EFFECTIVENESS OF BICHAT’S BUCCAL FAT PAD (BFP) TECHNIQUE FOR VERTICAL RIDGE AUGMENTATION IN THE MAXILLA.

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The aim of this study was to evaluate the efficacy of buccal fat pads (BFP) as a natural barrier to cover nonresorbable devices for vertical ridge augmentation (VRA). A total of 12 consecutive patients with 14 vertical bone defects in need of bone augmentation for implant-prosthetic rehabilitation were treated according to the described protocol. VRA was performed by means of (1) customized titanium meshes, (2) titanium-reinforced PTFE membranes, or (3) resorbable membranes plus titanium plates. After buccal flap release, the BFP was identified, isolated, then mesially and coronally advanced to cover the whole augmented area. BFP was used as a pedicle flap in 11 cases and as free graft in 3 cases. The mean surface of the BFP obtained was 13.5 ± 5.5 cm². In all 14 augmented sites, uneventful healing was assessed. No patients reported healing complications or facial volumetric changes. The
mean VBG was 4.2 ± 1.8 mm. In this limited number of cases, the technique using the BFP as a natural barrier has proven to be efficient in bone augmentation, as it has shown to improve the healing process while reducing the risk of complications. *Int J Periodontics Restorative Dent* 2022. *doi: 10.11607/prd.5437*

**INTRODUCTION**

Guided Bone Regeneration (GBR) is one of the most efficient techniques for vertical ridge augmentation in both the maxilla and mandible, as reported by many authors 1-3. Clinical outcomes can be affected by various factors such as: patient habits, defect morphology, biomaterials and above all, uneventful healing. In this regard, healing complications may represent the most severe adverse events that often lead to partial or complete failure of the bone augmentation; most of post-operative complications were infections without an exposure. Urban et al. (2019) 3 also reported that GBR using non-resorbable membranes revealed about 5.0% complications, although most of the authors agree that this technique remains difficult and requires expert surgeons 4.

In a recent systematic review, membrane exposure after GBR has shown a significantly negative influence on the outcome of bone gain 5. Similarly, Hartmann et al. (2019) 6 reported a healing complication rate of approximately 35% after grafting procedures; in particular, a strong correlation was found between barrier exposure and loss of grafted material while using customized titanium meshes. Recently, a cross-sectional study regarding healing complications after vertical and horizontal ridge augmentation with non-resorbable membranes has reported that 65% of exposures/infections were located in the maxilla but only 35% in the mandible 7.

For the aforementioned reasons, many authors have proposed different techniques for handling the surgical flaps to achieve tension-free primary closure and subsequent undisturbed healing, which is a key factor in GBR 8. A recent study has reported that exposure rates of approximately 65% were
observed in the maxilla compared to 10% in the mandible, after alveolar ridge augmentation using CAD/CAM customized meshes 9.

In order to improve soft tissue healing while consequently reducing the risk of barrier exposure, Bichat’s Buccal Fat Pad (BFP) can be used as a “natural barrier” to cover the augmented area before primary closure 10.

The BFP is a mass of adipose tissue, distinct from subcutaneous fat, which is localized in the zygomatic region: it extends behind the zygomatic arch, along the anterior border of masseter muscle, externally to the buccinator muscle reaching the lower and anterior part of the temporal muscle 11. It is characterized by a mean volume of approximately 10 mm3 and a mean weight of approximately 9 g; after a complete dissection, it can be employed to cover a surface of approximately 10 cm2 12. Moreover, the BFP is a source of mesenchymal stem cells, having multipotent properties due to secretion of trophic factors, which are capable of stimulating cell proliferation and differentiation as well as migration of various cell types 13,14.

Even though the BFP has been used to cover block bone grafts in reconstructive procedures to enhance immediate primary soft tissue closure, no study has applied this anatomical structure in the GBR technique.

