Overcoming pneumatization of the maxillary sinus

by Sam Lee

Abstract

Background: The placement of dental implants in the posterior maxilla is often a challenge due to pneumatization of the maxillary sinus. Dental surgeons have predictably overcome this obstacle by performing bone grafting procedures such as lateral window maxillary sinus augmentation (modified Caldwell-Luc). Although predictable, this technique produces patient morbidity including postoperative bruising, pain, and swelling. To reduce such morbidity, many internal (crestal) approaches to sinus grafting have been introduced using a variety of specialized instruments. One problem associated with such techniques is lack of visibility when opening the sinus floor and manipulating Schneiderian membrane. This case series reports on a new crestal approach to maxillary sinus augmentation that results in reduced patient morbidity and improved intrasurgical visualization. Methods: 5 patients were treated with the crestal window maxillary sinus augmentation approach. Preoperative radiograph and CT scan analyses were performed on all patients. A combination of specialised trephines was used at slow speeds (40-50 RPM) to access the maxillary sinus. Multiple specialized elevators were then used to elevate the Schneiderian membrane via the crestal window and particulate graft was added to the sinus. Dental implants were placed, typically in a single staged approach.

Results: All 5 cases in this series resulted in successful clinical outcomes with adequate sinus augmentation and implant survival. The patients experienced minimal morbidity associated with the crestal window approach to maxillary sinus augmentation.

Conclusion: The crestal window approach to maxillary sinus augmentation is a simple, predictable technique with low patient morbidity.

Introduction

Due to pneumatization of the maxillary sinus, poor bone quality and quantity, treatment of posterior edentulism has been and continues to remain a challenge for dental physicians. Traditionally, these obstacles are overcome by bone condensing and grafting into the maxillary sinus beneath the Schneiderian membrane.[1-18] Bone grafting into the sinus has produced predictable results enabling clinicians to place longer implants for more stable prostheses and better long term outcomes.[3] Although final outcomes have proved satisfactory, sinus augmentation via lateral window grafting procedures produces substantial patient morbidity.[5-7, 15, 17, 18] Because this technique involves flap elevation beyond the mucogingival junction, bruising, swelling, and pain are common postoperative complications.[5-7, 15, 17, 18] An additional intraoperative complication associated with this procedure may arise from the laceration of the intraosseous branch of posterior superior artery (branch of maxillary artery).[15] Finally, the technique sensitive nature of the lateral window approach carries a risk of Schneiderian membrane perforation during window preparation and membrane elevation. In an attempt to forgo the risks and complications of lateral window sinus augmentation, a number of internal (crestal) approaches to have been introduced such as osteotome[5-7], reamers[17], tapping drills[18], piezoelectric, ISM17, and HSC.15 With most of these internal techniques for sinus augmentation, poor visibility during manipulation of the Schneiderian membrane remains a problem. While a great solution for the premolar region, use of standard diameter implants (4.0mm) in the molar region has limitations such as poor emergence profile, implant fracture, and crestal bone strain.[19-21] Large platform diameter implants may overcome poor bone quality by increasing bone to implant surface contact in addition to producing superior emergence profile.[21] Use of such implants in molar areas may also decrease fracture risk, crestal bone stress, and allows fabrication of a natural occlusal table.[20] The purpose of this paper is to describe an innovative surgical technique that combines a crestal internal sinus lift with use of wide diameter implants.

Description of surgical technique

Flap elevation

Incision design that is at least 2mm palatal to desired implant position and flap elevation that does not extend beyond the mucogingival junction is recommended (figure 1). This incision design allows for minimal pain, unilateral flap retraction, the option of doing one or two stage implant placement without losing keratinized tissue, and the ability to treat oral antral communications in case of excessive Schneiderian membrane perforation.

Location of crestal window

When performing this technique, the lowest point of the maxillary sinus should be located by means of radiographic or cone-beam/ct options (see arrow in figure 2). It is most favorable when this position coincides with implant position. If implant placement at sites #2, 3, and 4 are anticipated with site #3 being the lowest point in the maxillary sinus floor, site #3 should be used to lift the sinus membrane.

