Chapter 1

Minimally Invasive Tunnel Technique, Bone Grafting for Dental Implant Placement Preparation

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Abstract

The ideal placement and restoration of dental implants is dependent on the presence of adequate bone volume and quality at the edentulous site. Various surgical and multiple bone grafting techniques, natural and synthetic graft materials have been developed to make possible the successful placement of dental implants in resorbed alveolar bone. This chapter shows minimally invasive tunnel technique for ridge augmentation and has been described as a safe, patient-friendly method to augment bone. There are several advantages of this technique compared to conventional bone augmentations. The minimally invasive tunnel technique is relatively less morbid and less technique-sensitive, and often it does not require flap elevation or membranes. Absence of flap elevation ensures better preservation of keratinized gingiva, and adequate overfilling is also possible since primary coverage is not directly required. Furthermore, the procedures for this technique bring forth minimal implant exposure and infection that result in good mechanical stability of bone graft material and to prevent post-operative complications. The author hopes that this chapter will prove a valuable resources and references for clinicians placing implants in patients requiring ridge augmentation in resorbed alveolar ridge to minimize the risk complications and to ensure predictable and stable long term results.

Introduction

A narrow alveolar ridge is a challenging situation that surgeons may face when considering implant oral rehabilitation. Many surgical approaches exist, and the most frequently used is bone grafting [1]. The subperiosteal tunneling approach is a minimally invasive procedure that allows the surgeon to allocate the graft in a space that is obtained between the soft tissues and the underlying bone through an access represented by a single incision on the mesial limit of the bone defect [2,3]. This approach ensures minimal discomfort for the patient after the surgery and mostly steady coverage of the graft during the healing time, with minimal risk of exposure, infection, and failure [4,5]. The subperiosteal tunneling technique uses autologous bone, which is still considered the gold standard for bone regeneration [6]. In 1987 Härle reported on a tunneling access in connection with a technique for preprosthetic jaw ridge grafting in the mandibular side-tooth region with bone replacement materials. In the clinical experience of the authors the use of a tunneling technique for preparation without a crestal incision can present an alternative with autologous bone grafts to conventional surgical procedures with a trapezoid flap design [7]. Flap necrosis and wound dehiscence are the two major problems in bone grafting surgery. They both contribute to uncover of the graft with subsequent infection of the surgical site and failure of the surgical procedure. The soft-tissue

complications are frequently the result of damaged blood circulation resulting from inadequate planning, insufficient flap extension or excessive surgical trauma. The great advantage of the flap design with the tunnel technique is the ability to avoid the crestal incision. This technique retains the blood circulation and does not damage the tissue. This is particularly important for patients with vascular problems, such as smokers, diabetics and patients with scar tissue [7]. Surgical exposure to augment alveolar bone defects is usually done by alveolar crestal approach. A tension free sealed closure of the crestal incision is mandatory for successful take of the graft. In mucosa deficient ridges healing period is often complicated by gaping at the crest due to compromised primary closure. This is mainly because of insufficient soft tissue coverage and thereby it results in partial or complete loss of graft. Use of barrier membranes [8], means for stabilization of the grafts and membrane, and attaining sealed tissue closure also demands further stretch of the already deficient mucosa and periosteum. Moreover, alveolar bone grafting of partial edentulism done through a crestal incision disrupts the crestal mucoperiosteum and the mucogingival junctions of the adjacent teeth. This may result in gingival recession and related complications [9]. In the technique presented in this chapter, vertical and lateral bone grafting was accomplished through a tunnel created by a conservative vertical incision placed far from the donor site. The fixation of the block graft for some clinical cases is often not

necessary as the tight mucoperiosteal tunnel is sufficient for stabilization. However, if stabilization is required, this can be done directly by a transmucosal approach with or without screws. Therefore this chapter is designed to evaluate the efficacy of the tunnel technique as minimally invasive approach, and the different bone grafting materials and procedures which can be applied to achieve normal dental implant placement preparation environments.

Bone Grafting Material for Tunnel Technique

The concept of minimally invasive surgery was devised to achieve vertical bone regeneration and to prevent post-operative complications and graft exposure [10–18]. A subperiosteal tunneling technique was developed in early 1980s by Kent et al. [11]. This technique involved a small surgical incision made in the alveolar ridge to elevate the periosteum and inject a low viscosity paste of hydroxyapatite (HA) particles. Although appealing, it was found that HA particles were unstable and diffused into adjacent tissues causing the formation of a fibrous capsule that prevented bone formation [9–12]. Newer graft materials with optimized viscosity and an improved surgical technique continued to offer potential for this method but results are controversial [11–12, 16–18]. There is still insufficient comparable quantitative data to assess the

clinical usefulness of this technique. However, some studies demonstrated that tunneling combined with screw or membrane mediated stabilization of the grafts can be a predictable vertical augmentation technique [10–20]. Calcium phosphate based biomaterials such as brushite cement pastes have been evaluated in various in vivo studies as injectable pastes with controlled viscosity and additives to achieve minimally invasive vertical bone augmentation [21–24]. Subperiosteal tunneling technique is a partially blind procedure that requires patience and delicate surgical maneuvers to develop the subperiosteal flap that could form a pocket for graft materials. Though this bone augmentation does not permit a direct view of the deficient ridge, it has advantages of less postoperative complications such as less bleeding, discomfort, bone loss, and surgery recovery time. Moreover, augmentation without application of fixation is still controversial [10,14,15].

