Tunnel Technique with a Subperiosteal Bag for Horizontal Ridge Augmentation

Benny Karmon, DMD1  
Lorenzo Tavelli, DDS2  
Giulio Rasperini, DDS3

Several approaches for horizontal ridge augmentation have been proposed, including guided bone regeneration (GBR), ridge split, and block grafts. Minimally invasive techniques for horizontal GBR have been introduced to reestablish an adequate bone volume, minimizing tissue trauma and patient morbidity. The present article describes a tunnel technique with a subperiosteal bag for horizontal GBR. A collagen membrane is partially perforated, folded, and sutured to form a bag that is filled with xenogeneic bone graft. The filled bag is inserted into a subperiosteal tunnel such that the perforated side faces the alveolar ridge and the nonperforated side faces the tunnel flap. The main advantage of this approach is the preservation of the periosteum and the enhanced blood supply to the flap, which may contribute to increased favorable wound healing and a reduced risk of flap dehiscence and membrane exposure. This novel tunnel approach for horizontal GBR using a customized bag made from a collagen membrane, specifically adapted and filled with deproteinized bovine bone, resulted in a significant ridge volume gain that allowed implant placement. Int J Periodontics Restorative Dent 2020;40:223–230. doi: 10.11607/prd.4508

Guided bone regeneration (GBR) has been shown to be an effective technique for reestablishing adequate horizontal and vertical alveolar ridge dimension.1,2 The basis for GBR is derived from the experimental studies of Nyman and Karring in the early 1980s that demonstrated that barrier membranes can promote the proliferation of certain cell types while excluding others within the bony defect.1,3,4 Several modifications of GBR have been introduced over the years, primarily involving the use of different barrier membranes (resorbable vs nonresorbable) with one or more bone grafts. Wang et al described the “sandwich” bone augmentation that utilizes autogenous bone, human allograft, deproteinized bovine bone mineralize (DBBM), and a resorbable collagen barrier membrane to correct peri-implant dehiscence or horizontal ridge defects.5 The rationale of this technique is to leave in direct contact with the alveolar ridge a layer of autogenous bone that can promote bone regeneration with its osteogenic, osteoinductive, and osteoconductive properties; the other graft materials act as a scaffold, maintaining the space and membrane while excluding the colonization of the defect by epithelial and connective tissue cells.5 A similar approach was later described by Buser et al6 and was demonstrated to be

1Private practice, Petach-Tikva, Israel.  
2Department of Periodontics & Oral Medicine, University of Michigan School of Dentistry, Ann Arbor, Michigan, USA.  
3Department of Biomedical, Surgical and Dental Sciences, University of Milan, Foundation IRCCS Ca’ Granda Polyclinic, Milan, Italy.

Correspondence to: Dr Giulio Rasperini, Department of Biomedical, Surgical and Dental Sciences, Foundation IRCCS Ca’ Granda Polyclinic, Via della Commenda 12, 20122 Milan, Italy. Email: giulio.rasperini@unimi.it

Submitted June 12, 2019; accepted July 31, 2019.  
©2020 by Quintessence Publishing Co Inc.
effective in correcting peri-implant facial bone dehiscence up to 10 years, with a success rate of 95% and stability of hard and soft tissue around the peri-implant structure.7 The combination of autogenous bone and bovine bone with a collagen membrane was found to be successful in horizontal alveolar ridge deficiencies in the posterior maxilla or mandible that did not allow simultaneous implant placement.8 Regardless of the bone grafts and membranes utilized, GBR has been related to several complications, including wound dehiscence, membrane exposure, infection, swelling, and patient morbidity.9,10 It has been suggested that tunnel flaps preserving the integrity of the papillae without vertical-releasing incisions may not only minimize postoperative morbidity but also enhance the blood supply of the flap, providing more-favorable wound healing.11 Therefore, it is not surprising that tunnel-like approaches have been performed for root coverage purposes, soft tissue augmentation, and regenerative therapy.11–13 Block and Kelley described a subperiosteal tunnel technique using a xenogeneic bone graft and a collagen membrane for horizontal GBR, reporting successful outcomes and minimal patient morbidity.14 Tunnel technique was also shown to have a decrease in membrane exposure rate, patient morbidity, and antibiotic intake compared to open-flap techniques when GBR was performed with a nonresorbable membrane.9 Nevertheless, tunnel GBR may also be more technique-sensitive than conventional approaches9,10 and may result in poor membrane stabilization and the dispersion of graft particles.9,10,14 Therefore, the aim of the present study is to describe a tunnel technique with a subperiosteal bag for horizontal GBR, highlighting its main advantages through a case presentation.

