

## Maxillary Sinus Floor Elevation Techniques with Recent Advances: A Literature Review

Simran Kaur Pawar, Harsimranjeet S Pawar, Nitin Sapra, Priya Ghangas, Ritu Sangwan, Radhika Chawla

DAV Dental College, Yamunanagar, India

### ABSTRACT

**Background:** In the rehabilitation of atrophic posterior maxilla, factors such as age, extraction of teeth result in loss of alveolar bone height together with increased pneumatization of sinus contradicting the implant surgery. Although adequate bone height can be achieved using various maxillary sinus augmentation techniques, these procedures have been practiced successfully. However, significant complications occur such as perforations or tearing. To maintain the integrity of Schneiderian membrane subsequently increasing the success rate a retrospective analysis is carried out on various techniques with complications which occur during and after treatment. **Methods:** A systematic online and manual review of the literature identified articles dealing with SFE. Applying rigid inclusion criteria, screening and data abstraction were performed independently by two reviewers. The follow-up of was a minimum of 6 months. The articles selected were carefully read and data of interest were tabulated. The identified articles were analyzed regarding implant outcome, with or without graft using different surgical techniques with complication rates using random-effects Poisson regression models to obtain summary estimates/ year proportions. This article reviews various sinus lift techniques for intact elevation of Schneiderian membrane based on advanced PUBMED, Medline, Cochrane database system search of English-language literature from the year 2004 to present in order to compare and evaluate the success rate with minimal complications selecting the most suitable which can fulfill the criteria of being non-invasive, less time-consuming, more reliable and less traumatic. **Result:** After reviewing various sinus elevation techniques; nasal suction technique (NaSucT), balloon antral elevation technique (BAOSFE), and Hydraulic Sinus Lift technique (HySiLift) emerges as more favourable among all these and can efficiently lift the Schneiderian membrane with minimal trauma. We must emphasize that these are new techniques and cannot replace the conventional techniques as a whole.

**Keywords:** Sinus lift up; Schneiderian membrane; maxillary sinus, dental implant; sinus membrane perforation

### Introduction

The maxillary sinus, largest of paranasal sinuses is pyramidal in shape with its base parallel to lateral nasal wall and apex pointing towards zygoma. [1]. The size of maxillary sinus remains insignificant until the permanent dentition fully erupts. The average dimensions of adult sinus are 2.5 to 3.5 cm in width, 3.6 to 4.5 cm in length and 3.8 to 4.5 cm in depth. The size of sinus will increase with age if the area is edentulous. Also, pneumatization varies from person to person [2]. It has an estimated volume of

approximately 12 to 15 cm<sup>3</sup> [3,4]. The inner lining of the maxillary sinus is lined by pseudostratified ciliated epithelium known as Schneiderian membrane with an average thickness of 0.8mm and is continuous with nasal epithelium through the ostium in middle meatus [2]. The superior wall is formed by the floor of the orbit, anterior wall constituted by facial portion of maxillary bone, posterolateral wall constituted by zygomatic bone and greater wing of sphenoid and floor is constituted by the alveolar process and the palatal process of maxilla [5]. It extends between adjacent teeth or individual roots, creating elevations of the antral surface, commonly referred to as 'hillocks' [6]. Because of the implications, this can have on surgical procedures; it is essential for the clinicians to be aware of the exact relationship between the roots of the maxillary teeth and the maxillary sinus floor [8]. When

\*Correspondence

**Dr. Simran Kaur Pawar**

DAV Dental college, Yamunanagar, India

**E Mail:** [simranpawar1992@gmail.com](mailto:simranpawar1992@gmail.com)

patients present with advanced ridge resorption, it could complicate the procedure of implant surgery. This problem is 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. [9] Maxillary sinus floor elevation (SFE) was initially described by Tatum at an Alabama implant conference in 1976 and subsequently published by Boyne in 1980. [3,9] The procedure is one of the most common preprosthetic surgeries performed in dentistry today. Numerous articles have been published in this field regarding different grafting materials and modification to the classic technique. In this review, we will describe various techniques such as transcresal approach, lateral window approach, piezosurgery, hydrodynamic ultrasonic approach, balloon elevation technique, osteotomy technique and nasal suction technique with their complications and success rate.

### Various techniques

1. **Transcresal Approach (tSFE):** Transcresal sinus floor elevation(tSFE) represents a surgical option to vertically increase the bone thickness in the posterior maxilla through the edentulous bone crest. Surgical techniques for tSFE are mainly based on the fracture or perforation of the sinus floor using osteotomes [10-12] or burs [13-19]. After displacing the Schneiderian membrane by transcresal approach, a graft material can be condensed under the elevated sinus membrane to maintain its position apically. A minimally invasive procedure for tSFE, namely the Smart Lift technique(Fig.1B to Fig.1J), uses specially designed drills and osteotomes to make transcresal access to the sinus cavity [20-22]. This procedure is a modification of the technique that was proposed by Fugazzotto [15]. The significance of this technique is that all the instruments are used with adjustable stop devices (fig.1A), hence restricts the working action of burs and osteotomes to the vertical amount of residual bone. With the Smart Lift technique, the condensed trephined bone core that is displaced into the sinus provides the vertical augmentation of the implant site. Therefore, this intrusion osteotomy procedure elevates the sinus membrane and creates a space for blood clot formation. It is conceivable that the contribution of the bone core to the intra-sinus bone formation may relate to the amount of residual bone at the implant site. Scientific evidence clearly indicates that using graft
- biomaterial in association with tSFE can effectively sustain bone regeneration. [19-24]. According to a systematic review, the incidence of membrane perforation following tSFE procedure ranges from 0 percent to 21.4 percent, and postoperative infection ranges from 0 percent to 2.5 percent.[25]. The smart lift technique research has demonstrated the biomaterial used in association with it, may provide a predictable elevation of the maxillary sinus floor along with limited post-surgical complications and post-operative pain/discomfort [26]. Thus, Smart Lift technique represents a minimally-invasive surgical option for sinus floor elevation aimed at preventing surgical complications [20].
2. **Lateral Window Approach (LatW):** Bone augmentation technique by LatW approach provides access to the lateral sinus wall by raising a full thickness mucoperiosteal flap from the alveolar crest with vertical releasing incisions (fig.2A). To access the Schneiderian membrane, high-speed surgical burs are used to prepare a window in the lateral sinus wall. After achieving access, the membrane is dissected carefully from the surrounding bone in three dimensions using curettes followed by placement of a bone graft in the space created below the sinus membrane. In Case the sinus wall is thin and close to the alveolar crest a full thickness mucoperiosteal flap is preferred from the mid crestal area or slightly toward the palate side. The flap should be designed by giving a releasing incision at the anterior or posterior edge with a slight flaring to ensure proper blood supply from the base. In some instances, a single anterior incision is sufficient to provide access for sinus approach. In case further access is necessary it is important to make releasing incisions at a distance from the proposed window site and position of overlying barrier membrane. To make a U-shaped trap-door opening(Fig.2B), either the rotary technique or the piezoelectric technique can provide adequate access to the cortical bone and to expose the thin sinus membrane, thereby creating a space for placement of bone graft. The membrane should be elevated across the sinus floor using an antral curette and up to the level of graft placement(Fig.2C). Furthermore, this elevation must extend anteriorly–posteriorly to provide a floor for graft and implant placement. Different graft fillers consisting of autogenous bone, bone substitute, or a mixture of these can be placed in the elevated sinus space below the lifted sinus membrane(Fig.2D). In general for primary

stabilization with minimum 4-5 mm bone height after 9-12 months when bone regeneration has completed (Fig.2E) implant placement can be done (fig.2F). The raised flap is then closed with primary suturing to avoid exposure of the graft or implants. In the second stage of the implant procedure, a partial thickness mucoperiosteal flap is raised consisting safe zone of palatal keratinized mucosa and laterally positioned to the buccal side. [27,28,29]. The LatW offers an average implant survival rate of 91.8 per cent (range, 61.7 per cent –100 per cent) [6] but involves potential complications such as membrane tear, bleeding, infection, and sinus obstruction, swelling and discomfort.

