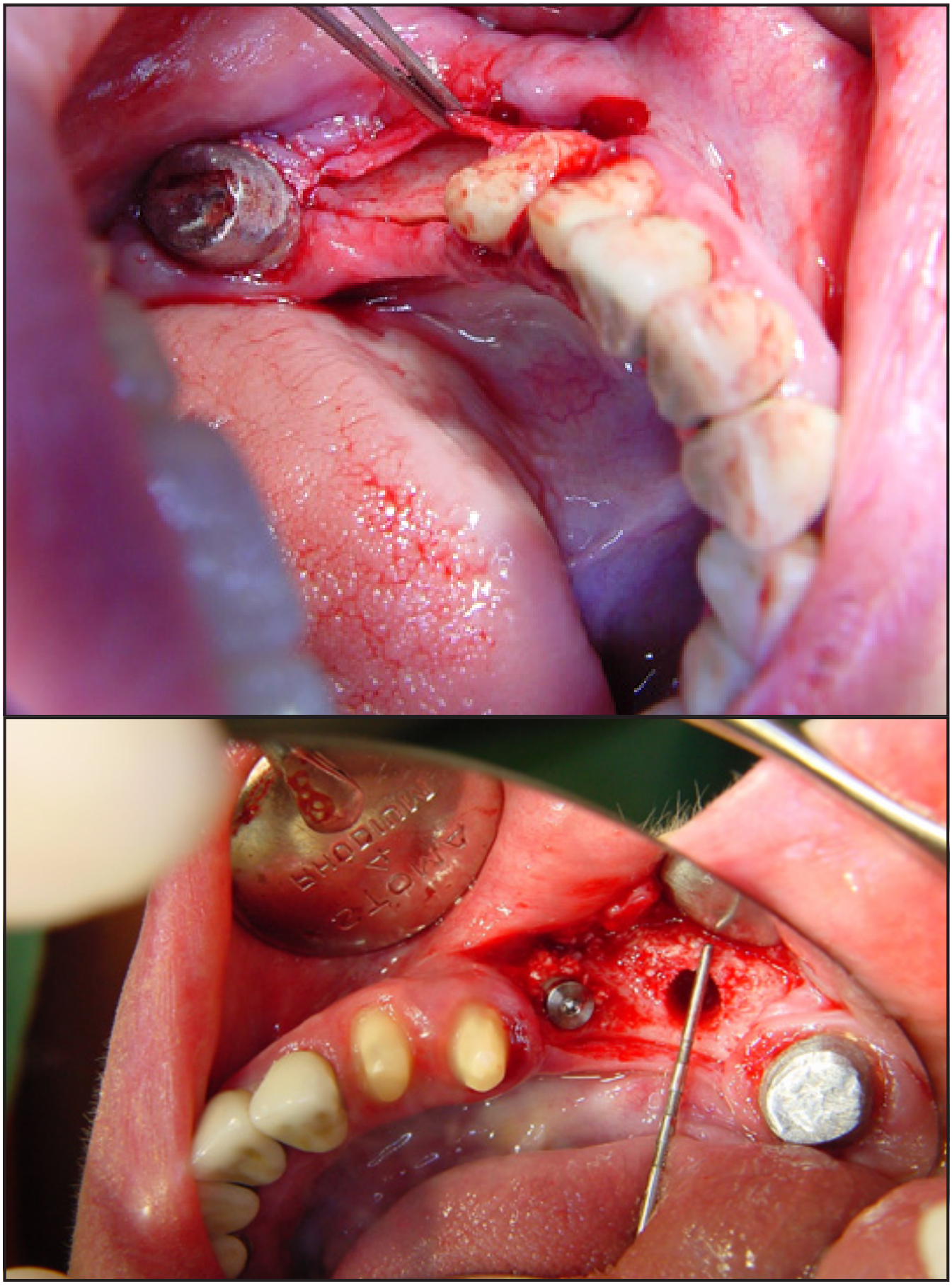
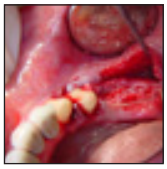