The Clinical Application for the Minimally Invasive Guided Bone Regeneration Using a Subperiosteal Tunneling Technique

Various authors and clinicians were described a minimally invasive GBR technique that uses nonconventional incision lines, along with balloon-assisted elevation of the periosteum, and reports its clinical application in several

patients [16,25]. This technique is indicated for partially or completely edentulous healthy adults, with insufficient localized jaw bone volume to receive dental implants. Presurgical radiographic evaluation is used to determine the severity of ridge resorption (CT, panoramic, and periapical radiograms) followed by clinical examination to evaluate the type of gingiva (attached or mobile). The patients should receive a detailed explanation regarding the technique and sign an informed consent prior to the procedure. Local anesthesia infiltration is used on the selected augmented area. A vertical incision is done in the mesial aspect of the augmented ridge from the free gingiva to beyond the mucogingival junction (Figure 1)

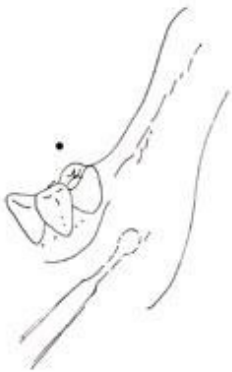
(1a)

(1b)

(1c)

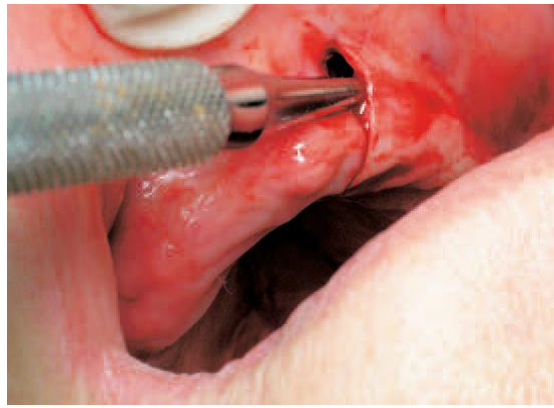
Figure 1: Vertical incision in unattached gingiva.

A dedicated mini-chisel or thin periosteal elevator is inserted through the incision between the bone and the periosteum and advanced to gently release the periosteum from the bone (Figure 2).



(2a)

(2b)



(2c)

Figure 2: Illustrates use of opposing thumb to resist tearing tissue preparing tunnel procedure reflecting unattached gingiva.

For the thin mandibular bone, the tunneling technique will be extended more to reflect the attached gingival connective tissue fibers on buccal and occlusal ridge areas to resist tearing buccal tissue by using opposing thumb (Figure 3) and use of dull bent wax instrument to relieve lingual attached gingival connective tissue fibers starting posteriorly and coming anteriorly to reduce risk of instrument penetrating the lingual tissue (Figure 4) [26].

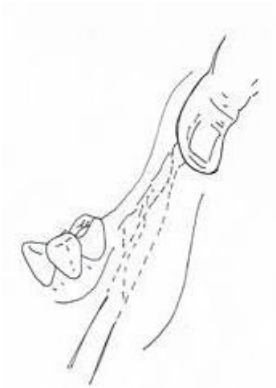


Figure 3: Reflection of the attached gingival connective tissue fibers on buccal and occlusal ridge to resist tearing buccal tissue by using opposing thumb.

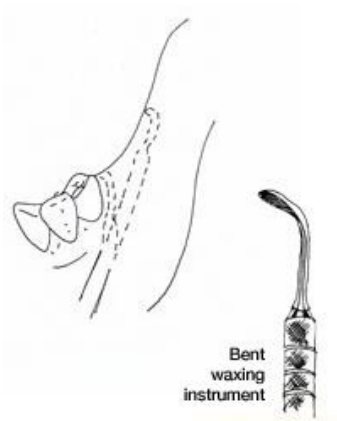


Figure 4: Relieve lingual attached gingival connective tissue fibers starting posteriorly and coming anteriorly by using a dull bent wax instrument to reduce the risk of lingual tissue penetration.

Once the crestolingual fibers are freed, the bent instrument is then manipulated to elevate the lingual mucosa to the mylohyoid muscle attachment. The periosteum or bent instrument was further released beyond the alveolar crest from both the palatinal and lingual aspects. Extreme caution must be exercised to avoid tissue perforation during these maneuvers (Figure 5).