Based on these factors, the aims of this case series were (i) to validate the feasibility of the BFP to cover titanium meshes or non-resorbable membranes under the primary flaps (ii) to evaluate the effectiveness of BFP to reduce healing complications, i.e. early and late exposures, after vertical ridge augmentation procedures in the maxilla (figure 1).

MATERIALS AND METHODS

STUDY DESIGN
In total, 12 consecutive patients were referred to the authors for horizontal and vertical ridge augmentation in the maxilla; all of which were enrolled and treated from October 2018 to September 2019.

All patients received a detailed explanation of the surgical protocol, information about advantages/disadvantages and benefit/risk ratio, and a written consent form and an informative sheet, detailing the protocol and the treatment he/she was scheduled to undergo.

The inclusion criteria included: the need of a vertical bone augmentation surgery, to place standard implants, in the maxilla. The exclusion criteria included general medical conflicts to implant surgery.

OPERATIVE PROTOCOL

All patients received a professional oral hygiene treatment one week before surgery and were instructed to perform correct oral hygiene home procedures.

The day of surgery (T0), antibiotic prophylaxis (Amoxicillin/Clavulanic Acid 2.0 g) was administered 2 hours prior to GBR intervention. Immediately before the surgery, professional oral hygiene was repeated and 3 different mouth rinses were administered to the patients: iodopovidone 10% for 1 minute, hydrogen peroxide 10vol. for 2 minutes, and chlorhexidine 0.3% for 3 minutes. A sterile protocol was adopted for both patient and clinician in order to avoid any contamination.

The area to be treated was anesthetized using Articaine hydrochloride 4% with epinephrine 1:100,000. The surgery started with a mid-crestal incision and two vertical mesial and distal incisions which are used to raise full-thickness buccal and palatal flaps in order to expose the residual alveolar ridge. Approximately, 0.5-1.0 g of autogenous bone was harvested from the buccal aspect of mandibular ramus using a bone scraper (Safe Scraper, Meta, Reggio Emilia, Italy). The grafting material was prepared by a mixture of: 50:50 of harvested autogenous bone and xenograft (Zcore, Osteogenics, Lubbock, Texas, USA; Bio-Oss, Geistlich Italia, Thiene, Italy) plus peripheral venous blood. The surgery proceeded with the fixation of the barrier device, i.e. CAD/CAM customized titanium meshes or titanium-reinforced dense-PTFE membranes (Cytoplast Ti-250, Osteogenics,
Lubbock, Texas, USA), on the palatal side with 2-3 titanium mini-screws (Profix system, Ostegenics, Lubbock, Texas, USA). A resorbable membrane was finally placed over the non-resorbable device (Cyotplast RTM, Osteogenics, Lubbock, Texas, USA; Bio-gide, Geistlich Italia, Thiene, Italy). Subsequently, the space under the barrier device was filled with grafting material, making it as compact as possible to avoid empty gaps. Finally, the device was carefully closed and perfectly fixed on the buccal side using 2-3 titanium mini-screws or/and 4-6 titanium tacks (Maxil System, Omnia, Parma, Italy).

At this time, the buccal flap was released by means a superficial periosteum incision from the distal vertical incision to the mesial one; subsequently, the alveolar mucosa was divided from muscular structures using a deep incision that was parallel to mucosal level; thus, adequate dissection and mobilization of buccal flap without any tension was achieved.

The access to BFP was performed in posterior region of the buccal flap by cutting the dense connective tissue which was exposed after the periosteal incision was performed on the inner surface of the flap, about 10-20 mm apically to the alveolar ridge in correspondence of the second and third upper molars. After first incision, the BFP was easily visible and identified as a yellowish area, because the fat tissue is usually encapsulated by a thin connective tissue; it is was needed to cut this capsule with a second incision to access to the BFP, that was held with a tweezer and gently detached with a blunt dissection and a simultaneous traction with rotational movements. This allowed a progressive excision of the BFP. In the most coronal portion of the BFP there are no significant blood vessels and the risk of hemorrhage is limited. Its dissection and mobilization without any tension was achieved and subsequently pulling it over to cover the augmented area.

