"Crestal Window Sinus Technique," Minimally Invasive, Predictable, and Systematic Approach to Sinus Grafting.

Samuel Lee, DDS*, Grace Kang-Lee, DDS†, Kwang-Bum Park, DDS, MS, PhD‡, Thomas Han, DDS, MS§

Abstract

Background: The placement of dental implants in posterior maxilla is often a challenge due to pneumatization of maxillary sinus. Dental surgeons have predictably overcome these obstacles by performing bone grafting procedures such as lateral window technique (modified Caldwell-Luc). But, morbidity has been a concerned due to postoperative brusing, pain, and swelling. To reduce the morbidity, many internal (crestal) approaches to sinus grafting were introduced using osteotome, reamers, tapping drills, piezo, ISM, HSC, etc. But still, all these internal techniques for sinus grafting are difficult to predict their results due of lack of visibility when opening sinus floor and manipulating Schneiderian membrane.

Purpose: Presenting a new sinus grafting technique that is systematic and predictable. This system utilizes crestal approach to reduce morbidity. Unlike the other crestal approaches to sinus grafting, the uniqueness of this system is that it is not a blind technique, has different indication from other crestal approach (1-7mm of residual bone height, less residual bone height is easier), and the result of membrane elevation is comparable to that of lateral approach.

Conclusion: The new systematic approach to internal sinus grafting is simple, predictable, without morbidity associated with lateral window technique.

KEY WORDS: Sinus, grafting, Lift, dental implants, lateral window, crestal window, internal sinus lift, crestal sinus lift, sinus elevation, osteotome, Schneiderian, sinus membrane, minimally invasive sinus surgery

Introduction

The treatment of posterior edentulism has been a challenge for dental physicians due to poor bone quality and quantity (due to pneumatization of maxillary sinus). We have overcome these obstacles by bone condensing and bone grafting into maxillary sinus under Schneiderian membrane.[1-18] Bone grafting into sinus have produced predictable results enabling clinicians to place longer implant for more stable prosthesis with better and long term outcome.[3] However, morbidity associated with lateral window grafting procedure has been concerned.[5, 6, 7, 15, 17, 18] Severe brusing, swelling, and pain are the common postoperative complications due to flap elevation beyond mucogingival junction.[5, 6, 7, 15, 17, 18] The intraoperative complication that arises from the rupture of intraosseous branch of posterior superiorior artery (branch of maxillary artery) is panic-striken[15]. Moreover, the technical nature of lateral window procedure is easily accompanying the possibility of Schneiderian membrane perforation while opening an window and elevating sinus membrane. Therefore, nowadays, many internal (crestal) approaches to sinus grafting have been introduced such as osteotome[5, 6, 7], reamers[17], tapping drills[18], piezo, ISM[17], HSC[15], etc. Nevertheless, all the internal techniques for sinus grafting to this date are unpredictable for average clinicians, because of lack of visibility when opening sinus floor and manipulating Schneiderian membrane.

Standard diameter implant (4.0mm) has been a great solution for premolar area, but it has some limitations in the molar area resulting poor emergence profile[21], fracture of implants[20], crestal bone strain[19], and narrow occlusal table. Minimum of 5mm to 8mm implants in diameter will overcome poor bone quality by increasing bone to implant contact surface as well as making superior emergence profile[21]. Such diameter of implants in molar area also decreases the fracture rate of implants, crestal bone stress, and allows fabrication of natural occlusal table[20].

Use of wide diameter implant, which is more appropriate for molar restoration as described above, opened a new door to sinus grafting. Crestal window, instead of lateral window, is made with trephine bur to elevate sinus membrane and graft bone into sinus with direct visualization (not a blind technique like previous crestal approach techniques published). The new innovation in sinus grafting described in this paper makes sinus grafting easy and predictable, without the cost of morbidity associated with lateral window technique.

Description of the Innovation/Method

Flap Elevation

Incision design that is at least 2 mm more palatal than implant position and flap elevation that does not open beyond mucogingival junction is recommended (figure 1). This type of incision design allows minimal pain, prevention of oral antral communication in case of perforation, unilateral retraction of flap, and option of doing one or two stage implant placement without losing keratinized tissue.

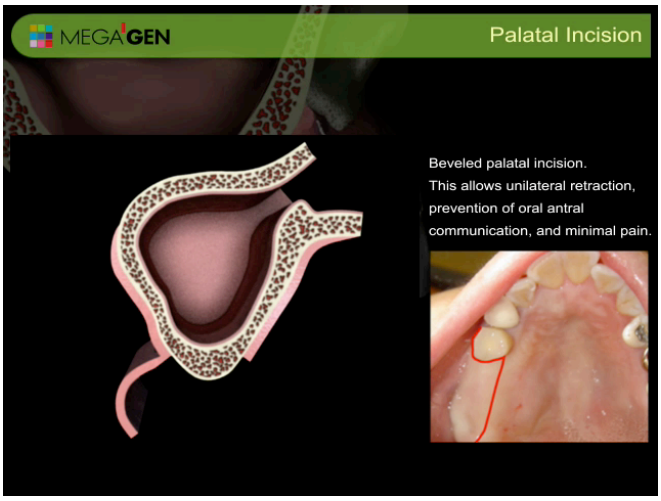

Figure 1. Palatal incision for minimal pain, prevention of oral antral communication in case of perforation, unilateral retraction of flap, and allows option of doing one or two stage implant placement without losing keratinized tissue.

Location of crestal window

Lowest point is located by aid of panoramic radiograph (figure 2). It is more favorable if this position coincides with implant position. If implant placement on #2, 3, and 4 are anticipated and #3 site is the lowest sinus floor, #3 site is used to lift sinus membrane. The rationale behind this method is that the elevation is done from the bottom to up. That being the case, this approach is easier to elevate from lowest point.

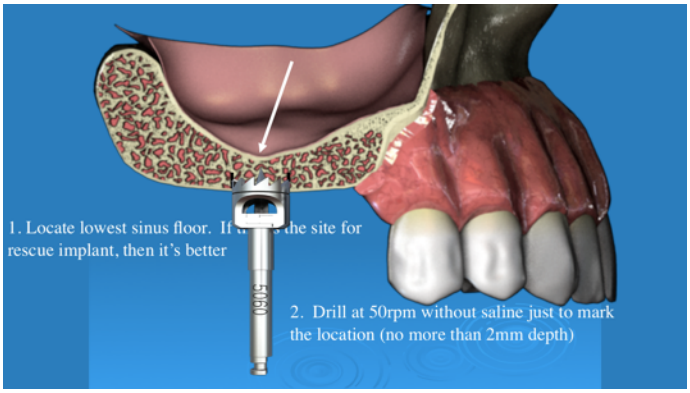

Figure 2. Internal sinus lift initiated from lowest location.

Crestal window with set of specially designed trephine burs#

Round windows is made on the crestal bone with set of specially designed trephine bur which is 1 mm smaller in diameter than final implant size. For example, if 6 mm implant is anticipated, 4.0 mm inner diameter and 5.0 mm outer diameter is used. Unlike the conventional trephine that uses 700-1000 rpm with ample amount of irrigation, this technique utilizes lower speed, 40-50 rpm without irrigation, for that reason it is called "Waterless technique.[18]" Waterless technique has many advantages of not using saline irrigation. For instance, a patient is more comfortable during waterless procedure, a surgeon is able to collect more autogenous bone, and this technique is more friendly to vital structure such as sinus membrane, lingual plate, buccal wall, arteries, and nerves. Moreover, this technique enables implant position and angulation more precise because it is performed at lower speed[18].