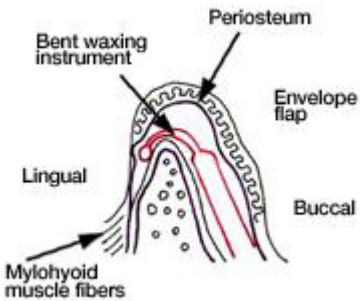


Figure 5: Extreme caution must to avoid tissue perforation during these maneuvers

Through the vertical access incision. A straight handpiece with a No. 4 round bur is now used to either scratch the buccal bone or, if thickness allows, create perforations into the medullary bone (Figure 6).

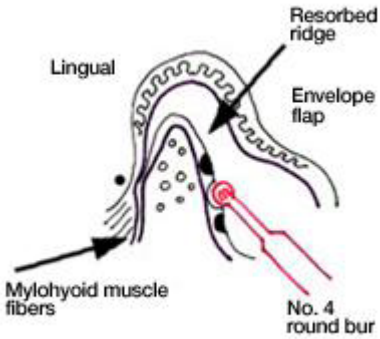
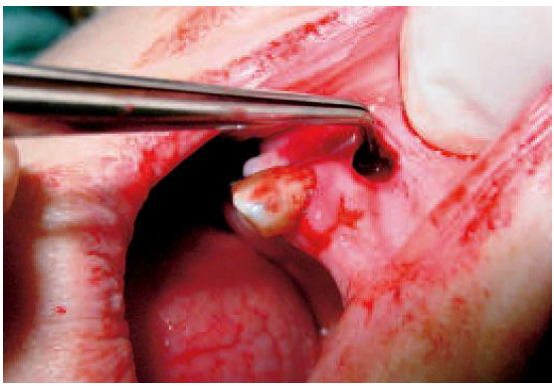
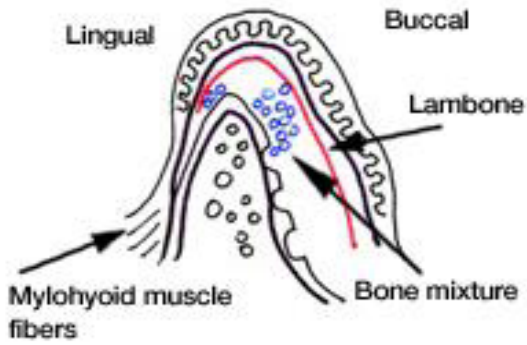


Figure 6: using a straight handpiece with a No. 4 round bur to either scratch the buccal bone or, if thickness allows, create perforations into the medullary bone.

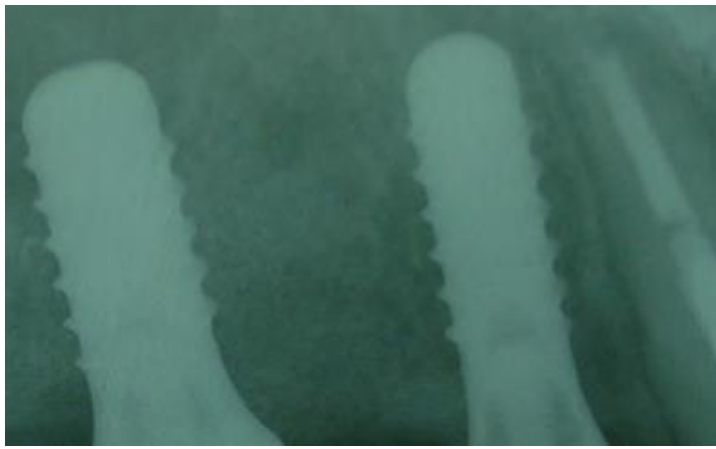
The membrane was trimmed to the desirable dimensions, thecnnel and adjusted to cover both buccal and palatinal (or lingual) surfaces of the bone (Figure 7).



7(a)



7(b)



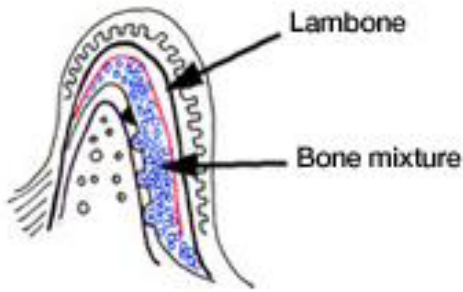
7(c)

Figure 7: Trimming the membrane to the desirable dimensions, then placed into the tunnel and adjusted to cover both buccal and palatinal (or lingual) surfaces of the bone.

The mixed bone material is placed and inserted repeatedly into the pocket, pushing the material into the tunnel until the receptor site and desirable ridge dimensions are obtained and filled with grafting material then suture is now used to close the vertical incision, starting at the superior portion of the incision (Figure 8). Finger pressure using wet gauze is applied to the area for 2 to 3 minutes to assist in achieving hemostasis, and to remold material in the tunnel pocket.

