A Simplified Approach for Sinus Augmentation to Avoid Sinus Membrane Perforation: An Analysis of 350 Cases

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Abstract:
The purpose of this study was evaluate a new surgical kit utilized for crestal sinus elevation to determine the incidence of sinus membrane perforation during surgery. A completely new approach, associated with new instruments allowing sinus bone grafting in all cases of atrophy of the posterior maxilla. Two kits are discussed with Kit A utilized to treat maxillary atrophy presenting less than 4 mm of sub-sinus bone height, and Kit B to treat maxillary atrophy presenting more than 4 mm of sub-sinus bone height. The technique involves minimally invasive simple surgery, using a very precise protocol. The results of this article focused on 100 cases for Kit A and 250 for Kit B allowing obtaining a 99% of success in avoiding sinus membrane perforation. .

Introduction:
Unfilled posterior extraction sockets in the maxilla lead to pneumatization of the maxillary sinus leading to atrophy of the bone. The atrophy results as the sinus pneumatizes towards the crest and the crestal bone resorbs in the direct of the sinus inhibiting implant placement.

Current treatment utilized to treat atrophy of the posterior maxilla to allow sufficient osseous anatomy for implant placement involves osseous grafting to increase crestal height and width. Two technique types have been utilized depending on the available crestal bone height, those being the lateral sinus augmentation technique and the crestal sinus augmentation technique.

Lateral sinus augmentation, also referred to as Lateral Sinus Floor Elevation (LSFE) first reported in the 1970's by Hilt Tatum, Jr and first published by Boyne and James in 1980.[1] This approach consisted of a full-thickness flap elevated to expose the lateral sinus wall of the maxilla. Access to the maxillary sinus was then accomplished by creation of a window on the lateral sinus wall, while maintaining sinus membrane integrity. An "incomplete fracture" technique involves mobilizing the bony island while maintaining its attachment to the sinus membrane and then rotating it to reposition it as the new sinus floor. An alternative technique is the "wall-off" technique which has complete removal of the bony island, permitting better access to the sinus.[2, 3]

Piezoelectric surgery, rather than rotary instruments, for lateral window preparation and membrane separation has demonstrated a reduction in intraoperative complications including sinus membrane tearing. The main advantages of the piezoelectric device are its selective cutting action of mineralized tissue, and its precise osteotomies enhance surgical control.[4] It has been demonstrated that bone height can be increased by 8-10 mm using the LSFE approach.[5] LSFE is indicated when minimal crestal bone height is present. However, the LSFE approach has some disadvantages as it is often associated with substantial patient morbidity. LSFE requires a wide mucoperiosteal flap with at least one vertical releasing incision for the creation of a lateral wall bony window. This may result in an increased risk of postoperative pain, facial edema, delay in healing, bleeding, and postoperative infection.[6] Additionally, up to 58% perforation of the sinus membrane and Antral artery involvement (21%) have been reported.

An alternative technique when crestal height of 4mm or greater is present is the Summer's technique. The transcrestal sinus floor elevation (TSFE) approach was introduced by Tatum in 1976 and modified by Summers in 1994. Unlike LSFE, where a buccal bone plate osteotomy must be done, the TSFE involves a crestal approach to the sinus membrane through the implant osteotomy drilled. This involves fracturing the sinus floor using a set of osteotomes of increasing diameter to elevate the floor of the sinus, while increasing the density of the surrounding maxillary bone, which results in better primary stability of the implants. Implant placement at the same surgical appointment is achieved. This technique is less invasive than LSFE with much less incidence of sinus membrane perforation. As no Antral artery is in the surgical area, potential damage as reported in LSFE is eliminated. The disadvantage to this technique is blind surgery as the membrane is not visible to the practitioner during treatment.

The transcrestal sinus floor elevation (TSFE) approach was introduced by Tatum in 1976 and modified by Summers in 1994.[7] Unlike LSFE, where a buccal bone plate osteotomy must be done, the TSFE involves a crestal approach to the sinus membrane through the implant osteotomy drilled. This involves up fracturing of the sinus floor using a set of osteotomes of increasing diameter to elevate the floor of the sinus, while increasing the density of the surrounding maxillary bone, which results in better primary stability of the implants.

Following analyzing different techniques, the authors developed a modified technique to avoid perforation of the sinus membrane which is an essential reason for failures of the older techniques. Indeed, in LSFE the percentage of perforation of the sinus membrane reached 58.3%.[8] Whereas, in crestal approach perforation was reported at 22%.[8] The perforation of the sinus membrane can happen at different stages of the augmentation surgery. This may occur when performing the lateral window for the Tatum technique, or during the creation of the crestal port for the TSFE technique. Additionally, it may occur when pushing on the membrane using curettes (LSFE), or when pushing the membrane using osteotomes (TSFE) during bone grafting.

The ASSEK (All Secure Sinus Elevation Kit) (ASSEK Technical, Jerusalem, Israel) allows the surgeon to carry out each step of the elevation of the sinus floor using secure tools avoiding any perforation or tearing of the membrane. B.Y drills for KIT A (Figure 1) or B.Y.S for KIT B (Figure 2), are diamond drills that are able to gently squeeze the bone crestally, due to its blunt end. (Figure 3)The central part of the terminal end of the drill is concave, allowing a bony disc to be formed which remains in contact with the sinus membrane. All of the drills have a stop to avoid any accidental penetration of the drill into the sinus, permitting precise control of penetration of the drill into the sub-sinus bone. The graduated osteotomes are also equipped with a secure stop, the end of the osteotome is slightly convex, aiding in pushing the bone disc and membrane towards the sinus without risk of perforation.

