Comparison of Guided Bone Regeneration with Periosteal Pocket Flap Technique Versus Autogenous Bone Block Graft for Horizontal Bone Augmentation: A Clinical Trial Study

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The aim of this study was to assess changes in the horizontal dimension of the alveolar ridge when the autogenous bone block (ABB) or periosteal pocket flap (PPF) techniques were performed prior to implant placement. This randomized trial study was conducted on 25 patients in need of horizontal bone augmentation, who were randomly divided into two groups as follows: 13 patients underwent ridge augmentation using ABB, allograft, and a collagen membrane, while the remaining 12 underwent horizontal bone augmentation via the PPF technique. For all patients, radiographic examinations via CBCT were performed both before and 26 weeks after the operation. Following the surgery, dimensional changes in the ridge width were measured both within and between the two groups in the three regions of 0, 3, and 5 mm from the top of the alveolar crest. A total of 11 patients in the ABB group and 12 patients in the PPF group successfully completed the study. Statistical analysis showed that the increase in alveolar ridge width in each group was significant, but not significantly different between the two groups at any of the measured spots (0 mm from the crest, \( P = .25 \); 3 mm, \( P = .38 \); and 5 mm, \( P = .73 \)). However, more postoperative complications were observed with the ABB technique. According to the results of the present study, there was no statistically significant difference between the PPF and ABB techniques in terms of horizontal bone gain. *Int J Periodontics Restorative Dent* 2022. doi: 10.11607/prd.5691

### Introduction

The alveolar process is a tooth-related tissue that evolves during and in relation to tooth eruption (1). As a result, after tooth extraction, the alveolar process undergoes atrophy and remodeling, most of which is horizontal in dimension and especially in the buccal aspect of the ridge (2). The volume of the remaining bone for implant placement significantly affects the outcome of the implant surgery (3) and determines whether bone augmentation could be performed concurrently with the implant placement or in a separate procedure prior to it (4, 5).
There are various surgical procedures and grafting materials for bone augmentation prior to implant placement (4). One of these methods is the use of autogenous bone block (ABB) grafts, which is the material having osteoconductive and osteoinductive properties simultaneously (6). Because of these properties and the lack of immunological response, autogenous bone is considered as the gold standard in bone regeneration process (7), but despite its interesting properties, this technique has some limitations that makes it difficult to use. Problems in this area include excessive resorption, pain, infection, and morbidity of the donor site and limited available bone from intra-oral resources (8). The use of guided bone regeneration (GBR) technique with allograft or xenograft materials to restore the atrophic ridges reduces the donor site morbidity resulting from autogenous bone graft harvesting (3, 9). One of these conservative GBR methods is the periosteal pocket flap (PPF) technique. In this method, the bone substitutes are inserted into the periosteal pocket created between the mucosal flap and the bone, then an absorbable collagen membrane is used to cover the bone substitutes (10). The primary aim of this study was to compare the ABB and PPF techniques in terms of changes following horizontal bone augmentation. The secondary aims of this study were to evaluate postoperative problems and the need for regrafting during implant placement.

Materials and Methods

Twenty-five patients requiring horizontal ridge augmentation in maxilla or mandible before implant placement were enrolled in this study. Patients were selected from individuals who were referred to the department of Implant dentistry at Mashhad Dental School between February and May 2019. The study protocol was approved by the Ethics Committee of Mashhad Dental School. This clinical trial was also registered at clinical trial registry IRCT.ir Iran. The treatment procedures were adequately explained to all of the participants before signing the informed consents. Inclusion criteria were as follows:

Adults over 18 years old with no history of bone graft surgery at the study site

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Presenting with a horizontal ridge defect with the width of less than 4 mm (class III or IV atrophy according to Cawood and Howell classification) (11).

Exclusion criteria consisted of a history of uncontrolled systemic disease, a history of radiotherapy in the head or neck area, immunocompromised or immunosuppressed patients, a history of amino-bisphosphonate therapy, poor oral hygiene, untreated periodontitis, a history of drug or alcohol abuse, smoking more than 10 cigarettes per day, pregnancy or lactation, infection or inflammation at the study site and tooth extraction at the site with less than 3 months repair.

Patients were randomly divided into two groups, using stratified randomization method. Thirteen patients were enrolled in the ABB group and 12 in the PPF group.

An examiner who was blind to the treatment method and did not intervene in surgery recorded outcome measurements.