3. **Piezoelectric Surgery (PS):**In 1988 Tomaso Vercellotti developed the piezoelectric bone surgery, to overcome the limitations of traditional instrumented oral bone surgery. Piezoelectric osteotomy devices consist of an active tip known as insert and three essential points to be considered precise and clean cutting, selective bone-cutting and surgical field relatively free of blood(Fig.3A)[30]. As a result, piezoelectric osteotomies are done in a frequency range of 25-30 kHz provide a cut in the bone structure without affecting the integrity of the surrounding soft tissues [31] but could harm soft tissues if the frequency is over 50 kHz. PS is based on piezoelectric effect which states that certain ceramics and crystals deform when an electric current passes through them, resulting in oscillations of ultrasonic frequency. [32]. The vibrations obtained are amplified and transferred to a vibration tip, which when applied with light pressure on bone tissue results in a cavitation phenomenon, an effect of mechanical cutting which occurs exclusively in mineralised tissues[33]. The cavitation effect of the system induces a hydropneumatic pressure of saline irrigant that helps to the elevate the sinus membrane without trauma(Fig.3B)[30]. It is reported that inadvertent perforation of the membrane can be avoided when PS technique is applied appropriately [34]. Flemming *et al.*, in 1998, illustrated this method in a study of 15 patients in which 21 piezoelectric osteotomies were performed. They found a success rate of 95 per cent. Perforations in the maxillary sinus membrane were observed in only 5 percent of patients [35]. Wallace *et al.* (2007) conducted a study in which 100 maxillary sinus surgeries were performed using the piezoelectric device. Only seven cases of perforation of the sinus mucosa

were observed. None of these perforations occurred because of the inserts of the piezoelectric unit. All of them were caused by the subsequent elevation of the Schneiderian membrane with hand tools. The presence of bony septum results in perforations (four cases) and during manipulation of extremely thin membranes (three cases). [36]. Active tip of the piezosurgical device is small as compared to micro- oscillating device. Therefore, increases the cutting efficiency and decreases the patient discomfort. [37] Because PS uses micro vibrations, therefore, produces less vibration and noise than conventional surgery. These features could minimize patient's psychological stress and fear in adjunct to local anesthesia during osteotomy [38]. In contrast to conventional micro saws where blood is moved in and out of the cutting area and the visibility is low, the operative field in PS remains almost blood-free during cutting procedure [39]. Authors have demonstrated a reduction in inflammatory cells and increased osteogenic activity around implants placed by a piezoelectric ultrasound device in comparison with other systems [40,41]. As PS collects bone particles with an optimal size and low heat generation, thereby minimizes the risk of thermal necrosis [42] But other studies have shown the possible risk of post-operative complications due to the presence of gap left after the PS thereby, reduces the overall success rate. [31].

4. **Hydraulic Sinus Lift Technique (HySiLift):** Hydraulic Pressure technique through crestal approach has been used recently for the elevation of sinus membrane. [43]. This method facilitates detachment of the Schneiderian membrane through injection of a liquid followed by its spontaneous expulsion or aspiration, to then pass on at the insertion of the graft material in the sub-Schneiderian space created this way. These methods, while effective, involve a prolongation of the operating procedure. Since it is conceptually simpler to use a graft material in a liquid state that when injected hydraulically raises the mucosa and fills the sub-Schneiderian space at once. Furthermore, this method uses conventional single-use syringes in which it is not possible to check on the progression of the piston since this depends on individual sensitivity. In 2010, [45] A new method was proposed that takes advantage of the hydraulic pressure exercised on a graft material of a pasty consistency to detach the antral mucosa and simultaneously fill the sub-antral space. The technique was named as Hydraulic Sinus Lift (HySiLift)[45]. The instruments made for this

purpose consist of three components: a titanium syringe equipped with a micrometric piston to assemble single-use plastic syringes of various volumes, a dispenser in threaded surgical steel available in different forms and measurements and a needle in surgical steel. The single-use syringes can be pre-loaded with the desired amount of graft material, or it is possible to directly use the syringe containing the graft material as provided by the manufacturer(Fig.4A) [46,47,48]. According to the report, 231 implants were placed with HPISE (hydraulic pressure induced sinus elevation) technique(Fig.4B) at three centers from January 2008 to May 2010; ten implants showed failure. Membrane perforation was developed in 14 implants (6.0 percent of perforation). Concentrated growth factor (CGF) alone was inserted in the new compartment under the elevated sinus membrane in 127 implants (54.9 percent). Bone graft was used in 100 implants (43.2 percent). Collagen membrane was inserted in three implants (1.3 percent). Hyaloss matrix was used in one implant (0.4 percent).The success rate of implants was 96 per cent[49] It shows that HySiLift technique allows the hydraulic detachment of the maxillary sinus mucosa with subsequent filling of the sub-Schneiderian space with the graft material. [49]. This technique is quite advantageous as it is having narrow learning curve, minimal invasiveness and greater precision.

5. **Balloon elevation technique:** Minimally invasive antral membrane balloon elevation(MIAMBE) is a modification of the bone-added osteotome sinus floor elevation (BAOSFE) method as the antral membrane elevation is performed through the osteotomy site (3.5 mm) using a specially designed balloon. This technique has been used as an alternative to conventional procedures[50-63]. MIAMBE balloon-harboring device (MiamiLTD, Netanya, Israel) consists of a stainless steel tube, three mm in diameter, that connects on its proximal end to the dedicated inflation syringe, and its distal portion has an embedded single use silicone balloon. The balloon is inflated with diluted contrast fluid that pushes up the Schneiderian membrane, creating the desired height for implant placement. Under local anesthesia, a four mm diameter punch was used to remove the epithelium to expose the underlining bone crest at the precise future implant location. An ultrasonic Piezoelectric (Mectron S.P.A, Genova, Italy) round diamond tip drill was used in the center of the exposed alveolar crest up to one to two mm below the sinus floor(Fig.5B). Depth

was predetermined(Fig.5A). Bone graft material and PRF were inserted into the osteotomy and MIAMBE osteotome subsequently, enlarges the osteotomy site from two to 2.9 mm. After removing the osteotome, the membrane integrity was assessed by Valsalva maneuver. The metal sleeve of the balloon harboring device (MiamiLTD), specifically designed for sinus augmentation procedures, was inserted into the osteotomy 1 mm beyond the sinus floor (controlled by Teflon stopper)(Fig.5C)(Fig.5E). The balloon was slowly inflated with the barometric inflator up to two atm. Once the balloon emerged from the metal sleeve under the sinus membrane, the pressure dropped to 0.5 atm. Subsequently, the balloon was inflated with a progressively higher volume of contrast fluid. After the desired elevation (11 mm) had been obtained, the balloon remained inflated in the sinus for five minutes to reduce the sinus membrane elasticity(Fig.5D)(Fig.5F). The balloon was then deflated and removed. A mixture of xenograft grafting material was placed followed by implant placement into the osteotomy site(Fig.5G)(Fig.5H). MIAMBE is a minimally invasive, single-sitting procedure of maxillary bone augmentation, and implant placement[51-53]. Advantages of using a flapless approach for dental implant placement includes [54-61] predictability, preservation of crestal bone and mucosal health surrounding the implants.