Prior to the flap closure, the BFP was carefully anchored to the palatal flap using a 6/0 suture, paying close attention to completely cover the titanium mesh or PTFE membrane. If necessary, the BFP was partially extruded and the fat free graft was sutured above the augmented sites. Finally, the
surgical flaps were coronally advanced and sutured using horizontal mattress for flap overlapping and multiple interrupted sutures for hermetic closure of the wound.

After 6 to 12 months of submerged healing (T1), after TC cone beam, the augmented sites were reopened with a crestal linear incision. The removal of the barrier devices and the mini-screws was followed by implant placement. Two or more tapered dental implants, depending on the clinical treatment plan, were placed in the prosthetically ideal position (Figures 2, 3, 4, and 5).

Antibiotic and anti-inflammatory therapies were prescribed for 7 days,

DATA COLLECTION AND MANAGEMENT

At the preliminary visit, personal data, medical and dental history, and patients’ habits were collected by asking the patients the required information. Written anamnestic and medical questionnaires were signed by all patients. A clinical evaluation was performed to assess the presence of local disease, i.e. periodontitis or peri-implantitis. During surgery and postoperative visits, all clinical and healing data were collected on a dedicated case report form (CRF), which was regularly updated at every patient appointment.

The following parameters were recorded between T0 and T1: region of interest, defect type, periosteum type (native/scarred), surgical approach (Ti-reinforced d-PTFE membranes, CAD/CAM customized Ti-mesh, Fence technique 15,16, BFP dimensions and total surface (measurements rounded to the nearest 5mm using UNC-15 periodontal probe), surgical complications (severe bleeding and hematoma, infraorbital nerve injuries, flap perforation or lacerations) and healing complications (exposure £ 3mm without suppuration, exposure 3mm without suppuration, exposure with suppuration, and abscess without exposure) 17, and facial asymmetry (frontal view and lateral view). During the implant surgery (T1), after removal of the barrier device, the data collection included vertical bone gain (VBG) which was measured on CBCT in correspondence to the maximum defect, bone density (soft, medium, hard), pseudo-periosteum type (class I, class II, class III) 18, the number of implants inserted, implant stability, implant osseointegration (Figures 6, 7, and 8).
RESULTS

Twelve patients, seven women and five men, mean age 54 years, showing 14 localized bone defects in need of bone augmentation were consecutively treated according to the data collection protocol, based on vertical ridge augmentation and application of the BFP before closure. Six patients had a history of periodontitis or peri-implantitis and other four patients had smoking habits (less than 20 cigarettes/die). No patients had severe systemic or metabolic disease. All surgeries were accomplished without unexpected events or adverse reactions, except for a hemorrhage and a transient paresthesia; and no drop-out occurred during follow-up period.

The majority of the sites (n=7) were located in posterior maxilla, five sites involved both the anterior and posterior maxilla, and only two were in anterior maxilla. The regions of interest were classified according to Kennedy’s classification (I=4; II=5; III=4; IV=1) and they had a median extension of 4.5 teeth (range: 3-8). Eight sites showed a native periosteum, while six sites had scarred periosteum which was due to previous invasive surgical procedures, i.e. augmentation interventions. Furthermore, most sites (n=8) were restored using customized meshes, three sites were treated by means of Ti-reinforced PTFE membranes, and three sites with titanium plates and collagen membranes. Finally, the BFP was used as a pedicled flap in eleven cases and as free graft in three cases; the mean surface of the BFP was 13.5 ± 5.5 cm² and in all sites the BFP was correctly mobilized and sufficient to cover the entire augmented area (Figures 9, 10, 11, 12, and 13).

