Ridge Augmentation Comparing a Cancellous Block Allograft to an Osteoinductive Demineralized Bone Matrix Allograft: A Randomized, Controlled, Blinded Clinical Trial

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Twenty-six patients with a horizontal ridge defect were entered into this 4-month randomized, controlled, blinded clinical trial to compare a cancellous block allograft to a demineralized bone matrix (DBM) allograft for ridge augmentation. Six patients were excluded from the study, leaving 20 for data interpretation. Both groups had a xenograft overlay and a collagen membrane. For the Block group there was a significant gain of 4.8 ± 1.9 mm (P = .00002; 95% confidence interval [CI]: 3.49 to 6.21), while the DBM group gained 4.6 ± 2.4 mm (P = .0002; 95% CI: 2.88 to 6.36). Vertical change was minimal for both groups (P > .05). The Block group had a mean of 40% vital bone while the DBM group had 35%. Int J Periodontics Restorative Dent 2020;40:571–578. doi: 10.11607/prd.4324

Alveolar ridge deficiencies, whether the result of bone loss due to physiologic bone resorption, trauma, tooth extraction, periodontal disease, or a congenital defect, may preclude ideal implant placement and negatively affect restorability and long-term prognosis. In cases of extreme bone resorption, implant placement may not be possible. Several studies have been published that show different techniques and combinations of graft materials in an effort to find the most predictable means of augmenting a deficient ridge.1–8

Autogenous block grafts are considered by many to be the gold standard; however, autogenous graft harvesting has potential complications, like donor site morbidity associated with a second surgical site. Allografts are available in block, particulate, or matrix (putty) form and are commonly used as alternatives in ridge augmentation procedures since they provide similar handling characteristics, good results, and avoid the morbidity associated with graft harvesting.9,10

Block grafts typically have rigid fixation and excellent dimensional stability while particulate or matrix grafts may be more susceptible to compression or movement due to external forces.

Recently, a demineralized bone matrix allograft (DBM) has become available that has many verified
osteoinductive properties.11,12 The putty-like consistency of this graft provides superior handling and ease-of-use characteristics. In addition, resorbable cortical bone pins are available to help resist compres-

The primary aim of this randomized, controlled, blinded clinical trial was to compare an osteoinductive cancellous block allograft to an osteoinductive DBM allograft. This will afford a comparison of a block graft with rigid fixation and dimensional stability to a compression-susceptible osteoinductive DBM with its ease-of-use and faster healing properties.

Materials and Methods

Study Design

A total of 26 patients were randomly selected to be enrolled in either the test or control groups for this 4-month study of ridge augmentation for horizontal ridge defects. The positive control patients received a cancellous block (10 × 10 mm², AlloSource; Block group) secured with one or more bone fixation screws (Salvin). Gaps were filled with a DBM allograft with cortical cancellous chips (Opticon+CCC, Exactech). The test patients (DBM group) received only the DBM allograft (Opticon+CCC) supported with press-fit cortical bone pins (Cortical Pins, Exactech). In both groups, defect grafts were overlaid with a xeno-

Clinical Parameters

At baseline and the 4-month re-

Surgical Treatment

The surgical procedure consisted of reflection of a superficial split-thickness flap to expose the residual alveolar ridge.14 The cancellous block allograft and bone screw(s) or the DBM and cortical pins were placed to achieve 8 to 10 mm of total horizontal ridge width (graft plus residual ridge). In the Block group, one to two titanium screws were used for rigid fixation of the block. In the DBM group, cortical bone pins were placed 3 to 4 mm into the
residual ridge with a 2.0-mm implant drill. Cortical perforations were performed with a ½ round bur to increase vascularization and growth factors in all defect areas. In both groups, the defect graft was overlaid with a xenograft and covered with a cross-linked collagen membrane. Tension-free primary flap closure was achieved and sutured using a 4-0 polytetrafluoroethylene suture (Cytoplast, Osteogenics). Implants were placed after a healing period of 4 months.