Crestal window preparation and membrane lift

To perform the crestal internal sinus lift, a round window is made on the crestal bone with a set of specially designed trephine burs that have a diameter 1mm less than the final implant size. For example, if a 6mm implant is anticipated, a 4.0mm (inner diameter) x 5.0mm (outer diameter) trephine is used. Unlike the conventional trephine techniques that require 700-1000 rpm with ample irrigation, this technique utilizes lower speeds of 40-50 rpm without irrigation and is referred to as a 'waterless technique.' The waterless technique has the advantage of not washing away autogenous bone filings during bone manipulation, thus allowing the surgeon to collect an increased amount of autogenous bone. Conventional trephining with precision is often challenging due to skipping or drifting of the trephine during initial bone cutting. To minimize this complication and maximize visualization and precision of the trephine bur, a 'pointed trephine' is used at a speed of 50 rpm without irrigation (figure 3). The pointed trephine is used to mark the location of the intended crestal window and only penetrates the cortical crest (figure 4). The second step in this technique utilizes a trephine with an internal adjustable stopper (ASBE trephine). Radiograph or cone-beam/CT is used to meas-

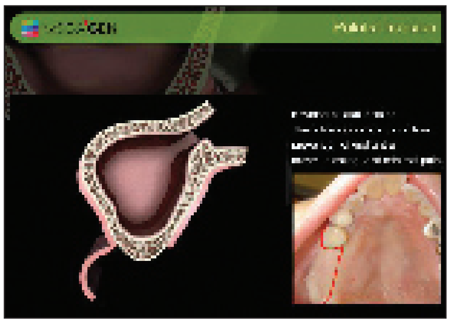


Figure 1: Incision design that is at least 2mm palatal to desired implant position and flap elevation that does not extend beyond the mucogingival junction is recommended

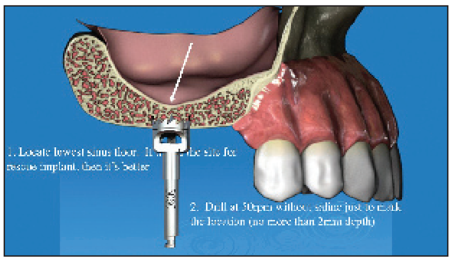


Figure 2: the lowest point of the maxillary sinus should be located by means of radiographic or cone-beam/ct options

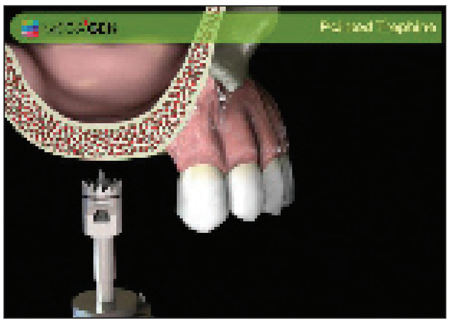


Figure 3: To minimize this complication and maximize visualization and precision of the trephine bur, a 'pointed trephine' is used at a speed of 50 rpm without irrigation

ure the width of residual native bone from the ridge crest to the floor of the sinus and 1mm is subtracted from this distance. The adjustable stopper within the ASBE trephine is then set to such a length to prevent perforation of the maxillary sinus floor. For example, if 6mm of native residual bone remains from the ridge crest to the floor of the maxillary sinus, the ASBE trephine adjustable stopper is set to 5mm. At a speed of 50 rpm, the ASBE trephine is used to penetrate the ridge crest and remove a bone core (figure 5). Although the ASBE trephine is set to a length 1mm short of the sinus floor, bone core removal will often expose the Schneiderian membrane (figure 6). In cases where the sinus floor is extremely dense or on an inclined plane, 1mm of cortical bone may remain at the floor of the maxillary sinus. In the event that 1mm of residual bone remains at the sinus floor following use of the ASBE trephine, a specialized wide diameter 'sinus diamond bur' is used to expose the Schneiderian membrane. The specialized sinus diamond bur contains a shoulder stop that prevents drilling into the Schneiderian membrane. Additionally, as the sinus diamond bur grinds the residual cortical bone, resultant fine bone particles act as a buffer between sinus membrane and diamond bur (figure 7). With the third step in this technique, elevation of the maxillary sinus Schneiderian membrane is accomplished. Following preparation of the crestal window, a 'mushroom elevator' is used as a probe for tactile feel of the sinus floor and detection of membrane exposure. The maxillary sinus floor is rarely perfectly flat, so it is common to find initial sinus membrane exposure at the corner of the osteotomy rather than at the centre (figure 8). Once the mushroom elevator slightly drops into the maxillary sinus and the Schneiderian membrane is felt, membrane elevation is initiated (figure 9). This same elevator is also used to break away any remaining ledges of bone in the osteotomy site that interfere with sinus

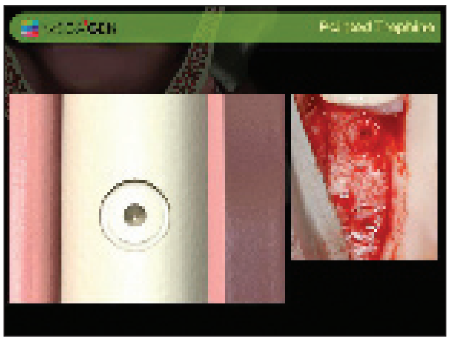


Figure 4: The pointed trephine is used to mark the location of the intended crestal window and only penetrates the cortical crest