8(a)

8(b)



8(c)

8(d)

Figure 8: Pushing the material into the tunnel and filled with grafting material then suture to close the vertical incision.

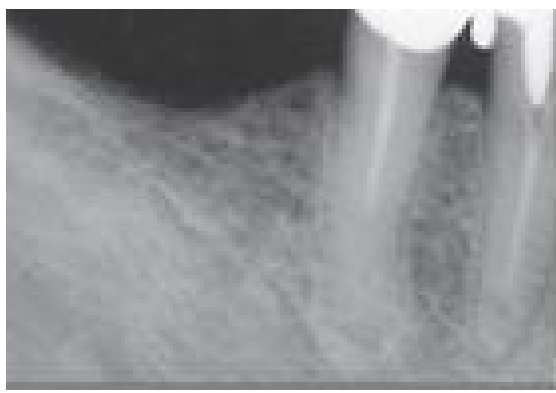
The cases were documented before the procedures (Figure 9) and after the procedures (Figure 10).

9(a)

9(b)

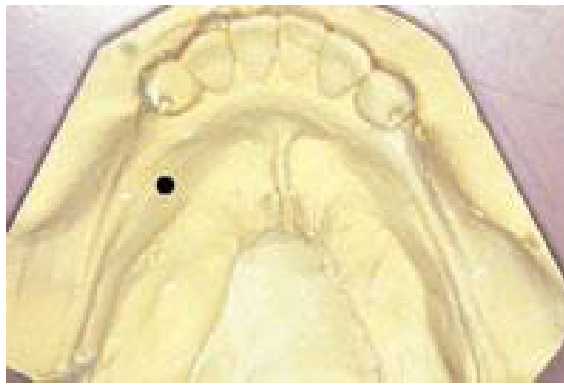
9(c)

9(d)

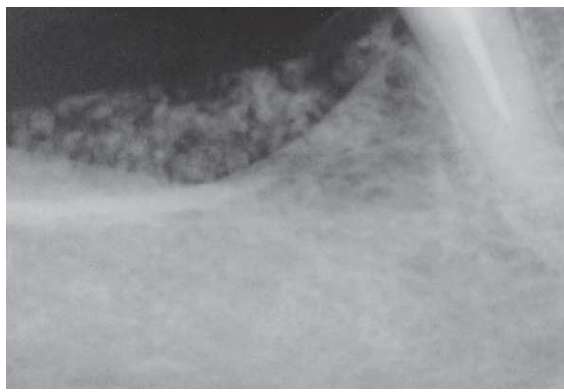


9(e)

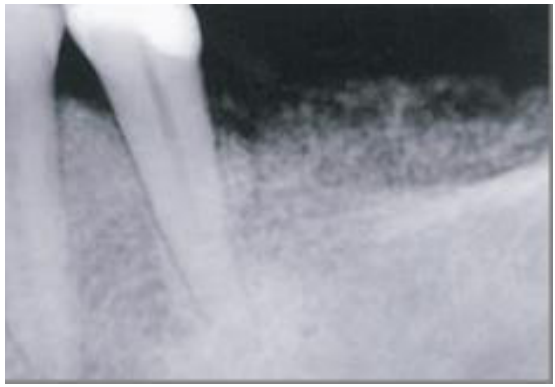
Figure 9: Clinical cases, diagnostic cast and pre-operative x-rays before tunnel technique procedures.



10(a)



10(b)



10(c)

10(d)

Figure 10: diagnostic cast and post-operative x-rays after tunnel technique procedures immediately and 6 months post-operative.

Is the Tunnel Technique More Effective than Open Augmentation Technique Using a Membrane in Preparation for Dental Implant Placement

One of the most common methods for treating horizontal bone deficiency is the use of barrier membranes for guided bone regeneration [27–29]. Both nonresorbable and bioresorbable barrier membranes have been used to provide space maintenance over the defect, prevent ingrowth or migration of undesired soft tissue, and promote osteogenic cell ingrowth [27]. Many variations of this approach have proved to be successful, but are not without complications. The most commonly encountered complication is wound dehiscence and early membrane exposure, which can lead to bacterial colonization and infection necessitating early removal of the membrane and debridement of the grafting materials. It has been shown that bone gain is considerably decreased with early membrane exposure [30,31]. The tunnel technique is an alternative method of horizontal augmentation, ideally used in sites with 2-wall defects or a prominent C-shaped curvature of the alveolar ridge (Figure 11) [32,33]. Deep et al compared the clinical outcomes of an open technique using a titanium reinforced PTFE membrane versus the tunnel technique for horizontal ridge augmentation. The study supported the use of the tunnel technique over the

open technique with a titanium-reinforced PTFE membrane for horizontal ridge augmentation of alveolar defects amenable to either technique. The tunnel technique was shown to be a simple, predictable, and no pain were noted and also more cost-effective and time-efficient option with similar success and fewer complications [34].