Trephining at precise location can be challenging due to drifting nature of trephine bur. In order to minimize heating of bone and to maximize visualization and precision of trephine bur, a newly designed "pointed trephine#" is used at the speed of 50 rpm without irrigation (figure 3). The pointed trephine is used to mark the location for crestal

window, and penetrates only cortical bone of crest (figure 4).

The second step of this system utilizes the trephine that has adjustable stopper inside the trephine#. One millimeter short of sinus floor from crestal ridge is estimated with aid of radiograph, and the "ASBE trephine" is used to set that length inside the trephine. For example, if 6 mm of bone height is anticipated, then stopper is set at 5 mm within trephine. Using 50 rpm speed, the "ASBE trephine" is used to take bone core out (figure 5A). If the sinus floor is weak and relatively flat, the sinus floor will fracture off and expose Schneiderian membrane (figure 6A). However, if sinus floor is dense or in incline plane, it will leave about 1 mm of cortical bone (floor of sinus).

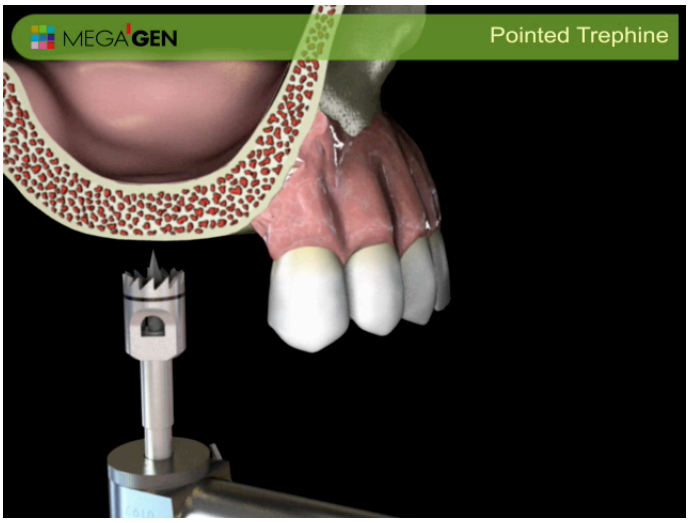

Figure 3. Pointed trephine to mark precise location of crestal window position.

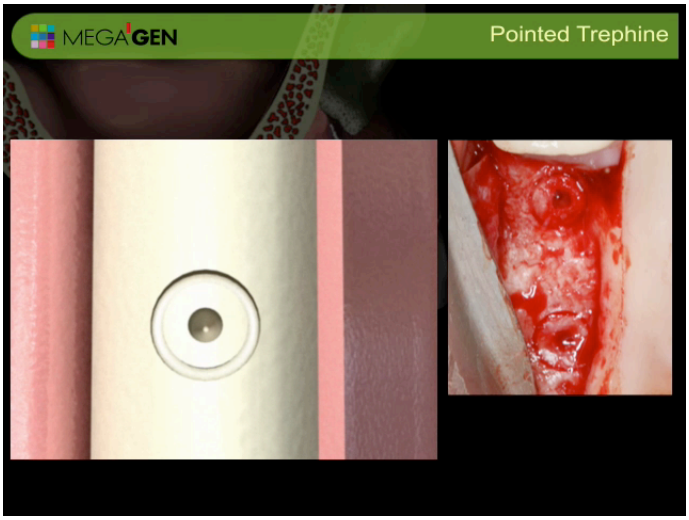

Figure 4. After use of pointed trephine. Pointe trephine is used to mark the position of implant not penetrating more than 2 mm.

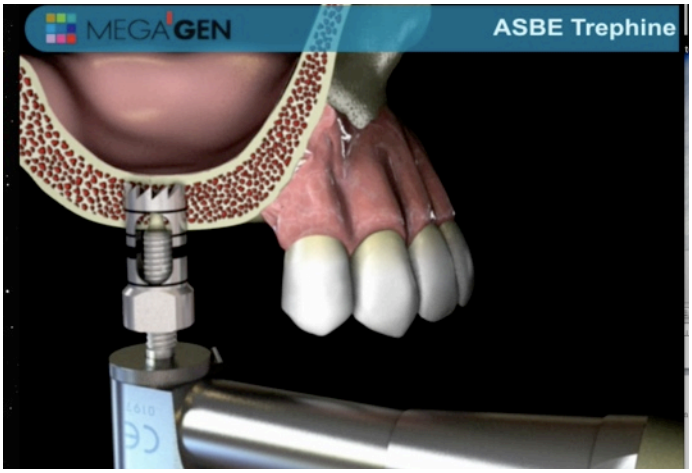

Figure 5A. ASBE (adjustable stopper & Bone Ejector) trephine used at 50 rpm 1 mm short of sinus floor. The stopper ensures that operator does not drill into the sinus floor.

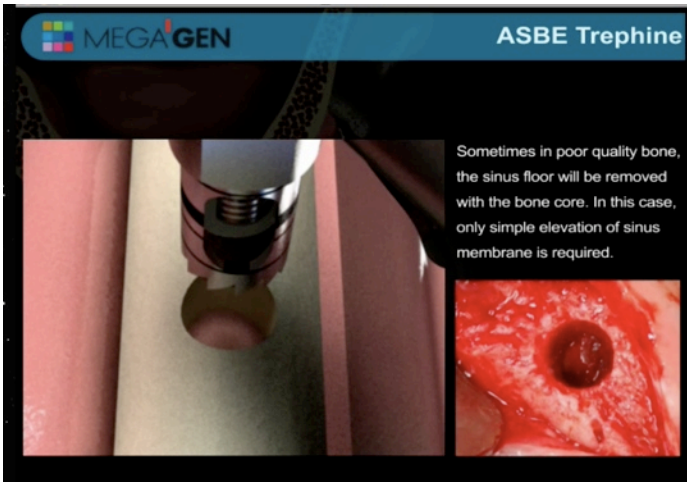

Figure 6A. Flat sinus floor will be taken out with trephine bur leaving just sinus membrane most of time.

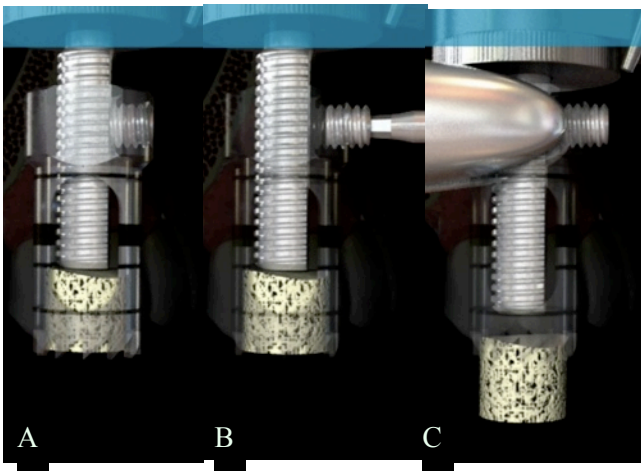

Figure 6B. Unscrew side screw of ASBE to expel and collect bone core from ASBE. This bone is made into particulate bone graft using bone mill and grafted into sinus later on.