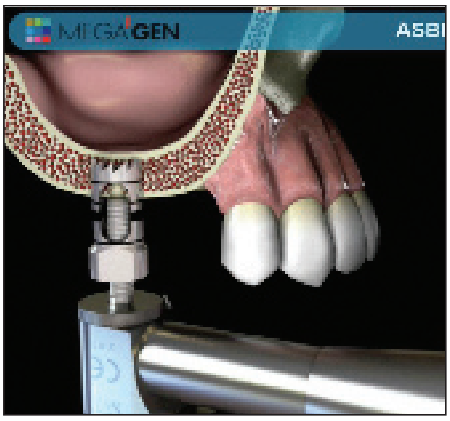
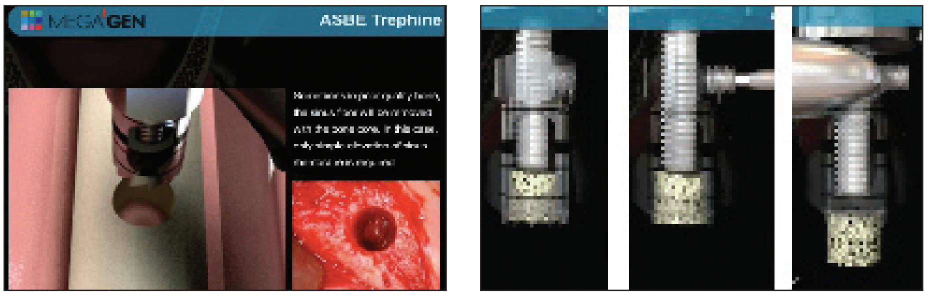


Figure 5: At a speed of 50 rpm, the ASBE trephine is used to penetrate the ridge crest and remove a bone core



Figures 6a and 6b: Although the ASBE trephine is set to a length 1mm short of the sinus floor, bone core removal will often expose the Schneiderian membrane

membrane elevation (figure 10). After initial Schneiderian membrane elevation, the 'Cobra sinus elevator' is used to further elevate the sinus membrane and scrape the bony sinus floor to promote bleeding in the sinus cavity (figures 11 and 12).

Bone condensing and implant insertion

To accommodate a wide diameter implant of sufficient length, bone graft is added to the maxillary sinus. A combination of lateral and vertical condensation of particulate bone is used to augment the sinus and produce additional lift of the Schneiderian membrane (figures 13 and 14). Lateral bone graft condensation is critical to reducing pressure on the Schneiderian membrane and, thus, reducing the risk of perforation. This method facilitates healing by increasing blood supply from the lateral and medial wall. Under-preparing the diameter of the osteotomy in relation to the implant is recommended to achieve bone compaction and improve initial fixture stabilization (figure 15).

Case 1

A 29-year-old non-smoking Asian female with a non-contributory medical history had extraction of tooth #14 three months prior to implant

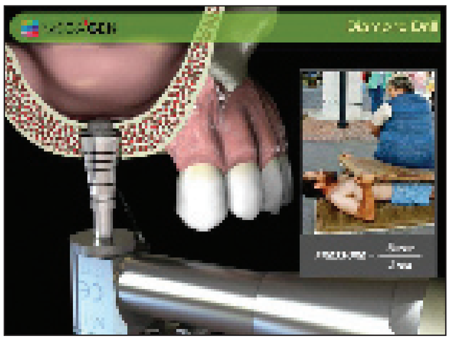


Figure 7: As the sinus diamond bur grinds the residual cortical bone, resultant fine bone particles act as a buffer between sinus membrane and diamond bur

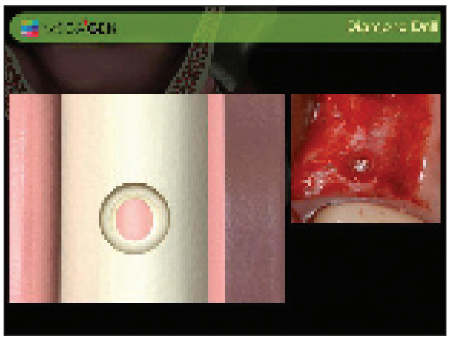


Figure 8: It is common to find initial sinus membrane exposure at the corner of the osteotomy rather than at the centre