Only two surgical complications occurred: one important intra-operative hemorrhage and one transitory paresthesia (< 1 month); consequently, the surgical complication rate was assessed to be 14.3%. Neither early or late exposures nor abscesses without exposure were observed between T0 and T1, having a healing complication rate of 0.0%. The median time of healing was 9 months, ranging from 6 to 12 months before implant surgery.
At re-entry surgery (T1), the majority of sites (n=7) showed a medium bone density, four sites had soft density, and only three sites showed a hard bone density; in regard to the pseudo-periosteum type most of sites (n=8) were assessed as belonging to class I, three sites belonging to class II, and other three were classified as class III. The mean VBG was measured, comparing the first and second CBTC, to 4.2 ± 1.8 mm (Figures 14, 15, and 16). In total, 35 implants were inserted in 12 patients and all implants achieved osseointegration. Characteristics and outcomes of all treated sites were resumed in table 1 and 2, while characteristics of the implants were reported in table 3.

DISCUSSION

The primary healing of soft tissues is an essential condition to prevent dehiscence of augmented sites, exposure of the underlying non resorbable barrier devices, and infectious complications which leads to the failure of GBR procedures 19.

Although a meta-analysis of the literature reported that resorbable membranes were more prone to complications than non-resorbable membranes (23% versus 7%) 3, non-resorbable membranes that are needed in the most severe deficiencies are obviously more prone to infection and suppuration in case of exposure compared with resorbable ones. The range of barrier device exposures was observed to be between 0% and 45% for vertical ridge augmentation 20.

In the literature, a variety of flaps and incision lines have been proposed so as to try to overcome this problem, which included: periosteal scoring, hockey stick line incision, palatal advanced flaps and coronally positioned advanced flaps 21,22. As reported by Gallo & Diaz (2019)7, the majority of healing complications was observed in the maxilla rather than in the mandible. The main cause of wound dehiscence is the failure to provide tensionless closure; moreover, in the posterior part of maxilla, this is not easily attainable due to the limited unextendible palatal tissue; in particular, for vertical reconstructions where the amount of reconstruction involves an essential advancement of the flaps. Some authors described the palatal advancement procedure, which involves splitting the palatal
tissues, rotating out a pedicle graft, and/or advancing coronally the palatal mucosa; moreover, these surgical procedures have not been widely used due to their complications and anatomical limitations 22-24. Consequently, many authors have thoroughly described the management of the buccal flap in order to maximize its mobilization and coronal advancement.26-30

Expert surgeons reported that defects treated simultaneously with sinus augmentation and vertical GBR gave similar results to other areas of the jaw treated with vertical GBR only, but surgical experience and knowledge are skills required for success 31. Since the high rates of healing complications reported by different authors after vertical ridge augmentation, Urban et al. (2016) 32 proposed a classification of flap designs that considers vestibular depth and scar formation around the periosteum.

Since the first description of its application in 1977 by Egyedi 33 the BFP has been successfully used for closing oral defects due to its reliability and easy harvesting. Later, some authors 9 reported the use of a free fat tissue grafts (FFG) in a case series of 20 atrophic ridges that were in need of bone augmentation for implant placement, in which the fat tissue was harvested from the BFP to cover bone grafts.