The graft material recommended for bone grafting must not be aggressive yet must fill the space prepared by the osteotomes. For this study Bond Apatite (Augma Biomaterials, Caesarea, Israel) was selected due to its resorbable nature over time allowing vascularization of the graft and replacement with host bone.[9, 10] Additionally, as the material sets hard it serves as a barrier preventing graft displacement into the sinus and avoids use of a separate resorbable membrane.

Study protocol:
When less than 4mm of available crestal height is present, a delayed implant placement protocol is followed after sinus elevation. A crestal incision is made mesial-distally slightly displaced in palatal direction. A full thickness flap is elevated to allow visualization of the crestal and buccally bone. Radiographically a crestal height between the inferior aspect of the crest and sinus floor is determined and set at 1mm less than the measured height. The stop is set for this length on a B.Y 1 drill on the surgical unit with external irrigation set at a speed between 600 and 1000 rpm. The

drill is utilized at the planned site until the stop comes into contact with the crest. When the drill plunges (sensation that the drill penetrates but penetration is blocked by the stop) this is the sign that contact with the sinus membrane has occurred. Clinically this indicates the bony disc is surrounded by a bloody sinus membrane. This bone disc and its membrane are pushed back using an osteotome with the stop set at the same length as the drill was set, plus 1 mm to each pass of the osteotome not exceeding more than 5 mm of the height of the crest. The graft material (Bond Apatite) is prepared before bringing it at the mouth using a graft syringe. The length is corrected by 1 mm that is reduced from the last length of the osteotome to allow graft materials to be pushed inside the osteotomy. This is repeated, removing 1 mm of length for each additional graft placement into the osteotomy until it is filled to the crestal surface. Dry gauze is then placed over the crestal graft material to remove any residual water from the graft. The soft tissue is then closed with sutures under compression. (Figure 4)

Should the osteotome's stop remain at a distance from the crest, the B.Y.S 5 drill is used to increase the osteotomy to 5 mm in length before inserting an osteotome of 6 mm diameter. The grafting of the site is similar to that described with kit A and upon completion of the elevation the implant is placed.

At 4 months post-surgical sinus elevation ASSEK kit B is utilized for a Summer's crestal approach and implant placement. Kit B protocol (when the sinus height is greater than 4 mm). A similar protocol as previously described is performed to expose the crestal bone. A B.Y.S reamer is placed on the contra angle surgical handpiece and a speed of 600 to 1000 rpm is set. Under external irrigation, the drill creates a 2.8 mm wide osteotomy at the crest. Next, an osteotome of 3.2mm diameter is utilized until the stop touches the crest. The sinus membrane is elevated 1 mm, repeating as the stop is increased by 1mm until the planned height is reached, and then the implant is placed. (Figure 5)

Case example:
A patient presented with fracture of a right maxillary 2nd premolar and missing 1st molar. A CBCT scan was performed noted minimal crestal bone height present at the 1st molar and pneumatization at both sites. (Figure 6) Discussion was had with the patient that implant placement would require sinus augmentation to develop adequate crestal height to accommodate implant placement. The treatment would require two surgical appointments 4-months apart, wherein initial sinus elevation would be performed and at the 2nd surgery further elevation and implant placement would occur. Treatment options were discussed with the patient, and they chose placement of implants at both sites.

Consent forms were reviewed and signed by the patient. Local anesthetic was administered and a crestal incision made with full thickness flap elevation performed. (Figure 7 left) initial osteotomy preparation was performed with a drill in kit A. (Figure 7middle) The osteotomy was completed with the subsequent drill to create the bone disk. (Figure 7 right) then the membrane is pushed mm to mm according to the protocol, Bond Apatite was mixed and a portion of the graft was carried to the osteotomy Additional graft material was placed into the site and an osteotome with set stopper was advanced towards the sinus floor. (Figure 8 right) Incremental elevation with graft placement is completed. (Figure 9 left) The osteotomy is then filled with additional Bond Apatite to the crestal level. (Figure 9 right) The flap is reapproximated to close the site and sutures are placed under compression. (Figure 10 left) A piece of Augma Shield (Augma Biomaterials) was placed over the sutures to protect the site from oral bacteria and other salivary components during the initial soft tissue healing phase. (Figure 10 right) A periapical radiograph was taken to document sinus elevation and augmentation. (Figure 11)

At 4-months post sinus elevation the patient presented for phase 2 of the surgical treatment that would include additional sinus elevation and implant placement. The soft tissue overlying the are presented with an absence of inflammation and the incision fully healed. (Figure 12 left) Following local anesthetic placement a full thickness flap was elevated similar to during phase 1 surgery. (Figure 12 right) As was performed in the prior surgery, using kit B, a drill was used to an osteotomy was created to be in contact with the sinus floor. (Figure 13 left) Further elevation was performed using the instruments in kit B. (Figure 13 right) Bond Apatite was placed into the osteotomy and compacted apically followed by placement of implants into the two sites. Additional Bond Apatite was placed over the crest to fill any implant thread exposure. (Figure 14 left) The flap margins were reapproximated and sutures placed under compression. (Figure 14 right) A periapical radiograph was taken to document the new sinus floor position and implant placement. (Figure 15)

Clinical study:
The study involved 100 patients who were treated with kit A, and 250 patients treated with kit B. All patients treated with kit A had a crestal bone height of 1 to 4 mm and all patients treated with kit B had a crestal bone height greater than 4 mm. The patients treated with kit A, which allowed an increase in crestal height by 3 to 5 mm, were subsequently treated 4 months later with kit B allowing placement of the implant.

