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NEW PERSPECTIVES IN THE TREATMENT OF THE SEVERE ATROPHIC POSTERIOR MAXILLA: INTERPOSITIONAL SANDWICH OSTEOTOMY COMBINED WITH SINUS FLOOR GRAFTING — A NOVEL TECHNIQUE

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Summary

Purpose: Dental implant installation in the posterior maxilla depends fundamentally on the presence of an adequate bone quantity. Tooth loss in the posterior maxilla is followed by extensive loss of the alveolar ridge and increased maxillary sinus pneumatization that often makes implant installation difficult to achieve.

Maxillary sinus floor augmentation is traditionally the common surgical technique to overcome this situation. When the deficiency in the vertical dimension relates more to severe ridge resorption, crestal ridge augmentation should also be considered. Posterior maxillary sandwich osteotomy combined with sinus augmentation, using inter–positional bone graft might be a viable option to address this problem. This study describes a successful implementation of this technique to solve a severe vertical osseous ridge defect under the sinus floor.

Material and Methods: A two–stage lateral wall sinus floor augmentation combined with inter–positional sandwich osteotomy followed by the insertion of dental implants with adequate length and diameter was performed. Deproteinized natural bovine bone mineral (DBBM) covered by a resorbable collagen membrane were used. Rehabilitation of this area was completed by a standard prosthetic protocol.

Results: As a result of completing the above procedure favourable bone mass and form was created to enable implant placement in positions that are optimal from a prosthetic and esthetic point of view in terms of reshaping the alveolar crest and normalizing the interocclusal distance improving the crown–implant ratio. **Conclusion:** This case demonstrates a step–by–step illustration of an innovative technique for overcoming a vertical ridge defect combined with increased maxillary sinus pneumatization. It can be concluded that this novel technique is recommended to meet the dimensional requirements of bone augmentation both crestal and intrasinusal in severe atrophic posterior maxilla to achieve an improved alveolar plane, equalized crown–to–implant ratios, and a more favourable gingival shape.

Key Words: *Atrophic Posterior Maxilla, Interpositional Sandwich Osteotomy, Sinus Floor Grafting*

Introduction

Dental implant installation in the posterior maxilla depends fundamentally on the presence of an adequate bone quantity. Tooth loss in the posterior maxilla is followed by extensive loss of the alveolar ridge and increased maxillary sinus pneumatization that often makes implant installation difficult to achieve.

Maxillary sinus floor augmentation is traditionally the common surgical technique to overcome this situation. When the deficiency in the vertical dimension relates more to severe ridge resorption, crestal ridge augmentation should also be considered. Posterior maxillary sandwich osteotomy combined with sinus augmentation, using inter–positional bone graft might be a viable option to address this problem. This study describes a successful implementation of this technique to solve a severe vertical osseous ridge defect under the sinus floor.

A two–stage lateral wall sinus floor augmentation combined with inter–positional sandwich osteotomy followed by the insertion of dental implants with adequate length and diameter was performed. Deproteinized natural bovine bone mineral (DBBM) covered by a resorbable collagen membrane were used. Rehabilitation of this area was completed by a standard prosthetic protocol. This study provides a step–by–step illustration of an innovative technique for overcoming a vertical ridge defect combined with increased maxillary sinus pneumatisation.

Aim of the Study

The purpose of the study is to step by step demonstrate whether a novel technique of a combination of sandwich osteotomy and sinus grafting can achieve sufficient bone quantity which allows placing standard implants and improving the intermaxillary relationship. The aim of this study is to describe and illustrate a new technique of a combination of sandwich osteotomy and sinus grafting.

Background and Review of the Literature

Continuous alveolar ridge resorption in the vertical dimension of the posterior maxilla accompanied with prominent sinus cavities may make implant placement difficult and prosthetic rehabilitation compromised or impossible. There are a variety of bone defects with increasing complexity, both horizontal and vertical deficiencies. Rehabilitation of the severe atrophic posterior ridge can be resolved in different ways. The most common surgical technique to overcome this situation is maxillary sinus floor augmentation, which is considered a reliable treatment procedure to regain bone volume deficiency. When the deficiency in the vertical dimension relates more to severe alveolar crest resorption due to previous pathologies or surgeries, vertical ridge augmentation in conjunction with sinus floor augmentation should be considered in order to achieve both an esthetic and functional rehabilitation [1–3].

Different surgical techniques are currently utilized to augment the alveolar ridge deficiency in the posterior maxilla which is related to alveolar crest resorption. The numerous surgical approaches consist of proposed guided bone regeneration (GBR), alveolar distraction osteogenesis (ADO), titanium mesh and autogenous bone graft (AB) and onlay bone graft [4–7].

Guided bone regeneration was introduced in 1991 by Dahlin and colleagues [4]. The use of expanded polytetrafluoroethylene membrane was a treatment option that has been used with varying degrees of success [8,9]. This technique was considered to be a highly sensitive technique. Distraction osteogenesis maintains the majority of the vascularity to the bone segment. The drawbacks of this technique are patient cooperation, technique sensitivity and a second surgery to remove the device [5]. Titanium mesh and autogenous bone graft have been used successfully and have shown promising results since its introduction [6].

Onlay grafts have been well documented, but the results have not been promising. Bone resorption of up to 50% has been reported even when autogenous bone from different sites (symphysis menti, ramus mandible, calvaria, iliac crest) were used [7]. Vertical onlay grafting can also be complicated by graft exposure and infection[10,11]. Another possible approach is to use an interpositional bone graft [12]. The rationaleof this technique is based on the theory that graft material placed between two pedicle bone segments will undergo complete healing and graft consolidation. This technique enables the positioning of the graft in a well–delimited area offering the advantage of ensuring greater vascular supply to the inlay graft to allow new bone formation. Vascularity seems to be the main factor in determining whether the graftcan be maintained in situ [13]. This described technique allows a simultaneous correction of vertical and the sagittal dimensions, improving the inter–maxillary relationship.