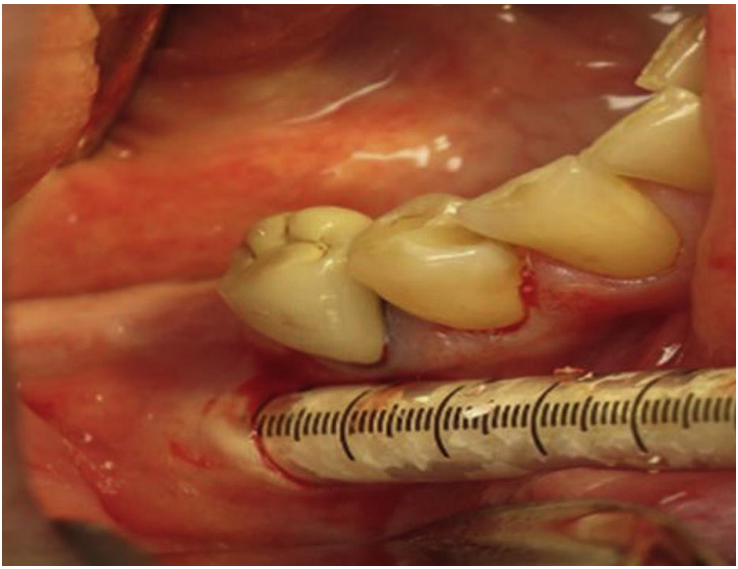
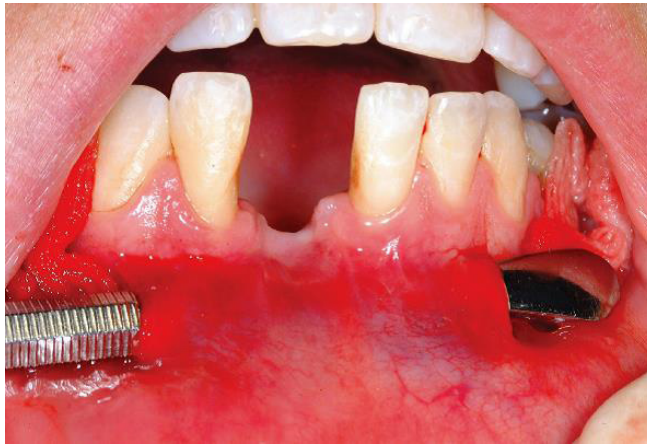


Figure 11: Bone graft material insertion into the tunnel.

Minimally Invasive Treatment Using Tunnel Technique for Soft Tissue Preparation Prior Guided Bone Regeneration or Block Graft

Other studies and clinical case reported that one of the most important factors in the success of GBR and block grafts is adequate and maintained soft tissue coverage. . Maintenance of soft tissue closure is a very important factor in the success of any bone grafting procedure. In cases of thin mucosa, the maintenance of soft tissue coverage may be more difficult due to inability of the tissue to overcome the continuous pressure from the block, and it can be easily penetrated by any sharp edges of the block or fixation screw [35-38]. Soft tissue preparation and grafting is a mandatory step prior to GBR and block grafting in cases of thin mucosa. The use of ADM for soft tissue preparation using a tunnel technique offers the advantage of increasing the soft tissue thickness prior to block grafting and may minimize or eliminate the early or late post-surgical soft tissue complications associated with this procedure [39,40]. The average time for the procedure was 30 to 45 minutes (Figure 12a–12e) [41].

12(a)



12(b)

12(c)

12(d)

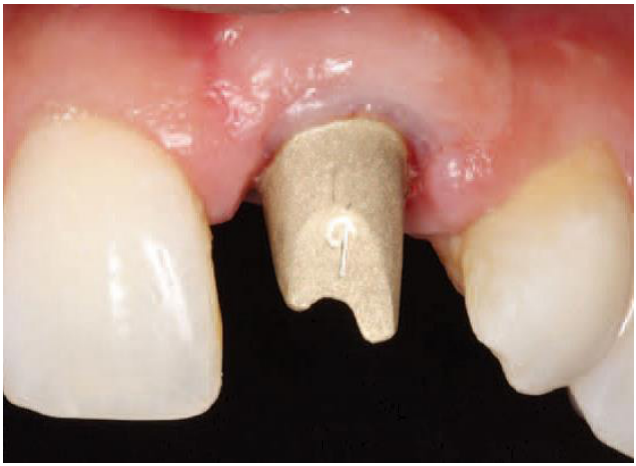
12(e)

Figure 12: A and B: Initial presentation of the first patient. Mandibular central incisor was missing with Class III ridge defect and thin mucosaC: The acellular dermal matrix (ADM) was sutured with a single knot to the straight instrument, and the instrument was pulled so that the graft could slide under the tunnel. D: The graft was positioned over the defect area using periosteal elevator and fixed in place using 5 suspension sutures.E: Healing 6 months post-surgery.