The rational for the use of the BFP in GBR techniques are both clinical and biological. First, the interposition of an adjunctive natural barrier under the primary flaps can reduce the risk of contamination of non-resorbable devices in case of wound dehiscence. Moreover, the pedicle BFP can completely re-epithelize in humans within 3 to 4 weeks, due to its vascularity through the descendent branches of the maxillary artery, the superficial temporal artery and the facial artery 34. Furthermore, BFP is a rich source of mesenchymal stem cells, including a sub-population characterized by the simultaneous expression of specific markers, which allow them to be classified as multilineage differentiating stress enduring cells 13-12. Finally, Khojasteh and colleagues 35-37 demonstrated that adipose-derived stem cells harvested and isolated from the BFP can enhance the amount of new bone formation and decrease bone resorption of autogenous iliac bone grafts. The aim of the present case
series was to evaluate the BFP in the GBR techniques in order to prevent the risk of exposure and infection after vertical ridge augmentation. Among the 14 severe defects treated with titanium mesh or non-resorbable membrane, no early or late exposure of the device was observed and all site treated healed uneventfully; All the defects treated were in the maxilla; moreover, due to their different morphology, three different techniques were used, namely Ti-reinforced d-PTFE membranes, CAD/CAM customized Ti-mesh and the fence technique (Tab.2). The number of patients within the groups are too small to compare them, but it allows to evaluate the feasibility of BFP in different clinical scenarios. The mean surface of the BFP obtained was $13.5 \pm 5.5$ cm$^2$, and allowed a complete coverage of the reconstruction sites in all cases. Apart from the primary flap closure, the evaluation of the effectiveness of the BFP and FFG, was based on the morbidity, postoperative complications, volumetric and vertical augmentation as well as dental implant integration.

A more accurate method to determine the volumetric bone gain should be used in further studies in order to compare the outcomes obtained in different defects. A volumetric analysis before and after bone augmentation can be performed using dedicated softwares, as described by the authors. In this case series, only VBG was calculated for all patients using CBCT analysis; volumetric parameters were instead calculated for patients treated with digital procedures, i.e. customized meshes and d-PTFE membranes (9 out of 14), giving a planned bone volume of augmentation of $1.44 \pm 3.1$ cm$^3$.

The following difficulties were observed during surgery: (i) the management of the adipose pedicle/graft, where the laxity and fragility of the BPF needed a gentle traction with a plier to avoid lacerations and careful dissection with blunt instruments; (ii) the need to advance the pedicle flap beyond the augmented area in order to achieve its passive fit and its tension-free stabilization over the barrier devices; (iii) the attention to suture the primary flaps to avoid to involve the fat tissue between their connective layers.

Regarding the risk of vascular damage, in these case series one patient had a severe hemorrhage due to a lesion of a descendent branches of the internal maxillary artery, which was not related to the
BPF detachment and advancement because it happened during buccal flap mobilization when the alveolar mucosa was divided from muscular structures using a deep incision. This complication was managed with 30 minutes of continuous manual compression without other procedures. The BFP procedure was used on small number of patients without any complications. However, potential complications such as exposure and necrosis of this adipose tissue may occur in a larger number of patients.

At the time of suture removal, at implant placement, and at follow-up visits, no significant facial asymmetry was reported and no complaint of esthetic changes was reported by any patients. This observation was justified by the extension and the dimension of the entire BFP, which was approximately 10 mm³ 39.

Different authors reported that main healing nature of the BFP was fibrosis of the graft and they suggested that this tissue may create satisfactory clinical attachment level and it can adhere strongly to the implant surface 10, 40-41. Although adipose tissue changes in fibrous tissue as reported by previous authors and a following intervention of soft tissue augmentation improves the peri-implant mucosal seal, clinical and radiographic evaluations about soft tissue attachment should be carried out over time 4.

While no clinical difference was observed in the healing when the BFP was used nor the FFG, a shallow vestibular sulcus depth was found in all pedicled cases, which needed an apically repositioned buccal flap and/or a free gingival graft at implant uncovering, in order to restore the muco-gingival junction and to increase the quantity of the keratinized tissue on buccal side of implants. It would be very interesting to leave a part of the BFP exposed to avoid this clinical circumstance, but no data are available regarding the capacity of the BFP alone to protect the non-resorbable device and the grafted biomaterial underneath, avoiding their exposure and infection, although it has been reported that FFG harvested from the BPF and left partially exposed over bone graft underwent epithelialization which was clinically evident at two weeks 9.
Moreover, the influence of the BPF on the pseudo-periosteum and bone density was clinically assessed at the time of device removal and implant placement. However, the reported data did not suggest a significant effect of BPF on these parameters, probably in relation to the use of barrier devices, i.e. non-resorbable and/or resorbable membranes, separating the BFP from the graft biomaterial and excluding any possible effects of BFP on grafted bone.