The sandwich osteotomy or the so called inter–positional sandwich osteotomy or segmental osteotomy in the posterior maxilla has only few publications. This technique has been documented mainly in the anterior maxilla and posterior mandible [14–17]. Since its description in the 70's, the sandwich osteotomy with interpositional bone graft has been found to be reliable for the reconstruction of ridge deficiencies of atrophic mandibles. A Visor osteotomy was first described in 1975 by Harle to increase the height of the atrophic posterior mandible to improve denture retention [18]. In 1976, Schettler and Holtermann described a sandwich osteotomy in the anterior mandible to improve denture retention [19–21]. In 1974, Stoelinga et al. successfully combined both techniques; the sandwich technique and visor osteotomy to successfully augment severely atrophic edentulous mandibles [22].

In 1977, Peterson and Slade modified Harle's visor osteotomy by raising the pedicled portion along a greater length of the mandible [21]. Many modifications followed, but simultaneous placement of dental implants was not considered [23–27].

In 1982, Frost et al. described a further modification of Harle's visor osteotomy incorporating inter–positional inlay graft [28].

In 1987, Mercier et al. reported on various types of visor osteotomies, evaluating the rate and patterns of resorption of the mandible on a long–term basis [29]. Due to the high rate of complications and risk of resorption of the graft, the visor osteotomy vanished for a long time from the literature.

In the literature, the sandwich osteotomy technique has become more popular in recent years among surgeons due to the low incidence of graft exposure, lack of complications and the easy nutrition of the graft and has been reported as a viableand predictable procedure with a high success rate and improved hard and soft tissue healing [30–36].

The variations of this surgical technique have been described by several authors [15,22–24,30–36]. The main advantages of this technique are the potential for three–dimensional reconstruction, providing a more stable alveolar crest with long–term outcome, and minimal morbidity [37,38].

Using this technique, it is possible to readjust crestal ridge height defects of up to 8 mm and enables precise placement of the implants, and the repositioning of mislocated implants thereby optimizing their long–term function, esthetics and stability [15,37,39,40]. However, since the technique leads to increased vascularization and predictability, recent literature has shown a preference for using biomaterials as an alternative to autogenous grafts, without negatively affect the clinical success [41,42]. Interpositional grafting in the posterior maxilla in conjunction with sinus floor grafting has very little exposure in the literature, yet is one of the most successful techniques to obtain alveolar height and width to enable placement of long implants [43–45]. Jensen reported of a posterior sandwich osteotomy combined with sinus floor elevation for severe alveolar atrophy using different biomaterials. According to his technique the sandwich osteotomy was performed trans–sinus curving anteriorly and posteriorly down the alveolar crest [44,46].

This study describes, using the aforementioned principles, a new perspective in the treatment of the severe atrophic posterior maxilla, based on the previous sandwich osteotomy techniques, with inter–positional bone graft combined with sinus augmentation. The technical aspects of this procedure will be presented here with clinical correlation.

Can the proposed innovative technique overcome a severe vertical ridge defect combined with increased maxillary sinus pneumatisation providing favourable bone mass and form to allow placing standard implants in the desired 3D location?

It is hypothesized that the combination of sandwich osteotomy and external sinus grafting leads to increased and adequate bone volume allowing the placement of standard implants compared to a single external sinus floor procedure.

Material and Methods

Intervention Procedure

A 55–year–old male patient, presenting partial edentulous right posterior maxilla, was looking for dental rehabilitation in the mentioned zone. Patient reported that two implants (10 years) were removed a year ago due to loss of osseointegration. The patient requested an evaluation for the purpose of rehabilitation with an implant supported prosthesis.

Patient was in a good physical health, a non–smoker with no contributing medical history including maxillary sinus diseases or allergies. The patient did not consume any medication.

A clinical examination including soft and hard tissue revealed the following results:

Maxilla

Absence of teeth in positions 15 and 16, and severe bone deficiency of the vertical dimension of the alveolar ridge with normal ridge width, class II according to the Seibert classification [47]. Implant supported restoration from 24 to 26. Moderate chronic periodontal disease with pockets of 3–6 mm with bleeding on probing (BOP).

Mandible

Bilateral implant supported restorations (35–37, 45–47). Gingival height defects of the inserted implants 36,37,46,47 exhibiting progressive peri–implantitis and pocket depth of up to 12mm. The implants seemed to be in a hopeless condition.

Radiographic Examination

The first panoramic radiograph, taken two years prior to treatment, showed two inserted short implants at regions 15 and 16 with a certain degree of radiolucency around the implants. Apical lesion on the mesial root of the second right molar was found. Three inserted implants in augmented left sinus supporting a four–unit fixed prosthesis. Severe angular bone defects of the implants in the mandible (Fig.1). The second panoramic radiograph taken immediately before treatment showed severe alveolar ridge resorption due to previously failed implant surgery and the removal of two implants in the right second premolar and first molar area. Apical lesion of the mesial root of the right second molar was noticed. Pneumatized maxillary sinus with limited residual bone height (RBH) was found insufficient for implant placement (Fig 2).

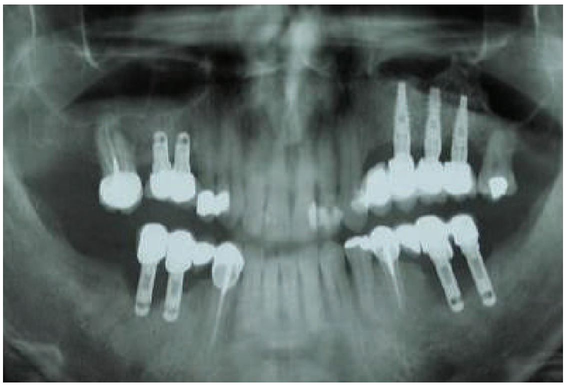

Fig 1: Panoramic radiograph demonstrating two inserted short implants in regions 15 and 16 with certain radiolucency around the implants and apical lesion on the mesial root of the second right molar

Fig 2: Panoramic radiograph demonstrating severe alveolar ridge resorption due to previous failed implant surgery and the removal of two implants in the right second premolar and first molar area and enlarged apical lesion of the mesial root of the right second molar.

Fig 3: Panoramic view of CBCT showing pneumatization of maxillary sinus coupled with severe marginal bone loss. Apical lesion of the mesial root of the right second molar is clearly visible.

Cone beam computed tomography (CBCT) revealed 6 mm vertical dimension of subantral bone at the region of previously failed implants, maxillary sinus without evident pathology, healthy osteo–meatal complex, RBH of 5.0 mm and of 5 mm width in average, existing small–sized maxillary septa on the lateral wall, small posterior superior alveolar artery (PSAA), moderate thickness of the lateral wall and wide latero–medial angle of the sinus (Fig 3,4).