Lee et al reported a Modified Vestibular Incision Supraperiosteal Tunnel Access (VISTA) technique for enhancing the soft tissue dimensions around implant supported restoration in the anterior maxilla. The author used the patient's own connective tissue for this grafting procedure (Figure 13a–e) [42].

13(a)

13(b)



13(c)

13(d)

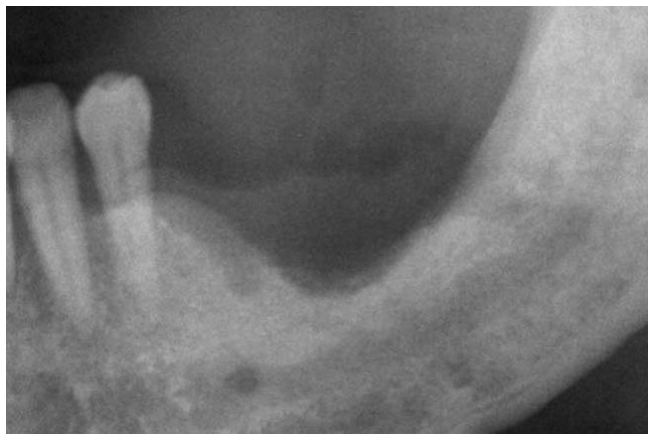
13(e)

Figure 13:A: Before the start of the surgical procedure, the cement enamel junction of the crown was moved 2 mm coronally and the crown profile was flattened to create additional space for the advancement of the flap.B: The buccal area was accessed and a split thickness tunnel flap was prepared. C: Healing after soft tissue augmentation and prosthetic phase.D: Follow-up after placement of final restoration 1 year post-op (frontal view). E: Occlusal view.

Minimally Invasive Approaches to Optimize Autogenous or Artificial Block Bone Graft Fixation with Screws:

Most of the clinical cases presented with remaining alveolar projection and showed a serious horizontal and vertical defect (Figure 14)

14(a)



14(b)

Figure 14: Clinical and x-ray preoperative views for remaining alveolar projection and showed a serious horizontal and vertical defect.

A vertical incision of full thickness was made approximately 8 mm away from the defect area of the mandible or maxilla, and a subperiosteal tunnel to the defect area was established. Tunneling was performed by lifting the periosteum using a periosteal elevator without a releasing incision on the periosteum (Figure15). Care was taken not to damage the mental nerve while detaching the periosteum. The Bio-Oss shaped block was placed in the defect area of the mandible through the subperiosteal tunnel [17,42,43].

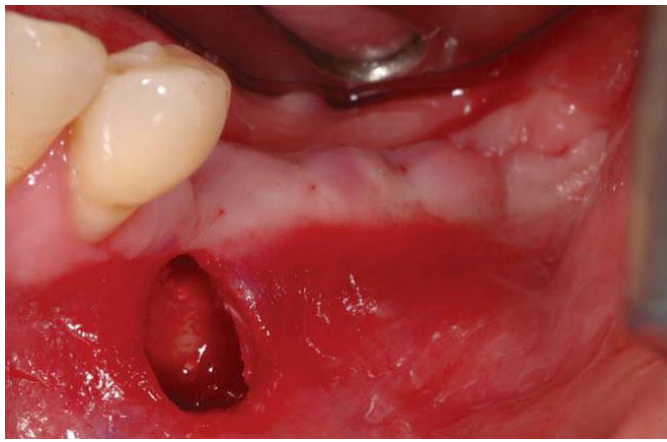
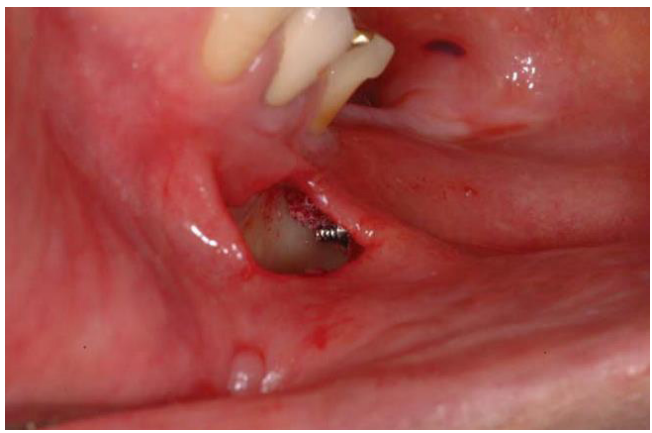


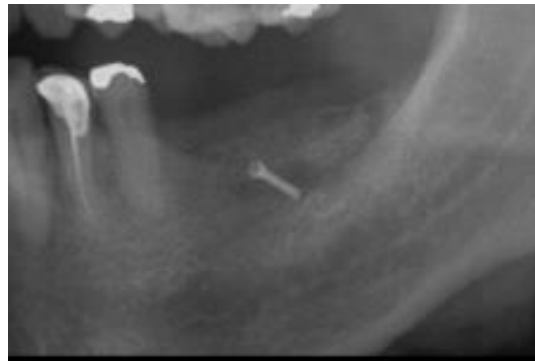
Figure 15: Tunneling was performed by lifting the periosteum using a periosteal elevator.