The first portion of the study consisted of checking for perforation of the membrane according to the steps of the protocol. Verification of the integrity of the sinus membrane during the first two stages of kit A, preparation of the osteotomy, lifting of the sinus membrane and carried out by the practitioner in direct vision. Verification of the integrity of the membrane during the third step (sinus graft) is verified radiographically; the material is well delimited by the membrane and in the shape of a dome. Evaluation of the 100 cases treated with kit A, found only 1 perforation occurred. (Table 1)
Verification of the integrity of the sinus membrane during the first step of kit B is done directly by the practitioner and by the Valsalva test. Confirmation of the integrity of the sinus membrane during the bone grafting stage and placement of the implant is done radiographically. Evaluation of the 250 cases treated with kit B noted a single case of sinus membrane perforation. (Table 2)

Conclusion:
Transcrestal sinus elevation provides a very good alternative utilizing ASSEK kit A compared to older techniques that have proven themselves to have associated complications including sinus membrane perforation. The design of the kit's components avoids any complications of sinus membrane perforation. The kit uses a minimally non-invasive surgery avoiding any healing complications that present, with more extensive surgical approaches. The ASSEK kit B allows you to perform a Summer's sinus elevation approach in direct vision for added safety.
Surgery in general has been moving for decades towards minimal surgery. The techniques using the ASSEK kit A and kit B allow oral surgery to take the same directions as general surgery.

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Figures:

Figure 1: ASSEK Kit A utilized for sinus elevation and graft placement when implant placement will not be performed at the same surgical visit and site healing is required before implant placement.

Figure 2: ASSEK Kit B utilized for sinus elevation and simultaneous implant placement.

Figure 3: The concave tip of the B.Y drill [kit A]

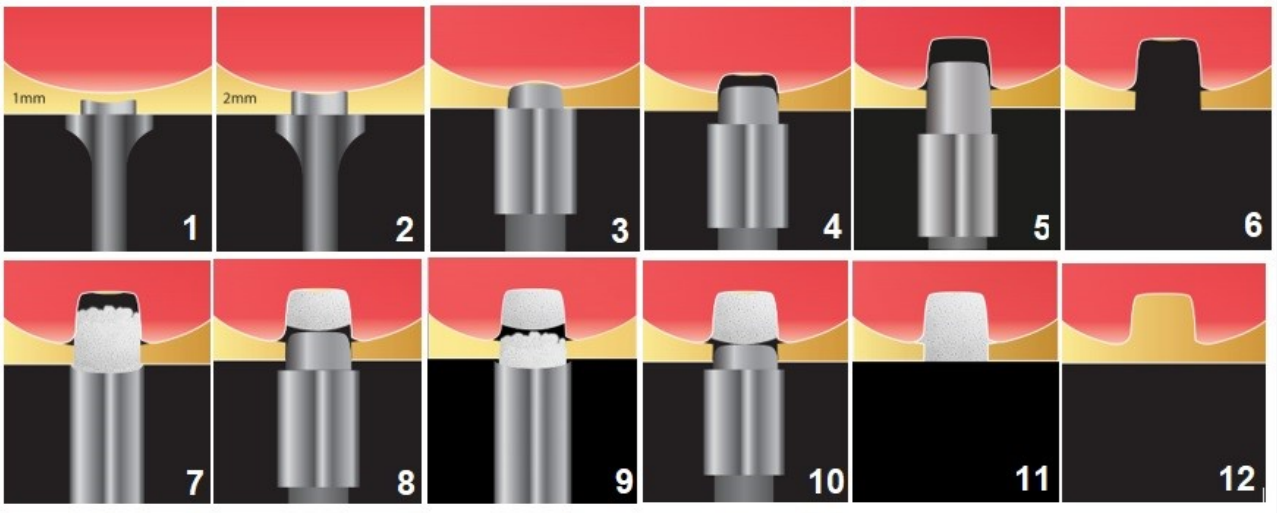

Figure 4: Clinical steps for ASEEK kit A usage.