6. **Osteotome Technique (OstSFE):** OstSFE technique utilizes osteotome and a surgical mallet to break sinus floor and to compact bone graft into the sinus cavity. (Fig.6A)A pilot drill is usually used to the depth 1-2mm short to the sinus floor to accommodate osteotome. (Fig.6B)Small diameter osteotome is inserted into the prepared bone to compress sinus followed by wider osteotome to accommodate implants.(Fig.6C) The insertion of osteotome would impose a light pressure on the sinus floor. To elevate the sinus floor indirectly and provide a buffering effect to sinus floor, bone graft material is added using an amalgam carrier.(Fig.6D)The sinus floor is elevated by repeated bone grafting and osteotome insertion followed by placement of implants(Fig.6E)[62]. In another study, Osteotomes can be used for SFE without bone grafting if residual bone height (RBH) is 5.4 mm and this could lead to a mean endo-sinus bone gain of 1.2-2.5 mm[63]. In this procedure, the osteotome (Straumann AG, Basel, Switzerland) was engaged to push the sinus floor axially. The sinus floor was then broken and

pushed into the sinus cavity to a maximal height of three mm and the integrity of the membrane was controlled with an undersized depth gauge of 2.1mm; however, micro-perforation of the Schneiderian membrane could not be excluded [64]. No grafting material was used[65]. The study showed that implants achieved primary stability. The healing period was uneventful latter even found to be inversely correlated with the RBH (i.e., the lower the RBH, the greater the bone gain) and to enhance the primary stability in low-density bone, the use of osteotomes is more relevant than the use of drills. The osteotomes by compression can laterally condense bone thereby creates a denser interface at the placed implants[66] and improves the initial bone-to-implant contact[67]. The studies have shown that the grafting technique has the advantage of surgical simplicity, resulting in minimal post-operative symptoms. But, also has the possibility of complications such as perforation of sinus membrane during bone drilling and bone compaction using osteotome. Also, benign positional paroxysmal vertigo (BPPV) can be caused by the damage to the internal ear from striking osteotome and surgical mallet when sinus floor is broken.11-13 [68-70].OstSFE is a blind technique, so sinus augmentation is limited. The OstSFE technique has lower success rates when residual bone height is 4mm or less (when compared to cases with 5mm or more residual bone height)[71]. Accidental sinus membrane perforation can be developed from improper drilling due to the magnification of radiograph, improper use of osteotome and excessive compaction of the bone graft. Membrane perforation can cause the failure of osseointegration and sinus pathosis. Also The OstSFE procedure described by Summers[72,73] involves a grafting material that is condensed in the osteotomy site and can migrate into the sinus if perforation occurs leading to inflammation The Non-grafting procedure, on the other hand, has eliminated the risk of undetected perforations that are likely to remain uneventful because the membrane can reform around four mm of protruding implants. The advantages of this procedure were the avoidance of invasive surgery and permitting treatment within a single surgical step.[74,75].

- 7. Nasal suction technique (nasuct):**The nasal suction technique (NaSucT) is characterized by the insertion of a suction catheter attached to a high-flow vacuum regulator that incorporates a suction canister connected to a 10 kPa medical vacuum.

As to the ultrasonic surgery approach, a voltage applied to a polarized piezoceramic causes it to expand in the direction of and contract perpendicular to polarity. Moreover, a frequency of 25 to 29 kHz is used to cut only mineralised tissue and not neurovascular tissue and other soft tissues, which are cut at frequencies higher than 50 kHz. In a study, nasal suction was applied in 24 consecutive patients through the ipsilateral nostril during SFE(Fig.7A). The suction device was attached to a high-flow vacuum regulator that incorporated a suction canister connected to a 10-kPa medical vacuum (-75 mm Hg). Fifteen subjects received unilateral SFE, and six subjects had bilateral staged lateral wall sinus elevation; the remaining three subjects had osteotome sinus floor elevation (three unilateral and one bilateral) with simultaneous implant placement. During SFE, the use of NaSucT facilitated the inversion of the sinus lining around the edges of the lateral access window. This procedure has made the sinus lifting easier, as the need for extensive instrumentation was reduced significantly. In three subjects, elevation of the sinus lining occurred spontaneously from the lateral, medial, and inferior surfaces of the antrum when nasal suction was applied. When Sinus lifting was facilitated by nasal suction, no perforation of the sinus lining occurred in that series(Fig.7B) [76]. In another study, standard sinus membrane elevation procedures were performed in group one using osteotomy surgery and in group two with the application of nasal suction and ultrasonic surgery device. In group one (control) an osteotomy was prepared using a round oral surgery bur with saline irrigation. Elevation of the sinus lining was completed by using standard sinus lift instruments (Implacil DeBortoli, Sao Paulo, Brazil). In group two (test), an osteotomy was prepared using an ultrasonic surgery with NaSucT, and elevation of the sinus lining was completed by using standard sinus lift instruments. The incidence of sinus membrane perforation was evaluated. Four patients belonging to the control group presented a small perforation of the membrane (<5 mm); conversely, in the test group, no perforation of membranes was observed. The application of nasal suction through the ipsilateral nostril resulted in the inversion of the sinus membrane around the edges of the lateral access window. NaSucT has made the sinus lifting easier and less prone to perforations because the need for extensive instrumentation was significantly eliminated. A statistically significant difference was present



between the incidence of sinus membrane perforation in group one versus two (control versus test) ( $P < 0.01$ ) [77].

### Discussion

Maxillary sinus floor elevation is one of the most common preprosthetic procedures associated with certain complications [78-80], the most important being the perforation of sinus membrane, which may lead to loss of graft materials and early failure of a dental implant. [79] Various techniques have been proposed to overcome this complication [81,82]. In tSFE technique as proposed by Fugazzotto [83] seems highly technique-sensitive, particularly under the control of the working action of both trephine bur and osteotome. A systematic review [84] reported an incidence of membrane perforation ranging from 0 per cent to 21.4 percent, and postoperative infection from 0 percent to 2.5 percent following tSFE. To overcome the complication of perforation, the Smart Lift technique was used that result in less trauma and discomfort to the patient, as the combined utilization of a trephine bur near the sinus floor limits the need for repeated malleting [85]. The another disadvantage of the crestal approach is that the initial implant stability is unproven if the residual bone height is less than six mm [86]. However, in LatW technique significant swelling and hematoma formation in the cheek and under the eye has been reported [87,88]. Although it provides a greater amount of bone augmentation to the atrophic maxilla but, requires a large surgical access. [90] and leads to much more patient's postoperative discomfort, pain, swelling, bruising, and risk of infection [87,89] Whereas in PS technique the perforation rate reported in the literature in surgeries performed by conventional technique without using the piezoelectric device ranges between 14 and 56 percent [90], with an average of 30 percent [91] but according to some authors the rate of perforation ranges between 5 percent [92] and 7 percent [91]. These authors also concluded that in most cases these perforations occurred during membrane handling with hand tools, rather than during the use of ultrasound [93,94]. However, ultrasonic vibration allows cortical bone splitting while preserving the surrounding soft tissues [94]. The use of ultrasonic tips has been reported extremely safe and effective, preserving vital structures such as nerves and blood vessels [95] Also, it is more effective in stimulating

osteogenesis around implants, promoting a greater number of osteoblasts in the implant receptor sites and reducing local inflammatory precursors [96,97]. The PS technique does not increase the total surgical time of the procedures because the time spent to protect the soft tissues is minimized [90]. Furthermore, the number of instruments required to perform the osteotomies in many cases is reduced to only the ultrasonic handpiece. This procedure leads to a reduction in the time spent with the exchange of instruments [33]. In HySiLift technique, the piezosurgical device promotes a clean surgical area as it keeps it free from bleeding during bone cutting, due to the effect of air-water cavitation effect of the ultrasonic device. This technique allows a better view of the surgical site [87]. The cooling solution by hydropneumatic pressure assists in the Schneiderian membrane release [98] which minimizes the risk of perforations. The strong point of this method includes brief learning curve, reduced invasiveness, reduction of the operating times and greater precision [99]. In Balloon technique, the BAOSFE yields modest antral membrane elevation and bone augmentation requires considerable skills, and may frequently result in membrane tear, even when selectively applied [100] and endoscopically controlled. The use of the specific dedicated MIAMBE balloon enables the operator to predictably elevate the Schneiderian membrane and place implants that are 13-mm long [101]. The flapless approach together with the MIAMBE used in above study has several advantages over the lateral window approach and the BAOSFE techniques. These include reduced patient trauma, improved patient comfort and recuperation, decreased surgical time, faster soft tissue healing, and normal oral hygiene procedures immediately postsurgery [102-104]. An alternative to the lateral approach is the OstSFE procedure. It is less invasive, and the treatment can be achieved with a single surgery [105]. To enhance the primary stability in low-density bone, the use of osteotomes is more relevant than the use of drills. By compression, the osteotomes can laterally condense bone and create a denser interface at the placed implants [106], improving the initial bone-to-implant contact [107]. The OstSFE procedure described in a study [108,109] involves a grafting material that is condensed in the osteotomy site to elevate the sinus membrane. If the Schneiderian membrane is perforated, the filling material can migrate into the sinus and lead to inflammation [110,111].

