Pros and Cons of Sinus Lifts on Implant Treatment

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ABSTRACT

The Maxillary Sinus Floor Elevation, Lateral or Transalveolar approach, has, over the last 35 years, been established as an accepted standard treatment of the edentulous maxilla for immediate or delayed implant placement.

While there are some relevant contraindications to the process of lifting the sinus, they are not prohibitive so as not to give solution to the patients.

With right preparation, proper education and experience, the sinus floor elevation, with or without graft, is a procedure that greatly benefits the patient, with a predictable outcome in implant treatment.

Alternatives such as short implants, although shown to be effective in the short term there is a lack of long-term studies to support routine use.

Mini dental implants may offer an ideal solution for the elderly edentulous population who may not be keen on invasive surgery for the placement of conventional dental implants.

Further work is required to show the longevity of these restorations, however, existing research and clinical experience show that they potentially offer a simple solution to this group of patients.

The design of the new implants specifically aims to overcome problems in managing severely atrophic ridges.

Also new techniques in Transalveolar Sinus Floor Elevation, allow us to minimize the risks involved in such treatment.

Each patient case with limited residual bone height in the posterior maxilla, is unique and needs a carefully personalized treatment planning, for the best functional and aesthetic result.

INTRODUCTION

For more than 35 years the Maxillary Sinus Augmentation Graft has been a mainstay of implant-directed maxillary reconstruction. [01]

Maxillary Sinus Floor Elevation (also known as Sinus Lift, Sinus Augmentation, Sinus Graft or Sinus Procedure) is a surgical procedure, which increases the amount of bone in the posterior maxilla by the elevation of the Sinus Membrane (Schneiderian Membrane) from the underlying sinus wall and by placing a bone graft under it or not.

The aim of Sinus Augmentation is to obtain bone to support a dental implant with sufficient primary stability.

Implants can be applied at the same time as sinus surgery (immediate placement) or after a healing period (delayed placement).

Since 1974 when the first surgery of Sinus Lift was performed from Dr. Hilt Tatum Jr., the science of biomaterials has improved by enhancing the possibilities of graft augmentation and allowing clinicians to perform Implant-Borne Dental Restorations in complex situations.

As a result, it is possible to perform an optimal implant placement and to achieve a good long-term prognosis for an implant-borne prosthesis in the posterior grafted maxilla.

Currently, Maxillary Sinus Augmentation is a well-documented surgery with long-term clinical success and survival of the implants similar to those placed in the pristine bone. [02-04]

In this study we will analyze the procedures of Sinus Lifts with Implant Placement, techniques and grafts, the complications and treatments in confrontation to other solutions for edentulous patients.

Finally we will end up with the advantages and disadvantages of Sinus Lifts on Implant Treatment.

LATERAL SINUS FLOOR ELEVATION

The Maxillary Sinus Lift, described by Tatum [05] by using a modified Caldwell-Luc approach and modified by Boyne et al., [01] is a recognized and versatile surgical technique in the treatment of the posterior region of the maxilla.

Various accesses have been used to perform this procedure, with crestal approach and the lateral window approach being the most frequent. [06]

A wide variety of materials have been used as bone grafts in the maxillary sinus lift, shown similar success rates, both in the stability of the reconstruction and in the stability of the implants [07]

Current analyses indicate that the success of the technique also is associated not only with the reconstruction material but also with other variables, such as the osteogenic potential of the sinus membrane [08] and the bone characteristics of the zone. [09]

In this sense, techniques for the immediate or delayed implant installation have shown that the use of the autogenous bone graft or the use of biomaterials could be equally as efficient. [10]

In recent years, reports on new intrasinus bone formation without graft installation or bone substitute have increased since Lundgren et al., [11] subsequent to the removal of an intrasinus cyst, observed new bone formation in the space left without the installation of any type of material.

Later, Lundgren et al., [12] performed maxillary sinus lifts on 11 patients with no type of bone graft, so that the space generated after lifting the sinus membrane would only be filled with the patient's blood, immediately installing 19 implants, all successfully.

Although there are clinical studies that use this technique, there are no analyses that assess the prognostic factors related to their survival.

However, there is a debate about the best biomaterial or combination of biomaterials regarding sinus surgery.

Studies reported that implants placed in the sinuses augmented with particulate grafts presented a higher survival rate than those augmented with block grafts. [13]

Bovine bone mineral acts as a slowly resorbing space maintainer [14] and can diminish sinus pneumatisation after augmentation.

Platelet-Rich Fibrin (PRF) [15] is a fibrin concentrate obtained from the patient's blood, with integrated growing factors and cytokines, which provides a favourable environment for cell migration and rapid vascularization. [16]

Studies showed that PRF promotes bone healing and could increase the success rate of bone grafting. [17, 18]

The association of particulate bovine bone graft with PRF could allow faster healing and earlier rehabilitation. (Fig. 1)

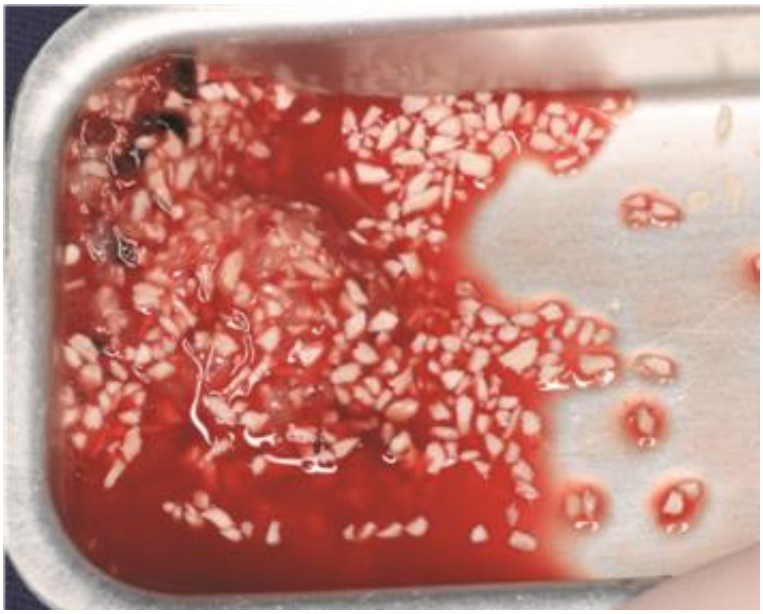


***Figure 1*:** Mixture of Xenograft Particles and shredded PRF membrane. The patient's blood samples for PRF preparation are harvested on the same day, before the sinus surgery.