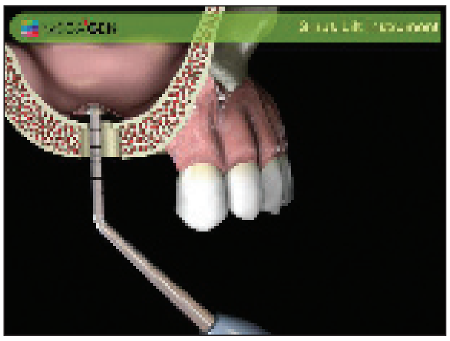


Figure 9: Once the mushroom elevator slightly drops into the maxillary sinus and the Schneiderian membrane is felt, membrane elevation is initiated

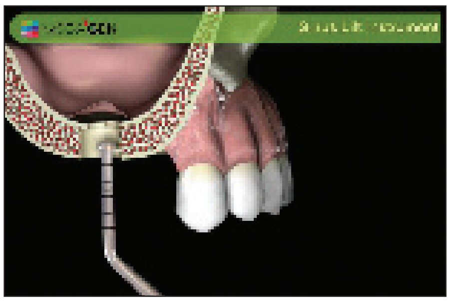
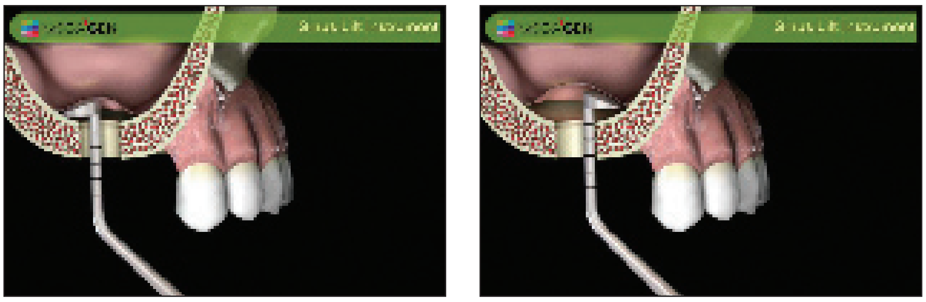


Figure 10: This same elevator is also used to break away any remaining ledges of bone in the osteotomy site that interfere with sinus membrane elevation



Figures 11a and 11b: initial Schneiderian membrane elevation

surgery and site #15 edentulism for 5 years. Preoperative radiographs showed 4-6 mm of residual bone height between the ridge crest and the maxillary sinus floor (figure 16). Cross sectional CT revealed no signs of sinusitis, ostium patency, and a thin Schneiderian membrane (figure 17). Coincidentally, the patient also had a very thin gingival biotype. There is no known study correlating gingival biotype with Schneiderian membrane thickness, but through the author's clinical experience it has been observed that patients with a thin gingival biotype tend to have thinner sinus membranes (unless he/she is a smoker). The patient's sinus floor was relatively flat, thus it was expected that the sinus floor could be removed with the bone core after use of ASBE trephine (figure 18). Trephine with the waterless technique was used to remove the crestal bone core. Rotation of the bone core within the trephine is an indication that the sinus floor is broken and no further apical pressure of the trephine is recommended to avoid cutting sinus membrane. Autogenous bone collected from the trephine was made into particulate graft and condensed into the maxillary sinus. After initial elevation of the Schneiderian membrane with the mushroom and cobra elevators, slow bone compaction was accomplished by inserting the condenser no more than initial height of residual bone (figure 19). Next, lateral condensation was achieved by the use of a 'sinus spreader' instrument (figure 20). To allow for single stage implant surgery, the implant osteotomy was under-prepared in diameter to achieve good initial stability through compaction of porous quality bone during implant placement. A palatal incision design allowed for preservation of keratinised tissue following placement of the healing abutments. (Figure 21). Panoramic and CT scans were accomplished after surgery to verify proper grafting of the maxillary sinus without perforation and to note horizontal compaction of bone graft touching the medial and lateral walls (figure 22).

Case 2

A 53-year-old non-smoking Asian male with a non-contributory medical history presented for implant placement. Preoperative radiographic and CT scan evaluation revealed a patent ostium and no signs of sinusitis. The lowest point of the maxillary sinus floor was located at site #3 with residual bone height of 6.5mm. In this case, due to the high density of the sinus floor, removal of the trephine core left approximately 1mm of residual bone on the sinus floor. The self-limiting sinus diamond bur was used to safely expose the Schneiderian membrane (figure 23). Next, the Schneiderian membrane was elevated with the aforementioned elevators and bone grafting was achieved using demineralized freeze-dried bone allograft (DFDBA) mixed with autogenous bone graft (figure 24).

Case 3

A 60-year-old Asian patient with a non-contributory medical history and current smoking status presented for implant treatment. Radiographic and CT scan evaluation revealed residual bone height of only 1.5mm at site #14.