**Histologic Analysis**

The bone cores were decalcified, and step serial sections were taken from the center of each longitudinally sectioned core. The sections were stained with hematoxylin and eosin (h&e). Percent vital bone, nonvital bone, and trabecular space were determined using an American Optics light microscope at ×150 with a ×10 objective and ×15 reticle eyepieces.

**Statistical Analysis**

Means and standard deviations were calculated for all parameters. The data were analyzed using paired t test to determine the statistical significance of the differences between initial and final data. Unpaired t test was used to evaluate statistical differences between the test and control groups. For primary and secondary outcome variables, 95% confidence intervals were calculated. The adjusted sample size of 10 gave statistical power of 80% to detect a difference with a mean of 1 mm ridge width and a standard deviation of 0.75 mm between the groups. The mean and standard deviation used for the power calculation were based on data from a previous study.\(^\text{15}\)

**Results**

A total of 26 patients were enrolled in the study, and 6 were lost to follow-up, leaving 20 patients for final data analysis. For the Block group there were 7 women and 3 men (mean age: 56 ± 9 years; range: 45 to 71 years), while for the DBM group there were 5 women and 5 men (mean age: 53 ± 12 years; range: 25 to 67 years). Specific tooth sites are noted in Table 1. Each group had four maxillary and six mandibular sites. The clinical procedures for the DBM and block groups are shown in Figs 1 and 2, respectively.

**Clinical Indices and Probing Measurements**

Plaque Index, Gingival Index, bleeding on probing, probing depth, and recession and mobility values were low at the start of the study and remained low at the 4-month reentry. There were no significant differences between groups (\(P > .05\); Table 2).

**Alveolar Ridge Width Changes at Crest**

For the Block group, crestal ridge width gain was 4.9 ± 1.9 mm (\(P = .00002\); 95% confidence interval [CI]: 3.49 to 6.21), and for the DBM group, crestal ridge width gain was 4.6 ± 2.4 mm (\(P = .0002\); 95% CI: 2.88 to 6.36). There were no statistically significant differences between groups (\(P = .82\); Table 3).

### Table 1 Predictability of Planned Implant Placement Entirely Within Hard Tissue

<table>
<thead>
<tr>
<th>Group</th>
<th>Sites (FDI system)</th>
<th>Planned size, n</th>
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</thead>
<tbody>
<tr>
<td>Block</td>
<td></td>
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<td>Reduced</td>
<td>14,12,12,31</td>
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<td>Regular</td>
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<td>1</td>
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<tr>
<td>Wide</td>
<td>36,36,44,46,46</td>
<td>5</td>
</tr>
<tr>
<td>DBM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduced</td>
<td>–</td>
<td>0</td>
</tr>
<tr>
<td>Regular</td>
<td>12,21,22,35,34,45</td>
<td>6</td>
</tr>
<tr>
<td>Wide</td>
<td>16,36,36,46</td>
<td>4</td>
</tr>
</tbody>
</table>

DBM = demineralized bone matrix.

For both groups, the planned implant size was placed in 9 of 10 sites (90% of the time). In the Block group, five implants were placed in Type 2 bone and four in Type 3 bone. In the DBM group, two implants were placed in Type 2 bone, four in Type 3 bone, and three in Type 4 bone.
Fig 1 Mandibular left first molar site in the DBM group. (a) Pre-treatment ridge appearance. Note that adequate keratinized tissue is available. (b) Flap release obtained using the superficial split-thickness flap necessary to cover the osseous graft and obtain primary closure. (c) Exposed ridge measuring 3.0-mm crestal width. (d) Ridge prepared to receive four resorbable cortical bone pins to support the DBM graft. Cortical perforations have also been performed. (e) Resorbable cortical bone pins in place. (f) DBM graft containing cortico-cancellous particles is positioned around and over the cortical bone pins. Graft is shown prior to overlay with bovine xenograft. (g) Reentry at 4 months reveals a crestal ridge width of 10.6 mm.
Fig 2  Mandibular left first molar site in the Block group.  
(a) Exposed ridge measuring 2.9 mm crestal width. (b) Block graft fixed with titanium screws prior to addition of DBM to fill spaces and the bovine xenograft overlay. (c) Reentry at 4 months reveals a crestal ridge width of 8.6 mm. Note that bone is covering the screw head, which is the slight discoloration seen apical to the probe tip. (d) Histologic evaluation shows appositional bone growth, which is vital bone forming on a nonvital residual graft particle. V = vital bone; NV = non-vital residual graft particle; and TS = trabecular space. (e) Radiographic view of the graft site at 4 months. (f) Radiographic view of the implant placed at the 4-month reentry.
Alveolar Ridge Width Changes 5 mm Apical to the Crest