Periosteal Pocket Flap for Horizontal Bone Regeneration: A Case Series



Marius Steigmann, DDS/Maurice Salama, DDS, MS**/ Hom-Lay Wang, DDS, MSD, PhD****

Guided bone regeneration has been shown to be a successful technique to increase the ridge width for dental implant placement. However, in cases of severe or localized horizontal bone deficiencies, sufficient soft tissue mobilization to ensure primary wound closure over the augmented area can be difficult or challenging. This article describes a buccal periosteal pocket flap proposed to overcome these challenges. The flap design results in a periosteal pocket, which allows filling of bone-grafting material while facilitating primary, tension-free soft tissue closure by splitting of the mucosa. The flap gives stability to the augmented volume within the pocket. Ridge width changes of five patients consecutively treated with this technique were recorded before and 24 weeks after augmentation. Results from these cases showed a mean 389% ± 301% gain in bone width (range, 50% to 1420%) when the periosteal pocket flap design was used. Data obtained from this study suggest that the periosteal pocket flap design could be a predictable alternative flap approach for correction of severe or localized horizontal bone deficiencies. (Int J Periodontics Restorative Dent 2012;32:xxx–xxx.)

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Guided bone regeneration (GBR) has proven to be effective in regenerating deficient alveolar bone to allow for proper implant placement.[1–6] The procedure can be used either with or without simultaneous implant placement, pending the ability of obtaining primary implant stability.

Despite the success of GBR in implant dentistry, vertically deficient and knife-edged alveolar ridges remain as two major obstacles because of their unpredictable outcomes.[7,8] GBR procedures for so-called knife-edged alveolar ridges can be successful if autogenous bone, biomaterials, and resorbable membranes are used.[8–15] Although the histologic outcomes can vary from patient to patient, implant survival has been satisfactory, even on a long-term basis.[11] Autogenous bone has been regarded as the gold standard for the aforementioned demanding indications either with or without newly introduced growth factors (eg, platelet-derived growth factors, bone morphogenetic proteins). Nevertheless, autogenous bone suffers from quick resorption,

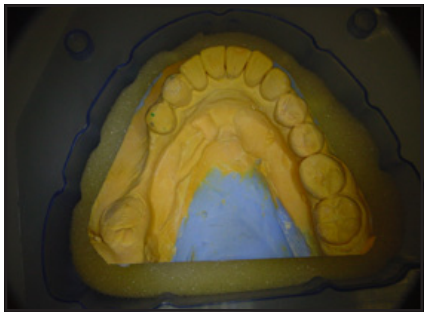


Fig 1 *Stone cast of a patient included in the study showing severe buccolingual bone resorption in the edentulous posterior mandible. [Au: Edit ok?]*

hence it cannot guarantee the stability of the augmented volume.[16,17] The use of slowly resorbing biomaterials—without any type of growth factor—has achieved good clinical outcomes in maintaining the augmentation volume.[11–13,15,17] However, the drawback of using such biomaterials is that the regeneration process is 1 to 3 months slower than autogenous bone–treated sites.[17]

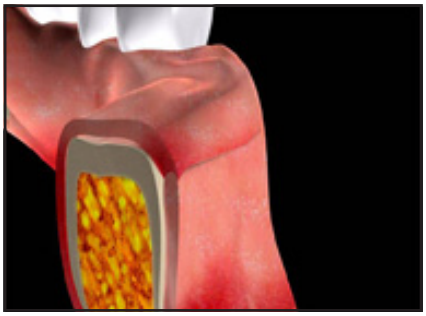
Another commonly encountered problem in vertical or horizontal GBR is soft tissue dehiscences. Since primary closure is a prerequisite for ensuring undisturbed bone regeneration, a soft tissue dehiscence often jeopardizes the outcome of treatment.[16,18–20] To achieve primary closure in vertical and horizontal GBR procedures, the soft tissue needs to be mobilized. For nonresorbable membranes, a soft tissue dehiscence will lead to early removal of the membrane, and therefore interfere with the final clinical outcome because of premature membrane exposure.[16,21,22] Collagen membranes do not need to be removed from the site if a soft tissue dehiscence occurs[22]; however, exposure to the oral environment leads to faster degradation of the material, thus jeopardizing the final clinical results.[19,20]

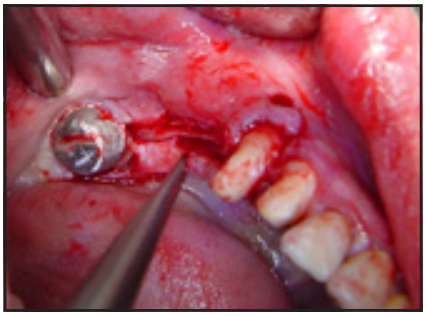
Soft tissue mobilization leading to tension-free primary closure is regarded as essential to achieving undisturbed bone regeneration. The periosteal pocket flap (PPF) technique presented here allows for tension-free primary closure of the soft tissue over horizontally augmented alveolar ridges.