As this site was the lowest point of the maxillary sinus in relation to the residual ridge, site #14 was used to lift the Schneiderian membrane and an implant was placed at sites #13 and #14 after grafting. The sinus diamond bur was used to penetrate to the bone directly instead of using trephine bur because the residual bone height was only 1.5mm (figure 25). After visual confirmation of sinus membrane exposure, membrane elevation was accomplished with the mushroom elevator (figure 26). A remaining ledge of bone in the osteotomy was removed with an implant osteotomy drill at low speed using the waterless technique (figure 27). After bony ledge removal, introduction of 'cobra elevator' was possible to further elevate the sinus membrane in all directions. Bone was then condensed into the sinus and the implant was inserted, skipping the last drill sequence (4.3 mm diameter drill instead of 4.6 mm drill for 5.1 mm implant). Good primary

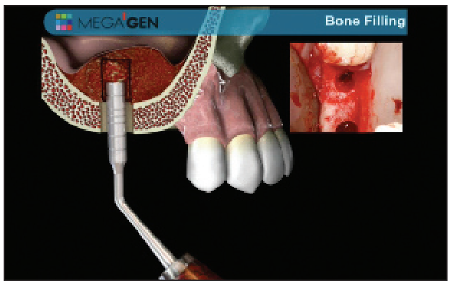
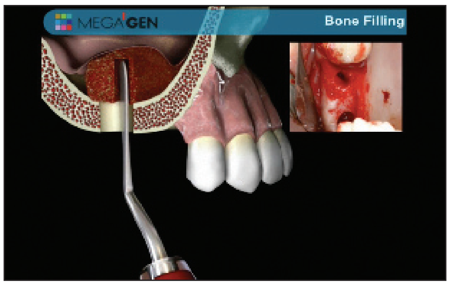


Figure 12: After initial Schneiderian membrane elevation, the 'Cobra sinus elevator' is used to further elevate the sinus membrane and scrape the bony sinus floor to promote bleeding in the sinus cavity



Figures 13 (above) and 14 (left): A combination of lateral and vertical condensation of particulate bone is used to augment the sinus and produce additional lift of the Schneiderian membrane

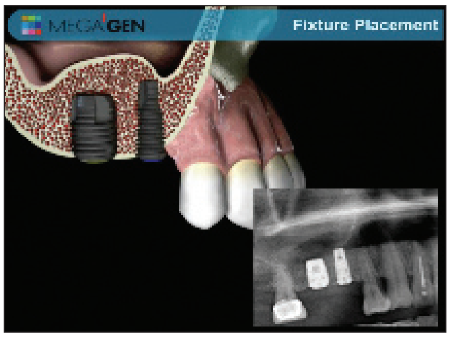


Figure 14

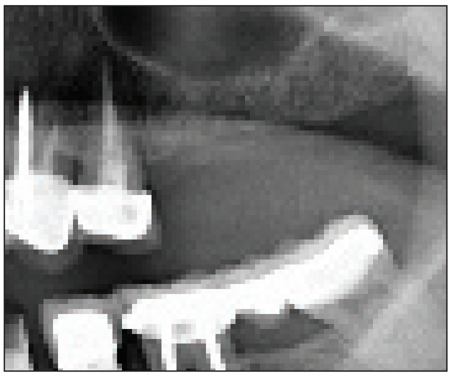


Figure 15: Under-preparing the diameter of the osteotomy in relation to the implant is recommended to achieve bone compaction and improve initial fixture stabilization

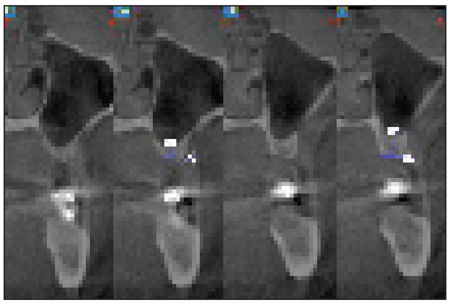


Figure 16: Preoperative radiographs showed 4-6 mm of residual bone height between the ridge crest and the maxillary sinus floor

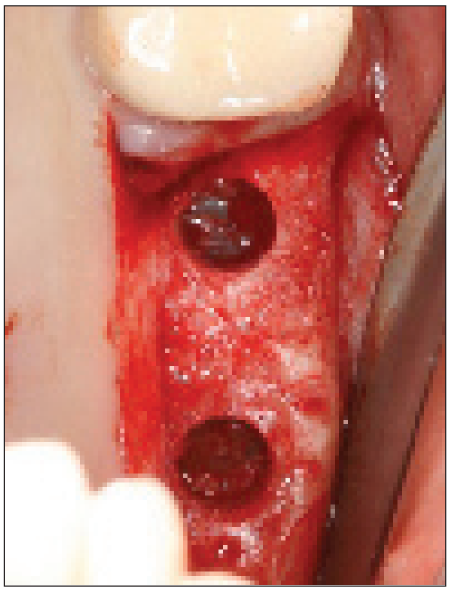


Figure 17: Cross sectional CT revealed no signs of sinusitis, ostium patency, and a thin Schneiderian membrane

stabilization of the implant was achieved and a postoperative radiograph revealed adequate sinus augmentation (figure 28). Cross section from a CT scan showed the medial and lateral wall fully elevated to maximise blood supply to the graft (figure 29). Note the thickness of the Schneiderian membrane on the un-elevated lateral and medial walls. Because this patient was a smoker, the membrane is exceptionally thick.