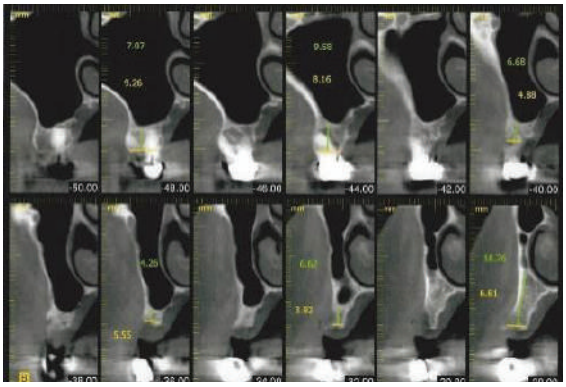

Fig 4: CBCT showing alveolar bone height of 5 mm in areas requiring augmentation procedure.

Treatment Plan

Based on the clinical and radiographic examination and due to the concave shape defect along with the Pneumatized right maxillary sinus, the proposed treatment plan involved segmental sandwich osteotomy with the interpositional placement of DBBM bone graft combined with lateral wall sinus floor augmentation. Delayed implant placement at sites 15, 16 for two–unit fixed implant supported prosthesis was scheduled 6 months after the first surgery. Second stage surgery involved also resection of the mesial root of the second right molar. Informed consent was accepted and signed by the patient.

Surgical Technique

Surgical procedure was carried out under local anaesthesia (Lidocaine 2% including 1:100000 adrenaline), following the concept of the out fracture osteotomy sinus grafting technique. Preoperative antibiotic prophylaxis included clavulanate–potentiated amoxicillin (Augmentin Glaxosmithkline). Full–thickness mucoperiosteal flap was reflected following mid–crestal and adequate vertical releasing incisions (Fig 5), to expose the sinus lateral wall. Palatal mucosa was not elevated to ensure palatinal blood supply by the periosteum. A thin osteotomy using a piezoelectric surgical saw (Mectron piezosurgery, via Lorita, Italy) (Fig 6) was outlined 3 mm away from the anterior and inferior borders of the sinus and extended antero–posteriorly and in vertical dimension to be 10 mm and 5 mm respectively.

The size of the lateral window was determined by the number of implants to be placed taking into consideration the remaining adjacent teeth. The bony window was separated and detached from the Schneiderian membrane. The piezo surgery saw was tilted in order to obtain a tapered osteotomy to ensure stable replacement of the bony window.

Fig 5: Clinical view showing the healthy conditions of the alveolar ridge.

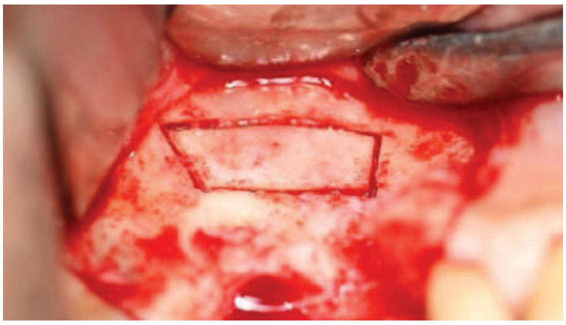

Fig 6: Rectangular bony window is outlined with piezoelectric saw, taking care to maintain the integrity of the Schneiderian membrane.

After the lateral window had been mobilized in one piece, a small Freer–elevator was carefully inserted into the osteotomy line and the bony window was safely detached from the sinus membrane and placed in saline (Fig 7, 8).

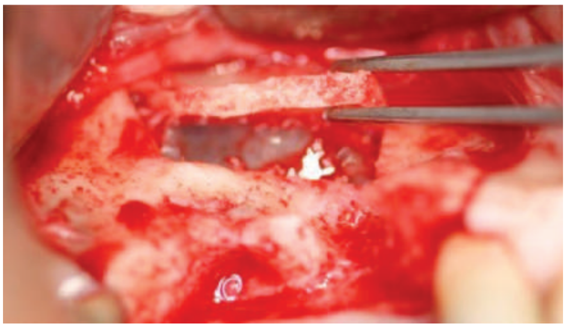

Fig 7: Removal of the repositioning lateral window — note the thickness of the lateral window.

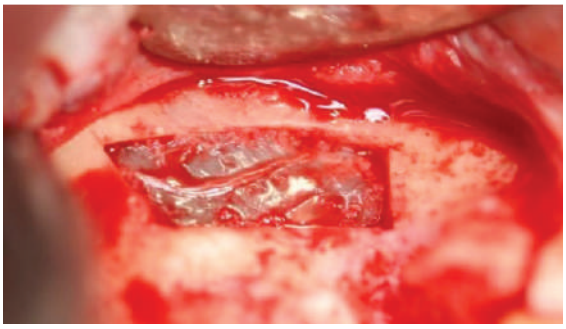

Fig 8: Intact exposed sinus membrane with intact PSAA.

The sinus membrane was carefully elevated to allow future placement of 13 mm long implants. (Fig 9a and 9b).

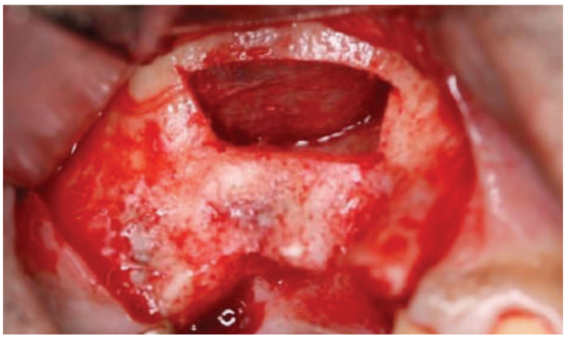

Fig 9a: Intraoperative photograph schowing the elevated membrane — note the exposed medial wall.