Method and materials

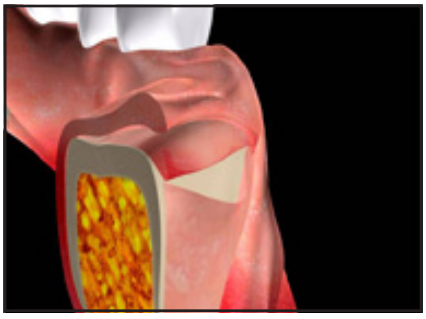
Five systemically healthy patients (two men, three women) between 38 and 62 years of age with inadequate alveolar ridge widths and in need of dental implants in the mandibular posterior region were included in this case series (Fig 1). Prior to enrollment, all patients were informed of the nature of the study and procedures involved as well as the potential risks associated with it. A consent form was then obtained before the patients were officially enrolled in this voluntary pilot trial. Medical histories were taken, oral soft and hard tissue examinations were performed, and, if indicated, patients were required to complete initial periodontal therapy. Preoperative radiographs were taken, including panoramic and standardized periapical films and computed tomography (CT) scans in three patients.

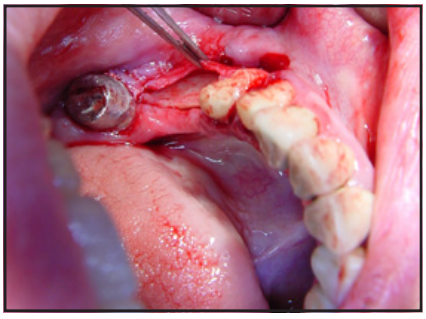
Two hours before surgery, patients were placed on 2 g **[Au: Correct?]** of amoxicillin. All patients were instructed to rinse with 0.12% chlorhexidine gluconate for 1 minute prior to the surgical procedure. Local anesthetic was administered for pain control. Bone-substitute material (Tutodent, Tutogen or Bio-Oss, Geistlich) was used to restore the alveolar ridge to a minimum of 6 mm wide, thus allowing each site





Figs 2a (left) **and 2b** (right) *The incision was made at the most coronal aspect of the bone at a 45-degree angle paracrestal to the buccal wall in the keratinized gingiva.*





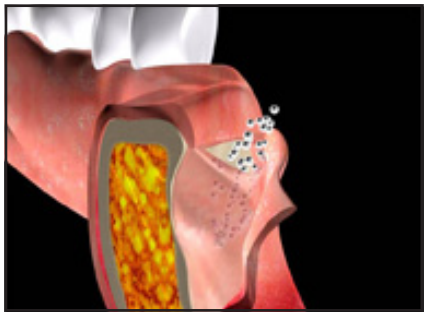
Figs 3a (left) **and 3b** (right) *The periosteum was detached from the bone using a periosteal elevator, forming a periosteal pocket, which was extended to the necessary vertical depth.*

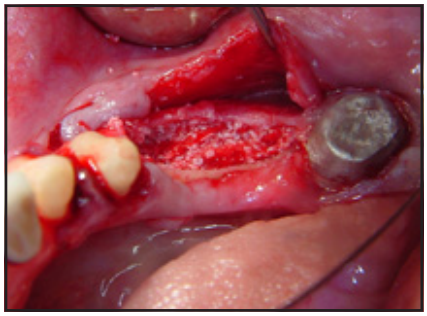
to receive a dental implant. In all cases, collagen membranes (three pericardium, Tutogen and two Ossix, Biomet 3i **[Au: Manufacturers correct?]**) were trimmed and placed over the graft material to protect the graft from contact with the mucosa and prevent soft tissue in-growth. No attempt was made to vertically augment the ridges above the height of the crest. Patients were seen for postoperative care at 3, 7, 14, and 30 days. Barrier coverage was evaluated for flap closure, and oral hygiene instructions were given. Flap sutures were removed at 15 days postoperative.