Case 4

A 53-year-old patient with a non-contributory medical history and current heavy smoking status presented for implant treatment. As was the case with the patient in Case 3 of this series, the patient's smoking history resulted in a Schneiderian membrane that was very thick. Radiographic and CT scans revealed a patent ostium, no signs of sinusitis, and 2mm of residual bone height at site #15 (figure 30). The lowest point of the maxillary sinus (site #15) was used to elevate the Schneiderian membrane. Sinus augmentation was achieved with DFDBA using mostly with lateral condensation rather than vertical condensation (figure 31). Implants were placed at sites #13, #14, and #15 (figure 32). One mistake that the author made was not over-grafting with DFDBA. It is the author's experience that DFDBA tends to resorb faster and have more shrinkage than other bone graft materials. However, one advantage is that it is not too radiopaque. Therefore, when DFDBA is replaced by host 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 33).

Case 5

A 39-year-old non-smoking Asian patient presented for implant treatment. Radiographic and CT scans revealed a patent ostium, no signs of sinusitis, and a residual bone height only about 2mm at sites #14 and #15 (figure 34). Under preparing the implant osteotomy is crucial in this case to make initial stabilization successful. As discussed above, the crestal window approach is easier if residual bone height is thin as in this case. To avoid bone shrinkage as observed in case 4, the author used a long lasting resorbable membrane under the Schneiderian membrane. The crestal window in this case was only 4mm in diameter. Therefore, insertion of the resorbable membrane was achieved by rolling the membrane after soaking in saline with tetracycline (figure 35). Lambone has excellent plasticity, so once inserted into sinus cavity via crestal window it will open and return to its original shape (see arrow in figure 36).

Postoperative radiograph evaluation revealed an adequate sinus augmentation housing implants at sites #13-15 (figure 37).

Discussion

The morbidity associated with lateral window sinus augmentation and the 'blind' nature of closed sinus lifts necessitated the need for an alternative to these techniques. As shown in the many clinical cases of this series, the 'Crestal Window Technique' predictably allows for elevation of the Schneiderian membrane without the morbidity associated with lateral window technique. With proper sinus instrumentation (mushroom, cobra, bone carrier, vertical condenser, lateral condenser) and bony cutting tools (pointed trephine, ASBE trephine, sinus diamond bur), the crestal window approach is predictable and results in similar outcomes to lateral window techniques in terms of membrane elevation and bone condensing.

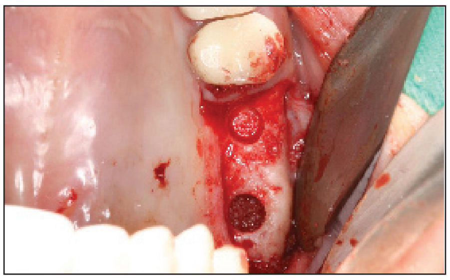


Figure 18: The patient's sinus floor was relatively flat, thus it was expected that the sinus floor could be removed with the bone core after use of ASBE trephine

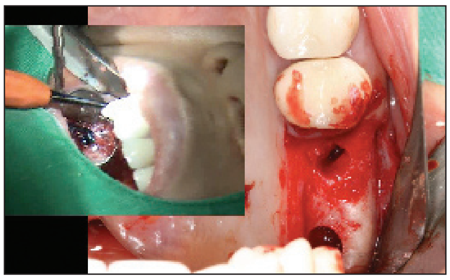


Figure 19: Slow bone compaction was accomplished by inserting the condenser no more than initial height of residual bone

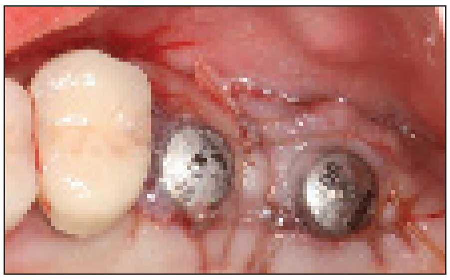


Figure 20: Lateral condensation was achieved by the use of a 'sinus spreader' instrument