Finally, the effect of the use of different augmentation procedures, i.e. titanium meshes or non-resorbable membranes, is not controlled in this case series and the adjunctive effect of the BFT procedure is unclear. Although all patients healed without exposures or infections, this case series did not prove a better healing potential of BFP, but it can suggest the favorable role of BFP after different bone augmentation approaches, used for vertical ridge augmentation in anterior and/or posterior maxilla.

CONCLUSIONS

Considering the limitations due to the small sample size, the Bichat’s Buccal Fat Pad technique showed promising results to prevent healing complications after vertical ridge augmentation in the maxilla; in particular, regarding early or late exposure of the non-resorbable membrane, titanium mesh or miniplate. The BFP used as “natural barrier” to cover augmented sites seems to be an efficient technique to improve soft tissue healing; however, studies with more cases are needed to validate this procedure.

ACKNOWLEDGMENTS

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data collection and parameters measurements for this study. The English of this manuscript was revised by a professional native-speaker, Nathalie Ann De Vito. All authors have no conflict of interest.

REFERENCES


FIGURE LEGENDS

Figure 1. Patient n. 10 - a) Reinforced PTFE membrane was filled with autogenous bone and bone xenograft and it was fixed with titanium tacs. b) Pedicled BFP was used to cover the whole area: the fat tissue has been released and advanced, without tensions, from second molar to central incisor. c) Horizontal mattress sutures were performed to stabilize the BFP and to coronally advance the buccal flap above BFP. d-e) Vertical mattress sutures and single interrupted sutures were used to achieve a primary closure, keeping attention to avoid the interposition of fat tissue between the primary flaps. f) Soft tissue healing 6 months after GBR surgery. No exposures or infections were observed during healing time.

Figure 2. Patient n. 7 - a-b) Vertical bone defect in anterior maxilla after failure of a previous iliac onlay graft. c) Scarred periosteum due to the previous surgery and related failure complicated the buccal flap mobilization. d) Application and fixation of a reinforced PTFE membrane for horizontal and vertical ridge augmentation. e-f) Free BFP graft was chosen because of anterior localization of the augmented site.

Figure 3. Patient n. 7 - a) 9 months after GBR surgery, soft tissues showed a perfect healing without any complications. b-c) Occlusal and buccal views of the reinforced PTFE membrane at re-entry surgery d) After membrane removal, augmented area showed hard bone density and type-1 pseudo-periosteum.

Figure 4. Patient n. 6 - a) Buccal view of a vertical bone defect after failure of two implants due to perimplantitis. b-c) A customized titanium mesh filled with a mixture of: 50:50 of harvested
autogenous bone and xenograft. d) Customised mesh fixed with 3 titanium miniscrews. d) A large pedicled BFP was used to entirely cover the augmented area.

Figure 5. Patient n. 6 - a) Occlusal view showing a good soft tissue healing before re-entry surgery. b) After flap reflections, fat issue remnants with its typical yellowish color were observed in the inner part of the buccal flap. d) After mesh removal, a complete bone regeneration was observed and hard bone density and type-1 pseudo-periosteum were measured in the augmented site.
Appendices

Appendix Table 1. Characteristics of treated sites.

<table>
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<th>Number ID</th>
<th>Initials ID</th>
<th>Age</th>
<th>Sex</th>
<th>Period. disease</th>
<th>Smoking habit</th>
<th>Region of interest</th>
<th>Surgical Site</th>
<th>Extention (teeth)</th>
<th>Kennedy's class</th>
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* Bilateral augmentation site.
Appendix Table 2. Characteristics and outcomes of surgical procedures.

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* Bilateral augmentation site.
Appendix Table 3. Characteristics of implants in augmented sites.

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<th>Num. of implants</th>
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* Bilateral augmentation site.
Figures #5473

Fig 1

Fig 2
Fig 3
Fig 5