In ABB group at the graft recipient site, after local anesthesia with lidocaine 2% and 1:80000 epinephrine (Daroupakhsh, Tehran, Iran), mid crestal and intracrevicular incisions were applied with two vertical releasings if needed. For medullary space exposure and to increase the regional acceleratory phenomenon, a delicate 1 mm diameter diamond bur was used for producing a number of fine holes on the cortical bone. Then the block was harvested from mandibular ramus area as the donor site. After complete anesthesia with lidocaine 2% and 1:80000 epinephrine of the inferior alveolar nerve the sulcular incision originated from the last posterior mandibular tooth or crestal incision on the alveolar ridge was made, then continued to the external oblique ridge and finally on the buccal vestibule. After full thickness removal of the mucoperiosteal flap with the periosteal elevator, the lateral ramus site of the mandibular bone was exposed. The bone block size was adjusted to the required size for the graft recipient site. Ramus osteotomy was performed using the OT6 tip of the piezoelectric device (Mectron, Italy). After harvesting of the bone block in the form of corticocancellous, the mucoperiosteal flap was closed using 4-0 silk suture (Supa Medical Device, Tehran, Iran). Sharp edges around the harvested bone block was smoothed using a delicate diamond
bur under sterile saline irrigation. The bone block was then fixed in the recipient area using titanium screws (JEIL Medical Corporation- Seoul- Korea) (Figure 1). Flap tension was eliminated by applying periosteal releasing. The spaces around the fixed bone block graft were filled using allograft bone substitutes (Regen Allograft- Iranian Tissue Product Company-Tehran-Iran) with the particle size of 0.5 - 1.0 mm. A collagen membrane (Regen Alloderm- Iranian Tissue Product Company-Tehran-Iran) of 0.6 – 1.0 mm width was then placed over the graft (Figure 2). Finally, the flap was closed without any tension using the 4-0 vicryl suture (Supa Medical Device, Tehran, Iran) with horizontal mattress and continuous lock or single interrupted sutures.

In the other group the PPF technique was done with the crestal incision applied to the area after local anesthesia with lidocaine 2% and 1:80000 epinephrine (Daroupakhsh, Tehran, Iran). A horizontal incision was then applied to the periosteum to create a small space between the periosteum and the mucosa. This space was then deepened using a periosteal elevator to completely separate the mucosa from the periosteum. Vertical releases were applied just to the mucosa if needed. The mucosal flap was then removed using the periosteal elevator to extend beyond the mucogingival line, and the periosteum was then elevated from the bone to create a periosteal pocket between the bone and periosteum. The size of the created envelope was large enough to accommodate the bone substitutes (Figure 3). After bone substitute application including particulate allograft bone substitutes (Regen Allograft- Iranian Tissue Product Company-Tehran-Iran) with the size of 0.5 - 1.0 mm, a collagen membrane with 0.6 - 1.0 mm width (Regen Alloderm- Iranian Tissue Product Company-Tehran-Iran) was placed over it. Subsequently, the membrane was sutured to the periosteum using 4-0 vicryl suture (Supa Medical Device, Tehran, Iran) and the suture knot was placed on the palatal or lingual flap (Figure 4). Finally, the buccal flap containing only the alveolar mucosa and the attached gingiva was sutured to the palatal or lingual flap using 4-0 vicryl suture (Supa Medical Device, Tehran, Iran) with single interrupted or continuous lock sutures. After surgery, all patients were prescribed Amoxicillin 500 mg capsules concomitant with Metronidazole 250 mg tabs every 8 hours for 10 days and Ibuprofen 400 mg tabs.
every 6 hours for pain relief if needed (Daroupakhsh, Tehran, Iran). After two weeks the sutures were removed. CBCT images were taken before and 26 weeks after surgery to measure the width of the alveolar ridge. All CBCT images were acquired by the same device (CPO; ProMax; Planmeca Oy, Finland, Helsinki) with 2 mm slice intervals with the matching of focal through. To calculate the width of the alveolar ridge, three points at 0, 3 and 5 mm distance from the crest of the ridge were selected. (Figure 5)

In the second stage of surgery, local anesthesia was performed to access the augmented area and implants were inserted. In the ABB group if further access was required to remove the titanium screws a vertical release incision was then used. Also, if the screws did not interfere with the implant placement, they were left in place.

In this study, changes in the horizontal dimension of the alveolar bone in the augmented areas measured in 3 sections of 0, 3 and 5 mm distance from the crest of the ridge were considered as primary outcomes. These outcomes were determined by comparing the cross-sectional CBCT images which taken before the surgery (baseline) and 26 weeks after it.