Materials and Methods

Patients referred to a private clinical practice in Petach-Tikva, Israel, for implant rehabilitation and requiring horizontal bone augmentation prior to implant placement were screened for inclusion in this case presentation. The indication for horizontal GBR resulted from a deficiency in the alveolar ridge width, while the vertical bone height was within normal limits. Patients in good physical health who were able to maintain good oral hygiene were included in the present study, while pregnancy, taking medications or receiving treatment that could negatively affect the healing of periodontal tissues (eg, steroids), uncontrolled diabetes, and bisphosphonate therapy excluded patients from the present study. Cone beam computed tomography (CBCT) scans were taken before and 6 months after the bone augmentation procedure. After a thorough explanation of the study protocol and the related risks and benefits, patients signed informed consent forms. The study protocol was in accordance with the Declaration of Helsinki of 1965, revised in Tokyo in 2004. Surgeries were performed by one experienced dentist (B.K.) between July 2017 and February 2018. The intervention involved a horizontal ridge augmentation using a bilayer resorbable collagen membrane (Bio-Gide, Geistlich) and bovine-derived xenograft bone substitute (Bio-Oss, Geistlich). The bilayer collagen membrane was extraorally perforated, folded, and sutured with a resorbable suture (Vicryl 3-0, Ethicon) to create a “bag” with an opening. The bag was perforated with a punch only in one side (Fig 1a). A vertical incision was performed in the buccal alveolar mucosa mesial to the alveolar ridge defect. Blood from the vertical incision was sucked inside the syringe of the Bio-Oss Pen (Geistlich) to soak the bone substitute particles. The bag was then filled with the xenogeneic bone graft through the opening of the bag (Fig 1b), which was then closed using a resorbable suture (Vicryl 3-0, Ethicon) (Fig 1c). At least 20 cm of the resorbable suture and its needle were left extending from the bag.

When the bony defect was located in the maxilla, a buccal subperiosteal tunnel with a vertical incision was performed with elevators. The subperiosteal dissection was extended beyond the bone deficiencies and also at the level of the alveolar crest until the tunnel flap was tension-free and ready for the insertion of the bag. Efforts were made to avoid any lacerations in the tunnel flap and to maintain the integrity of the periosteum. The dimensions of the subperiosteal tunnel were assessed using a bullet-like tool (Surgical Template, Osmed), which was inserted inside
the tunnel. After that, a sufficient volume of the tunnel was achieved, and the needle and the long end of a resorbable suture, which was connected to the bag, were inserted inside the tunnel from the opening of the subperiosteal tunnel and taken out distal to the bone defect. The bag was then inserted inside the subperiosteal tunnel in a way that the perforated side of the bag was facing the alveolar ridge and the nonperforated side of the bag was facing the flap. The excess resorbable suture connected to the bag was used to pull the bag inside the subperiosteal tunnel. The bag was not fixed. Simple interrupted resorbable sutures (Vicryl 3-0, Ethicon) were then used to achieve primary closure of the vertical incision.

In the mandible, a lingual subperiosteal tunnel was also made and connected through the crestal region to the buccal subperiosteal tunnel. The opening of the lingual subperiosteal tunnel was performed at the lingual aspect of the anterior mandibular teeth using an intrasulcular incision. The purpose of the lingual subperiosteal tunnel is to enable the insertion of the subperiosteal bag from the lingual aspect to avoid compression of the mental nerve. The subperiosteal bag was inserted inside the lingual tunnel and slid over the crestal region to be placed adjacent to the buccal aspect of the posterior mandible. Simple interrupted resorbable sutures (Vicryl 3-0, Ethicon) were then placed for closure of the lingual flap and the buccal vertical incision. Postoperative instructions included the prescription of amoxicillin/clavulanic acid 875 mg/125 mg two times a day for 1 week as well as 275 mg of naproxen sodium every 4 to 6 hours for the first 3 days with further doses only taken as needed. It was recommended to intermittently apply an ice bag on the operated area for the first 2 hours. Patients were instructed to rinse twice daily with 0.2% chlorhexidine and to avoid any mechanical trauma, toothbrushing, and excessive muscle traction in the surgical area for 4 weeks. The patients were recalled at 1, 3, and 6 months, at which time a CBCT scan was performed and implant placements were planned.