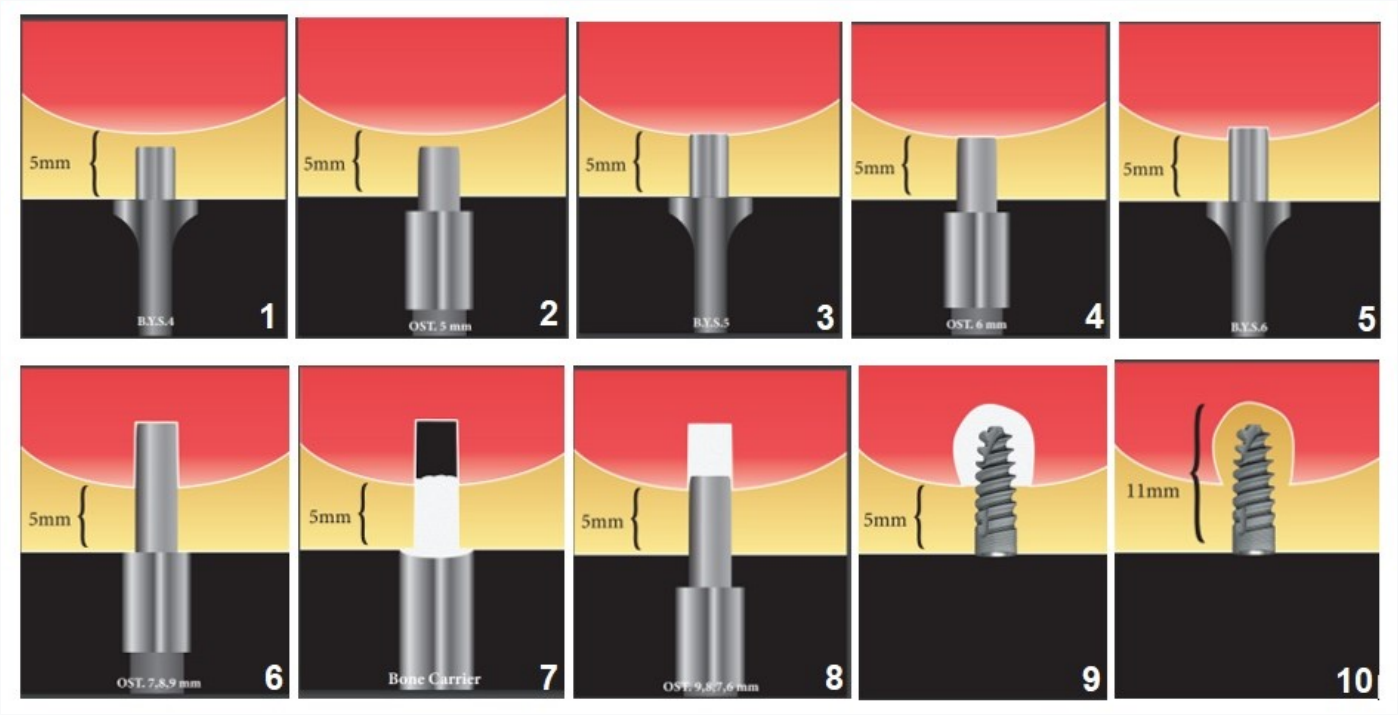

Figure 5: Clinical steps for ASEEK kit B usage.

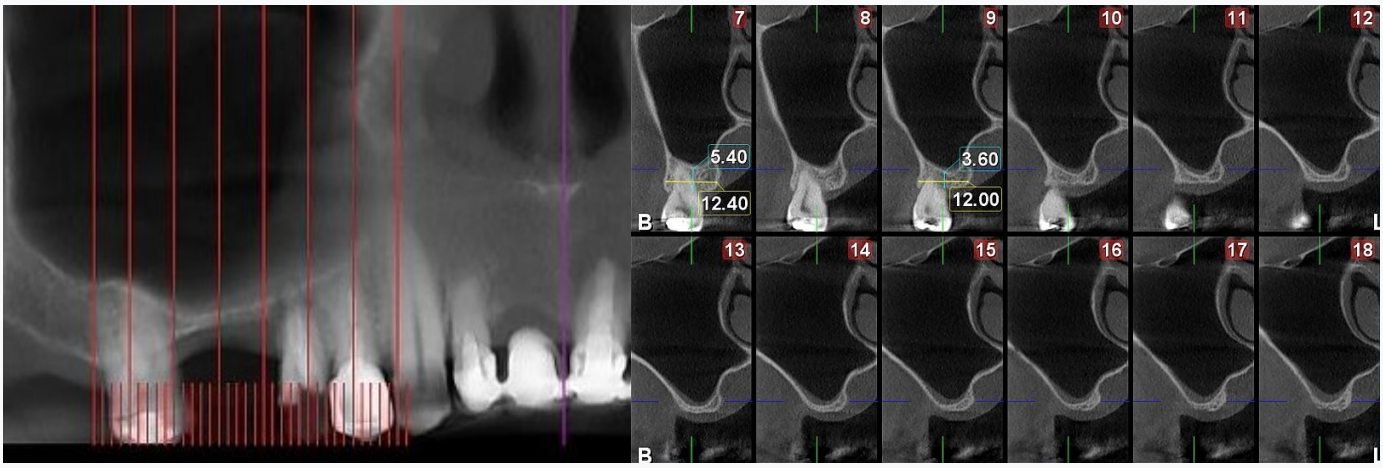

Figure 6: CBCT radiographs demonstrating minimal crestal bone in the posterior maxilla.

Figure 7: Flap elevation to expose the crestal ridge (left), initial osteotomy preparation with the kit A drill (middle) and the crestal aspect after utilization B.Y.1 Drill (right).