In CBCT analysis an anatomical reference was identified and a cross sectional bucco- palatal plan of the image was carried out. Cortical bone that lines the trabecular bone represent the buccal and palatal surfaces. Horizontal bone gain was measured at three lines (0, 3 and 5 mm from the crest). Images was dissected into two section buccal and palatal by a bisector, based on bone inclination. All of these measurements performed by an imaging software (ProMax 3D Mid, Planmeca, Helsinki, Finland).

Secondary outcomes considered as:

- Postoperative problems in the surgical area that were diagnosed as:
  - Swelling with the evidence of inflammation during the first 4 weeks after surgery.
  - Infection with pus secretion during the healing period (26 weeks).
• Flap dehiscence during the healing period (26 weeks).

• Sensory problems in graft donor site (in ABB group only) and recipient site (in both groups).

SPSS version 16 was used for statistical analysis. Shapiro-Wilk test was used to evaluate the normality of the data. Paired t-test or its nonparametric equivalent Wilcoxon test was used to compare the width of the ridge before and after surgery in each group and Independent T-test or its nonparametric equivalent Mann-Whitney U test was used to compare the pre and postoperative ridge width between the two groups. A P-value < 0.05 was considered as statistically significant.

Results

A total of 25 patients in need of horizontal bone augmentation recruited for the study. As shown in figure 5, 13 patients were augmented with ABB and in 12 cases GBR was performed using PPF technique. Among these patients in one patient who received ABB in the posterior mandible mandibular flap dehiscence occurred, which despite prescribing antibiotics and 0.2% chlorohexidine oral gel (PerioKin, Barcelona, Spain), graft exposure continued and grafted bone block was eventually removed. In another case the bone block in the posterior mandible became infected, which did not heal and the resorbed bone block was then removed. Another bone block which placed in the anterior maxilla suffered a flap dehiscence and membrane exposure, which was managed well using antibiotics and 0.2% chlorohexidine oral gel (PerioKin, Barcelona, Spain). Therefore, the remaining 11 ABB and 12 PPF cases successfully completed the study.

The mean age of patients was 36.27 ± 5.31 in ABB group and 36.5 ± 5.56 in PPF group (P> 0.05). Gender was not significantly different between the groups (P> 0.05). Demographic information is listed in the Table 1.
For the remaining 11 patients in ABB group, 20 implants (11 in anterior and 9 in posterior regions) were inserted, and for 12 patients in PPF group, 17 implants (8 in anterior and 9 in posterior regions) were placed. The implant insertion areas are listed in Table 2.

Considering the primary outcomes, measurement of horizontal bone width (HBW) as shown in Tables 3-5, were done in three regions of 0, 3 and 5 mm from the crest of the ridge. According to the results, mean HBW at baseline was 1.90 ± 0.71 mm for ABB and 1.70 ± 0.79 mm for PPF group at 0 mm from crest. These values at baseline were 3.23 ± 1.07 mm and 2.80 ± 0.85 mm for ABB and PPF group respectively at 3 mm from crest. At 5 mm from crest the mean HBW was 3.81 ± 1.10 mm for ABB group and 3.79 ± 1.23 mm for PPF group at baseline. There were no statistically significant differences between the two groups at baseline at each measured sections (P > 0.05). After 26 weeks the mean HBW at 0 mm from crest were 3.33 ± 1.12 mm for ABB group and 2.83 ± 0.90 mm for PPF group. At this time the mean HBW was 6.51 ± 1.08 mm and 6.20 ± 1.31 mm for ABB and PPF groups respectively at 3 mm from crest. The mean HBW at 5 mm from crest were 6.93 ± 0.75 mm for ABB group and 7.07 ± 1.10 mm for PPF group 26 weeks after surgery. As well, there were no statistically significant differences between the two groups at 26 weeks after surgery at each measured section (P > 0.05). Also, according to the obtained results as can be seen in Tables 3-5, the increase in HBW after the surgery in all measured sections in both groups was statistically significant compared to its value before the operation (P < 0.05).

In regards of the secondary outcomes which is shown in the Table 6, swelling was seen in all patients in both groups during the first two weeks and gradually disappeared over the next two weeks. Only one case in ABB group was infected, resulting in the removal of the bone block in the mandibular posterior area. Flap dehiscence also occurred in two patients in ABB group, one in the mandibular posterior area eventually leading to removal of the grafted bone block and one in the anterior maxillary region that successfully improved and passed the rest of the follow-up period completely. No sensory problem was reported in any of the groups.
Discussion

In the present study, the use of ABB and PPF methods both increased the horizontal bone width and the difference in the amount of this increase between the two groups was not statistically significant in any of the measured sections.