Therefore, the chances of achieving a sufficiently high elevation with the OstSFE are limited. [112]. On the other hand, in NaSutT no intraoperative or postoperative complications were observed in any patients. Four patients belonging to the control group presented a small perforation of the membrane (<5 mm); conversely, in the test group, no perforation of membranes was observed. The application of nasal suction through the ipsilateral nostril resulted in the inversion of the sinus membrane around the edges of the lateral access window. This procedure has made the sinus lifting easier and less prone to perforations because the need for extensive instrumentation was significantly eliminated [78].

### Conclusion

After describing various techniques, we conclude that nasal suction technique(NaSutT), balloon antral elevation technique(BAOSFE), and Hydraulic Sinus Lift technique(HySiLift) prove to

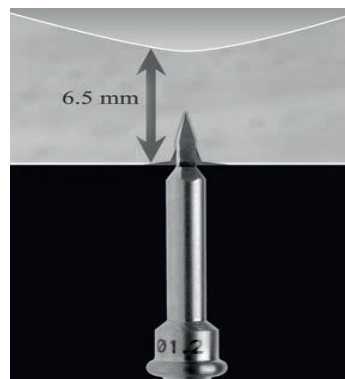
be possibly more effective and efficient. These techniques have less perforation rate, less chair side time, less technique sensitivity, eliminates the need for extensive instrumentation and can increase the success rate as compared to the conventional techniques which pose the patient to a greater risk of discomfort, more tissue trauma, more time-consuming and can expose the patient to high infection rate. By using these recent techniques, one can increase the effectiveness of bone augmentation and implant placement subsequently maintaining the integrity of Schneiderian membrane. However, further controlled clinical trials are needed to evaluate the efficacy and safety of these techniques for their appropriate implementation in the field of oral surgery.

### Ethics statement/confirmation of patient permission

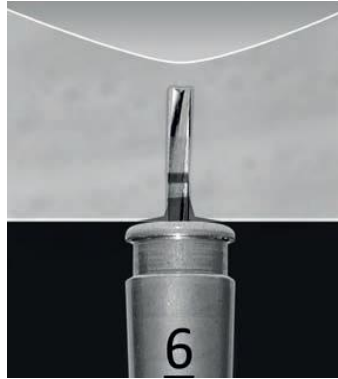
None declared.



**Fig 1A:** All manual and rotating instruments of the Smart Lift technique is used with adjustable stop devices ( length ranging from 4 to 11 mm).



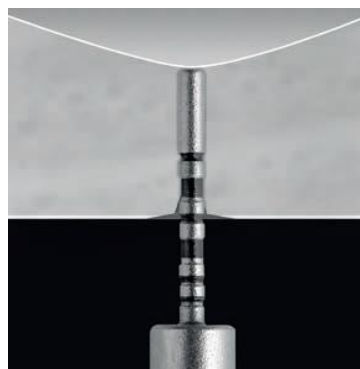
**Fig 1B:**The Locator Drill perforates the Cortical Bone to a depth of 3.5mm at the site Where an implant is to be placed.



**Fig 1C:**The Probe Drill ( $\text{\O} 1.2 \text{ mm}$ ) is used to define the position and orientation of the implant.



**Fig 1D:**The “surgical working length” is obtained by gently forcing the probe osteotome( $\text{\O}1.2 \text{ mm}$ ) in an apical direction until the resistance of the sinus floor is met.



**Fig 1E:**A Radiographic Pin ( $\text{\O} 1.2 \text{ mm}$ ) or  $\text{\O} 4.0 \text{ mm}$  is used to check the orientation and depth of the prepared implant site.





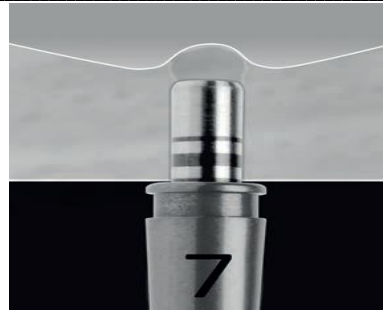
**Fig 1F:** According to implant diameter a Guide Drill of either  $\text{\O} 3.2\text{m}$  or  $\text{\O} 4.0\text{mm}$  is used to create a crystal countersink, 2 mm deep, where the trephine bur will be inserted



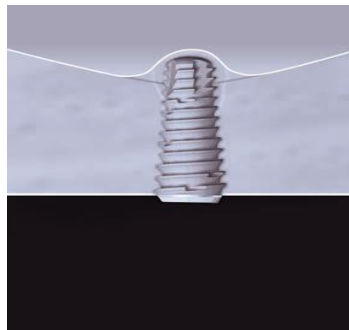
**Fig 1G:**The trephine bur (Smart Lift Drill,  $\text{\O} 3.2\text{ mm}$  or  $\text{\O} 4.0\text{ mm}$ ) produces a Bone core up to the sinus floor



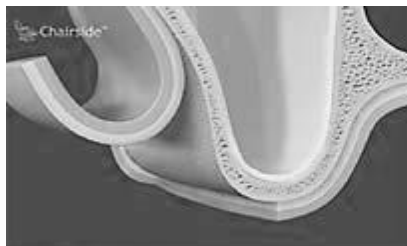
**Fig 1H:** Calibrated osteotome having the same diameter (Smart Lift Elevator,  $\text{\O} 3.2\text{ mm}$  or  $\text{\O} 4.0\text{ mm}$ ) as of trephine preparation fractures the sinus.



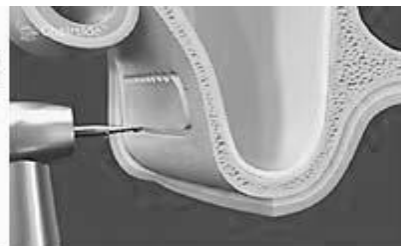
**Fig 1I:** To implode the trephined bone core over the sinus floor, Smart Lift Elevator is used under gently malleting forces



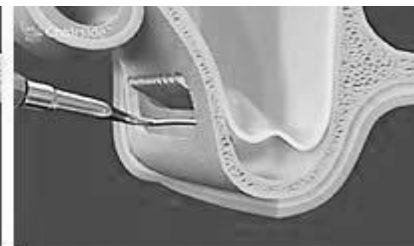
**Fig 1J:** The implant is inserted



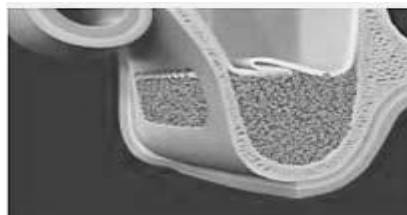
**Fig 2A:** Raising full thickness mucoperiosteal Flap



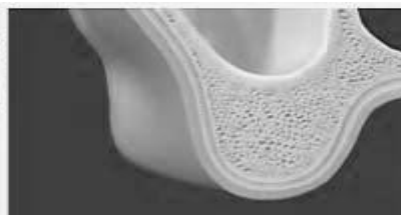
**Fig 2B:** Making U-shaped trap door opening to create access to the sinus membrane