Lateral Window Technique

This surgical technique consists of osteotomies to form a bony window and either the removal or medial rotation of this window without perforating the sinus membrane. [19]

Before starting, local anesthetic with epinephrine is administered by performing a posterior superior alveolar nerve block, anterior superior alveolar nerve block, and palatal infiltration.

Local anesthesia can be used with intravenous sedation or general anesthesia if indicated.

Conventionally, prophylactic antibiotics and steroids are administered before starting the procedure.

There is no solid evidence to suggest whether the surgeon should use these medications preoperatively, therefore one should weigh the benefits and risks before administering these medications.

Before making the incision it is recommended to have the patient rinse and expectorate with 0.12% chlorhexidine rinse.

A crestal incision is made from the maxillary tuberosity to a point just anterior to the anterior border of the sinus.

Vertical releasing incisions are then made in the anterior and posterior aspect to the depth of the vestibule.

The incisions must allow adequate exposure of the sinus and should not be placed in the area of the sinus window.

A full-thickness mucoperiosteal flap is then elevated, exposing the lateral wall of the maxilla.

At this point the 4 linear osteotomies are performed with a #6 or #8 round bur.

The first to be done is the inferior horizontal osteotomy, which is made as close as possible to the floor of the sinus and no more than 2-3mm above the floor.

The osteotomy runs from the area of the first or second molar posteriorly to the anterior extent of the maxillary sinus.

When performing the osteotomies one must take care to do so with a light touch and a brushing stroke so not to tear the Schneiderian Membrane.

When bicuspid teeth are present, care must be taken not to damage them and one should limit the osteotomy 4mm from the distal aspect of the tooth.

The superior horizontal osteotomy is performed next at the level of the planned augmentation height.

The superior and inferior osteotomies are connected with the anterior and posterior vertical osteotomies.

The vertical osteotomies are made parallel to the lateral nasal wall and the anterior border of the maxillary tuberosity (or the maxillary buttress), respectively.

Once the window is created and the membrane exposed, the bone that is adherent is either removed or rotated in medially. (Fig. 2)

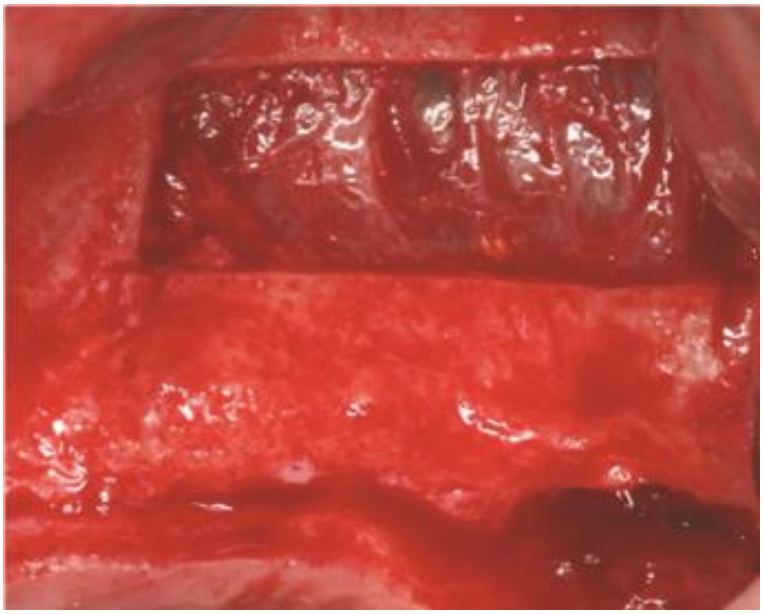


***Figure 2*:** Lateral Osteotomy. The Schneiderian Membrane is now exposed to be lifted up carefully.

If the bony window is rotated inward it then becomes the new floor of the maxillary sinus.

The Schneiderian Membrane is then elevated by starting at the edges and then gradually increasing the amount of membrane elevation.

If elevation is too excessive in one area, perforation may occur.

The elevation can be performed using broadbased freers or curettes.

The membrane can and should be elevated higher than the superior osteotomy.

It is important to do this to prevent excessive pressure on the bone graft material.

Perforation of the sinus membrane is a possibility, and may occur.

Small perforations can be left untreated, but if a large perforation occurs the clinician should either abort the procedure or use a collagen membrane to patch the membrane.

If the procedure is aborted, it should not be reattempted for an additional 4 to 6 months.

Once the membrane is elevated, the bone graft material is placed under the membrane in an anterior and inferior direction.

The graft should contact the medial wall of the maxillary sinus.

The graft is placed in the cavity loosely and should not be overpacked.

The surgeon should add an additional 20% of bone graft to compensate for loss of graft volume. (Fig. 3)