**Case 1**

A 53-year-old woman presented with missing maxillary left premolars and molars and a maxillary horizontal bone deficiency at the molar region. The patient refused to undergo a sinus lift procedure, and thus staged GBR followed by angulated implant placement was planned. Figures 2a and 2b show the horizontal defect. After the subperiosteal tunnel flap preparation involving a vertical incision above the lateral incisor, the collagen membrane was folded and sutured to form a bag that was then filled with 1.5 cm³ of xenogeneic bone graft particles soaked with the patient’s own blood. A resorbable suture, which was connected to the bag, was inserted inside the subperiosteal tunnel and taken out distally at the molar region to facilitate the insertion of the bag, which was then inserted into the tunnel flap (Figs 2c and 2d). The vertical incision was then closed with simple interrupted sutures (Fig 2e). Soft tissue healing was uneventful, and the patient reported minimal postoperative discomfort. Six months after
the surgery, an additional CBCT scan was performed (Fig 2f). The bone volume gain was also shown at the “re-entry,” where four implants (NICE and SPI implants, Alpha-Bio Tec) were placed (Fig 2g).

Case 2
A 72-year-old woman with a severe osteoporosis condition presented with missing maxillary left premolars and molars and a horizontal bone deficiency at the premolar region (Figs 3a and 3b). The bag was prepared and filled with xenogenic bone graft. The tunnel technique for horizontal GBR was performed with a vertical incision in the facial

Fig 2 Clinical case of horizontal ridge deficiency in the maxillary posterior area treated with tunnel technique and subperiosteal bag. (a) Preoperative clinical view. (b) CBCT scans showing bone dimension. (c and d) Via the vertical incision, the bag is inserted in the tunnel flap such that the perforated side faces the alveolar ridge and the nonperforated side of the bag faces the flap. (e) Flap closure. (f) CBCT scans showing horizontal bone gain 6 months after surgery. (g) Reentry and implant placement 6 months after the guided bone regeneration procedure.
mucosa, above the mesial region of the left upper canine. A subperiosteal tunnel was formed while verifying with a bullet-like tool that the subperiosteal tunnel was large enough for bag insertion. A resorbable suture, which was connected to the bag, was inserted inside the subperiosteal tunnel and taken out distally at the molar region. The suture was then pulled to facilitate the insertion of the bag, which was positioned with its perforated side facing the bone (Fig 3c). Resorbable mattress sutures (Vicryl 3-0, Ethicon) were then placed to achieve primary closure of the vertical incision. Postoperative healing was uneventful, and minimal discomfort was reported by the patient. After 6 months, the new CBCT showed a significant increase in the horizontal bone dimension (Fig 3d) compared to baseline (Fig 3b). Four implants (NICE and SPI implants) were placed at reentry (Fig 3e).

Case 3

A 58-year-old woman presented with missing mandibular left second premolar and molars and a mandibular horizontal bone deficiency at the premolar region, in particular in the coronal facial aspect (Fig 4a). A tunnel approach with a facial vertical incision at the level of the facial mesial aspect of the canine was performed together with a full-thickness flap elevation on the lingual side such that the subperiosteal tunnel extended from the buccal to the lingual aspects of the posterior alveolar ridge. The collagen membrane was extraorally folded, sutured, and filled with xenogeneic bone graft soaked with the patient’s own blood. The insertion of the bag into the tunnel, which was facilitated by the use of a resorbable suture, was made from the lingual aspect of the alveolar ridge. The bag was then manipulated over the alveolar ridge to be at the buccal aspect with the perforated side of the bag facing the bone (Fig 4b). In this case, the bag