The block either autogenous or artificial bone graft was used as the sole grafting material. After placing it in the defect, it was stabilized and fixed with screws without a barrier membrane (Figure 16,17) [44,45].

16(a)



16(b)

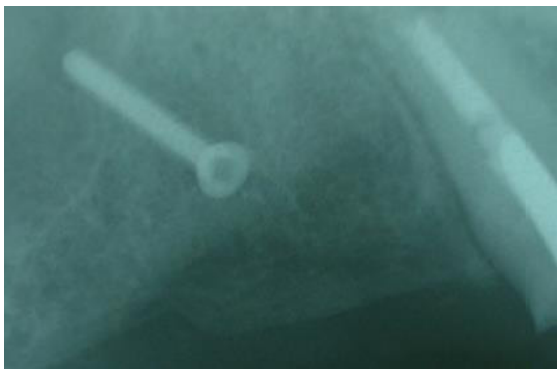


16(c)

Figure 16: The block was used as the sole grafting material. After placing it in the defect, it was stabilized and fixed with screws without a barrier membrane (Clinical and x-rays views for maxilla).

17(a)

17(b)



17(c)

Figure 17: The block was used as the sole grafting material. After placing it in the defect, it was stabilized and fixed with screws without a barrier membrane with implants placement (Clinical and x-rays views for mandible).

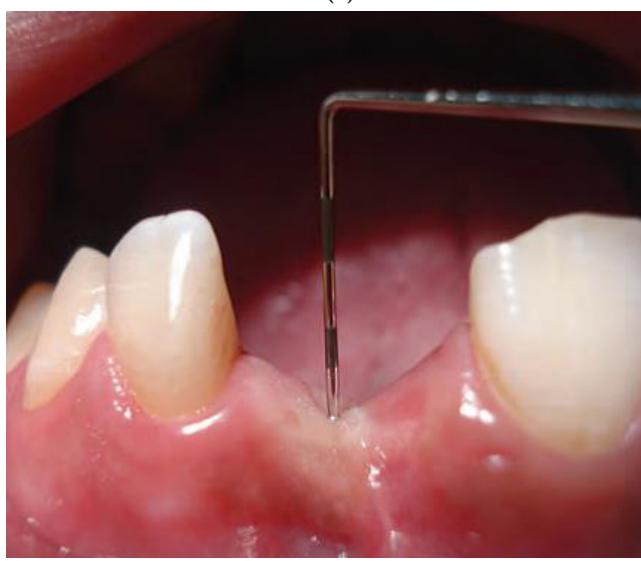
Bone Grafting of Mucosa Compromised Alveolar Ridges by Tunnel Technique and Permucosal Fixation without Screws

A tension free sealed closure of the crestal incision is mandatory for successful take of the graft. In mucosa deficient ridges healing period is often complicated by gaping at the crest due to compromised primary closure. This is mainly because of insufficient soft tissue coverage and thereby it results in partial or complete loss of graft. Use of barrier membranes [8], means for stabilization of the grafts and membrane, and attaining sealed tissue closure also demands further stretch of the already deficient mucosa and periosteum. Kavarodi et al and Li et al were presented a technique with vertical and lateral bone grafting and was accomplished through a tunnel created by a conservative vertical incision placed far from the donor site [17,46]. The fixation of the graft (Bio-Oss shaped block based on the preoperative simulation (Figure 18) is often not necessary as the tight mucoperiosteal tunnel is sufficient for stabilization. However, if stabilization is required, this can be done directly by a transmucosal approach. During insertion of the graft, trimming of the sharp bone edges of graft is necessary to help in atraumatic insertion of the graft. A tight mucoperiosteal cover can stabilize the graft, however fixation of the graft is a necessity in cases requiring vertical augmentation to maintain planned height of the

graft. A stable tight fitting graft do not require any fixation however extensive dissection or cases requiring crestal buildup to attain alveolar height may necessitate a fixation of the graft. Grafts that are stable under the tension of mucoperiosteum and do not require any fixation. In order to attain a tension free closure, release of the labial flap is usually accomplished by a periosteal incision at the base of the flap followed by stretch of the soft tissue of labial sulcus [47]. All clinical cases are presented where the tunnel and pouch technique was used for alveolar bone grafting prior to implant placement in mucosa deficient ridges. All cases attained sufficient bone augmentation and had undergone successful implant placement (Figure 19,20).

Figure 18: Bio-Oss shaped block based on the preoperative simulation.