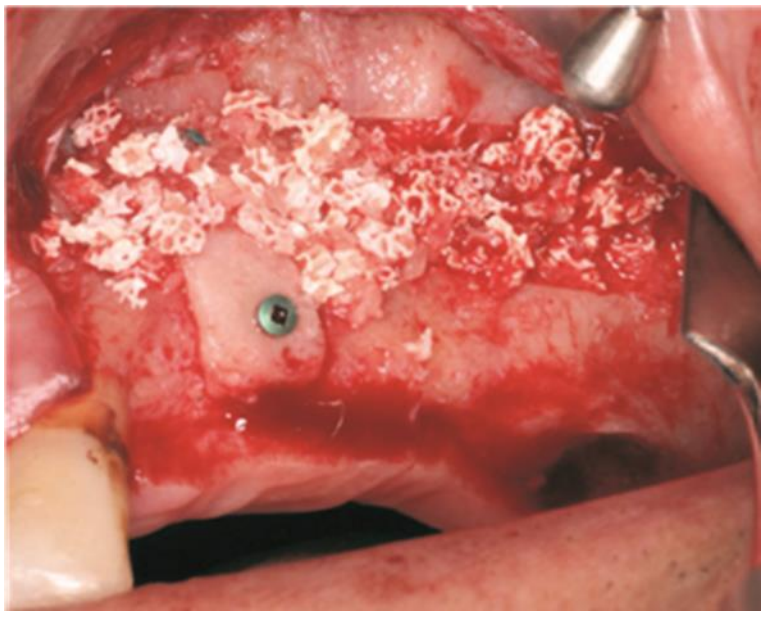


***Figure 3*:** The placement of the mixture in the Subsinusal Cavity.

After the bone is placed in the sinus, the mucoperiosteal flap is repositioned and sutured. (Fig. 4)

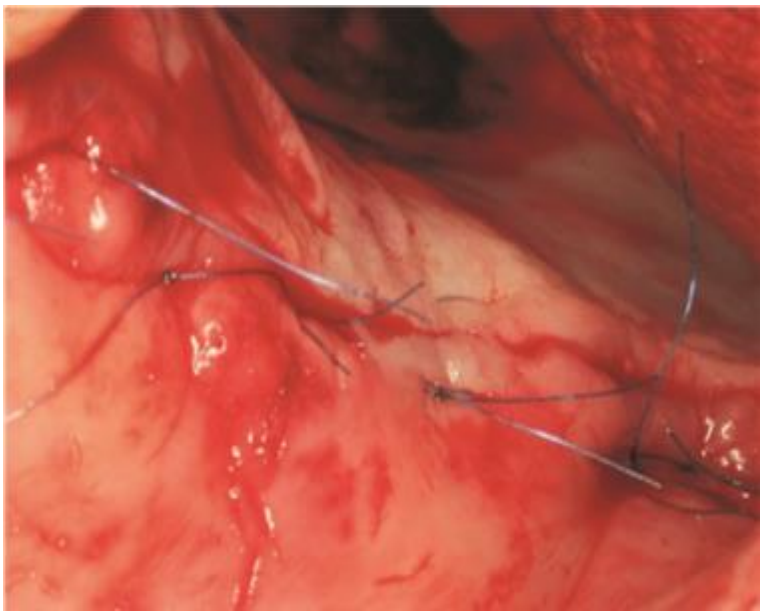


***Figure 4*:** Wound closure. Implant Placement: Two-Stage Lateral Sinus Augmentation.

Implants can be placed 6 months after the sinus lift procedure is performed.

If there is adequate alveolar bone to stabilize the implants, the implant sites are prepared and the implants are placed before the bone graft, with the bone graft material being packed around the implants.

It is recommended to place the patient on postoperative antibiotics and decongestants for 2 weeks.

Patients should also be placed on sinus precautions, should not blow their nose, and should cough or sneeze with their mouth open.

Piezoelectric Technology

Piezoelectric technology is an ultrasonic device that is used to make the osteotomies.

This system has been shown to help avoid perforating the sinus membrane.

The piezoelectric surgery systems have been designed to use a specific power that is higher than traditional ultrasonic instruments.

This higher power allows the osteotomies to be made even in thicker, more compact cortical bone.

The real advantage of this system is that it does not cut soft tissue and helps to reduce the chance of perforating the membrane.

The surgical instrument can even be used to assist in the elevation of the sinus membrane.

The piezoelectric surgery systems come with many different inserts, from osteotomes, to diamond-cutting inserts, to inserts to help elevate the sinus membrane.

Once the window is made the lifting of the membrane is accomplished by separating the endosteum from bone, and a hydropneumatic pressure of the physiologic saline solution is subjected to the piezoelectric cavitation. [20]

A study by Vercellotti et al. [21] was performed on 15 patients, creating 21 bony window osteotomies with a Mectron Piezosurgery System (Mectron Medical Technology, Mectron SPA, Carasco, Italy).

After reflection of the flap the piezoelectric scalpel is used to make the bony window.

The membrane elevator tip is then used beginning at the apical position, then moving to the mesial and distal aspects.

Then attention is drawn to the floor of the sinus, a common place to find adhesions, where the membrane is elevated and the risk of perforation reduced.

All sinus augmentations in the study were performed with Autogenous Bone Grafts and Platelet-Rich Plasma.

Of the 21 cases, only 1 resulted in perforation of the membrane and there was a 95% success rate.

TRANSALVEOLAR SINUS FLOOR ELEVATION

When placing implants in the posterior maxilla, the dentist could often face the challenge of insufficient bone volume or poor bone quality or both. [02, 22]

Some efforts have been made to ensure successful implant treatment in the atrophic posterior maxillae.

Sinus floor elevation has been proven to be a predictable surgical procedure to increase the bone height in the posterior maxilla which can be accomplished either through Transalveolar Sinus Floor Elevation or through a Lateral Window technique. [05, 23-25]

The Transalveolar Sinus Floor Elevation (TSFE) described by Summers in 1994 has been proven to be a predictable surgical procedure to increase bone volume in atrophic maxilla vertically. [23, 24]

The original procedure is indicated when the residual volume of alveolar bone is between 4 and 8 mm below the sinus floor and the Sinus Membrane is elevated with osteotomes of increasing diameter from a crestal approach through the osteotomy prepared for dental implant placement but without need for a Lateral Window. [23, 24]

Compared with the Lateral Sinus Floor Elevation (LSFE), the Transcrestal Sinus Floor Elevation technique has the advantages of limited trauma, bleeding, and swelling. [26]

However, unlike LSFE, the surgical procedure in the TSFE is a visually restrictive technique, which makes it a technique-sensitive procedure, especially when direct visual examination of the sinus membrane is required.

Furthermore, the bone height which could be augmented by the osteotomes is limited when compared with the Lateral Window technique. [27]

Some studies reported a relatively high incidence of sinus membrane perforations when TSFE is performed. [28]

Thus, some scholars have suggested modifying the operation procedure to reduce the incidence of the membrane perforation and increase the height of the membrane elevation.