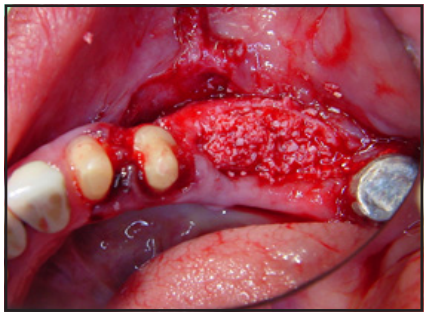
PPF surgical procedure

A full-thickness incision was made at a 45-degree angle paracrestal to the buccal wall in the keratinized gingiva. The incision was made at the most coronal aspect of the bone crest (Figs 2a and 2b). The mucoperiosteal flap was elevated from the horizontal part of the crest lingually. The buccal portion of the flap was split, separating the periosteum from the buccal mucosa for 10 to 13 mm apically, according to the programmed implant length. No releasing incisions were made. After splitting the flap, vertical releasing incisions were placed in the mucosa from the inside out on both sides, beyond the mucogingival junction (mesial and distal). Care was taken not to cut the periosteum and leave it remaining on the bone. Splitting of the mucosa allows for more flap elasticity.

Starting from the crestal incision, the periosteum was detached from the bone using a periosteal elevator extending apically between 8 and 12 mm, thereby forming a pocket between the buccal bone plate and the elevated periosteum. The vertical depth was determined by the shape of the bone and the planned implant length (Figs 3a and 3b).







Figs 4a to 4c (left to right) *Flap elasticity was increased by splitting the mucosa from the periosteum, and the periosteal pocket was filled with grafting material.*

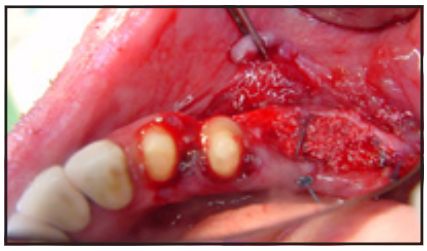
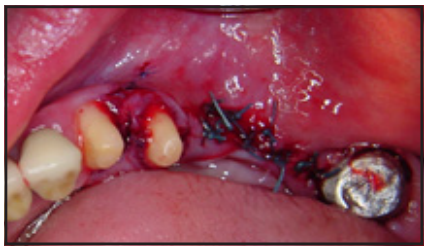


Fig 5a (left) *The initial mattress sutures kept the periosteum in place and extended from the lingual to the buccal apsects. Only the periosteum was sutured.*

Fig 5b (right) *A second layer of mattress sutures fixed the mucosa to the lingual mucoperiosteal flap.*



The periosteal pocket was filled with a slowly resorbing graft material after intra–bone marrow penetration to encourage angiogenesis, ensuring the volume stability of the augmented space (Figs 4a to 4c). An absorbable collagen membrane was then placed to cover the crestal portion of the graft material over which the periosteum did not extend.

Suturing was performed in two steps. The sutures were initiated through the lingual full-thickness flap going to the buccal periosteum and then returning through the buccal periosteum and continuing in the lingual full-thickness flap, as a mattress suture. Knots were placed lingually (Fig 5a). A second mattress suture fixed the mucosa buccally to the lingual mucoperiosteal flap. Knots were placed on the buccal aspect (Fig 5b).

Implant surgery

Prior to implant placement, CT scans were performed in three patients, and they confirmed the success of the grafting procedure (Figs 6a to 6c). The implants were placed 24 weeks after ridge augmentation (Figs 7a and 7b). The changes in mean ridge height and width were evaluated. All implants (Tapered Screw Vent **[Au: Zimmer?]**) were submerged. After implant placement, the flaps were sutured using interrupted sutures. Written and verbal postoperative instructions were provided. The implants were allowed to heal for 12 weeks, after which they were uncovered and

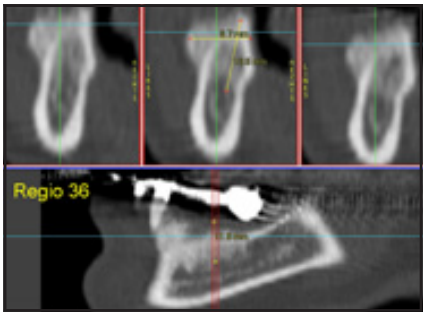


Fig 6a *CT scan after 24 weeks.*

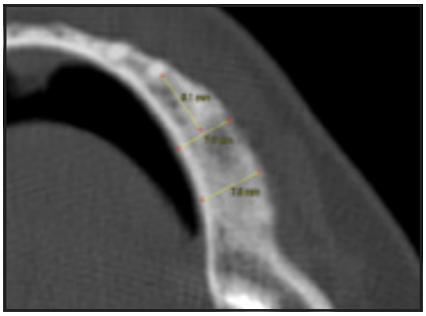


Fig 6b *Magnified view of the augmented area. The ridge width 2 mm from the peak of the crest was 7.8 mm.*