If cortical bone (sinus floor) is still intact after the use of the "ASBE trephine", then the "sinus diamond bur#" is used to open the sinus floor without perforating the sinus membrane (figure 7 and 8). This is done very predictably because of the formula below:

Pressure = Force / Area

The force is minimized by utilizing the stopper at the shoulder of the diamond bur. Clinician will feel drop into the sinus once all the cortical bone is ground away, but the stopper will prevent unwanted force into sinus membrane. The diamond surface will grind out bone rather than cutting it. These fine bone particles will act as buffer between sinus membrane and diamond bur, which creates larger surface area. In addition, large diameter of diamond bur is used, rather than small one to increases surface area. Therefore "sinus diamond drill" puts minimal pressure on Scheiderian membrane by decreasing force and increasing surface area, which dramatically reduced the pressure. This concept is similar to the "nail bed" (figure 7), that does not penetrate magician's skin.

figure 7. diamond bur that minimizes pressure on sinus membrane by putting minimal force and maximizing surface area.

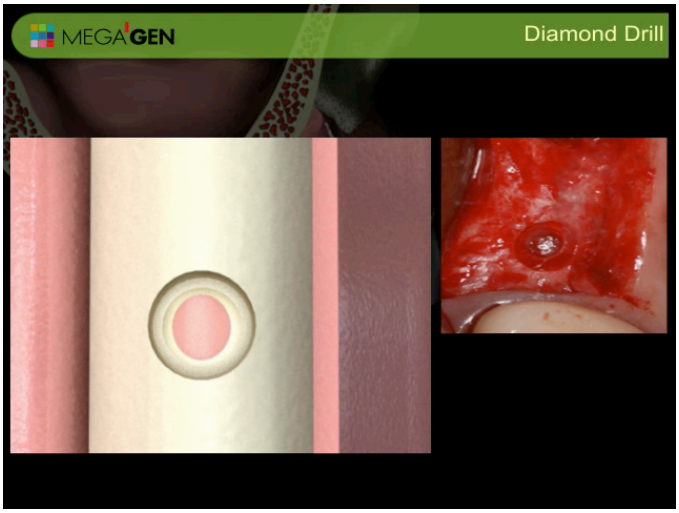

Figure 8. After the use of the "sinus diamond bur." sinus floor is open without damaging sinus membrane.

Next, the mushroom elevator# is used as a probe to feel sinus floor to detect membrane exposure. Sinus floor is never flat, therefore it is common to find initial sinus opening not on center of osteotomy, rather on corner of osteotomy depending on the incline plane of sinus floor. Once slight drop into sinus membrane is felt, the elevation of the membrane is initiated with the "mushroom sinus elevator" (figure 9), and it is also used to break away the remaining ledge of the bone that interferes with sinus membrane elevation (figure 10). Subsequently, the "Cobra sinus elevator#" is used to further elevate sinus membrane, and to scrape the sinus floor to promote bleeding in the sinus cavity (figure 11 and 12).

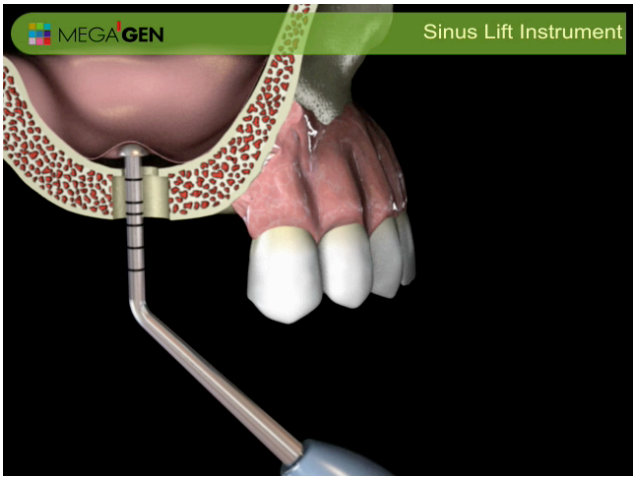

Figure 9. Mushroom elevator to initial sinus membrane elevation.

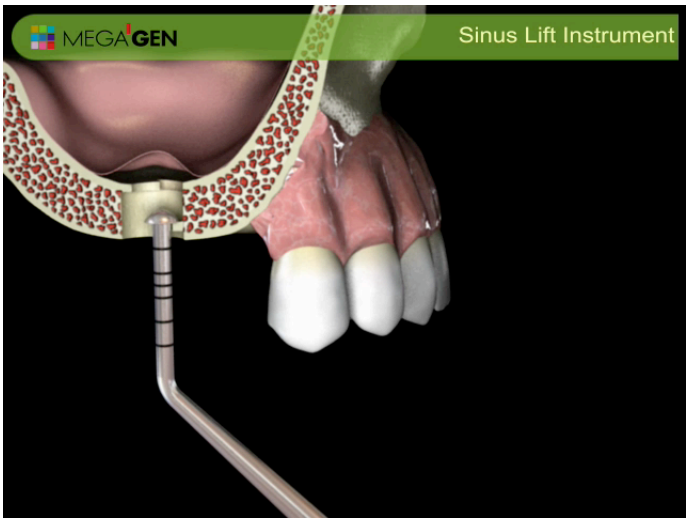

Figure 10. Mushroom elevator to break away ledge of bone that interferes with sinus elevation.

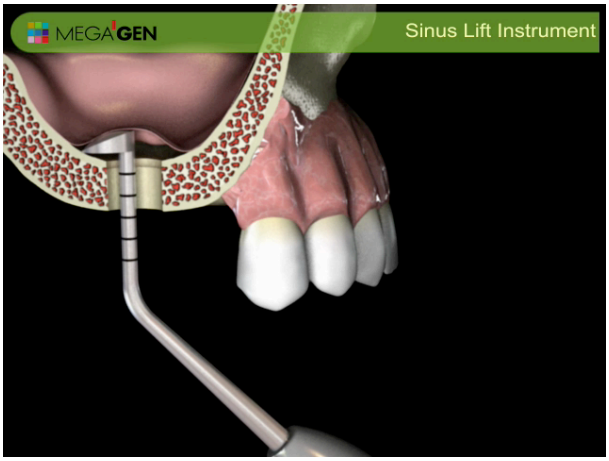

Figure 11. Cobra elevator to further elevate sinus floor distally and medially. Also used to scrape sinus floor to promote bleeding.

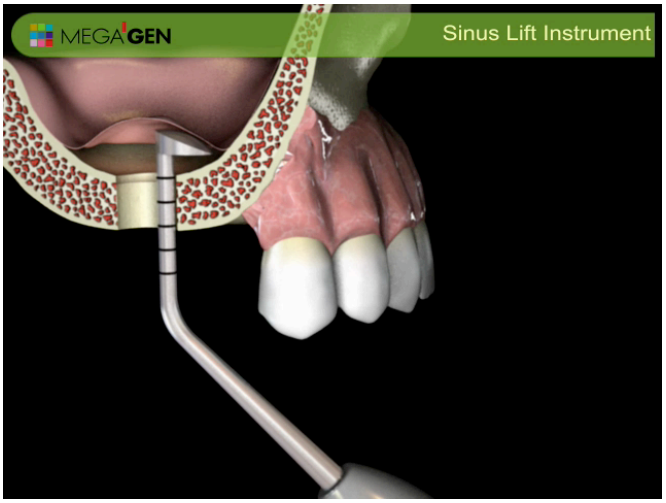

Figure 11. Cobra elevator to further elevate sinus floor mesially and laterally. Also used to scrape sinus floor to promote bleeding.