The methods of hydraulic pressure techniques, crestal non-cutting drills, and piezoelectric equipment have already been introduced to this field and achieved nearly ideal clinical outcomes. [29-32]

The crestal non-cutting drills were designed in a dome-like shape, which could remove or push the residual cortical bone gently into the sinus without damaging the membrane.

Furthermore, the specially designed instruments similar to the instruments for LSFE were used to elevate the membrane gently through the implant bed. [31]

Thus, the membrane could be elevated in a more comfortable and gentle way.

Because this technique does not involve the use of osteotomes and mallet, discomfort in patients can be reduced compared with conventional osteotome techniques. [33]

Besides, the necessity of the application of the grafting material as bone substitute during the TSFE procedure is still under debate.

According to Summers's original publications, grafting material is recommended to be added into the elevation area. [23, 24]

In a classic systemic review which was published in 2008, the author also mentioned that while performing Transalveolar Sinus Floor Elevation by using osteotome techniques, clinicians are advised to apply grafting materials to maintain the necessary spaces between the Schneiderian Membrane and the floor of the sinus for bone regeneration. [02]

Furthermore, a series of studies have attempted to investigate the bone remodeling pattern after the TSFE and suggested that the TSFE with bone grafting could achieve more favorable results in bone remodeling when compared with TSFE without bone grafting. [34]

However, several recent studies have reported that ideal clinical outcomes could be achieved when applying TSFE without bone grafting. [22, 35-41]

In these studies, high implant survival rate and satisfying endo-sinus bone regeneration were found although the bone graft material was not applied.

Thus, such a method was considered to be equally predictable as the TSFE with bone grafting. [22, 37, 39]

Besides, spontaneous novo-bone formation could be found in these studies in which the bone grafting procedure was not performed. [36, 37, 41]

Therefore, it is worthwhile to evaluate and compare the clinical results of the TSFE with different surgical protocols with or without bone grafting.

Traditional TSFE

For the traditional TSFE, the surgical procedure will be in accordance with the modified Summers's method which was described by Pjetursson in 2009 [33], and the implant placement procedure will be in accordance with the product description by Straumann AG.

The specific procedures are listed as below:

The implant bed is prepared with the conventional steps.

First, the alveolar ridge will be prepared with the Φ2mm round bur.

Then, the Φ2.2 mm pilot drill will be used to ensure the direction and the insertion depth of the implants.

The twist drills with Φ2.8 mm, 3.5 mm, and 4.2 mm will be used to enlarge the sockets separately (the diameter of the final drill is determined by the width of the implant).

The drills will be stopped at 1–2 mm under the sinus floor.

The socket preparation procedures will be irrigated by the 4 °C saline solution to reduce chances of osteonecrosis which may result from the drill overheating.

After that, the Φ2.2 mm osteotome with a concave head will be placed into the socket and the head of the osteotome will be knocked into the sinus cavity about 1 mm.

The Φ2.8 mm osteotome then will be placed and knocked in to the sinus just about 1 mm less than the designed length.

Finally, the Φ3.5 mm or Φ4.1 mm osteotome will be placed and knocked in to elevate the membrane to the ideal position. (Fig. 5)

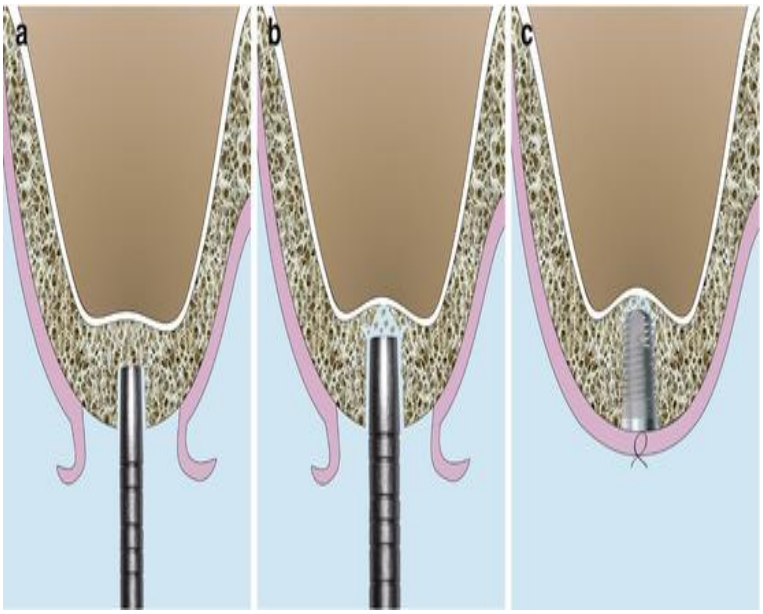


***Figure 5*:** Traditional Transalveolar Sinus Lift technique with Osteotomes.

Prior to the filling of the bone substitute and implant placement, the sinus membrane will be tested for any perforations by the Valsalva Maneuver (nose blowing test).

If any air leaked through the implant site, it would have to be assumed that the sinus membrane was perforated.

The patient will receive the appropriate therapy when the membrane is healed.

Modified TSFE

For the modified TSFE, I will present the procedure performed by the Dentium Advanced Sinus Kit (DASK) drills from Dentium Corporation (Cypress, CA, USA).

After the preparation of the implant bed by the twist drills, the residual cortical bone will be elevated or grinded by the DASK #1 and #2 drills gently with minimum pressure.

Then, the sinus membrane will be separated and elevated by the #3 drill.

With the internal irrigation, the elevation procedure could be assisted by the water pressure.

When the membrane is elevated with enough height, the bone substitute will be filled into the cavity and the implant will be placed.