Fig 3 Clinical case of horizontal ridge deficiency in the maxillary posterior area treated with tunnel technique and subperiosteal bag. (a) Preoperative clinical view. (b) CBCT scans showing preoperative bone dimension. (c) A collagen membrane was perforated and sutured to form a bag, which was filled with xenogeneic bone graft and then inserted into the flap. (d) Six-month CBCT scans showing horizontal bone gain. (e) Reentry and implant placement 6 months after the bone regeneration procedure.
was fixated using two titanium tacks (Botiss Biomaterials) (Fig 4c). The vertical incisions at the buccal aspect and the lingual flap were sutured with simple interrupted sutures. Healing was uneventful, and minimal discomfort was reported by the patient. After 6 months, a new CBCT scan was performed. Significant horizontal bone gain was observed (Fig 4d) compared to the initial situation (Fig 4a). The amount of bone gain was confirmed at reentry, in which an adequate alveolar ridge allowed for the placement of three implants (SPI) (Fig 4e).

Discussion

The predictability of horizontal GBR has been well established in the literature, as well as the risk of membrane exposure as a main complication related to this procedure.\textsuperscript{1,10,15} Flap design and management are
believed to be crucial for obtaining healing by primary closure of the surgical site following GBR. In this view, tunnel-like approaches avoiding vertical releasing incisions have been proposed for managing deficiencies of hard and/or soft tissues in an attempt to minimize tissue trauma, enhance blood supply, and obtain uneventful wound healing.\textsuperscript{10,11,16} Therefore, it is not surprising that Deeb et al found that GBR with tunnel technique (with injection of particulate bone graft into a subperiosteal pocket) was associated with less wound dehiscence/membrane exposure and lower morbidity than GBR with an open approach involving the use of a nonresorbable membrane.\textsuperscript{9} Another advantage of the tunnel technique highlighted by the authors was the lower number of postoperative visits and surgical procedures, leading them to conclude that tunnel technique was a more cost-effective approach with similar clinical outcomes compared to “traditional” GBR.\textsuperscript{9} In line with these results, the present article suggests that an adequate horizontal ridge dimension can be obtained with a tunnel approach and the use of a subperiosteal bag containing xenogeneic bone graft. It can be speculated that inserting particulate bone graft material into a folded bioreabsorbable collagen membrane, such that the perforated side of the membrane was facing the alveolar ridge and the non-perforated side the flap, may provide additional benefits by preventing the ingrowth of competing non-osteogenic cells into the defects.\textsuperscript{16–18} Another advantage of this technique is the preservation of an intact periosteum layer in the flap that can also contribute to the bone regeneration with its osteoinductive properties.\textsuperscript{10,19} Further, in line with the literature,\textsuperscript{7,20,21} the present authors found that the combination of xenogeneic bone graft and collagen membrane was found to be effective in regenerating an adequate horizontal bone volume, as suggested by the CBCT 6 months after the tunnel GBR and as confirmed at the time of the reentry for implant placement. Two recent systematic reviews and meta-analyses further validated that the most successful treatment for horizontal ridge deficiencies was the combination of grafting material with a barrier membrane\textsuperscript{22} and that the use of xenogeneic bone graft (in addition to autogenous grafting) was effective in reducing graft resorption.\textsuperscript{23} Other minimally invasive tunnel-like techniques for ridge augmentation have been described.\textsuperscript{10,16} These approaches rely on the properties of platelet-derived growth factor that stimulated a cascade of events, including chemotaxis and proliferation of bone cells,\textsuperscript{24,25} without needing the addition of barrier membranes.\textsuperscript{25,28} Lastly, it has to be mentioned that several techniques other than GBR have been proved to be effective in clinical scenarios with limited bone volume, such as alveolar ridge-split technique and narrow/short implants.\textsuperscript{27–30}

Within the limitations of the presented technique, the limited visibility and the relative difficulty in flap releasing compared to “open” approaches have to be mentioned. Additional studies with a larger sample size are needed to further evaluate the predictability of the present technique in horizontal ridge augmentation.

Conclusions

The present article presents a tunnel technique with a subperiosteal bag for horizontal guided bone regeneration that may enhance the clinical and patient-related outcomes of horizontal GBR. In the illustrated cases, this novel technique resulted in a significant horizontal bone gain that allowed for implant placement. Further studies comparing the present technique to traditional approaches are needed to assess the efficacy of tunnel GBR with a subperiosteal bag in regenerating horizontal bone volume, as well as in reducing the incidence of complications and patient discomfort.

Acknowledgments

The authors declare no conflicts of interest.

References