Bone Condensing

The lateral condensation (figure 13) of bone is more critical than vertical condensation (figure 12) to decrease pressure on sinus membrane. This method facilitates healing time by increasing blood supply from lateral and medial wall, thus this leads to better prognosis and long term success. By the way, the cross sectional slide from CT scan is crucial to verify elevation of lateral and medial wall rather than dome shape graft as seen in most internal techniques.

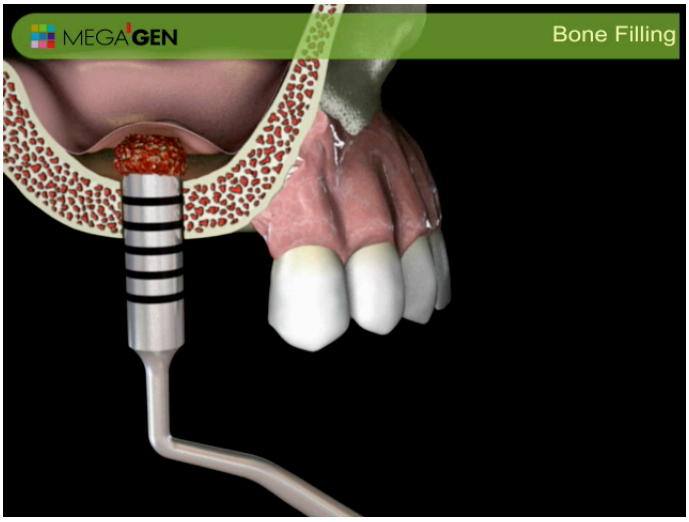

Figure 12. vertical condensation of autogenous bone (graft collected from the trephine) only to just above residual bone height.

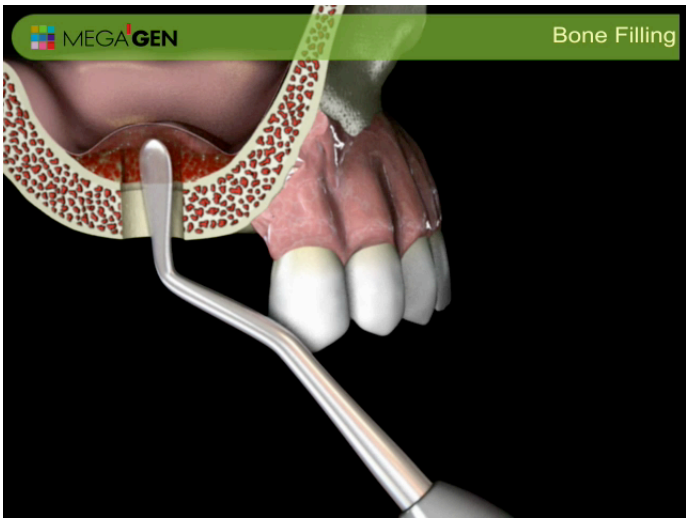

Figure 13. Lateral condensation of bone graft to increase blood supply by graft entering lateral and medial wall, instead of making dome shape grafting as seen on other internal sinus grafting procedures.

Insertion of implant

Skipping last drill sequence of implant is recommended to achieve bone compaction and improve initial stabilization of implant (figure 14). If an implant is loose, a larger healing cap is recommended to prevent implant dropping into sinus cavity, especially if residual bone height is short.

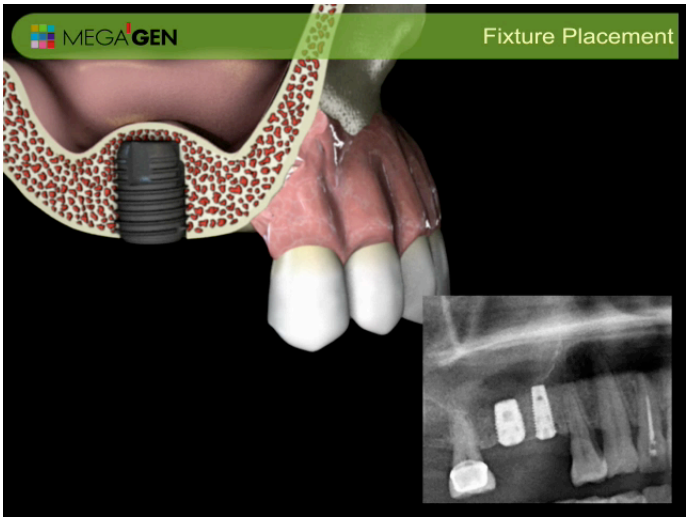

Figure 14. slow insertion of implant. Under prepping osteotomy is crucial to achieve good initial stabilization. Then adjacent implants can be inserted after sufficient sinus grafting.

Case report 1

A 29 years old female asian patient who had extraction of #14 three months prior to implant surgery and #15 edetulism for 5 years. She is a non smoker and a healthy individual. Preoperative radiograph shows 4-6 mm of residual bone height. Ostium is wide open and there were no signs of sinusitis.

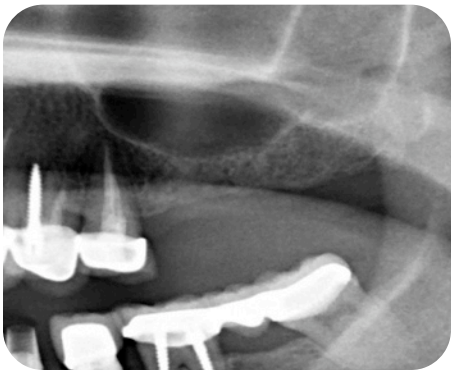

Figure 15. preoperative radiograph showing only 4-6 mm of residual bone height.

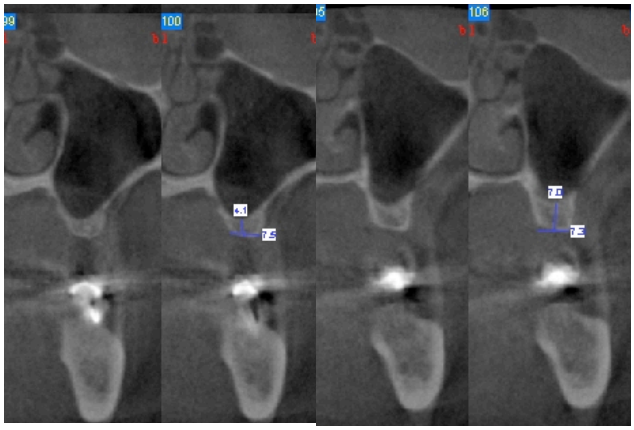

Figure 16. Cross section of sinus shows thin sinus membrane, no signs of sinus disease and patency of ostium. Sinus floor is relatively flat.

The cross section of CT showed healthy sinus, but her sinus membrane is thin and gingival bio type is a thin type as well. There is no known study correlating between gingival biotype and thickness of sinus membrane, but through the author's clinical experience it is observed that thin gingival biotype tends to have thinner sinus membrane unless he/she is a smoker.