As with the traditional TSFE group, the Valsalva Maneuver will be performed prior to the bone substitute filling and implant placement. (Fig. 6)

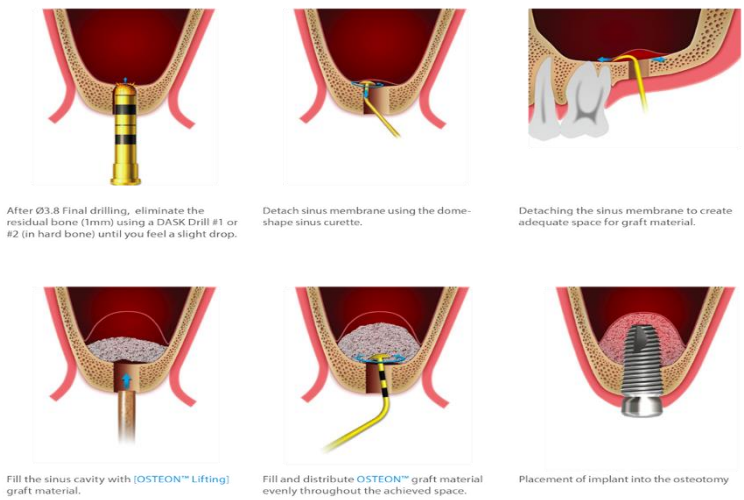


***Figure 6*:** Modified Transalveolar Sinus Lift technique by Dentium Advanced Sinus Kit (DASK).

Osseodensification

Primary stability in implant placement is one of the most critical factors determining the outcome of implant therapy.

The key factors in enhancing implant primary stability are bone density, [42, 43] surgical protocol, [44] and implant thread type and geometry. [45]

Primary stability is provided by the mechanical friction between the external implant surface and walls of the implant osteotomy.

The insertion torque peak is directly related to implant primary stability and host bone density; [46] high-insertion torque could significantly increase the initial bone-to-implant contact percentage (%BIC) compared to implant inserted with low-insertion torque values. [47]

Ottoni *et al*. [48] showed a reduction in failure rate of 20% in single-tooth implant restoration for every 9.8 *N* cm of torque increased.

Osseodensification (OD) is a new method of biomechanical bone preparation performed for dental implant placement and Transalveolar Sinus Floor Elevation.

The procedure is characterized by low plastic deformation of bone that is created by rolling and sliding contact using a densifying bur that is fluted such that it densifies the bone with minimal heat elevation.

OD, a bone nonextraction technique, was developed by Huwais 2013 [49] and done using specially designed burs (Densah™ burs) that help densify bone as they prepare an osteotomy. [50]

These burs provide advantages of both osteotomes combining the speed along with improved tactile control of the drills during osteotomy.

Standard drills excavate bone during implant osteotomy, while osteotomes tend to induce fractures of the trabeculae that requiring long remodeling time and delayed secondary implant stability.

The Densah burs allow for bone preservation and condensation through compaction autografting during osteotomy preparation, thereby increasing the bone density in the peri-implant areas and improving the implant mechanical stability. [51]

The bone-remodeling unit requires more than 12 weeks to repair the damaged area created by conventional drills that extract substantial amount of bone to let strains in the walls of osteotomy reach or go beyond the bone microdamage threshold.

Hence, OD will help preserve bone bulk and increase density, thereby shortening the healing period. [52]

Unlike traditional osteotomy, OD does not excavate bone but simultaneously compacts and autografts the particulate bone in an outward direction to create the osteotomy, thereby preserving vital bone tissue.

This is achieved using specialized densifying burs. (Fig. 7)

When the specialized drill is used at high speed in an anticlockwise direction with steady external irrigation (Densifying Mode), the dense compact bone tissue is created along the osteotomy walls. [53]

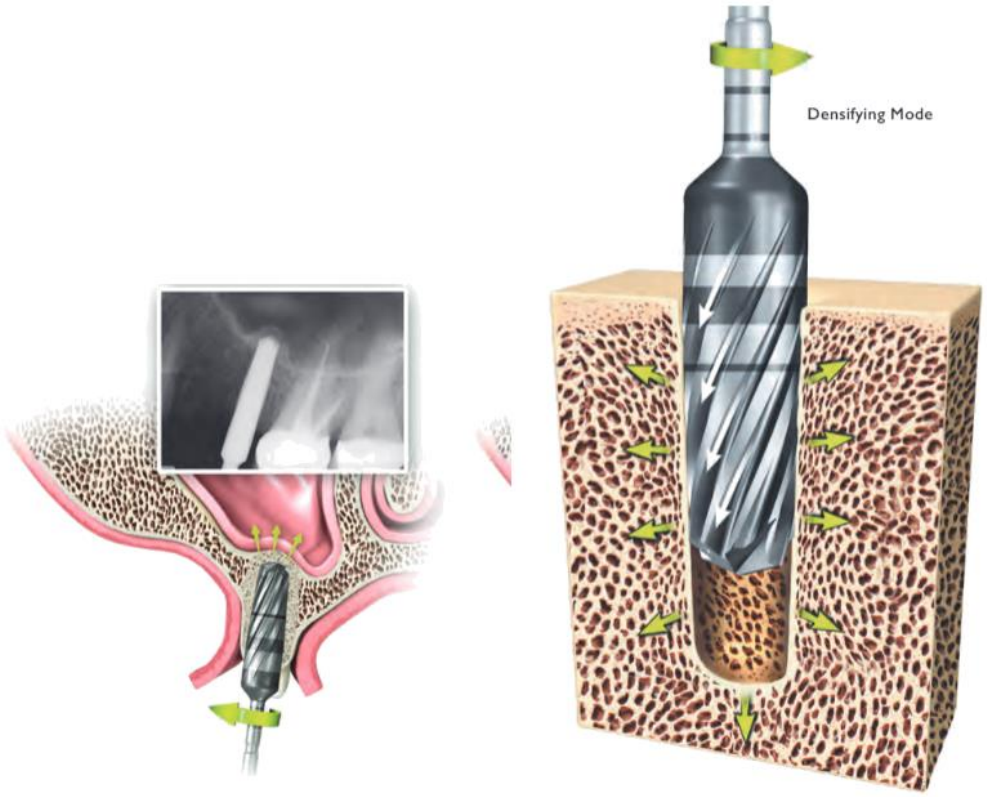


***Figure 7*:** Transalveolar Sinus Floor Elevation by Densah drills.

The pumping motion (in and out movement) creates a rate-dependent stress to produce a rate-dependent strain and allows saline solution pumping to gently pressurize the bone walls and the sinus floor.