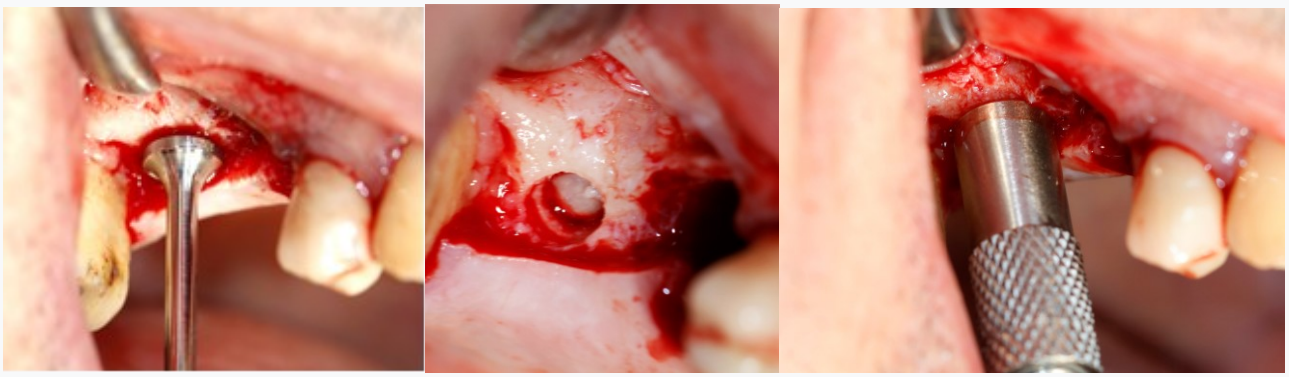

Figure 8: Osteotomy drill utilized B.Y.2 Drill (left), crestal aspect after B.Y.2 plunged (bone disk) (middle) and utilization of the osteotome with stopper to elevate the membrane (right)

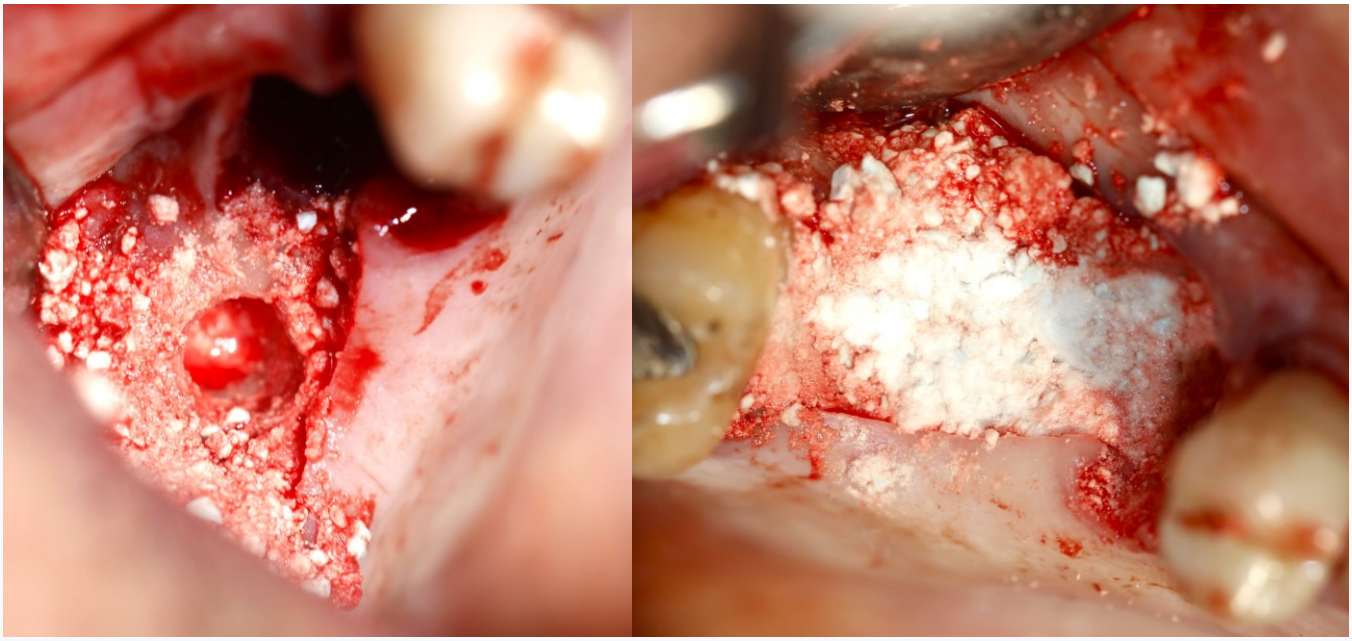

Figure 9: Elevation and graft placement has been completed (left) and the osteotomy was filled with additional graft material (right).