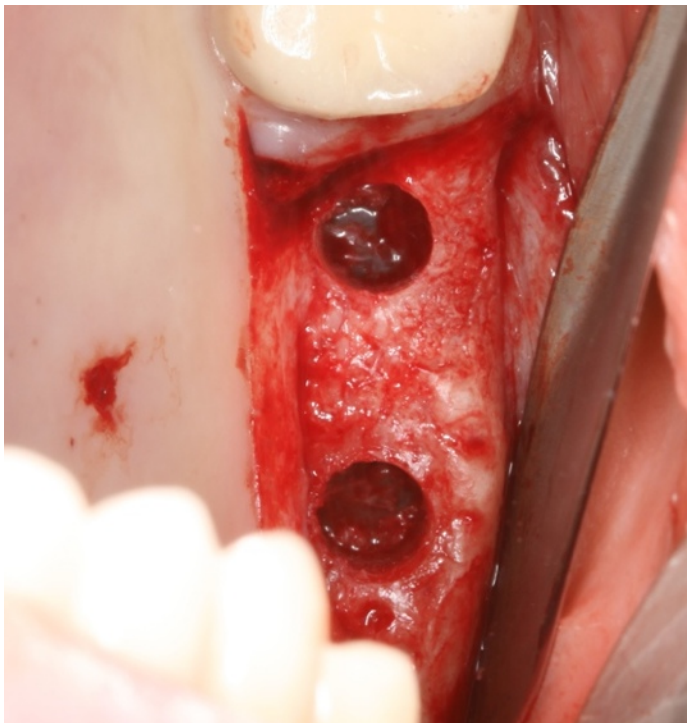

figure 17. after bone core is removed sinus floor came out with it. Thin sinus membrane is observed with some bone ledge still intact (which can be removed with mushroom elevator).

The patient's sinus floor is relatively flat, thus it was expected that the sinus floor can be removed with the bone core after use of "ASBE trephine" (figure 17). Trephine at the low speed, 50 rpm ("Waterless technique") is used to take out the bone core. The rotation of bone core within trephine is clinical indication that sinus floor is broken and no further apical pressure of trephine is recommended to avoid cutting sinus membrane.

Autogenous bone collected from trephine is made into particulate graft and condensed into the maxillary sinus. After elevation of sinus membrane, slow bone compaction is introduced inserting condenser no more than initial height of residual bone (figure 18). Then, lateral condensation is achieved by the use of "sinus spreader" (figure 19)

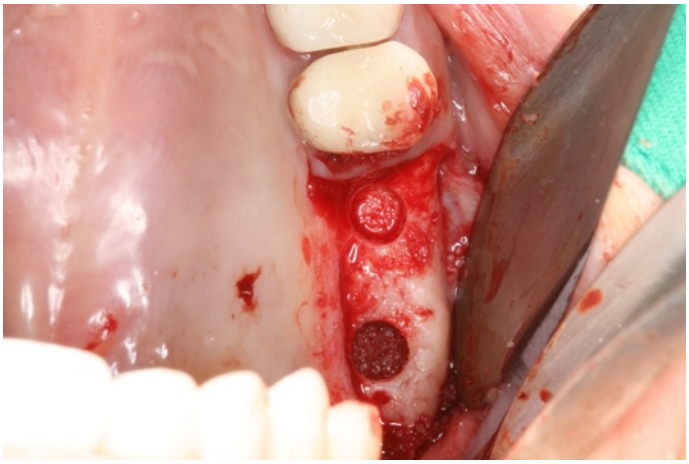

Figure 18. vertical condensation into sinus no more than initial height of sinus floor.

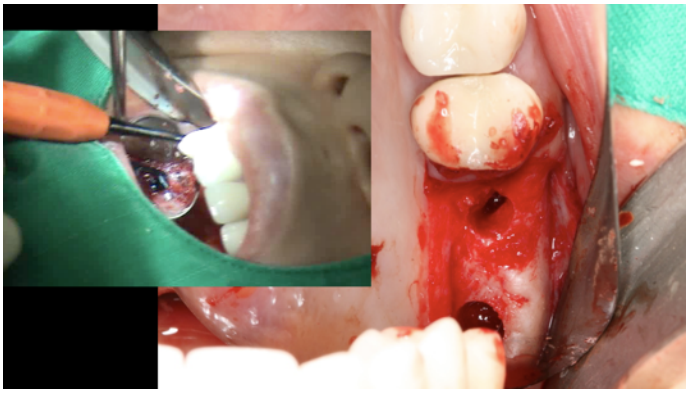

Figure 19. after lateral condensation with "spreader."

Figure 20. after suture. Notice that by doing palatal incision we have preserved attached gingiva on buccal side.

Implant osteotomy is under-drilled in diameter, so good initial stability is achieved allowing one stage implant surgery as well as condensing poor quality bone. Initially we started doing surgery with palatal incision, so we have option of doing two stage surgery with incision line away from implant site as well as one stage with preservation of keratinized tissue (figure 20).

Panoramic and CT scan should be taken after surgery to verify proper grafting of maxillary sinus without perforation. It is more important to note horizontal compaction of bone graft touching medial and lateral wall, which maximize blood supply to the graft and determines longevity of graft after loading.

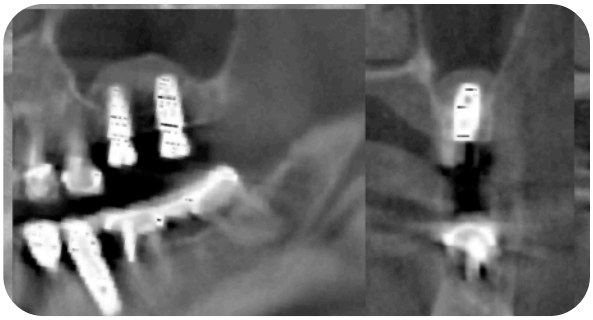

Figure 21. Postoperative radiograph. Note excellent lateral condensation of graft reaching medial and lateral wall of sinus.

Case 2

A 53 years old male asian patient who is healthy and non-smoker. Ostium is patent and no sign of sinus disease is detected. Lowest sinus floor was located on #3 area with residual bone height of 6.5mm. In this case, due to high density of sinus floor the trephine core came out without the sinus floor. "Sinus diamond bur" was used to expose Scheneiderian membrane safely (figure 22). Then, elevation of membrane and bone grafting was achieved using DFDBA** mixed with autogenous bone graft (figure 22). Overgrafting was planned due to high shrinkage rate of DFDBA** (figure 23).

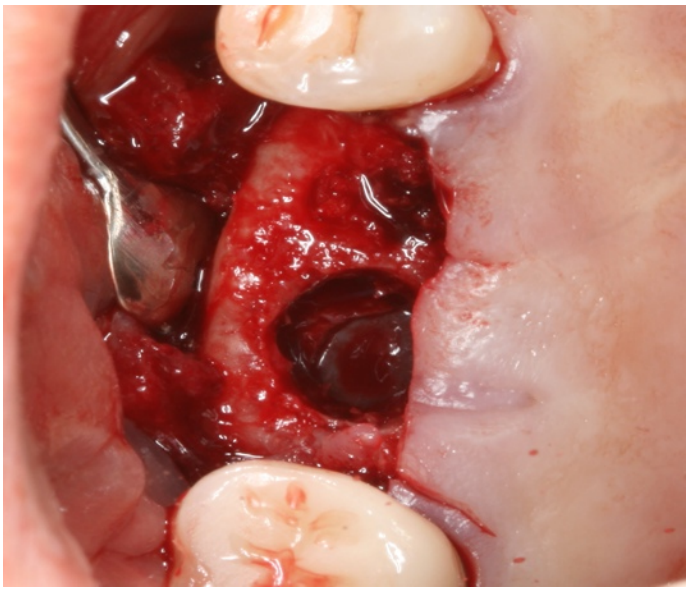

figure 22. after 5 mm trephine, sinus floor was still intact. Therefore, "Sinus diamond bur" used to grind out the floor. Visualization of sinus membrane is clearly seen.