Autogenous bone is considered as the gold standard material for horizontal reconstruction of alveolar ridge (7, 12). Based on the findings of various studies, since block resorption is significant with the ABB technique, especially cortical blocks, it has been suggested to reduce the resorption rate by using particulate bone substitutes in combination with collagen membrane (13-16). Bone substitutes can also create a fine connection between the bone block and the natural bone, creating a scaffold for bone reconstruction (17, 18). Based on these findings, in our study in the ABB group, particulate allograft bone substitutes with collagen membrane was used in combination with the block to reduce resorption. However, to examine the effect of this on the reduction of bone block resorption in this study, a longer follow-up period may be needed.

Block bone harvesting can be done in forms of cortical, cancellous or corticocancellous. Cancellous bone blocks have the advantage to be adjusted to match the ideal height and width of the graft recipient site. Cortical bone blocks have a higher rate of remodeling (up to 60%) than cancellous blocks (10%) (19-21). Also the process of revascularization is faster in the cancellous bone blocks than cortical ones, but cortical bone is much denser. So, the combination of both cortical and cancellous bone can lead to primary vascularization and greater maintenance (22). Therefore, in our study, to improve the outcome in ABB group, corticocancellous bone was harvested in all cases.

Another possible drawback of the ABB method is the higher prevalence of flap dehiscence and membrane exposure in this method. Membrane exposure can lead to infection and colonization of bacteria at the site of surgery (23, 24). These side effects are reduced by the use of absorbable membranes (20). In the Azpur's et al study, with the use of absorbable membranes, membrane
exposure and infection in the autogenous block group were higher than in the GBR group, but the difference between the two groups was not statistically significant. They had 2 cases of graft exposure in GBR group and 4 in ABB group. Also they had reported only 1 case of infection in the mandibular posterior site in ABB group (13). Accordingly, in our study, absorbable membranes were used in the ABB group, however, two cases of membrane exposure and flap dehiscence and one case of infection were seen only in the ABB group.

Although the use of autogenous bone is still considered as the gold standard bone augmentation procedures (25, 7), but due to its disadvantages, GBR techniques have become more popular. In this method, the use of membrane mechanically separates the osteogenic cells from the surrounding soft tissue and provides a successful treatment with sufficient evidence to reconstruct the width of the alveolar bone. (26, 27). Two studies for horizontal bone augmentation with prospective design using particulate autogenous bone in combination with xenograft in 50 to 50 percent with a resorbable membrane (sausage technique) reported 5.03 and 5.68 mm bone gain. These result are in accordance with our results but these two studies had no control groups. (28, 29)

The PPF method was first introduced by Steigmann et al. in 2012. In this technique, bone decortication allows mesenchymal cells to penetrate from inside the bone marrow. The created envelope increases the stability of the bone substitutes (10). Primary clot stabilization activates repair by evoking cells and growth factors to the wound site, which can eventually lead to predictable bone regeneration (10, 30, 31). Another advantage of the PPF technique is that the soft tissue closure takes place without stretching (10, 32). Primary wound closure is essential to ensure bone regeneration under the placed membrane (33, 34). Soft tissue dehiscence is a common complication in the treatment of bony defects with GBR techniques, which can lead to failure of the treatment. In various studies, the rate of soft tissue dehiscence following different GBR methods for reconstruction of horizontal bone defects has been reported 26 - 62.5% (35-37). Appropriate soft tissue coverage, increases the likelihood of bone regeneration (22, 38). In the PPF technique, separation the periosteum from the
mucoperiosteal flap that originates from the beginning of the flap close to the crestal area, increases the soft tissue elasticity. On the other hand, the created envelope provides better support for bone substitutes and reduces the likelihood of flap dehiscence. In the previous two case series that used PPF technique for horizontal bone reconstruction, no cases of flap dehiscence or infection were reported which were in agreement with the findings of our study and confirm the possible effectiveness of PPF technique in creating and maintaining the primary closure (10, 32).

Since the introduction of the PPF technique, no clinical study has been performed to compare it with other bone regeneration methods. The results of this study showed no significant difference in terms of the horizontal bone gain created by the two methods of PPF and ABB techniques. Therefore, considering the advantages mentioned for PPF technique and the results of limited studies published in relation to this method (10, 32), if the results are confirmed in future studies, the PPF could be considered as a possible alternative for the ABB technique with less post-operative problems.