This combination facilitates an increased bone plasticity and bone expansion.

Huwais demonstrated that OD helped ridge expansion while maintaining alveolar ridge integrity, thereby allowing implant placement in autogenous bone, also achieving adequate primary stability.

OD helped in preserving bone bulk and shortened the waiting period to restorative phase. [54]

COMPLICATIONS AND TREATMENT

Postoperative Instructions

The patient should be provided with a printed set of postoperative instructions as well as an oral review of the instructions with the surgeon.

Typically the patient is cautioned against consuming anything hard or rough that may damage the sutures and lead to wound dehiscence.

Sinus precautions are advised as well, and include avoiding anything that can cause sudden pressure changes in the sinus such as nose blowing and sneezing.

The patient should be instructed to sneeze only with an open mouth so that pressure can be directed away from the sinus.

There are several things that the patient should be told to expect after surgery.

Soreness is, of course, normal and expected for several days after surgery.

It is normal for some patients to experience some bleeding from the surgical incision for up to 24 hours after surgery.

This bleeding will appear to be worse than it is, due to the blood mixing with saliva.

The blood should be swallowed (not expectorated), and if bothersome is controllable with direct wet gauze pressure.

If after 2 applications of gauze of 1 hour each the bleeding persists or if the volume is of concern, the patient should inform the surgeon.

Swelling and occasional skin bruising is not uncommon after sinus lift surgery.

Management of Comlications

The most common surgical complication of the maxillary sinus lift is perforation of the Schneiderian membrane.

In a recent prospective observational uncontrolled study, 70 patients underwent 81 sinus lifts and were followed through to loading of a total of 212 implants.

44% of the sinuses were perforated intraoperatively but were repaired, and the procedure was completed without other complications.

2% of the sinuses suffered perforations so severe that the procedure was aborted.

33% of the perforations occurred in sinuses that had septae noted on preoperative radiographs, and of those sinuses with septae 52% suffered perforations.

Two of the 36 perforations were so severe that the surgeon aborted the procedure.

Common modalities for dealing with sinus perforation include doing nothing if the perforation is less than 2 mm in diameter and placement of a slowly resorbing collagen membrane if larger than 2 mm.

Postoperative complications in the study included graft extrusion into the sinus cavity in one patient presenting as an acute sinusitis after implant placement.

After surgical and medical treatment, the infection resolved and the implants went on to be restored.

Late complications included persistent peri-implantitis and a peri-impant cyst.

Of importance is that although membrane perforations were associated with postoperative complications such as swelling, pain, and local infection, there is no association between intraoperative perforations and long-term implant survival.

Overall, this study demonstrated a 95.5% 7-year survival rate for implants placed in the grafted sinuses.

Also of note is that of the 9 implants that failed, 5 were placed in patients who were heavy smokers.

Chronic infections leading to severe sinusitis and possible graft exposure, extrusion, and/or failure are rare events.

Management typically involves treatment based on the presenting symptoms, and can range from antibiotics to surgical debridement drainage to a Caldwell-Luc procedure. [55-57] (Table 1)

TABLE 1

Common Sinus Lift Surgery Complications

Complication	Treatment
Graft exposure	Gentle daily normal saline irrigation, allow for creeping epithelialization
No graft present after maturation phase	Assess for possible etiology and retreat
Paresthesia CN V2 distribution immediately postop	Medrol dose pack if no contraindication
Facial swelling 2–3 days post surgery	No Treatment, Normal Postop
Severe facial ecchymosis appearing 1-3 days postop	No Treatment, Normal Postop
Facial pain and swelling ,1 week postop	Clinical Examination, CT Scan, consider Antibiotics
Swelling, acute onset	Possible Air-Emphysema; Antibiotics, Reinforce Nasal Precautions

Although the Lateral Window Approach and Crestal Osteotome Technique have been shown to be safe and predictable procedures for increasing alveolar bone height for appropriate positioning of dental implants in regions close to the maxillary sinus, complications associated with these procedures are not rare.

Kim et al. [58] reported that the incidence of sinusitis after sinus lift surgery was 9.8%, and it was higher with the lateral approach (12.1%) than with the crestal approach (4.1%).

In most cases, this can be resolved with antibiotic therapy.

Chronic maxillary sinusitis requiring surgical intervention occurs in 1.3% of all patients, [59] and often leads to medical disputes.

According to a review of the literature, the possible causes of chronic maxillary sinusitis after dental implantation include sinus penetration by the implant, [60] formation of an oroantral fistula, [61] uncontrolled graft infection, [60] dislodged bone grafts or dental implants with a foreign body reaction, [62] perforation of the Schneiderian membrane, [63] postoperative obliteration of the ostium, [64] and preoperative chronic rhinosinusitis. [59]

Endoscopic sinus surgery is the first choice of surgery because of its low morbidity and good prognosis. [65]