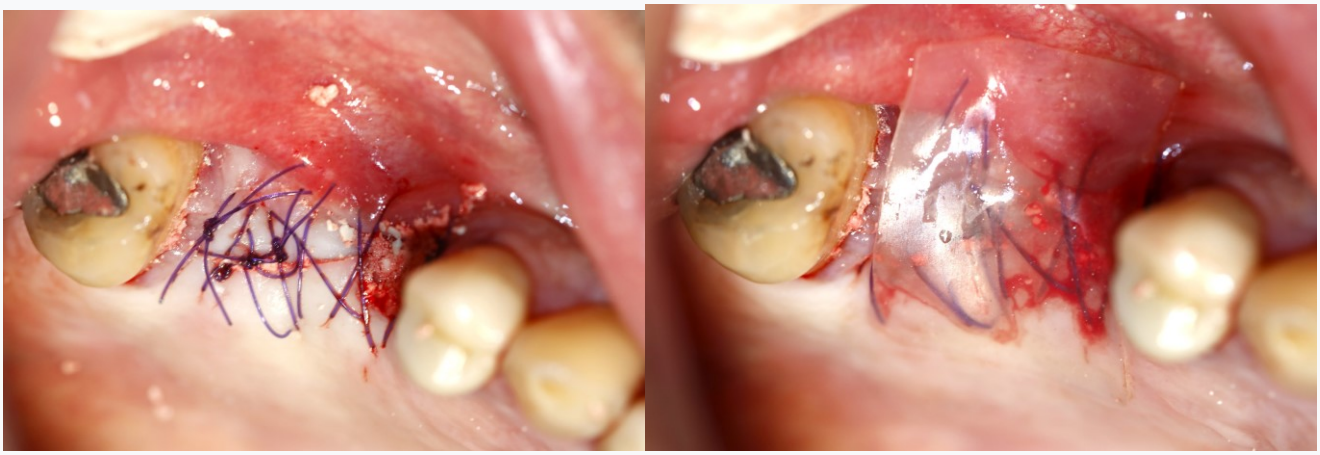

Figure 10: Soft tissue repositioned and sutured under compression (left) and placement of Augma Shield to protect the site during initial soft tissue healing (right).

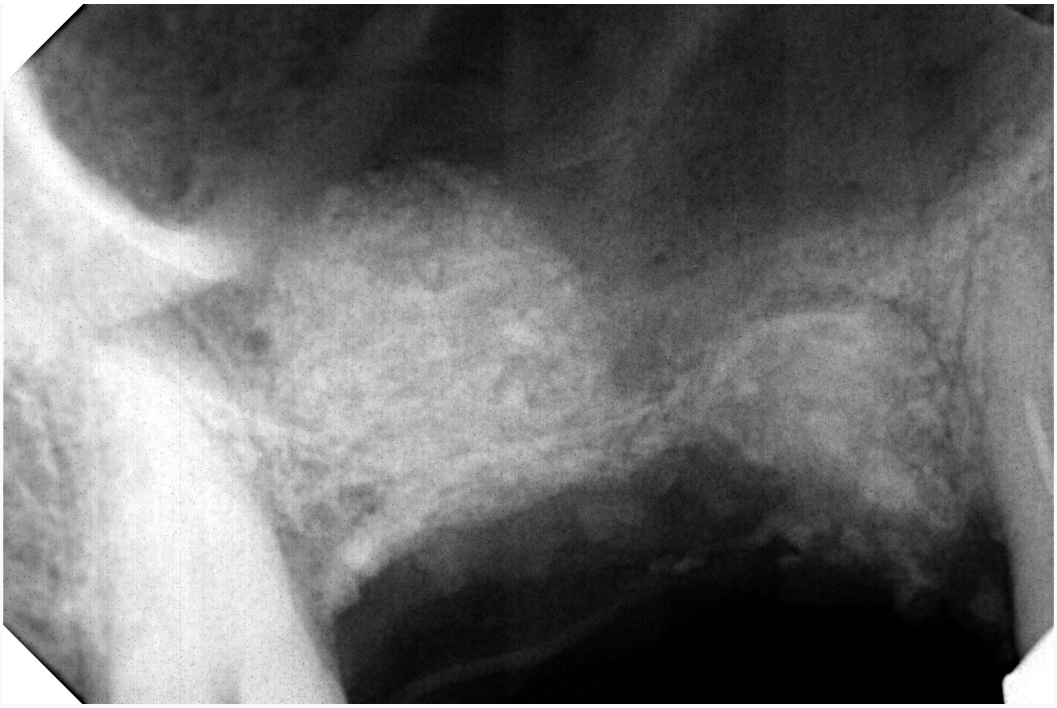

Figure 11: Periapical radiograph following sinus elevation and placement of Bond Apatite grafting.