**Fig 2C:** Elevating the sinus membrane using an antral curette



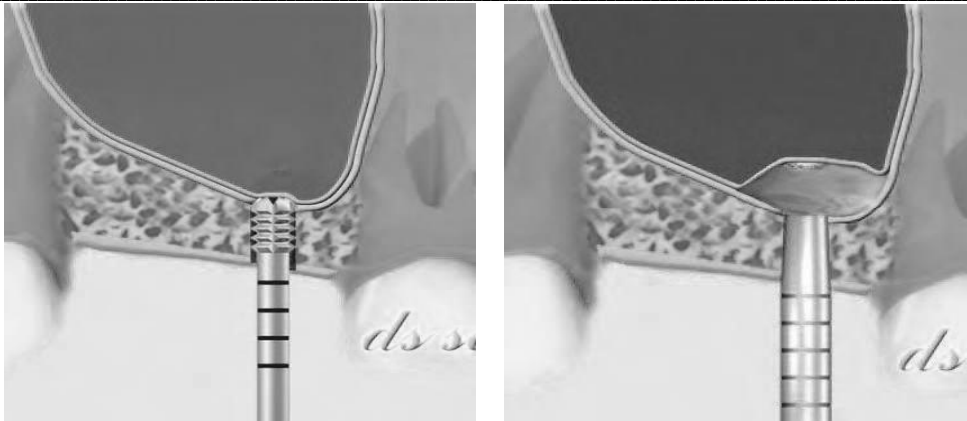
**Fig 2D:** Placing graft material in the created space below the lifted sinus membrane



**Fig 2E:** Regenerated bone after graft placement

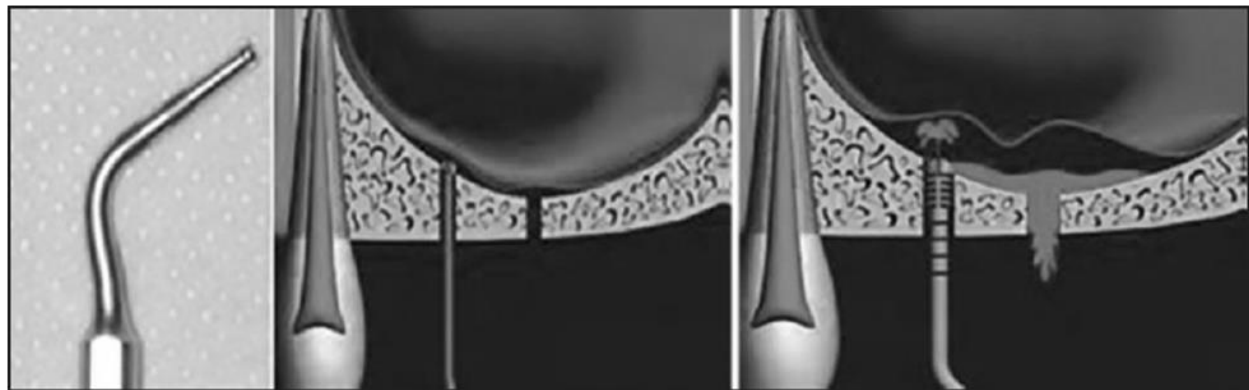


**Fig 2F:** Implant placement is done



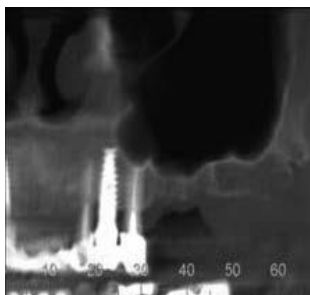
**Fig 3A:** Sinus floor is penetrated with PISE tip directly At this stage, the exact bone height from alveolar crest to sinus floor is estimate

**Fig 3B:** PISE tip using vibration to elevate sinus membrane



**Fig 4A:(left)** Round carbide tip is used to break sinus floor directly. This tip provides the surgeon with the tactile feeling of using ultrasonic vibration and elevate membrane.

**Fig 4B:(right)** HPISE is inserted to break sinus floor sinus membrane using water pressure.



**Fig 5A:** Panoramic projection of the residual ridge underneath the sinus floor.



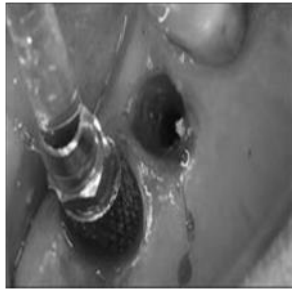
**Fig 5B:** Osteotomy preparation using the Piezosurgery device 1mm beyond the sinus floor



**Fig 5C:** The metal sleeve of the balloon harboring device inserted into the mesial osteotomy.



**Fig 5D:** Periapical radiograph demonstrating balloon inflation in mesial site



**Fig 5E:** The metal sleeve of the balloon harboring device inserted into the distal osteotomy, 1 mm beyond the sinus floor



**Fig 5 F:** A periapical radiograph is showing balloon inflation in the distal site



**Fig 5G:** A mixture of xenograft grafting material PRF is injected to the sites after balloon removal



**Fig 5H:**Self-threading implants, 5 mm in diameter and 13 mm long, inserted into the osteotomy site



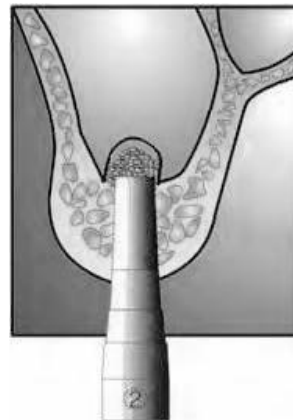
**Fig 6A:** A pilot drill is usually used to the depth 1-2mm short to the sinus floor to accommodate osteotome.



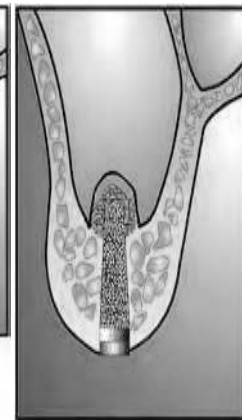
**Fig 6B:** Small diameter osteotome is inserted



**Fig 6 C:** To elevate the sinus indirectly and provide a buffering effect to sinus floor; bone graft material is added



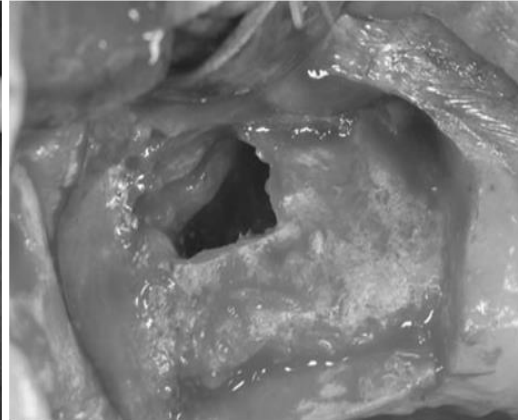
**Fig 6D:** The sinus floor is elevated by repeated bone grafting and osteotome insertion.



**Fig 6E:** Implant placement is done.



**Fig 7A:** Application of nasal suction through the nostril on ipsilateral side elevation on applying nasal suction without instrumentation to standard surgical suction equipment.



**Fig 7B:** An instantaneous and complete membrane as the sinus elevation being carried out. The suction device is attached.