Conclusions

Despite the limitations of this study, horizontal bone augmentation before implant placement was successful with both ABB and PPF techniques. However, a few more postoperative problems were observed with ABB technique that in two cases led to complete removal of the block. Given the fact that PPF technique might be less technique sensitive, compared to ABB technique, it is possible to suggest studies with higher sample sizes and longer follow-up time to check its adequacy in reconstruction of horizontal bone defects.

Acknowledgments

The authors declare there is no conflict of interest

References


Figure Legends

Figure 1: After Autogenous block harvesting from the ramus, bone block fixed to the recipient bone with titanium screws

Figure 2:

A: After block fixation on the bed, allograft bone particles inserted around the block borders and between block and recipient bone

B: membrane fixation on the block and allograft particle with periosteal suturing to the palatal flap

Figure 3:

A: after flap reflection to the muco-gingival junction periosteum splitted from the mucosa with blunt dissection then periosteum retracted from the bone and creating a pocket between them.

B: perforating the cortical bone by round bur for regional acceleratory phenomenon and better revascularization of the grafts

Figure 4: Clinical view of suturing the periosteum to the lingual flap. Allograft and membrane placed under the periosteum and then with periosteal suturing, membrane completely fixed and immobilized
Figure 5:

A: CBCT image before treatment in test group (block graft). Bisector line and perpendicular line showed as example

B: CBCT analysis after 6 months in test group. (bisector and perpendicular line)

Figure 6: Consort flow chart of the study.
Tables

TABLE 1. Patients' demographic data

<table>
<thead>
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<th>ABB (n= 11)</th>
<th>PPF (n= 12)</th>
<th>P-value</th>
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<td>Age (SD) [min; max]</td>
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<td>(years)</td>
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<td>Gender (female/male)</td>
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TABLE 2. Implant insertion areas based on each group

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<td>Premolars</td>
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<td>Molars</td>
<td>3</td>
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<tr>
<td>Total</td>
<td>20</td>
<td>17</td>
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TABLE 3. Results of horizontal bone width measurements at 0 mm from crest

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<th>Baseline</th>
<th>Mean (mm)</th>
<th>SD (mm)</th>
<th>Min-Max (mm)</th>
<th>26 weeks</th>
<th>Mean (mm)</th>
<th>SD (mm)</th>
<th>Min-Max (mm)</th>
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<td>PPF</td>
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<td></td>
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<td>0.79</td>
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<td>P-value</td>
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TABLE 4. Results of horizontal bone width measurements at 3 mm from crest

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<th>Baseline Mean (mm)</th>
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<th>Baseline Min-Max (mm)</th>
<th>26 weeks Mean (mm)</th>
<th>26 weeks SD (mm)</th>
<th>26 weeks Min-Max (mm)</th>
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<tr>
<td>ABB (n=11)</td>
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TABLE 5. Results of horizontal bone width measurements at 5 mm from crest

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<th>Baseline Min-Max (mm)</th>
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TABLE 6. Complications occurred during follow-up period

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<tr>
<td>Infection</td>
<td>1</td>
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<tr>
<td>Flap dehiscence</td>
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<td>0</td>
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<tr>
<td>Sensory problem</td>
<td>0</td>
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Figures

Fig 6 (flowchart)

**Enrollment**

Assessed for eligibility (n=25)
- Excluded (n=0)
  - Not meeting inclusion criteria (n=0)
  - Declined to participate (n=0)
  - Other reasons (n=0)

Randomized (n=25)

**Allocation**

Allocated to guided bone regeneration (GBR) with periosteal pocket flap (n=12)
- Received allocated intervention (n=12)
- Did not receive allocated intervention (n=0)

Allocated to guided bone regeneration (GBR) with autogenous block graft (n=13)
- Received allocated intervention (n=13)
- Did not receive allocated intervention (n=0)

**Follow-Up**

Lost to follow-up (give reasons) (n=0)
- Discontinued intervention (give reasons) (n=0)

Lost to follow-up (n=0)
- Discontinued intervention (n=2)
  (One of them was because of wound dehiscence and graft exposure and the other one was due to infection)

**Analysis**

Analysed (n=12)
- Excluded from analysis (n=0)

Analysed (n=11)
- Excluded from analysis (n=0)
Slice Interval 2 mm