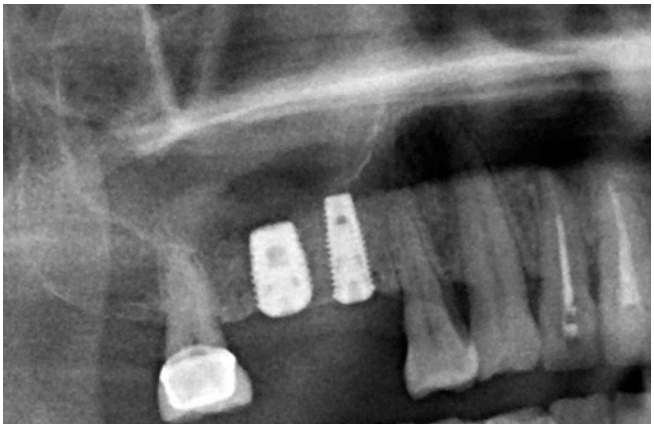

Figure 23. 6X8.5mm and 4X10mm implant placed after grafting with DFDB and autogenous bone graft internally into maxillary sinus. To anticipate shrinkage, over grafting has been achieved.

Case 3

A 60 years old asian patient who is a smoker, otherwise healthy individual. Residual bone height is only about 1.5mm on #14 site. #14 site was used to lift the sinus (because it is the lowest point), then #13 implant was placed after grafting. Sinus diamond bur is used to penetrate to the bone directly instead of using trephine bur because the residual bone height is only 1.5 mm.

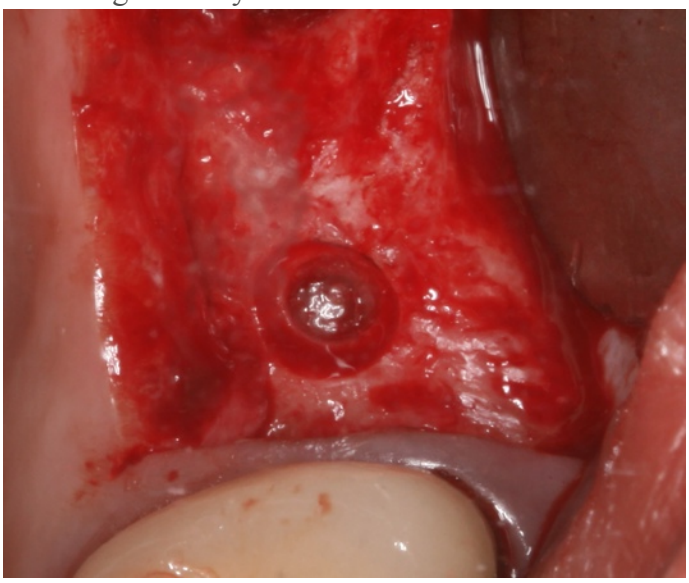

figure 24. after use of sinus diamond bur. Note sinus membrane on the center of the ring.

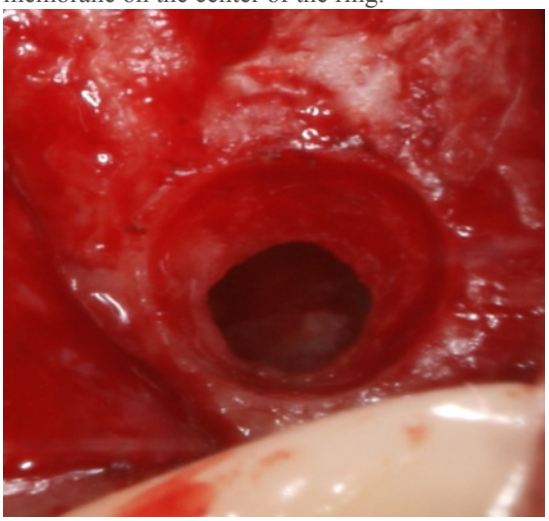

figure 25. after elevation of membrane with mushroom elevator.

After visual confirmation of sinus membrane exposure, the membrane elevation was done with the "mushroom elevator." Then, ledge of bone was removed with osteotomy drill at low speed using "waterless technique" (figure 26). After removal of ledge of bone, introduction of "cobra elevator" was possible to further elevate sinus membrane in all directions. Bone condensed into the sinus, then implant was inserted with skipping the last drill sequence (4.3 mm diameter drill instead of 4.6 mm drill for 5.1 mm implant). Good primary stabilization was achieved (figure 27).

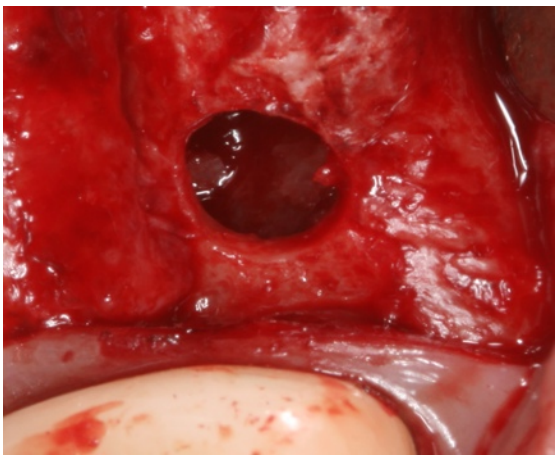

figure 26. ledge of bone removed with 4.3 mm implant osteotomy drill at low speed (Waterless technique[18]).

As seen on the figure 26, the crestal window technique is easier if residual bone height is short. Moreover, this technique permits better access and visualization. The elevation of membrane with cobra elevator is easier if there is less residual bone height, because there are less interference of bone on the instrument while elevating the membrane. Movement of Scheneiderian membrane is observed as a patient is breathing. This serves as a confirmation that sinus membrane is intact after elevation. Then, as a final step prior to bone grafting, cobra elevator is used to make bleeding surface inside the sinus by scraping the floor.

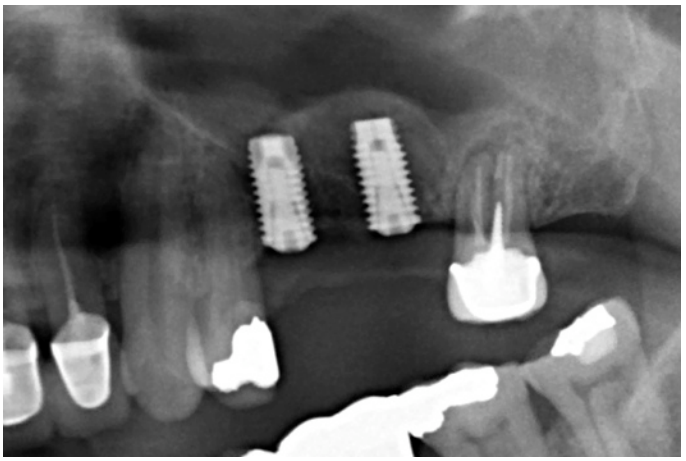

figure 27. Postoperative radiograph showing 12 mm of elevation from #14 site. Only 1-2 mm residual bone height.