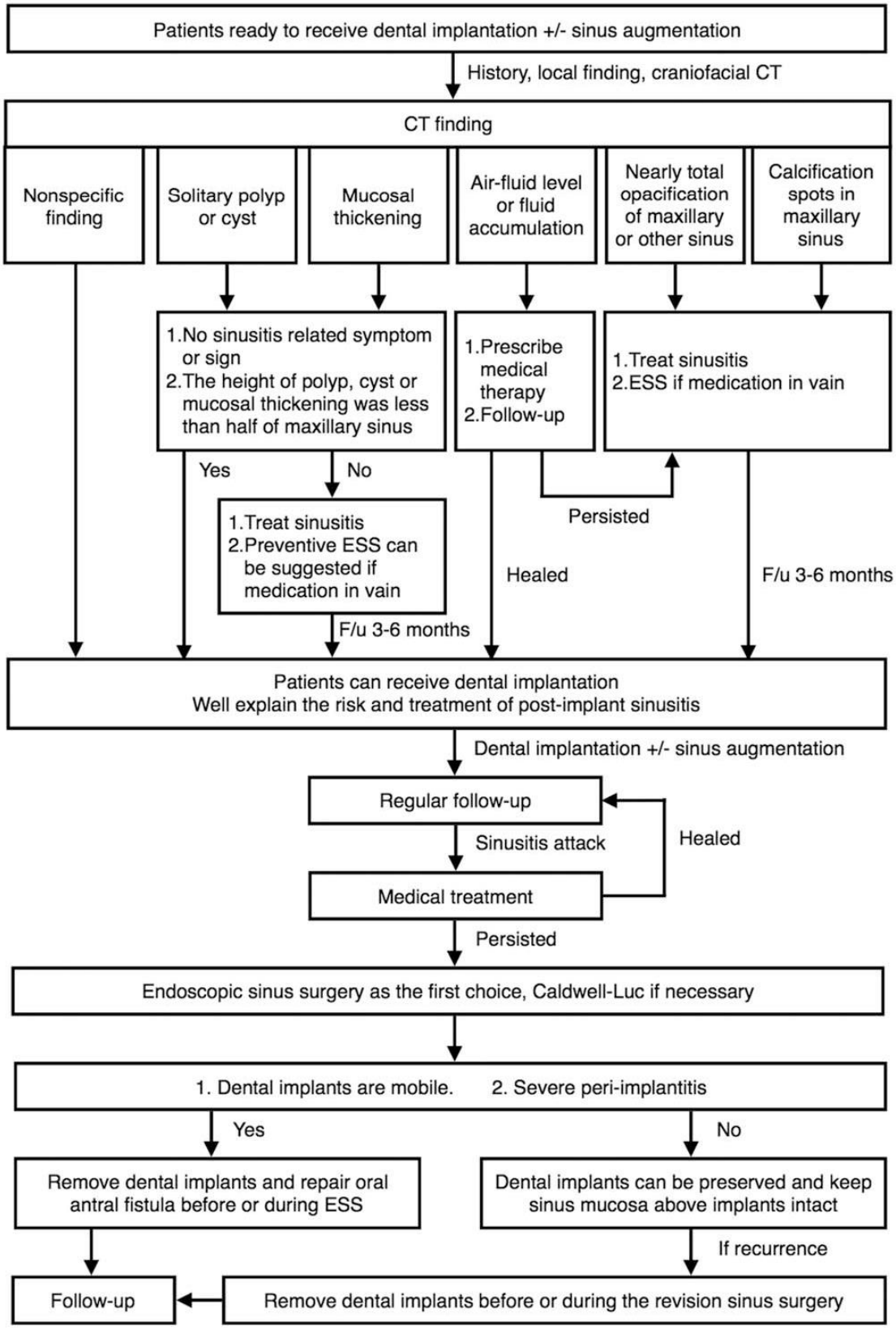
The risk of rhinosinusitis after dental implant surgery is higher in patients with preoperative chronic sinusitis, which is a major concern for dentists.

Before placing dental implants, dentists usually acquire Cone Beam Computed Tomography (CBCT) images or panoramic radiographs to confirm the height of the alveolar bone and to determine the necessity for the Sinus Lift procedure.

Maxillary Sinus lesions in various stages of severity often are revealed in imaging findings, and these patients are first advised to consult Ear, Nose, and Throat (ENT) specialists.

However, there is no specific protocol for Maxillary Sinus evaluation and management before dental implant surgery.

The search for safer and simpler Sinus Elevation procedures is ongoing.



A paradigm protocol for evaluation and management of Maxillary Sinus conditions before Dental Implantation with or without Sinus Augmentation.

DISCUSSION

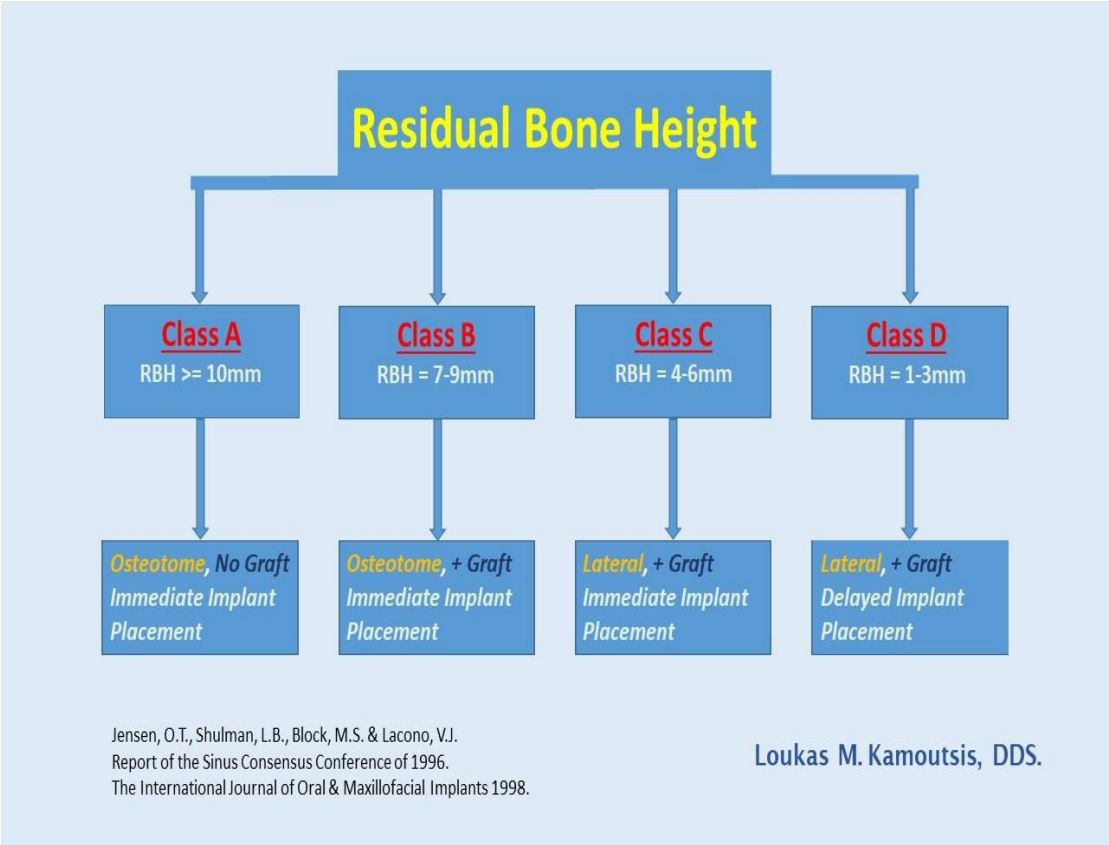
Surgeons have three options for grafting the maxillary sinus and implant placement:

- Two-Stage Lateral Sinus Augmentation,
- One-Stage Lateral Sinus Augmentation (with Simultaneous Implant Placement), and
- One-Stage Crestal Approach (with Simultaneous Implant Placement),

each one with advantages and disadvantages.

The choice of surgical technique depends on the quantity and quality of crestal alveolar bone.

In 1996 Jensen, Shulman, Block and Lacono presented a protocol about Residual Bone Height, Sinus Lifting and Implant Placement.



After 20 years of clinical study, according to Kendrick DE 2016, [66] Two-Stage Lateral Sinus Augmentation is indicated when the crestal bone is less than 3mm high, One-Stage Lateral Approach when we have 3-4 mm bone height available, and One-Stage Crestal Approach when bone height is above 4-5mm.

The lateral approach is considered to be prone to more complications than the crestal one [67] because it is a more invasive technique, but the use of piezoelectric surgery for lateral window preparation and membrane separation led to a dramatic reduction in the occurrence of intraoperative complications. [68]

In addition to this, the lateral approach offers better control of the operative site, and it is considered more predictable and useful when extensive implantations are needed. [69]

The most common intraoperative complication during sinus surgery, as we mention before, is damage to the Schneiderian Membrane.

Postoperative complications include wound infection, abscess, or dehiscence with drainage, maxillary sinusitis of the surgical site, exposure of the graft, and loss of the graft.

Bio-Oss is deproteinized bovine bone, frequently used in dental practice to promote bone regeneration because it is biocompatible and osteoconductive and slowly resorbed in humans, [70] and it is one of the best-documented biomaterials used in sinus surgery. [71]

PRF is an autologous fibrin matrix used to enhance bone regeneration because it can stimulate the proliferation of osteoblasts. [72]

Inchingolo et al. 2010 [73] used the association of Bio-Oss and PRF to treat severe bone maxillary atrophy with vertical bone higher than 5 mm.

Zhang et al. 2012 [74] assessed the combination of Bio-Oss and PRF in comparison with Bio-Oss alone in two-stage sinus lift and reported neither advantages nor disadvantages of the application of PRF in conjunction with deproteinized bovine bone mineral in sinus augmentation after a healing period of six months.

On the other hand, it is worth mentioning that adding fibrin gel, like PRF, to particulate bovine bone makes the procedure easier to manage. [75]

A combination of Bio-Oss and PRF in association with second-stage sinus lift and piezo-surgery reduced the healing time to 106 days from 150 days. [76]

PRF alone can be used for sinus floor augmentation as mentioned in several studies. [77-81]

When PRF alone is used with simultaneous implant placement vertical bone gain after six months is substantial: 10.1mm, [77] 10.4mm, [78] or 11.8mm. [79]

The histological samples confirmed new bone formation in case of sinus lift with PRF alone in both situations, with and without simultaneous implantations, [80] and proved that PRF as a sole graft material during sinus floor augmentation induces natural bone regeneration. [81]

According to Nizametal. 2018, [82] there was no qualitative difference in the histological analyses or the improvement of the amount of regenerated bone when the effect of PRF in combination with deproteinized bovine bone mineral was compared with deproteinized bovine bone mineral alone in maxillary sinus augmentation.

Other studies specified the formation of more new vital bone around implants when PRF was added to freeze-dried bone allograft [83] or deproteinized bovine bone mineral [76] in comparison to freeze-dried bone allograft or deproteinized bovine bone mineral alone.

However, PRF as the sole filling material without simultaneous implant placement or particulate bone substitute may not be able to maintain an adequate space under the elevated sinus membrane, because it is resorbable.

In these cases, when sinus lift is performed with PRF alone without simultaneous implantation, it is possible that crestal sinus lift is needed during a second surgery for implant insertion.

There is no standardized protocol available for PRF in sinus lift surgery, [84] but clot and membrane can be used.

Barrier membrane has a positive outcome when considering implant survival after sinus surgery. [69, 85]

The advantage of a PRF membrane is that it stimulates the gingival periosteum and the regeneration of the bone window. [86]

Furthermore, the PRF membrane can be used to cover sinus perforation because its self-adherent property eliminates the need for suturing. [87-91]

CONCLUTIONS

Overall, the evidence is not sufficiently robust to determine the best treatment for implant prosthetic rehabilitation in partially edentulous patients presenting bone atrophy.

In terms of vertical defects, if the short implants can be used they should be used because the number of complications are reduced compared to longer implants with sinus lift or bone augmentation.

Nevertheless, caution should be exercised because long-term follow-up studies were not available.

No conclusions can be drawn regarding the comparison between different vertical bone augmentation techniques in atrophic posterior mandible because quantitative meta-analyses were not performed.

With regards to horizontal defects, the use of a membrane appears to increase the regeneration of the hard tissue but no differences were detected in prosthesis or implant failures or in complications.

One-stage lateral sinus piezo-surgery using Bio-Oss and PRF clot as filling material and PRF membrane as a barrier membrane can be performed as a predictable and effective technique in the treatment of posterior edentulous maxilla with 4-5 mm vertical bone height.

The outcome in cases of Schneiderian Membrane perforation treated with PRF membrane was similar to the cases without perforation.

Each patient case with limited residual bone height in the posterior maxilla, is unique and needs a carefully personalized treatment planning, for the best functional and aesthetic result.

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