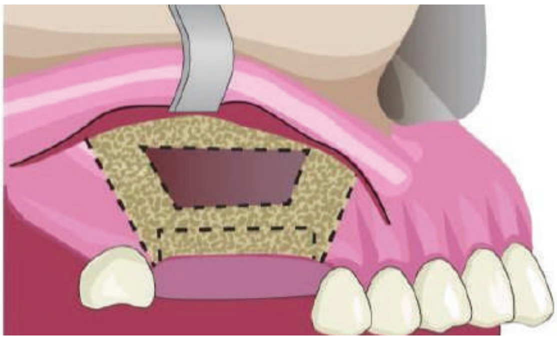

Fig 9b: Illustration of the elevated mmembrane

Care was taken to mobilize the sinus mucosa around the inner bone surface. The elevation was accomplished without membrane perforation.

Using the piezoelectric saw, a horizontal osteotomy was then created 2 mm below and parallel to the sinus floor under direct visualization and then connected to two vertical osseous vertical incisions which tapered to the alveolar crest distally to the first premolar, and posteriorly to the second molar (Fig 10a and b).

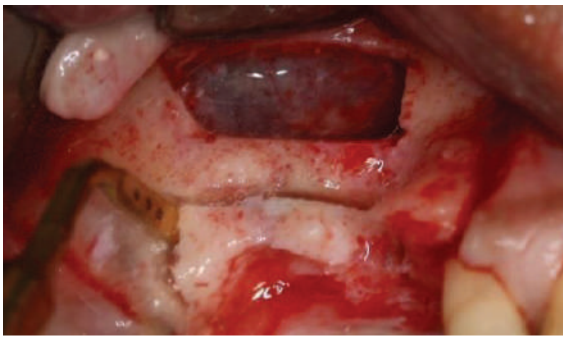

Fig 10a: Using a piezoelectric saw, the alveolar bony segment is outlined keeping it attached to the palatal flap.

The osteotomy cuts were made to the palatal periosteum avoiding the perforation of the palatal mucosa. After all bone cuts were completed, chisel was used to mobilize the designed pedicle bone segment, 8 mm coronally to the adjacent teeth alveolar level. Care was taken to avoid palatal soft laceration. The buccal aspect of the segment was elevated while palatal aspect served as a hinge creating increased vertical and horizontal dimensions (Fig 11).

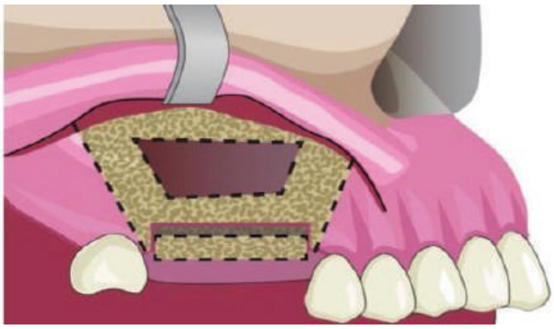

Fig 10b: Illustration of the alveolar bony segment

Once the segment has been pushed coronally, the graft material (DBBM) was mixed with blood from the wound and hydrated with saline. It was then applied into the created space underneath the elevated sinus mucosa. The material was gently packed first at the superior aspect of the sinus and against the medial wall of the created compartment (Fig 12).

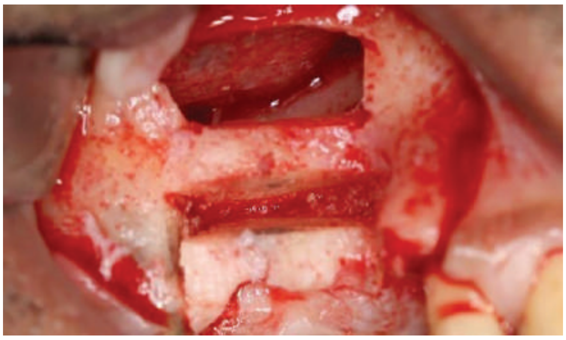

Fig 11: Clinical view of the down–fractured and mobilized palatal pedicled bone segment taking care to maintain the integrity of the sinus floor and to maintain the segment attached to the gingiva.

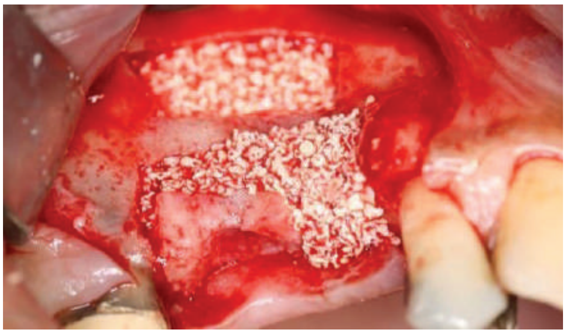

Fig 12: DBBM is inserted into the sinus cavity and in the created space after segment mobilization.

DBBM was then placed as an interpositional graft apical to the segmental block.

There was no need for fixation of the segment because of stability, which was attributed to the fact that DBBM had excellent mechanical properties for stabilizing the fragment. Lateral bony window was repositioned and gentle pressure was applied prior to collagen membrane placement and flap tension free suturing. (Fig 13, 14).

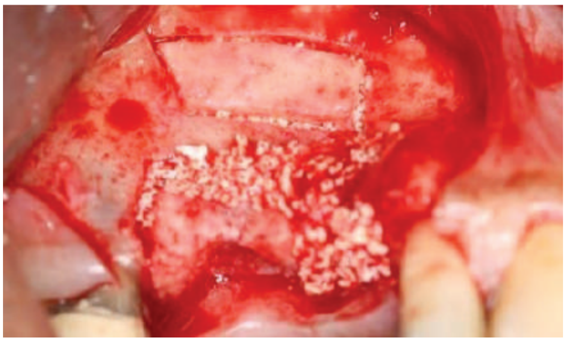

Fig 13: The removed bony window is positioned in situ — no fixation is required.

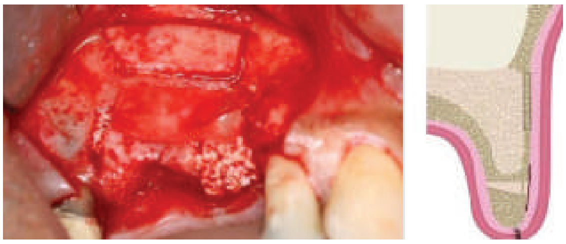

Fig 14: The interpositional grafted site is covered with a collagen membrane.