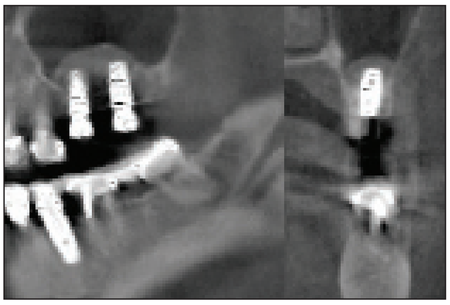


Figure 21: Panoramic and CT scans were accomplished after surgery to verify proper grafting of the maxillary sinus without perforation

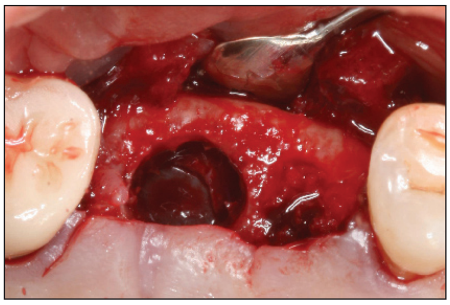


Figure 22: Horizontal compaction of bone graft touching the medial and lateral walls

Figure 23: The self-limiting sinus diamond bur was used to safely expose the Schneiderian membrane

Indications for the crestal window technique are an edentulous maxillary posterior site with residual native bone height of 1-7mm. It is the author's experience that elevation of the Schneiderian membrane with the cobra elevator is easiest when there is less residual bone height as this reduces interference of bone on the instrument during membrane elevation. In cases of extremely thin residual bone, the author recommends that the sinus diamond bur be used to penetrate to the bone directly instead of using the trephine. This will reduce the likelihood of Schneiderian membrane laceration. Finally, as a terminal step prior to bone grafting, the author recommends the cobra elevator be used to induce bleeding inside the sinus by scraping the bony floor.

Conclusion

The crestal window technique is an alternative to conventional lateral window and closed maxillary sinus augmentation techniques. This technique requires the use of specialized instrumentation that is unique to the procedure.

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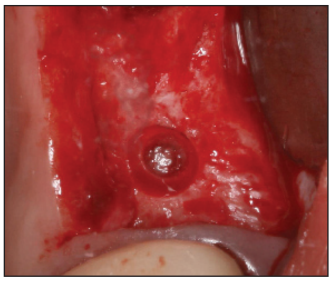

Figure 24: The Schneiderian membrane was elevated and bone grafting was achieved using demineralized freeze-dried bone allograft (DFDBA) mixed with autogenous bone graft

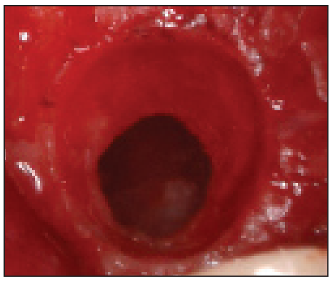

Figure 25: Residual bone height was only 1.5mm

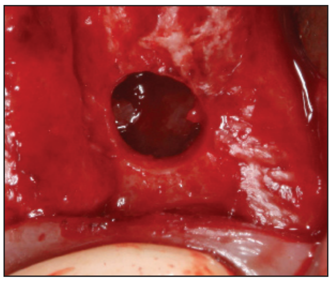

Figure 26: After visual confirmation of sinus membrane exposure, membrane elevation was accomplished with the mushroom elevator

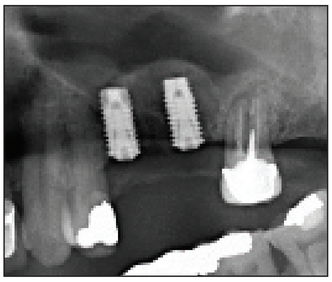

Figure 27: A remaining ledge of bone in the osteotomy was removed with an implant osteotomy drill at low speed using the waterless technique

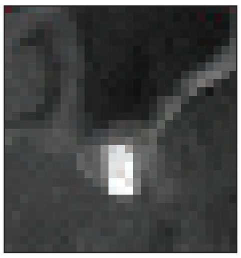

Figure 28: Good primary stabilization of the implant was achieved and a postoperative radiograph revealed adequate sinus augmentation

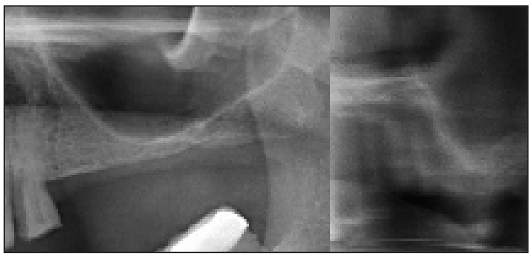

Figure 29: Cross section from a CT scan showed the medial and lateral wall fully elevated to maximize blood supply to the graft