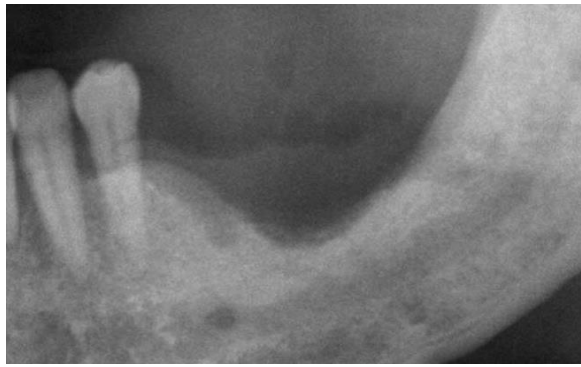
19(a)



19(b)

19(c)

19(d)

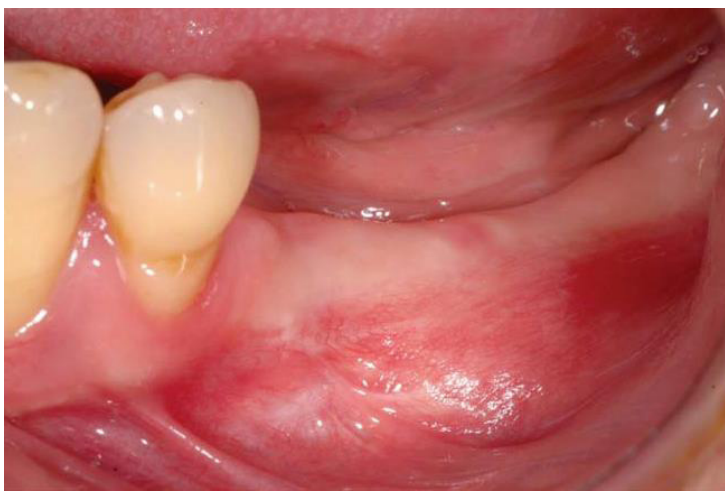


19(e)

Figure 19: Preoperative intraoral views and radiograph showing severe atrophic alveolar bone defects.

20(a)

20(b)



20(c)

Figure 20: Intraoral views after 6 months postoperatively.

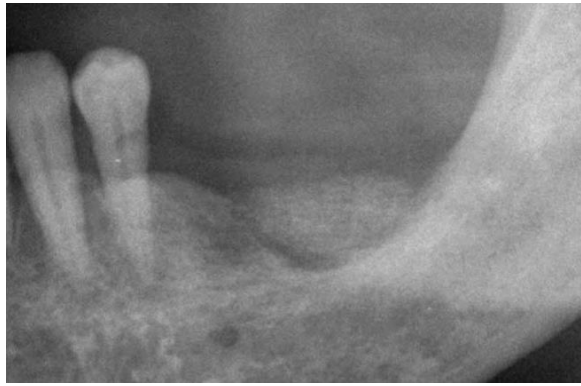


Figure 21: Radiograph showing the block placed in the defect area of the mandible. Note that the block was not fixed to the recipient site with screws.

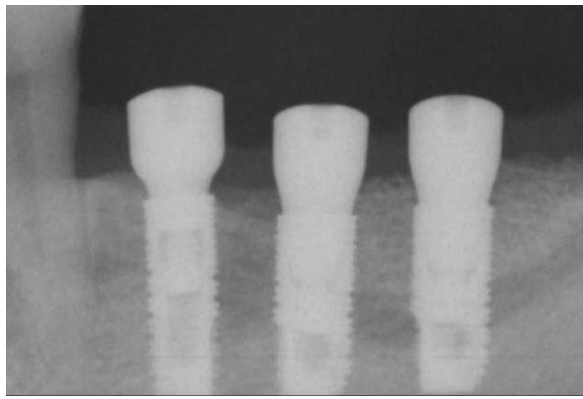


Figure 22: Radiograph taken immediately after placing implants in the graft site.

Conclusion

The bone graft material retained within a pouch formed by U-shaped incision and tunneling technique resulted without much complications. Minimally invasive tunnel technique, Bone grafting for dental implant placement preparation can provide the following advantages:

- Relatively simple, safe, and effective method of reconstructing alveolar bone ridge defects in partially and complete edentulous patients concentrated in the areas of implants placements.
- Microsurgical minimally invasive and non-sensitive surgery technique
- No limitation of augmentation sites.
- Low complication rate.
- Conservation of vital bone and blood supply.
- Adequate bone height independent of preoperative bone height.
- Optimized visualization of the surgical site.
- Endoscopic management of mucosal tears.
- Precise, endoscopically controlled placement of graft material.
- Reduces surgical trauma, postoperative discomfort, and the risk of exposure and failure of the graft during the healing phase.

This chapter will be of great benefit to clinicians placing implants in patients requiring ridge augmentation in resorbed alveolar ridge to minimize the risk complications and to ensure predictable and stable long term results.

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