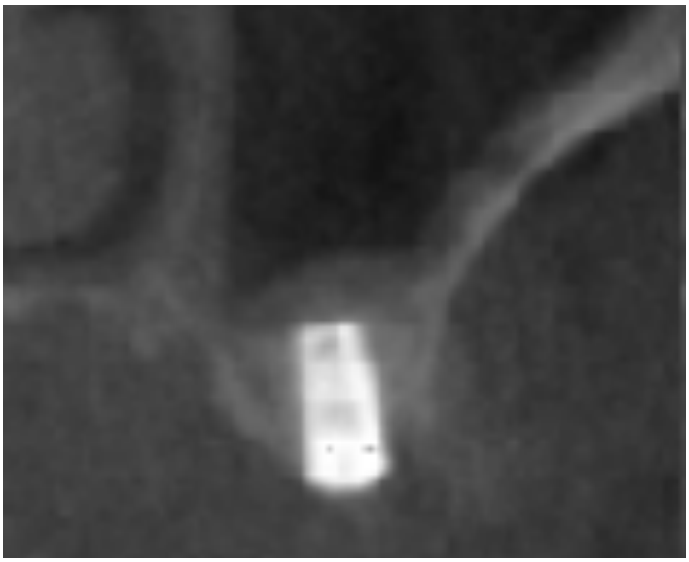

figure 28. Postoperative radiograph showing good lateral condensation. Note relatively thick sinus membrane due to smoking.

Cross section from CT scan shows medial and lateral wall fully elevated to maximize blood supply to the graft (figure 28). Note the thickness of Scheneiderian membrane on the unelevated lateral and medial wall, which is usually thickened due to smoking.

Case 4

A 53 years old patient who is healthy, but a heavy smoker. Scheneiderian membrane is often thickened in smokers as discussed in case 3, which makes surgical elevation of membrane much more predictable. This author feels comfortable doing

sinus lift procedure if thickness of Scheneiderian membrane is less than 3mm, no clinical sign of sinusitis, and ostium is patent.

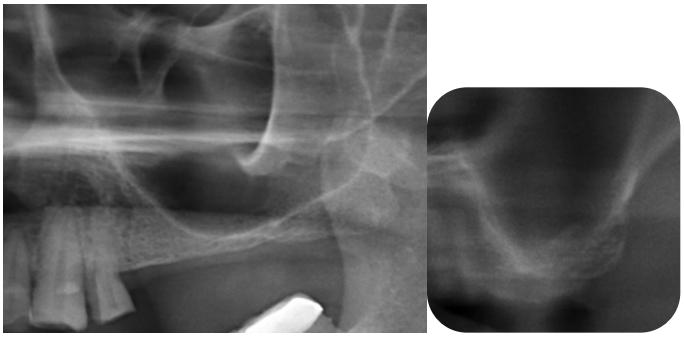

figure 29. Preoperative radiograph showing lowest sinus floor around #15 with 2 mm of residual bone height. #15 site was used to elevate sinus membrane using crestal approach.

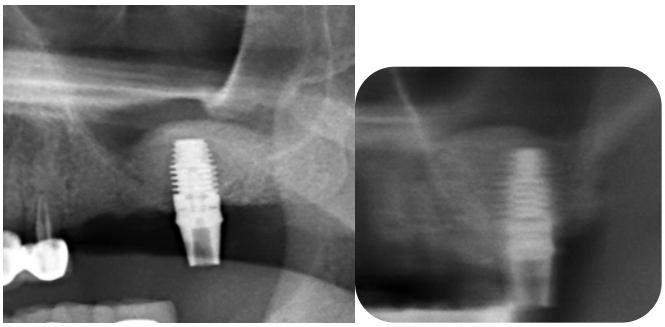

figure 30. After proper sinus grafting and insertion of 6X10 mm implant. Note the graft touching medial and lateral wall of sinus wall on the cross sectional view.

Preoperative radiograph showing only 2mm of bone height on #15 area (figure 29). Lowest point (#15) is used to elevate sinus membrane and insert bone graft material. DFDB (1.5cc) was used mostly with lateral condensation rather than vertical condensation (figure 30). Then, two more implants have been placed mesially on #13 and #14 area (figure 31). One mistake that the author made is not overgrafting. DFDB tends to resorb faster and cause more shrinkage than other bone graft materials. However, advantage is that it is not too radiopaque. Therefore, when it gets replaced by true bone, the clinician can have visual confirmation by observing radiopacity from new bone as well and new cortical bone formation on the new sinus floor (figure 32).

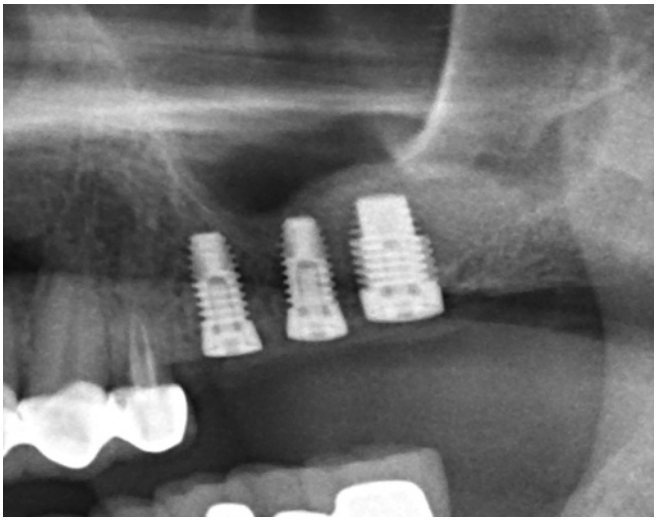

figure 31. Insertion of 4X10 mm implant into #13 and #14 site after bone grafting from #15 site.

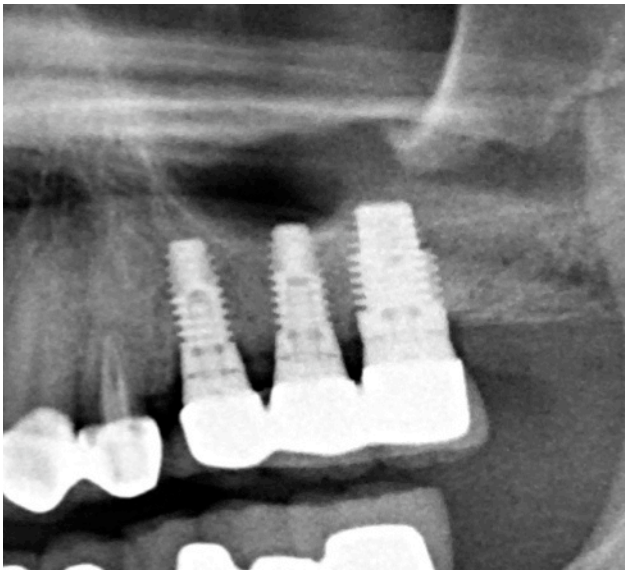

figure 32. Two year post operative showing new cortical bone formed on sinus floor confirming natural morphology of true bone. Note shrinkage of bone graft due to faster resorbing nature of DFDB.