Postoperative medication included Clavulanate–potentiated amoxicillin (Augmentin Glaxosmithkline) twice a day, and non–steroidal analgesics were prescribed. Chlorhexidine rinses and a nasal decongestant were also prescribed twice a day for 10 days. Blowing the nose, sucking liquid through a straw, and smoking cigarettes, all of which create negative pressure, was avoided for at least 2 weeks after surgery. Coughing or sneezing had to be done with an open mouth to relieve pressure. Pressure at the surgical site, ice, elevation of the head, and rest besides appropriate oral hygiene were also recommended. Care had to be taken not to pressurize the reconstructed area with any prosthesis.

Panoramic radiograph was performed immediately following surgery to confirm the absence of graft material displacement into the sinus cavity and to ensure precise location of grafted material. Postoperative healing was uneventful.

Six months later, panoramic radiograph was taken, showing excellent consolidation with well–defined contours of the fragment and the augmented sinus floor showing more than 20 mm of bone height (Fig 15).

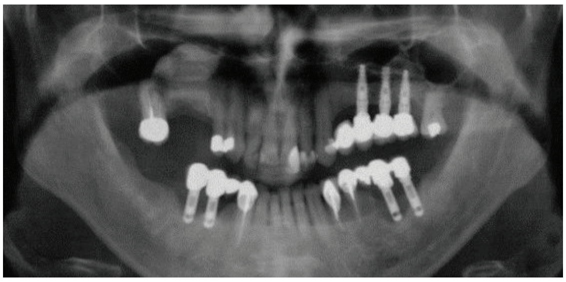

Fig 15: Panoramic radiograph taken 6 months after sinus floor augmentation and interpositional grafting showing excellent consolidation with well–defined contours of the fragment and the augmented sinus floor showing more than 20 mm of bone height.

The 8 mm concaved alveolar defect was corrected by about 6 mm. which left the site allowing anatomical dental restoration. The clinical appearance of the operated alveolar crest was improved dramatically.

Second Stage Surgery

After a healing period of 6 months full thickness flap was reflected (as previously described) and a fairy well–consolidated bone was clearly visible (Fig 16–17).

Fig 16: Clinical view of healthy soft tissue 6 months after uncomplicated healing

Fig 17: Mid–crestal incision line with mesial and distal vertical releasing incisions

The alveolar ridge was prepared to receive implants (Alpha–Bio Tec (Petah Tikva, Israel) in accordance with a conventional surgical protocol. (Fig 18–23).

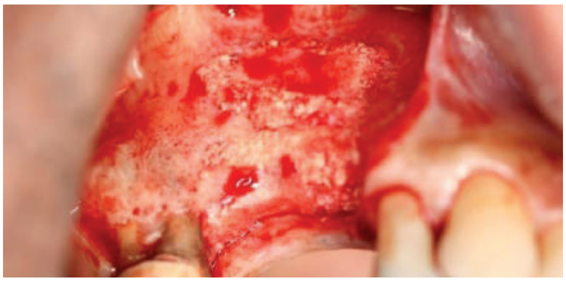

Fig 18: Full–thickness flap was reflected. a fairy well–consolidated bone graft was clearly visible

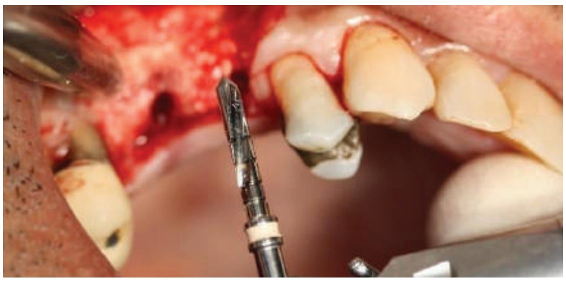

Fig 19: After the planed implant positions were marked with a pilot bur, a 2.0 mm diameter twist drill was used to attain the desired length.

Fig 20: Further preparation was performed using a 2.8 mm diameter twist drill for the outer 0.8 mm of bone preparation

Fig 21: A 3.65 mm diameter twist drill was used for the final preparation of the bone

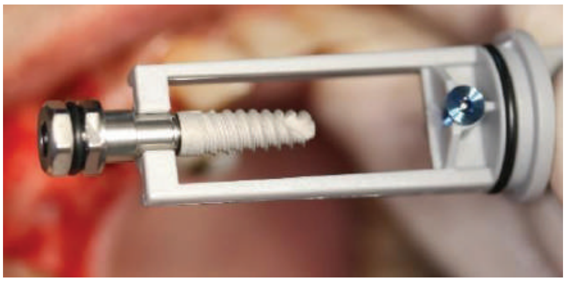

Fig 22: Alpha Bio Tec NEO implant, 4.2 mm diameter and 13 mm long

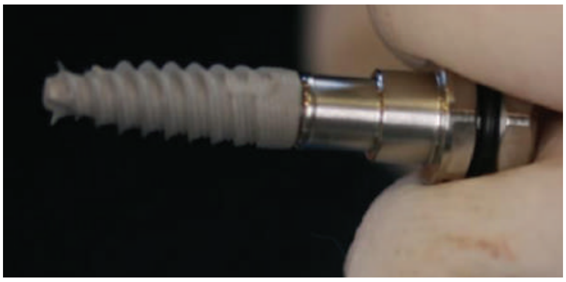

Fig 23: Alpha Bio Tec NEO implant, 4.2 mm diameter and 13 mm long

Two NEO implants (Alpha Bio Tec ABT) 4.2 mm diameter and 13 mm in length, were inserted in the augmented area of the region of teeth 15,16 with an insertion torque of 60–70 Ncm (Fig 24–27).

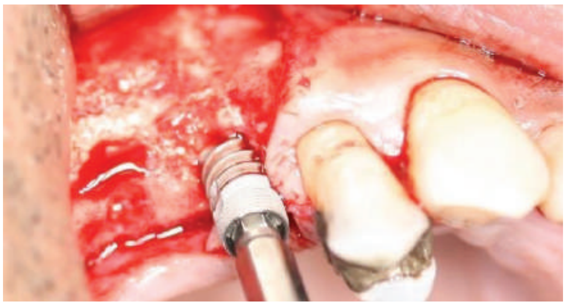

Fig 24: A standard implant, 4.2 mm diameter, 13 mm long, was placed at site 15

Fig 25: Insertion torque values were measured and recorded for implant 15.