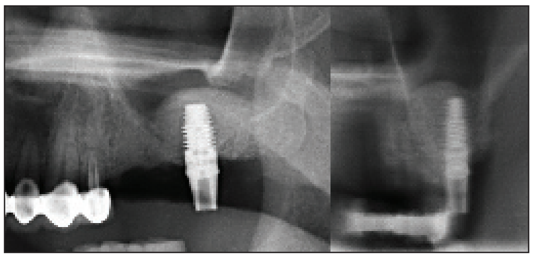

Figure 30: Radiographic and CT scans revealed a patent ostium, no signs of sinusitis, and 2mm of residual bone height at site #15

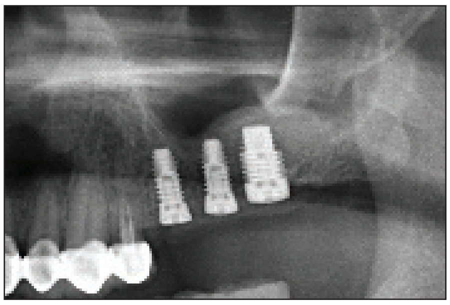

Figure 31: Sinus augmentation was achieved with DFDBA using mostly with lateral condensation rather than vertical condensation

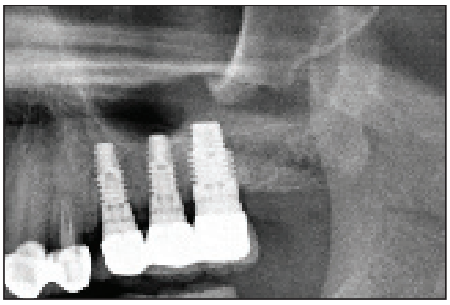

Figure 32: Implants were placed at sites #13, #14, and #15

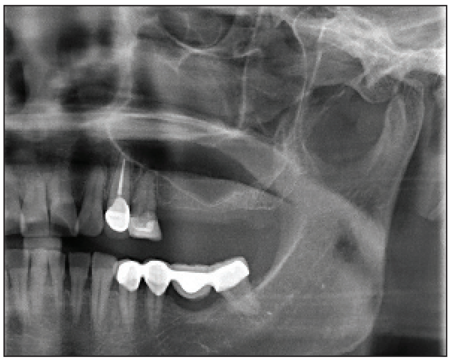

Figure 33: The clinician can have visual confirmation by observing radiopacity from new bone as well and new cortical bone formation on the new sinus floor

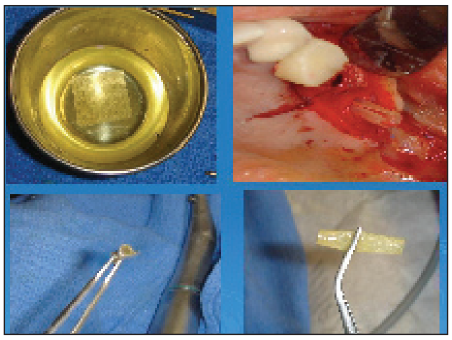

Figure 34: Insertion of the resorbable membrane was achieved by rolling the membrane after soaking in saline with tetracycline

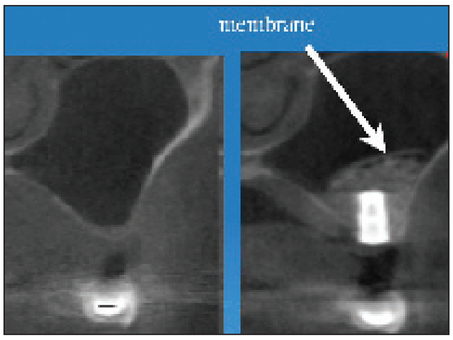

Figure 35: Lambone has excellent plasticity, so once inserted into sinus cavity via crestal window it will open and return to its original shape

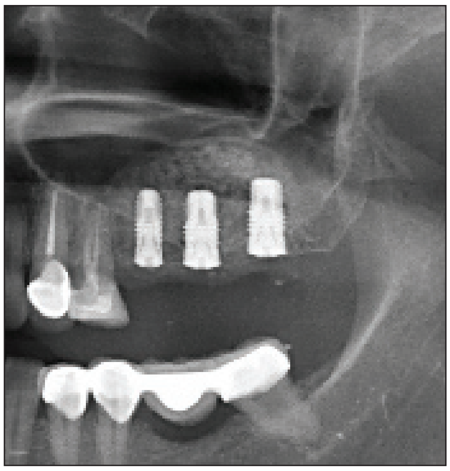

Figure 36: Postoperative radiograph evaluation revealed an adequate sinus augmentation housing implants at sites #13-15