Case 6

A 39 years old asian patient who does not have history of sinusitis and is not a smoker. Ostium patency is observed on CT scan and no clinical sign of sinus disease was detected prior to surgery. However, residual bone height is only about 2 mm around #14 and #15 area (figure 33). Under prepping of osteotomy is crucial in this case to make initial stabilization successful. As discussed above, crestal window approach is easier if residual bone

height is thin like in this case. To avoid bone shrinkage as observed in case 5, the author used long lasting membrane (Lambone**) under Scheneiderian membrane.

figure 33. Preoperative panoramic radiograph showing clear sinus cavity, but severe pneumatization leaving only 1-2 mm bone height at lowest point.

Crestal window in this case is only 4 mm in diameter. Therefore, insertion of resorbable membrane is achieved by rolling the membrane ("Kim Bap Technique") after soaking in saline with tetracycline[19](figure 34). Lambone is tough and has excellent plasticity, so once inserted into sinus cavity via crestal window it will open up (go back to original shape) (figure 35).

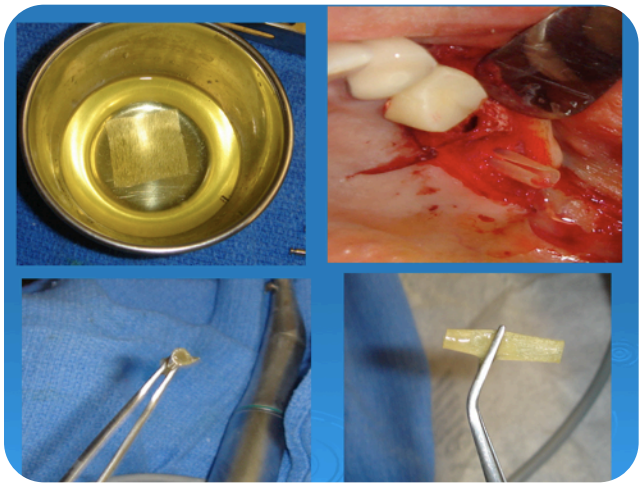

figure 34. after soaking resorbable membrane, Lambone, in tetracycline for 10 min, roll it up like Korean rice roll ("Kim Bap technique") and insert into sinus cavity.

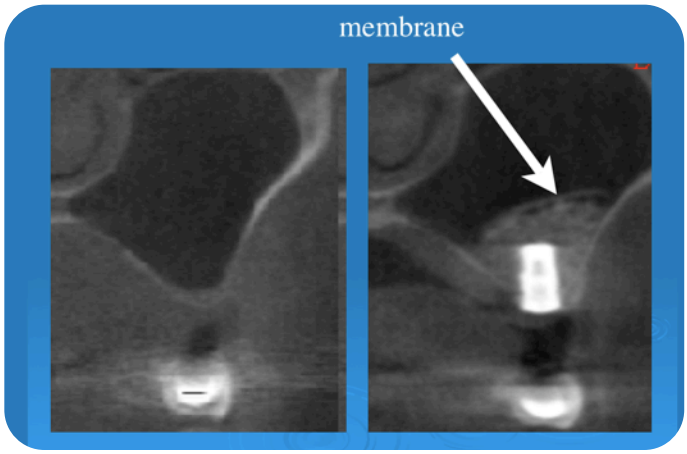

figure 35. Preoperative cross section on the left and postoperative cross section on the right. Note good lateral compaction of bone against sinus wall and membrane on top of graft to protect it from shrinkage.

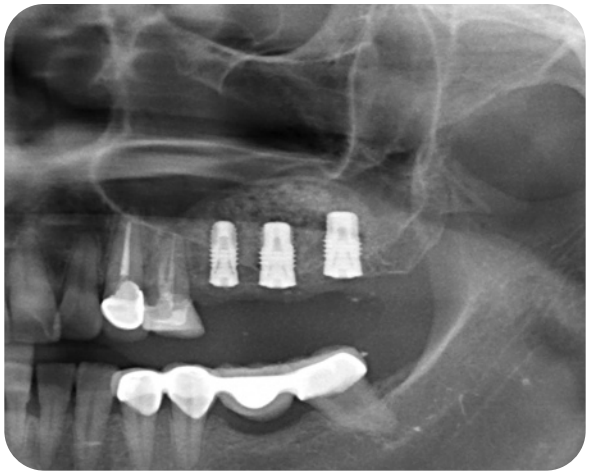

figure 36. Postoperative radiograph after internal sinus grafting and insertion of 4X10 mm on #13, 5X10 mm on #14, and 5X10mm on #15.

Discussion

As shown on many clinical cases above, the new "Crestal Window Technique" allows elevation of Scheneiderian membrane predictably without the mobidity associated with lateral window technique, because the flap elevation does not extend beyond mucogingival juction. With proper instruments (mushroom, cobra, bone carrier, vertical condenser, and lateral condenser) and tools (pointed trephine, ASBE trephine, and sinus diamond bur), crestal

window approach is predictable and results in similar outcome as lateral window technique in terms of membrane elevation and bone condensing. However, as perforation do occur in lateral window technique, perforation also can occur in crestal window technique (mostly during membrane manipulation rather than during opening crestal window).

Perforation of sinus membrane

In case of perforation, primary closure is achieved since palatal incision was made. This prevents possibility of oral antral communication especially in a case where residual bone height is very thin. Non resorbable membrane is recommended to be placed over the crestal window to prevent soft tissue ingrowth. After 2-3 months after healing, reattempt of crestal window is most likely to be successful because repaired sinus membrane (previously torn) is tougher in nature. Because low post operative discomfort associated with the procedure, patients accept 2nd attempt without much objection.

Time to load implant

The best indicator that the graft turned into true bone without doing biopsy is observation of new cortical bone formation on newly formed sinus floor (figure 32). Typically it takes 3 + 1 month for every 1 mm of bone grafting. For example, if 5 mm of bone graft elevation was done, the new cortical bone will be formed around 8 months later (3 + 5 = 8 months). But, this formula slightly varies depending on age of patient and buccal lingual dimension of sinus cavity.

Conclusion

The new innovative "Crestal Window" technique is a good alternative to conventional lateral window technique. This technique results in similar outcome as lateral window technique without the mobidity associated with it. Unlike other crestal approach to sinus lift, it is unique in that it is not a blind technique, indications are for bone height (1-7mm, thinner height is easier), and it does not result in dome shape grafting (because membrane is fully elevated palatally and laterally before introduction of bone graft). The only disadvantage is that it requires use of 4.5 mm or larger implant placement. However, as discussed earlier, 5.0 mm diameter or larger should be used for molar site anyway for better emergence profile, reduce risk of implant fracture, and reduce crestal bone stress by minimizing bending moment force.[20]

* Dr. Samuel Lee is in private practice, First Choice Dental Group, Buena Park, CA, USA. He is the inventor of the tools described in this article.
† Dr. Grace Kang-Lee is in private practice, First Choice Dental Group, Buena Park, CA, USA.
‡ Dr. Kwang-bum Park is in private practice, Mir Dental Hospital, Dae Gu, Korea
§ Dr. Thomas Han, is in private practice, WPD, Los Angeles, CA, and also is clinical professor at Periodontal Department at UCLA.
# All instruments mentioned above relating to "Crestal Window Sinus Grafting" is manufactured by Megagen Implant, Inc.
** DFDB is purchased from Pacific Coast Tissue Bank, Los Angeles, CA.
†† Lambone is purchased from Pacific Coast Tissue Bank, Los Angeles, CA.

Disclosure

The author of this article is the inventor of this "Crestal Window Sinus Grafting System," and has financial interest with the product.

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