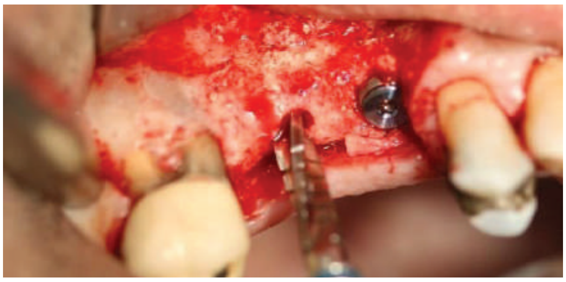

Fig 26: Implant site preparation at site 16

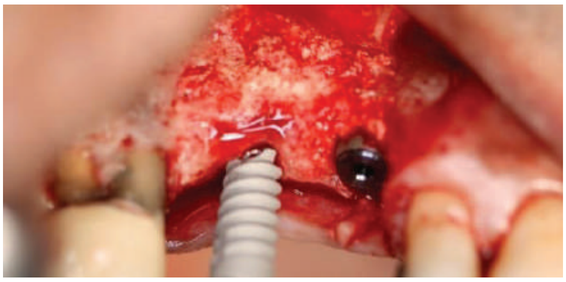

Fig 27: standard implant, 4.2 mm diameter, 13 mm long, was placed at site 16.

The mesial root of the second molar was resected followed by enucleation of the apical granulation lesion (Fig 28–29).

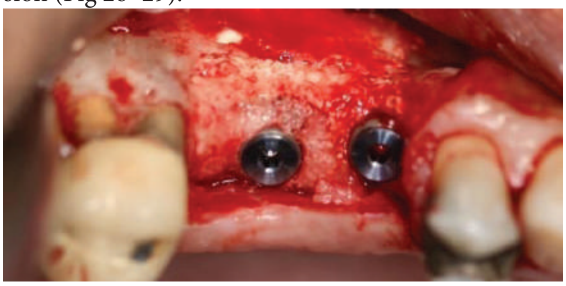

Fig 28: Two implants in situ — note the favorable biological inter–implant distances.

Fig 29: radictomy of the involved mesial root of the second right molar

The inserted implants showed good primary stability at the end of the surgery. Grafting the empty socket of the removed mesial root of the second molar and further contour grafting to shape, contour and realign the alveolar ridge after completion of the implant placement was done with DBBM as needed (Fig. 30).

A resorbable collagen membrane was placed over the grafted region (Alpha–Bio's Graft) (Fig. 31) and a soft tissue flap was mobilized from the buccal to close the wound primarily (Fig. 32, 33).

Fig 30: Grafting the empty space of the removed mesial root of the second molar and further contour grafting to shape the ridge using DBBM

Fig 31: The grafted area was covered using collagen membrane

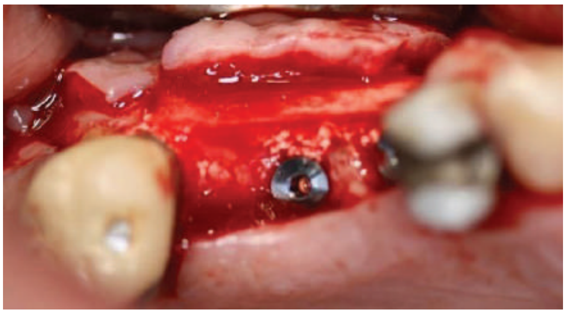

Fig 32: Occlusal view showing grafting material, collagen membrane and repositioned flap prior closure

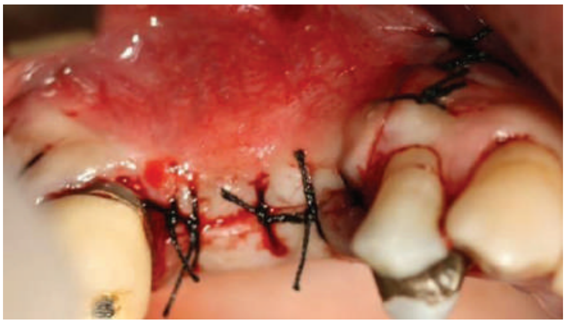

Fig 33: After surgery was completed, flap was closed primarily tension–free with interrupted sutures.

Postoperative antibiotic regime included 0.5 g amoxicillin three times a day for 7 days postoperatively.

Clinical examinations were carried out 1 week, 1 month, and 2 months after surgery. The soft tissues were examined for signs of soft tissue perforation or inflammation. The implants were then allowed 2 months to osseointegrate before temporary restoration. Final restoration was connected 4 months after implant placement. Radiographic confirmation using panoramic radiograph of the desired implants positions into the grafted osteotomy and the sinus was evident one week postoperatively (Fig 34). Standard trans–mucosal abutments were connected at second stage surgery two months later (Fig 35) and provisional crowns were inserted (Fig 36). Final restorationwas connected 2 months later (Fig 37).

Results

Healing was uneventful, and primary wound healing ensued throughout the entire surgery healing phase. Six months after implant placement, the crestal bone remained stable and well–seen graft consolidation was clearly shown in the taken panoramic radiograph (Fig 38).

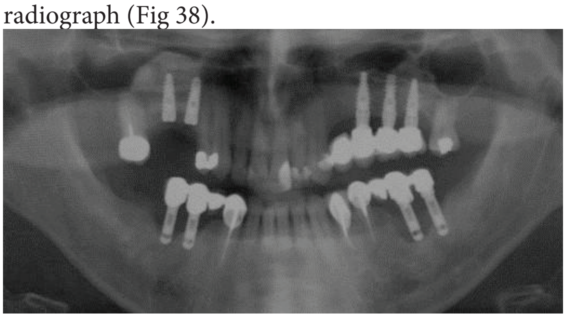

Fig 34: Panoramic radiograph taken 6 months after implants placement and radictomy of the mesial root of the right maxillary second molar showing well–osteointegrated implants into the grafted osteotomy and the grafted sinus at site 15, 16.

Fig 35: Clinical view of prepared solid abutment for temporary prosthesis

Fig 36: Temporary prosthesis in situ; note the crown design at the neck for soft tissue management.

Fig 37: Final prosthesis in situ; note the ingrowth of soft tissue.