## References

1. Bjarni E. Pjetursson and Niklaus P. Lang, Ch.50: Elevation of the Maxillary Sinus Floor. In: Jan Lindhe, Niklaus P. Lang, and Thorkild Karring editors. *Clinical Periodontology and Implant Dentistry*, 2008; 5th Ed. vol 1: 1099-118.
2. Vand Den Bergh JPA, Ten Buggen-Kate CM, et al. Anatomical aspects of Sinus floor elevations. *Clinical Oral Implants Resources*. 2000; 11:256-265.
3. Boyne P, James R A. Grafting of the Maxillary Sinus floor with autogenic bone. *J Oral Maxillofac Surg*. 1980; 17:113-116.
4. Chanavaz, M. Maxillary sinus: anatomy, physiology, surgery and bone grafting related to implantology—eleven years of surgical experience (1979–1990). *J Oral Implantol*. 1990; 16(3):199-209.
5. Ameet Singh, Conner J Massey, *Paranasal Sinus Anatomy. Drugs & Diseases. Anatomy. Medscape.* <http://emedicine.medscape.com/article/1899145-overview#a2>. 26 May 2016.
6. Waite DE. Maxillary Sinus. *Dent Clin North Am*. 1971; 15:349-68.
7. McGrowan, Baxter PW, James J. *The Maxillary Sinus and its Dental Implications*. 1<sup>st</sup> ed London: Wright Co; 1993: 1-25.
8. Tank PW. *Grant's Dissector* 13 ed. Philadelphia: Lippincott Williams & Wilkins; 2005. p. 198.
9. Tatum H Jr. Maxillary, and sinus implant reconstructions. *Dental Clinics of North America*. 1986; 30: 207-229.
10. Coatoam, G.W. Indirect sinus augmentation procedures using one-stage anatomically shaped root-form implants. *Journal of Oral Implantology*. 1997; 23: 25-42.
11. Bruschi, G.B., Scipioni, A., Calesini, G. & Bruschi, E. Localized management of sinus floor with simultaneous implant placement: a clinical report. *The International Journal of Oral & Maxillofacial Implants*. 1998; 13: 219-226.
12. Deporter DA, Todescan R, Caudry S. Simplifying management of the posterior maxilla using short, porous-surfaced dental implants and simultaneous indirect sinus elevation. *Int J Periodontics Restorative Dent*. 2000; 20(5): 476-485.
13. Tatum H Jr. Maxillary, and sinus implant reconstructions. *Dental Clinics of North America*. 1986; 30: 207-229.
14. Cosci, F. & Luccioli, M. A new sinus lift technique in conjunction with placement of 265 implants: a 6-year retrospective study. *Implant Dentistry*. 2000; 9: 363-368.
15. Fugazzotto, P.A. Immediate implant placement following a modified trephine/osteotome approach: success rates of 116 implants to 4 years in function. *International Journal of Oral and Maxillofacial Implants*. 2002; 17: 113-120.



16. Le Gall M.G. Localized sinus elevation and Osseo compression with single-stage tapered dental implants: technical note. *The International Journal of Oral & Maxillofacial Implants*. 2004; 19: 431-437.
17. Soltan, M. & Smiler, D.G. Trepine bone core sinus elevation graft. *Implant Dentistry*. 2004; 13: 148-152.
18. Chen, L. & Cha, J. An 8-year retrospective study: 1100 patients receiving 1557 implants using the minimally invasive hydraulic sinus condensing technique. *Journal of Periodontology*. 2005; 76: 482-491.
19. Vitkov, L., Gellrich, N.C. & Hannig, M. Sinus floor elevation via hydraulic detachment and elevation of the Schneiderian membrane. *Clinical Oral Implants Research*. 2005;16: 615-621.
20. Trombelli, L., Minenna, P., Franceschetti, G., Farina, R. & Minenna, L. SMART-LIFT: a new minimally invasive procedure for the elevation of the maxillary sinus floor. *Dental Cadmos*. 2008; 76: 71-83.
21. Trombelli, L., Minenna, P., Franceschetti, G., Minenna, L. & Farina, R. Transcrestal Sinus Floor Elevation with a Minimally Invasive Technique. A Case Series. *Journal of Periodontology*. 2010; 81: 158-166.
22. Trombelli, L., Minenna, P., Franceschetti, G., Minenna, L., Ito, A. & Farina, R. A Minimally Invasive Approach for Transcrestal Sinus Floor Elevation: a Case Report. *Quintessence International*. 2010; 41: 363-369.
23. Pjetursson, B.E., Rast, C., Brägger, U., Schmidlin, K., Zwahlen, M. & Lang, N.P. Maxillary sinus floor elevation using the (trans-alveolar) osteotome technique with or without grafting material. Part I: Implant survival and patients' perception. *Clinical Oral Implants Research*. 2009; 20: 667-676.
24. Pjetursson, B.E., Ignjatovic, D., Matuliene, G., Brägger, U., Schmidlin, K. & Lang, N.P. Maxillary sinus floor elevation using the osteotome technique with or without grafting material. Part II – Radiographic tissue remodeling. *Clinical Oral Implants Research*. 2009; 20: 677-683.
25. Tan WC, Lang NP, Zwahlen M, Pjetursson BE. A systematic review of the success of sinus floor elevation and survival of implants inserted in combination with sinus floor elevation. Part II: Transalveolar technique. *J Clin Periodontol* 2008; 35 (Suppl. 8):241-254.
26. Trombelli L, Franceschetti G, Rizzi A, Minenna P, Minenna L, Farina R. Minimally invasive transcrestal sinus floorelevation with graft biomaterials. A randomized clinical trial. *Clin Oral Implants Res*. 2012 Apr; 23(4):424-32.
27. Garg.A.K. Augmentation Grafting of the Maxillary Sinus for Placement of dental implants: anatomy, physiology, and procedures. *Implant Dent*,1999; 8:36-46.
28. M.D.Rosen, B.G.Sarvat. Change of the volume of the Maxillary Sinus of the dog after extraction of adjacent teeth *Oral Surg, Oral Med, Oral Pathol*, 1995; 8:420-429.
29. M.Del Fabbro, G.Rosano, S.Taschievi: Implant survival rates after Maxillary Sinus augmentation. *Eur J Oral Sci*, 2008; 116:497-506.
30. Vercellotti T. Technological characteristics and clinical indications of piezoelectric bone surgery. *Minerva Stomatol*. 2004; 53(5):207–214.
31. González-García A., Diniz-Freitas M., Somoza-Martín M., García-García A. Piezoelectric and conventional osteotomy in alveolar distraction osteogenesis in a series of 17 patients. *Int. J. Oral Maxillofac. Implants*. 2008; 23(5):891–896.
32. Leclercq P., Zenati C., Amr S., Dohan D.M. Ultrasonic bone cut part 1: State-of-the-art technologies and common applications. *J. Oral Maxillofac. Surg*. 2008; 66(1):177–182.
33. Crosetti E., Battiston B., Succo G. Piezosurgery in head and neck oncological and reconstructive surgery: personal experience on 127 cases. *Acta Otorhinolaryngol. Ital*. 2009; 29(1):1–9.
34. Vercellotti T., De Paoli S., Nevins M. The piezoelectric bony window osteotomy, and sinus membrane elevation: the introduction of a new technique for simplification of the sinus augmentation procedure. *Int. J. Periodontics Restorative Dent*. 2001; 21(6):561–567.
35. Misch C.M. Comparison of intraoral donor sites for onlay grafting prior to implant placement. *Int. J. Oral Maxillofac. Implants*. 1997; 12(6):767–776.
36. Wallace S.S., Mazor Z., Forum S.J., Cho S.C., Tarnow D.P. Schneiderian membrane perforation rate during sinus elevation using piezosurgery: clinical results of 100 consecutive cases. *Int. J. Periodontics Restorative Dent*. 2007; 27(5):413–419.
37. Schlee M., Steigmann M., Bratu E., Garg A.K. Piezosurgery: basics and possibilities. *Implant Dent*. 2006; 15(4):334–340.