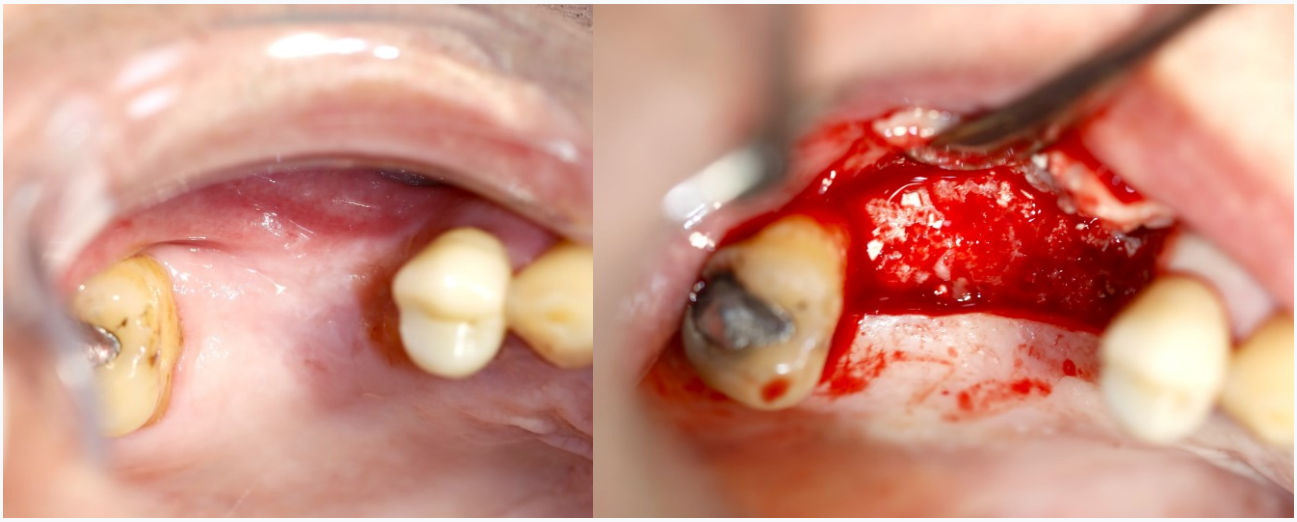

Figure 12: Crestal appearance at 4-months following initial crestal elevation with kit A (left) and following flap elevation to expose the crest (right).

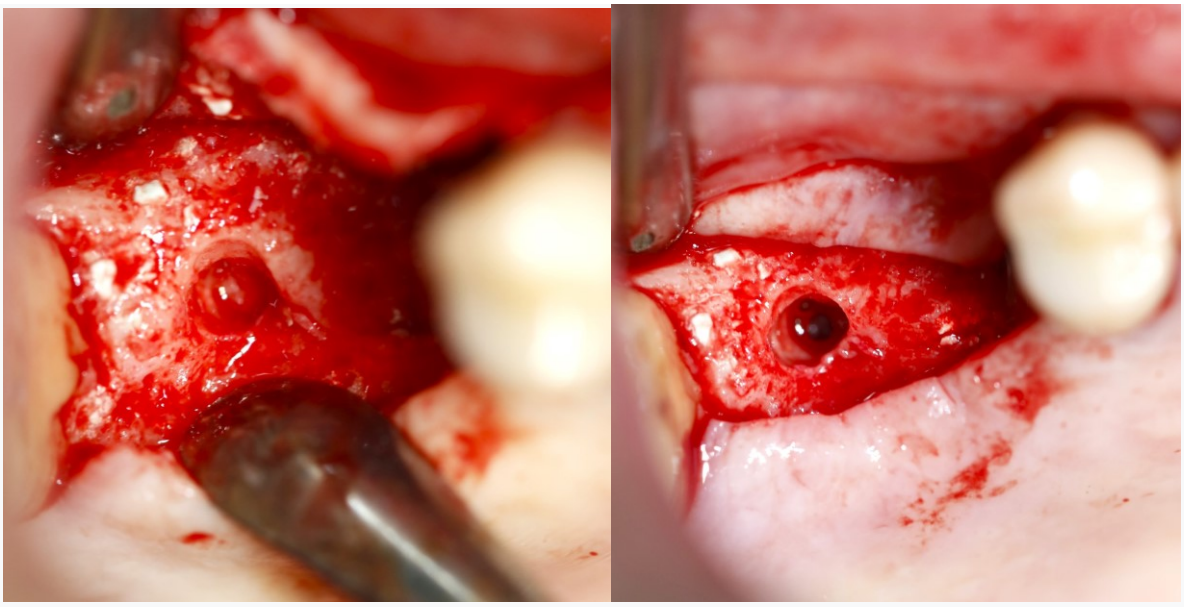

Figure 13: Initial osteotomy created to contact with the sinus membrane (left) and following elevation with the instruments in kit B (right).