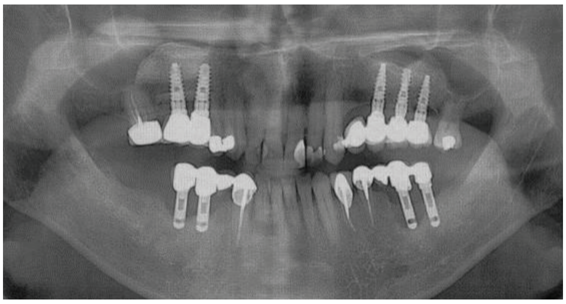

Fig 38: Panoramic radiograph taken 6 months after loading showing well–defined contoursof the osteotomized fragment and the augmented sinus floor besides well– osseointegrated implants.

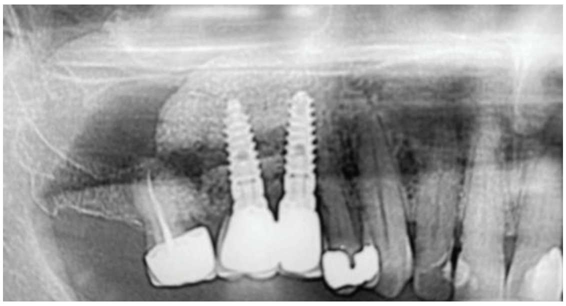

Fig 39: panoramic radiograph taken 3 years after loading

Discussion

Bone augmentation prior dental implants have been widely studied over years as there is no consensus regarding the ideal method of augmentation. Many factors as the degree of deficiency, anatomic locations and orientations, and patient compliance navigate the surgeon to the appropriate method for each situation.

The combined nature of limited alveolar bone amount and pneumatisation of maxillary sinuses makes the posterior maxilla so difficult in a face of vertical defect augmentation.

There are also many ways to avoid bone augmentation in the posterior maxilla using the existing native bone facilitating short implants, angulated implants, palatal positioning implants or pterygoid implants.

This study better than any other approach assessing the performance of an innovative technique of interpositional sandwich osteotomy combined with sinus floor augmentation that offers a new approach to the management of patients suffering from posterior maxillary vertical ridge height deficiency related both to severe crestal ridge resorption and pneumatized sinus.

To the best of my knowledge, the use of this technique has not been reported in the literature. It appears to be an excellent method to mobilize a resorbed alveolar ridge toward the crest combined with lateral wall sinus floor augmentation providing favourable bone mass and form to enable implant placement in positions that are optimal from a prosthetic and esthetic point of view. Based on the study results, the vertical bone gain was almost 20 mm in the area of the greatest bone defect. Dental implants were placed with 100% success rate over 3 years.

The vertical alveolar crest defects extend from the first premolar to the molar region including 3 to 4 teeth, in contrary of Jensen technique, it should not extent to the pterygomaxillary suture [44]. This technique should only be applied in patients with at least 6 mm of RBH, and the alveolar ridge must not be less than 5 mm in width to re–establish a more ideal crestal bone level to facilitate desired esthetic results [34], this technique is contraindicated when the alveolar residual bone is too narrow, too short, <5 mm.

This technique permits dental rehabilitation in terms of reshaping the alveolar crest and normalizing the interocclusal distance improving the crown–implant ratio [48]. Although the issue of an ideal crown–to–implant ratio seems to be no longer essential for biomechanics, it is still essential for esthetic reasons [48], particularly for patients with high lip smile that extending to the first molar region. In addition, it can avoid a ridge–lapped restoration due to mislocated implants, which may create bad conditions for adequate oral hygiene [49].

Simultaneous implant placement is not recommended, as implant stability and placement axes may not be ideal, because of the lack of implant primary stability due to the absence of apical engagement.

The described novel surgical technique can address both bone deficiencies better than any other procedure and has several advantages over other techniques, such as GBR with barrier membranes, titanium meshes and autogenous graft. They are helpful for modest amount of vertical corrections and should probably be limited to smaller defect cases. [50,51]. These procedures can present a higher incidence of infection or membrane exposure, probably not observed in the sandwich osteotomy technique [52,53]. A recent randomized clinical trial comparing the use of titanium mesh and xenograft with the sandwich osteotomy technique showed that mesh can predispose to soft tissue complications, while none was reported with the sandwich osteotomy. An important advantage of the interpositional grafting is that bone exposure doesn't necessarily lead to resorption as the transported segment still receives blood supply through the intact palatal and crestal attached mucoperiosteum [31].

Alveolar distraction osteogenesis and onlay bone grafts are indicated for large alveolar bone defects. The use of one of the procedures mentioned above alone can be done but this cannot correct both deficiencies.

Potential advantages of this technique include less morbidity, less compliance, reduced costs and surgical time and a consistent gain of vertical bone mass and contour with stable cortical native bone in the crestal aspect, along with the lower incidence of infections and wound dehiscence that may lead to graft exposure [54]. Moreover, the interpositional graft zone is protected from occlusal trauma [55,56]. A minor disadvantage of this procedure is that commonly the alveolar crestal morphology requires further modifications and grafting at the time of implant placement. Preimplant grafting is more likely to avoid complications in terms of soft tissue and keratinized mucosa which is beneficial for maintaining optimal periodontal health, as it establishes favorable biological, functional, and esthetic outcomes [57]. Augmented bone induces regeneration of keratinized tissue to a certain extent, as we know 'bone sets the tone' [46,58].

The use of sinus grafting alone can be done but doesn't correct alveolar hight and orientation toward the crest that is not favourable from a prosthetic and esthetic point of view and cannot normalize the interocclusal distance leads to an increase in the crown–implant ratios [59]. Sinus floor augmentation can also be limited because of the condition of the maxillary sinus as the floor morphology, the presence of septa, the thickness of the sinus membrane and sinus pathologies [60,61]. Considering these issues, the interpositional technique using biomaterials can be advantageous to the sinus grafting in terms of vertical bone gain. In this study the vertical bone gain was almost 20mm, this is higher than the vertical gain of 10–12 mm of sinus grafting alone.

Alveolar ridge remodeling and resorption is a common occurrence after many augmentation procedures, with more resorption reported over a longer duration and follow–up periods.