38. Sohn D.S., Ahn M.R., Lee W.H., Yeo D.S., Lim S.Y. Piezoelectric osteotomy for the intraoral harvesting of bone blocks. *Int. J. Periodontics Restorative Dent.* 2007; 27(2):127–131.
39. Schlee M., Steigmann M., Bratu E., Garg A.K. Piezosurgery: basics and possibilities. *Implant Dent.* 2006; 15(4):334–340.
40. Preti G., Martinasso G., Peirone B., Navone R., Manzella C., Muzio G., Russo C., Canuto R.A., Schierano G. Cytokines and growth factors involved in the osseointegration of oral titanium implants positioned using piezoelectric bone surgery versus a drill technique: a pilot study in minipigs. *J. Periodontol.* 2007; 78(4):716–722.
41. Robiony M., Polini F., Costa F., Toro C., Politi M. Ultrasound piezoelectric vibrations to perform osteotomies in rhinoplasty. *J. Oral Maxillofac. Surg.* 2007; 65(5):1035–1038.
42. Berengo M., Bacci C., Sartori M., Perini A., Della Barbera M., Valente M. Histomorphometric evaluation of bone grafts harvested by different methods. *Minerva Stomatol.* 2006; 55(4):189–198.
43. Kfir E, Kfir V, Mijiritsky E, Rafaeloff R, Kaluski E. Minimally invasive antral membrane balloon elevation followed by maxillary bone augmentation and implant fixation. *J Oral Implantol* 2006; 32(1):26-33.
44. Bucci-Sabattini V, Salvatorelli G. New simplified technique for augmentation of the maxillary sinus. *Montpellier ACTA*; 1999.
45. Andreasi Bassi M, Lopez MA, Confalone L, Fanali S, Carinci F. Hydraulic sinus lift technique: description of a clinical case. *Annals of Oral & Maxillofacial Surgery* 2013 Jun 01;1(2):18.
46. Busenlechner D, Huber CD, Vasak C, Dobsak A, Gruber R, Watzek G. Sinus augmentation analysis revised: the gradient of graft consolidation. *Clin Oral Implants Res* 2009 Oct; 20(10):1078-83.
47. Carmagnola D, Abati S, Celestino S, Chiapasco M, Bosshardt D, Lang NP. Oral implants placed in bone defects treated with Bio-Oss, Ostim-Paste or PerioGlas: an experimental study in the rabbit tibiae. *Clin Oral Implants Res* 2008 Dec; 19(12):1246-53.
48. Smeets R, Grosjean MB, Jelitte G, Heiland M, Kasaj A, Riediger D. [Hydroxyapatite bone substitute (Ostim) in sinus floor elevation. Maxillary sinus floor augmentation: bone regeneration by means of a nanocrystalline in-phase hydroxyapatite (Ostim)]. *Schweiz Monatsschr Zahnmed* 2008; 118(3):203-12.
49. Dong-Seok Sohn. *New Bone Formation in the Maxillary Sinus With/Without Bone Graft, ImplantDentistry - The Most Promising Discipline of Dentistry*, Prof. Ilser Turkyilmaz (Ed.),2011; ISBN: 978-953-307-481-8.
50. Kfir E, Kfir V, Eliav E, et al. Minimally invasive antral membrane balloon elevation: Report of 36 procedures. *J Periodontol.* 2007; 78:2032-2035.
51. Kfir E, Goldstein M, Rafaelov R, et al. Minimally invasive antral membrane balloon elevation in the presence of antral septa: A report of 26 procedures. *J OralImplantol.* 2009; 35:257-267.
52. Kfir E, Goldstein M, Yerushalmi I, et al. Minimally invasive antral membrane balloon elevation—Results of a multicenter registry. *Clin Implant Dent Relat Res.* 2009; 11(Suppl 1):e83-e91.
53. Ziv Mazo, Efraim Kfir, Adi Lorean, Eitan Mijiritsky, Robert A. Horowitz: *Flapless Approach to Maxillary Sinus Augmentation Using Minimally Invasive Antral Membrane Balloon Elevation*;1056-6163/11/02006-434 *Implant Dentistry*Volume 20. No. 6 2011 DOI: 10.1097/ID.0b013e3182391fe3
54. Campelo LD, Camara JR. Flapless implant surgery: A 10-year clinical retrospective analysis. *Int J Oral Maxillofac Implants.* 2002; 17:271-276.
55. Becker W, Goldstein M, Becker B, et al. Minimally invasive flapless implant surgery: A prospective multicenter study. *Clin Implant Dent Relat Res.* 2005; 7:21-27.
56. Rousseau P. Flapless and traditional dental implant surgery: An open, retrospective comparative study. *J OralMaxillofac Surg.* 2010; 68:2299-2306.
57. Noelken R, Kunkel M, Wagner W. Immediate implant placement and provisionalization after long-axis root fracture and complete loss of the facial bony lamella. *Int J Periodontics Restorative Dent.* 2011; 31:175-183.
58. Ravindran DM, Sudhakar U, Ramakrishnan T, et al. The efficacy of flapless implant surgery on soft-tissue profile comparing immediate loading implants delayed loading implants: A comparative clinical study. *J Indian Soc Periodontology* 2010; 14:245-251.
59. Bayounis AM, Alzoman HA, Jansen JA, et al. Healing of peri-implant tissues after flapless and flapped implant installation. *J Clin Periodontol.* 2011; 38:754-761.

60. Barter S. Computer-aided implant placement in the reconstruction of a severely resorbed maxilla—A 5-year clinical study. *Int J Periodontics Restorative Dent*. 2010; 30:627-637.
61. Dong-Seok Sohn. 3 New Bone Formation in the Maxillary Sinus With/Without Bone Graft. [cdn.intechopen.com/pdfs/21545.pdf](http://cdn.intechopen.com/pdfs/21545.pdf). Sep 30, 2011.
62. Nedir R, Bischof M, Vazquez L, et al.: Osteotome sinus floor elevation without grafting material: A 1-year prospective pilot study with ITI implants. *Clin Oral Implants Res* 2006; 17:679.
63. Berengo M, Sivoletta S, Majzoub Z, et al. Endoscopic evaluation of the bone-added osteotome sinus floor elevation procedure. *Int J Oral Maxillofac Surg*. 2004; 33:189.
64. Trisi P, Rao W: Bone classification: a Clinical-histomorphometric comparison. *Clin Oral Implants Res*. 1999; 10:1.
65. Hahn J: Clinical uses of osteotomes. *J Oral Implantol*. 1999; 25:23.
66. Nkenke E, Radespiel-Troger M, Wiltfang J, et al.: Morbidity of harvesting of retromolar bone grafts: A prospective study. *Clin Oral Implants Res*. 2002; 13:514.
67. Girolamo MD, Napolitano B, Arullani CA, et al. Paroxysmal positional vertigo as a complication of osteotome sinus floor elevation. *Eur Arch Otorhinolarygol*. 2005; 262: 631-633.
68. Peñarocha M, García A. Benign paroxysmal positional vertigo as a complication of interventions with osteotome and mallet. *J Oral Maxillofac Surg*. 2006; 64:1324.
69. Saker M, Oqle O. Benign paroxysmal positional vertigo subsequent to sinus lift via closed technique. *J Oral Maxillofac Surg*. 2005; 63:1385-1387.
70. Rosen PS, Summers R, Mellado JR, Salkin LM, Shanaman RH, Marks MH, Fugazzotto PA. The bone-added osteotome sinus floor elevation technique: multicenter retrospective report of consecutively treated patients *Int J Oral Maxillofac Implants*. 1999; 14(6):853-858.
71. Summers RB: A new concept in maxillary implant surgery: The osteotome technique. *Compend Continuous Educ Dent*. 1994; 15:154.
72. Summers RB: The osteotome technique. Part 3. Less invasive methods in elevation of the sinus floor. *Compend Continuous Educ Dent* 1994; 15:698.
73. Pikos M: Maxillary sinus membrane repair: Update on technique for large and complete perforations. *Implant Dent*. 2008;17:24.
74. Raghoobar GM, Timmenga NM, Reintsema H, et al.: Maxillary bone grafting for insertion of endosseous implants: Results after 12-124 months. *Clin Oral Implants Res*. 2001; 12:279.
75. Ucer C, Nasal suction technique for maxillary sinus floor elevation: a report of 24 consecutive patients; *Int J Oral Maxillofac Implants*. 2009 Nov-Dec; 24(6):1138-43.
76. Antonio Scarano, MD, Luan Mavriqi, Ilaria Bertelli, Carmen Mortellaro and Alessandro Di Cerb Occurrence of Maxillary Sinus Membrane Perforation Following Nasal Suction Technique and Ultrasonic Approach Versus Conventional Technique With Rotary Instruments. 2015 [doi.org/10.1097/SCS.0000000000001755](https://doi.org/10.1097/SCS.0000000000001755).
77. Tidwell JK, Blijdorp PA, Stoelinga PJ, et al. Composite grafting of the maxillary sinus for placement of endosteal implants. A preliminary report of 48 patients. *Int J Oral Maxillofac Surg* 1992; 21:204.
78. Proussaefs P, Lozada J, Kim J. Effects of sealing the perforated sinus membrane with a resorbable collagen membrane: a pilot study in humans. *J Oral Implantol* 2003; 29:235.
79. Sakka S, Krenkel C. Simultaneous maxillary sinus lifting and implant placement with autogenous parietal bone graft: outcome of 17 cases. *J Craniomaxillofac Surg* 2011; 39:187.
80. Proussaefs P, Lozada J. The “Loma Linda pouch”: a technique for repairing the perforated sinus membrane. *Int J Periodontics Restorative Dent* 2003; 23:593.
81. Oh E, Kraut RA. Effect of sinus membrane perforation on dental implant integration: a retrospective study on 128 patients. *Implant Dent* 2011; 20:13
82. Fugazzotto, P.A. Immediate implant placement following a modified trephine/osteotome approach: success rates of 116 implants to 4 years in function. *International Journal of Oral and Maxillofacial Implants*. 2002; 17: 113-120.
83. Tan WC, Lang NP, Zwahlen M, Pjetursson BE. A systematic review of the success of sinus floor elevation and survival of implants inserted in combination with sinus floor elevation. Part II: Transalveolar technique. *J Clin Periodontol* 2008; 35 (Suppl. 8):241-254.
84. Giovanni Franceschetti, Pasquale Minenna, Roberto Farina, Leonardo Trombelli. Smart Lift

