4.40 mm increase in bone height was achieved in the augmented area.

AUTOGENOUS CORE LIFT TECHNIQUE IN COMBINATION WITH ALLOPLASTIC PHOSPHOSILICATE PUTTY - UMESH PAI et al [2017][41,42,43,44,45]
This technique creates an autogenous "bone bed" beneath the implant apex, ensuring vital bone surrounds the implant on three sides. Alloplastic phosphosilicate putty promotes osteoconduction and new bone formation. After creating a core with a trephine bur, the core is pushed to the desired depth using an osteotome. The osteotomy is packed with phosphosilicate putty, graft material, and a slightly wider implant for stability. Tapered implants are recommended for stability, especially in low-density areas. This technique has a 97% success rate of implant placement, increasing bone volume within 4 to 6 months and offering shorter healing times and good tissue compatibility.

Common post-operative complications observed with indirect sinus lift techniques are:

- Displacement of implant into sinus.
- Perforation of Schneiderian membrane.
- Intraoperative or post-operative haemorrhage.
- Hematoma.
- Swelling.

- Infection.
- Graft resorption.
- Loss of the graft or implants,

Careful pre-operative planning and intraoperative surgical technique can help decrease or prevent complications.

Advantages associated are:

- More conservative procedure than direct sinus lift.
- Minimally invasive surgical procedure.
- Procedure requires less time and expertise.
- Less frequency of sinus membrane rupture.
- Possibility of simultaneous implantation.
- Good bone healing noted.
- Better positioning of bone grafting material.
- Less/ no chances of resorption.
- Highly predictable implant survival rate.

Disadvantages associated are:

- Blind procedure.
- More chance of errors to occur.

DISCUSSION:

Different techniques for sinus floor elevation in implant dentistry offer a range of methods designed to tackle the issue of inadequate bone height in the posterior maxilla, which often results from sinus expansion following tooth loss. These techniques vary in invasiveness, complexity, and outcomes, each offering distinct advantages and considerations.

Indications and Patient Selection

The choice of sinus lift technique depends on residual bone height, density, patient health, and anatomy. Minimally invasive methods like Intralift and Sinu Lift are ideal for cases with 3-6 mm of residual bone, while complex cases with less bone may require the two-stage lateral window approach for greater augmentation.[27,29,30,40]

Clinical Considerations and Challenges

Despite advancements, challenges like sinus membrane perforation, infection, and graft failure persist.

Surgeon experience, patient compliance, and careful preoperative planning are crucial for success.

Bone Grafting Materials

The choice of bone grafting material is crucial for sinus lift success. Autogenous bone grafts are the gold standard for their osteogenic properties but require a donor site, leading to potential morbidity. Alloplastic materials like hydroxyapatite or synthetic substitutes offer convenience but vary in biocompatibility and resorption rates.[19,20]

Comparative Effectiveness

Each technique has different success rates and complications. Traditional methods like the lateral window and Summers' osteotome have long-term success but are more invasive with longer healing times.[21,22,25,26] Newer techniques, such as the hydraulic sinus lift and MITSA, aim to minimize trauma, reduce operative time, and promote faster healing.[36,37,39]

Advancements in Surgical Techniques

Recent advancements like computer-guided surgeries (TGSL) and innovative tools (Sinu Lift System) highlight the trend towards precision and minimally invasive approaches. These technologies enhance surgical accuracy, improve outcome predictability, and reduce intraoperative complications.[39.40]

Future Directions

The evolution of techniques such as hydraulic sinus lifts and minimally invasive methods signals a promising future for sinus augmentation. Further research into biocompatible materials, advanced imaging, and regenerative techniques may enhance implant predictability and stability in augmented sinus sites.

While the choice of technique for sinus lift largely depends on individual patient factors and clinician expertise, ongoing advances in surgical techniques and grafting materials continue to broaden options available for achieving successful implant placement in the challenging area of posterior maxilla.

CONCLUSION:

Indirect sinus floor techniques in implant dentistry have advanced significantly, offering various approaches for addressing bone deficiency in the posterior maxilla. Traditional methods like the osteotome technique contrast with newer, minimally invasive options such as the Sinu Lift System and hydraulic sinus lift, each balancing invasiveness with effectiveness and recovery time. Advances in precision, guided technologies, and biocompatible materials aim to improve outcomes and patient satisfaction. However, challenges such as membrane perforation and graft failure necessitate careful patient selection, thorough preoperative planning, and ongoing research to refine techniques and materials. Continued advancements promise greater predictability and success in implant placements, enhancing clinical outcomes.

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