The interpositional bone graft material varied widely between autogenous bone graft, allografts, and xenografts. The graft biomaterial also affected time of implant installation after the augmentation occurred due to the different resorption rate of the biomaterials. In cases using xenografts 6 to 7 months are recommended for implant installation.

The surgeon must decide on the most suitable material to augment the created defect. Although autogenous bone is considered as the gold standard, DBBM have shown excellent results and excellent mechanical properties for stabilizing the mobilized fragment compared with autogenous grafts. Its rigidity prevents collapse of the bone segment and its stability prevents graft displacement. The use of DBBM also eliminates the need for harvesting autogenous bone graft from another donor site so decreasing patient morbidity, discomfort, and saving time.

This method assures a good vascular supply to the interpositional graft leading to reduced resorption because the grafts are in contact with 4 walls which increases its nourishment, facilitating a rapid angiogenesis and vascular connection to surrounding tissue [15,37,39,62,63]. In the alveolar crest, in contrary, bone growth spontaneously stops at a few millimetres above the defect alveolar crest. The more distant particles instead heal within fibrous tissue leading to a scar. As a result, the implant shoulder interface in terms of pristine and augmented bone is in contact to the original bone [37]. It appears that some resorption of the fragment cannot be avoided, possibly as a result of the poor blood supply to the fragment due to elevation of the mucoperiosteal flap buccally and to the osteotomy of the remaining alveolar bone. Therefore, augmentation should be slightly exaggerated to compensate for resorption.

Given these facts, the use of interpositional osteotomy bone grafts must be considered superior to other techniques when attempting to gain alveolar vertical bone height [64–67].

Further studies are warranted to compare graft material and particle size and their effect on graft incorporation and resorption in the setting of the interpositional osteotomy [68].

There is a positive correlation between span length and the stability of the vertical bone achieved. Smaller bone segments (i.e., two–tooth spans) positioned coronally can result in a compromised lingual or palatal periosteum blood supply. When the segment is displaced coronally, it stretches the soft tissue attachment. Undue tension on this narrow periosteum by excessive repositioning can result in a poor blood supply, which may affect graft viability [62]. In fact, Jensen et al. recommended not positioning the segment greater than 5 mm vertically, due to a risk of vascular embarrassment [15].

In contrast, larger segments advanced coronally have a broader base of attached periosteum, so the degree of periosteal tension is less, and the resulting blood supply is greater. Greater vascularity to the transport segment is important, as it will improve the delivery of osteogenic factors and decrease graft resorption [69]. Similar findings have been reported in distraction osteogenesis, with a positive correlation between bone resorption and the amount of transport.

Evidence suggests larger bone segments are more resistant to resorption than smaller ones [70].

In the clinical case presented in this study, DBBM grafts were used to augment the sinus floor and the created space of the osteotomized segments. This provided a clinically satisfactory result after 3 years follow–up. It should be noticed that using DBBM grafts requires a healing period not less than 6 months before implant installation due to the properties of the graft.

In my case, there was no need for plates and screws for fixation of transported segment depending on the first factor that the height of the transported segment which shouldn't be less than 5mm to be rigid enough thus eliminating the need of extra fixation. The second factor is the almost parallel vertical cuts which contribute for more means of retention, so there was no need for extra fixation using plates and screws that might on the other hand compromise the integrity and viability of the segment. Unlike other clinicians who prefer to stabilize the mobile segment using plates and screws for eliminating the possible micromotion at the graft–recipient interphase that might lead to increased graft resorption, this was reported by Tamimi and colleagues [71].

A 5–6 mm vertical movement can usually be obtained due to the rotation and pull of the bone segment attached to the palatal mucosa. However, the alveolar crest is often displaced slightly to the palatal, which sometimes requires contouring, shaping and additional grafting at the time of the implant placement. This can be considered a minor disadvantage. Another disadvantage is the limitation of the degree of alveolar bone augmentation in vertical dimension by the palatal periosteum.

Authors stated that efforts to displace the segment greater than 5mm may not only risk the potential for vascular embarrassment by detaching periosteal blood supply, but also can excessively rotate the segment palatally, compromising esthetic outcome [15].

The palatal periosteum and flap should be maintained for maximum blood supply to the segmented bone, which is the most important factor [72], so that the bone is not devitalized as a result of ischemia after the bone is detached from its blood supply [73]. The use of piezoelectric device contributes for precise control of the osteotomy to reduce trauma to the soft tissue.

The strength of this technique is that an increase of 5–6 mm of alveolar bone toward the crest can be obtained besides the augmented sinus floor. A total vertical bone mass of approximately 20 mm was gained. This enabled the placement of two long implants in the region.

The measurements of vertical bone gain in the present study were based on accurate 2D panoramic radiograph measurements made prior to and after the procedure at fixed anatomical positions, as described in previous studies [74–76].

Studies of sandwich osteotomies and sinus grafting procedures have shown it to be a relatively simple technique to provide satisfactory results in terms of surgical successand predictability. On the other hand, alveolar augmentation procedures depend on the operators experience and are technique sensitive. The most common difficulty is how to manage the soft tissues to maintain the blood supply to the transported segments, releasing incisions make tension–free watertight closure possible. Although, from a technical and surgical management standpoint, this technique is easily conceptualized. This technique should be restricted to skilled surgeons with experience of sinus grafting and osteotomy surgery.

Conclusion

Within the limitation of this study, it can be concluded that this novel technique is recommended to meet the dimensional requirements of bone augmentation both crestal and intrasinusal in severe atrophic posterior maxilla. The dental restoration featured an improved alveolar plane, equalized crown–to–implant ratios, and a more favourable gingival shape. Surgical improvement and the encouraging result obtained with this study have made it appropriate for management of this kind of vertical deficiencies.

The technique appears to be a viable alternative to other vertical augmentation techniques (GBR, onlay graft, distraction osteogenesis, etc.) to enable implant rehabilitation in terms of increasing bone volume, reshaping the alveolar crest and normalizing the interocclusal relationship. The use of biomaterials between the osteotomized segments was shown to be viable.

Due to the few results available of this novel technique, it is necessary to carry out further research with a larger sample size and with a longer period of follow up to validate the predictability of this regenerative technique and to obtain a more statistically significant result. It is important to choose the appropriate augmentation method for each patient. The decisive factor influencing the proper method is the degree of the deficiency.

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