- Technique for Minimally Invasive Transcrestal Sinus Floor Elevation Implant Tribune Italian Edition Novembre 2012. [http://www.thommenmedical.com/files/franceschetti\\_et\\_al\\_2012\\_smart\\_lift\\_technique\\_for\\_minimal\\_inv\\_transcrestal\\_sinus\\_floor\\_elevation](http://www.thommenmedical.com/files/franceschetti_et_al_2012_smart_lift_technique_for_minimal_inv_transcrestal_sinus_floor_elevation)
85. Summers RB. Sinus floor elevation with osteotomes. *Journal of Esthetic Dentistry*. 1998; 10:164–171.
  86. Suzanne Caudry; Michael Landzberg. Lateral Window Sinus Elevation Technique: Managing Challenges and Complications *J Can Dent Assoc* 2013; 79:d101.
  87. Traxler H, Windisch A, Geyerhofer U, Surd R, Solar P, Firbas W. Arterial blood supply of the maxillary sinus. *Clin Anat*. 1999; 12(6):417-21.
  88. Baldi D., Menini M., Pera F., Ravera G., Pera P. Sinus floor elevation using osteotomes or piezoelectric surgery. *Int. J. Oral Maxillofac. Surg.* 2011; 40(5):497–503. doi: 10.1016/j.ijom.2011.01.006.
  89. Wallace S.S., Mazor Z., Froum S.J., Cho S.C., Tarnow D.P. Schneiderian membrane perforation rate during sinus elevation using piezosurgery: clinical results of 100 consecutive cases. *Int. J. Periodontics Restorative Dent*. 2007; 27(5):413–419.
  90. Vercellotti T., De Paoli S., Nevins M. The piezoelectric bony window osteotomy, and sinus membrane elevation: the introduction of a new technique for simplification of the sinus augmentation procedure. *Int. J. Periodontics Restorative Dent*. 2001; 21(6):561–567.
  91. Stübinger S., Kuttenger J., Filippi A., Sader R., Zeilhofer H.F. Intraoral piezosurgery: preliminary results of a new technique. *J. Oral Maxillofac. Surg.* 2005; 63(9):1283–1287.
  92. Schlee M. Piezosurgery: a precise and safe new oral surgery technique. *Aust. Dent. Pract.* 2009:38–142.
  93. Happe A. Use of a piezoelectric surgical device to harvest bone grafts from the mandibular ramus: report of 40 cases. *Int. J. Periodontics Restorative Dent*. 2007; 27(3):241–249.
  94. Preti G., Martinasso G., Peirone B., Navone R., Manzella C., Muzio G., Russo C., Canuto R.A., Schierano G. Cytokines and growth factors involved in the osseointegration of oral titanium implants positioned using piezoelectric bone surgery versus a drill technique: a pilot study in minipigs. *J. Periodontol*. 2007; 78(4):716–722.
  95. Labanca M., Azzola F., Vinci R., Rodella L.F. Piezoelectric surgery: twenty years of use. *Br. J. Oral Maxillofac. Surg.* 2008; 46(4):265–269.
  96. Vercellotti T., Nevins M.L., Kim D.M., Nevins M., Wada K., Schenk R.K., Fiorellini J.P. Osseous response following resective therapy with piezosurgery. *Int. J. Periodontics Restorative Dent*. 2005; 25(6):543–549.
  97. Andreasi Bassi M, Lopez MA, Confalone L, Fanali S, Carinci F. Hydraulic sinus lift technique: description of a clinical case. *Annals of Oral & Maxillofacial Surgery* 2013 Jun 01; 1(2):18.
  98. Fugazzotto PA. Augmentation of the posterior maxilla: A proposed hierarchy of treatment selection. *J Periodontol*. 2003; 74:1682-1691.
  99. Rosen PS, Summers R, Mellado JR, et al. The bone-added osteotome sinus floor elevation technique: Multicenter retrospective report of consecutively treated patients. *Int J Oral Maxillofac Implants*. 1999; 14:853-858.
  100. Rousseau P. Flapless and traditional dental implant surgery: An open, retrospective comparative study. *J Oral Maxillofac Surg*. 2010; 68:2299-2306.
  101. Noelken R, Kunkel M, Wagner W. Immediate implant placement and provisionalization after long-axis root fracture and complete loss of the facial bony lamella. *Int J Periodontics Restorative Dent*. 2011; 31:175-183.
  102. Ravindran DM, Sudhakar U, Ramakrishnan T, et al. The efficacy of flapless implant surgery on soft-tissue profile comparing immediate loading implants to delayed loading implants: A comparative clinical study. *J Indian Soc Periodontol*. 2010; 14:245-251.
  103. Simunek A, Kopecka D, Brazda T, Somanathan RV. Is lateral sinus lift an effective and safe technique? Contemplations after the performance of one thousand surgeries. *Implantologie Journal*. 2007; 6:1-5.
  104. Hahn J: Clinical uses of osteotomes. *J Oral Implantol*. 1999; 25:23.
  105. Nkenke E, Radespiel-Troger M, Wiltfang J, et al.: Morbidity of harvesting of retromolar bone grafts: A prospective study. *Clin Oral Implants Res*. 2002; 13:514.
  106. Summers RB: A new concept in maxillary implant surgery: The osteotome technique. *Compend Continuous Educ Dent*. 1994; 15:152.

- 
- 107.** Summers RB: The osteotome technique. Part 3. Less invasive methods in elevation of the sinus floor. *Compend Continuous Educ Dent.* 1994; 15:698.
- 108.** Pikos M: Maxillary sinus membrane repair: Update on technique for large and compete for perforations. *Implant Dent.* 2008; 17:24.
- 109.** Raghoobar GM, Timmenga NM, Reintsema H, et al.: Maxillary bone grafting for insertion of endosseous implants: Results after 12-124 months. *Clin Oral Implants Res.* 2001; 12:279.
- 110.** Zitzmann NU, Scharer P. Sinus elevation procedures in the resorbed posterior maxilla: Comparison of the crestal and lateral approaches. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod.* 1998; 85:8–17.

**Source of Support:** Nil

**Conflict of Interest:** None