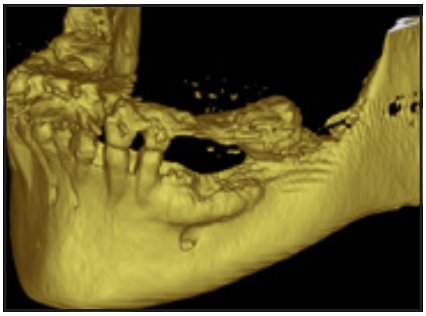
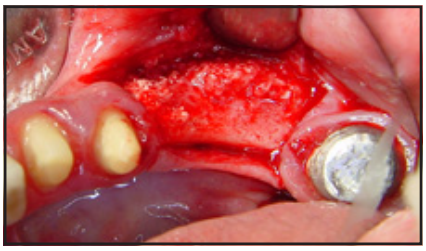
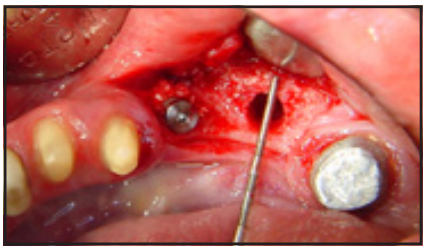


Fig 6c *Three-dimensional reconstruction of the CT scan showing the augmentated area.*



Figs 7a and 7b *Clinical view* (a, left) *before and* (b, right) *after the first implant was placed.*



healing abutments were placed. After 3 to 4 weeks, the definitive prosthesis was delivered. Each patient underwent a clinical follow-up protocol of clinical examinations every 3 months, and a periapical radiograph was taken after 1 year. **[Au: Edit ok?]**

Clinical measurements

After flap elevation, the ridge width was measured exactly at the midpoint of the programmed implant position using a periodontal probe (Stoma Dental System). The probe was placed at the most coronal level of the crest, perpendicular to the apicocoronal axis of the crest. One measurement of each implant site was taken for each patient. The same measurement was performed at implant placement. The difference between the two measurements (pre- and postaugmentation) was recorded (Table 1).

Table 1 **Clinical ridge measurements before and after the PPF augmentation procedure**

Patient no.	No. of implants	Baseline (preaugmentation, mm)	6 mo (postaugmentation, mm)	Change in ridge width (mm)	Bone gain (%)
1	3	0.5	7.6	7.1	1,420
		0.7	7.2	6.5	928
		1.0	7.8	6.8	680
2	2	2.4	7.6	5.2	225
		2.0	7.8	5.8	290
3	3	3.5	6.2	2.7	77
		3.2	5.5	2.3	72
		3.2	4.8	1.6	50
4	1	3.0	6.0	3.0	100
5	1	4.3	6.6	2.3	53
Mean		2.38 ± 1.11	6.71 ± 1.01	4.33 ± 1.92	389 ± 301

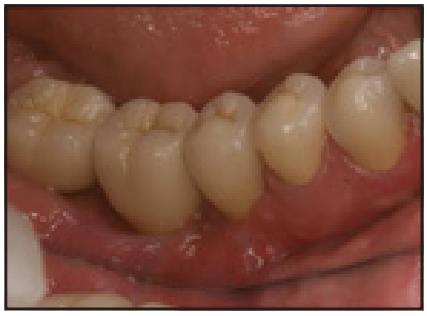


Fig 8 *Clinical view 2 years after the definitive restoration was placed.*

Results

All augmented sites healed without complication or membrane exposure. No persistent infection or pain was observed, indicating that the alveolar nerve was not affected by the procedure. The alveolar ridge width was increased by an average of 4.3 ± 1.9 mm (range, 1.6 to 7.1 mm). This represents a bone gain of 389% ± 301% (range, 50% to 1,420%). In one patient, a small buccal bone dehiscence was observed after implant placement, and a standard grafting procedure was performed. Primary implant stability was not jeopardized.

At the 2-year follow-up, all implants were functional, and no more than 1 mm of bone loss was observed around the implant shoulders in any of the periapical radiographs. Healing was otherwise normal (Fig 8).