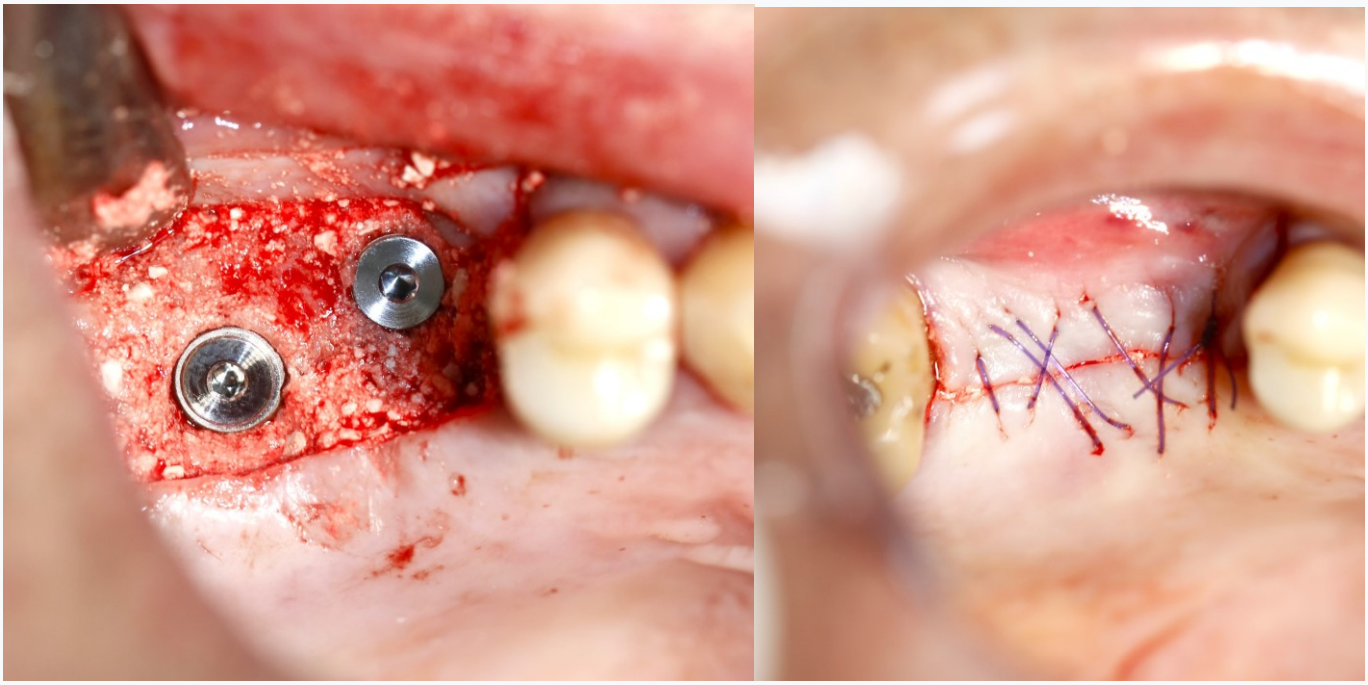

Figure 14: Implants placed and additional Bond Apatite placed crestally (left) and soft tissue closed under compression with sutures (right).

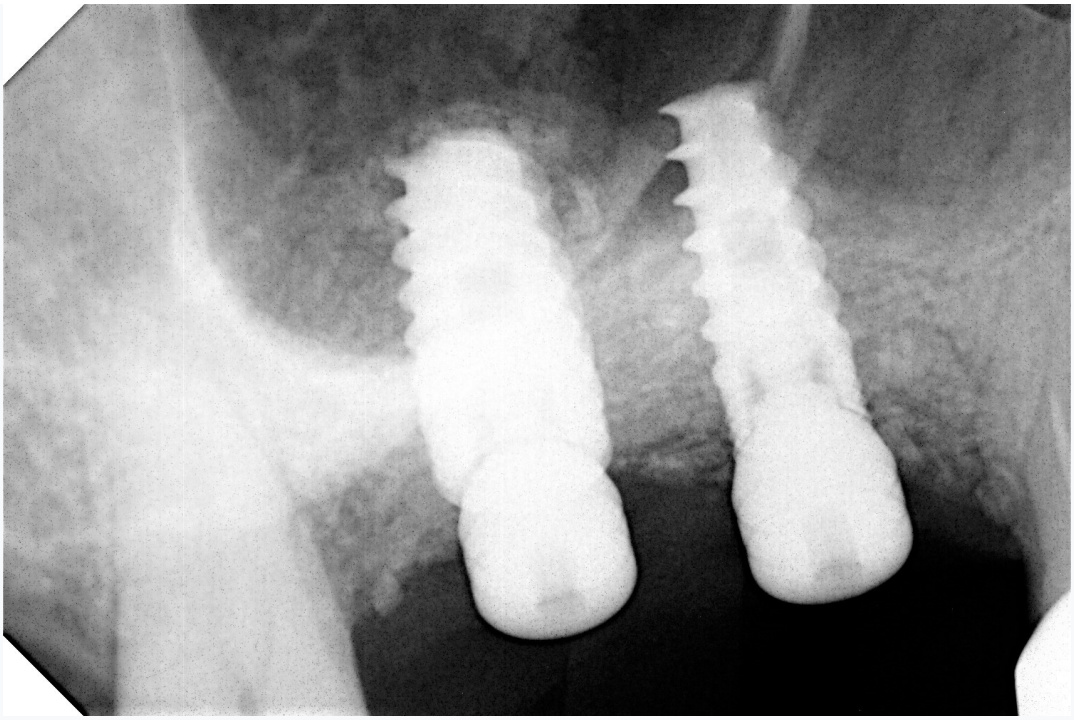

Figure 15: Periapical radiograph taken following additional sinus elevation and implant placement.

Stage Protocol	Number of perforations Membrane
Preparation of the osteotomy Strawberries B.Y. 1,2,3,4	0
Elevation of the Membrane Osteotome 3.7 mm	1
Grafting of the osteotomy Bond Apatite	1
Closure of the osteotomy Bond Apatite	0

Table 1: Perforations identified in the 100 cases utilizing kit A.

Stage / Protocol	Number of perforations Membrane
Preparation of the osteotomy B.Y.S. 4,5,6,7,8,9	0
Elevation of the Membrane Osteotome 3.2 mm	1
Grafting of the osteotomy Bond Apatite Implant placement DIS remix	0

Table 2: Perorations identified in the 250 cases utilizing kit B