Discussion

The objective of this case series was to introduce and evaluate the feasibility of a modified flap design, the PPF, to augment knife-edged alveolar ridges in preparation for dental implants. To verify the usefulness of the flap design, the dimensions of the alveolar ridge width were measured pre- and postoperatively. This flap design used during GBR proved highly successful in augmenting the ridge width. To achieve a predictable GBR outcome, a PASS principle that includes primary wound coverage, angiogenesis, space creation, and wound stability has to be abided by.[18,23] Primary wound closure with tension-free sutures provides an enclosed and undisturbed healing environment, away from bacterial and mechanical insults. This greatly enhances the healing potential of the surgical site. Angiogenesis, which is the formation of new blood vessels, enhances the growth and regeneration of the wound. Decortication or intramarrow penetration creates channels of communication for the osteogenic and pluripotent mesenchymal cells to travel from the bone marrow to the bone graft. It not only increases the bone graft and host tissue interface but also provides mechanical interlocking between the bone graft and resident bone, thus promoting better healing. Additionally, a regional acceleratory phenomenon[24] is also activated, resulting in faster bone remodeling because of increased multiple mineralization foci formation. Space is needed for the osteogenic cells to creep into the wound site, differentiate into osteoblasts, and form woven bone. However, the osteoblasts migrate at a slower pace compared to epithelial cells. Hence, a barrier membrane is used to prevent the unwanted cells from populating the wound site. The stability of the initial clot formation dictates the success of wound healing. This is because the initial clot is a large reservoir of growth and differentiation factors and the precursor to granulation tissue, which will organize and remodel to form bone.

The pocket generated by the PPF technique increases the stability of the augmentation material, even in cases of severe bone deficiencies. Studies on periodontal regeneration of hypermobile teeth have shown a reduction in clinical attachment gain.[23,25] It could be speculated that the mobility of the teeth resulted in an unstable surgical site, therefore affecting the wound-healing sequence. Extrapolating this concept to GBR, it was found that the stability of the initial clot formation activated the healing process by recruiting cells and growth factors to the wound site.[26,27] This in turn promotes predictable bone regeneration. The second advantage of the PPF technique is that it allows for tension-free soft tissue closure in demanding horizontal bone-grafting procedures. This can be used in cases of very limited horizontal bone width and still ensures abundant soft tissue for primary tension-free closure. Primary closure is absolutely necessary to ensure that bony regeneration can take place under the membrane.[16,18,21] The PPF technique proposed here allows for primary wound closure and also minimizes the micromovements in the augmentation material to ensure wound/graft stability for more predictable healing. These are essential criteria for a successful GBR procedure.

Various authors have investigated GBR in horizontally deficient alveolar ridges and have reported on both the overall success as well as complications. Zitzmann et al[22] showed approximately 26% soft tissue dehiscences leading to exposure of the membrane. The number of soft tissue dehiscences was significantly higher for nonresorbable membranes (42%) than for the collagen membrane (10%). However, in contrast to the nonresorbable membrane, the dehiscences involving the collagen membrane did not threaten the overall outcome of treatment. Friedmann et al[19] used a cross-linked collagen membrane in 16 patients with alveolar ridge deficiencies. Ten of these patients (62.5%) exhibited soft tissue dehiscences exposing the membrane. The soft tissue dehiscences triggered early collagen membrane degradation. Norton et al[12] used bovine bone mineral and a collagen membrane in both sinus floor augmentations and horizontal GBR. Twenty-six percent of the patients exhibited membrane exposure, and two of the three exposure membranes investigated **[Au:**

ok?] were examined histologically and showed poor or no bone regeneration, verifying that soft tissue dehiscence can compromise the outcome of GBR. Furthermore, Moses et al[20] showed a 35% soft tissue dehiscence rate while treating horizontal deficiencies with GBR. A significant reduction in bone regeneration was noted when primary wound closure was not maintained throughout the healing period. This was primarily a result of the colonization of bacteria at the surgical site, which jeopardized the uneventful wound healing.[21,28,28] These studies support that of Hiatt and Schallhorn,[28] who showed that the degree of regeneration increased when the adequacy of soft tissue coverage also increased. These studies show that soft tissue dehiscences are a common complication of horizontal GBR treatment and can lead to treatment failure. Because the PPF technique increases the mobility of the soft tissue and allows for tension-free primary closure, the number of soft tissue dehiscences should decrease.

Conclusion

Splitting the mucoperiosteal flap from the very beginning appears to significantly increase soft tissue mobility and elasticity, thus permitting coverage of even severe ridge deficiencies when using the periosteal pocket for GBR. Splitting the flap from the highest point of the crest creates a vertically enlarged periosteal pocket that better supports bone-substitute material. **[Au: Edit ok?]** More studies are needed to validate the results of the periosteal buccal flap presented here.

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