The mean ridge width gain for the Block group was 4.2 ± 1.6 mm ($P = .00001$; 95% CI: 3.07 to 5.32) while the DBM group increased by 4.1 ± 2.4 mm ($P = .0004$; 95% CI: 2.4 to 5.88). There were no statistically significant differences between groups ($P = .96$).

Soft Tissue Thickness Changes

For the Block group, the soft tissue thickness had a gain of 1.2 ± 1.2 mm ($P = .009$; 95% CI: –2.06 to –0.37).
For the DBM group, it was a gain of 1.2 ± 0.9 mm (P = .001; 95% CI: –1.85 to –0.58). There were no statistically significant differences between groups (P = .99).

**Histologic Evaluation**

For the Block group, there were eight trephine cores with a mean of 40% vital bone, 21% nonvital bone, and 39% trabecular space. For the DBM group, there were eight cores with a mean of 35% vital bone, 25% nonvital bone, and 40% trabecular space. There were no statistically significant differences between vital, nonvital, and trabecular space groups (P = .59, P = .46, and P = .97, respectively).

**Discussion**

In this 4-month randomized, controlled, blinded clinical study of ridge augmentation, both groups showed a statistically significant gain in crestal ridge width at 4 months (P < .05; Table 3a). In this study, a xenograft was used as a buccal overlay on the defect graft. This was based on the rationale by Wang et al that a slowly resorbing outer layer of bone graft can resist resorption, provide dimensional stability, and impact the final ridge dimensions.16

The significant ridge width gain achieved (P < .05) indicates that both the Block and the DBM treatments were similarly successful. The magnitude of the mean changes (4.9 mm and 4.6 mm, respectively) compares favorably with previous literature and demonstrates that both treatments worked well.10-16-18 A recent systematic review reported a mean ridge width gain from block grafts (primarily autogenous) of 4.3 mm and mean final ridge width of 7.5 mm, while particulate or DBM grafts yielded a mean gain of 3.3 mm and a final ridge width of 6.2 mm.19 In contrast, the present study gained 4.6 mm with the DBM graft and a final mean ridge width of 7.3, which is larger than shown in the systematic review by Milinkovic and Cordaro.19

Schwartz et al reported that many materials had unreliable osteoinductive efficacy due to various factors, especially donor age.20 The DBM used in this study was verified to have osteoinductive ability using a nude mouse model to test ectopic bone formation in muscle tissue.

Jensen and Terheyden in a review article reported a mean ridge width gain of 4.4 mm from autogenous block graft compared to the 4.8-mm gain obtained by using cancellous block allograft in this study.11 This suggests that under certain circumstances, allograft blocks may substitute for autogenous blocks and produce similar or better results.

Three cases series articles of cancellous block allografts reported mean ridge width gains of 4.6, 5.0, and 5.6 mm. The first two of these reports used only maxillary grafts, while the last used only mandibular grafts.22–24 It is interesting to note that the mandibular sites tended to have a greater gain than maxillary sites. This suggests maxillary sites may not respond as well as mandibular sites, although further study is needed to confirm this observation.

Predictability is a key element in evaluating the clinical usefulness of a procedure. Determining the frequency of an augmentation procedure achieving ≥ 6, ≥ 7, or ≤ 4 mm ridge width allows for a comparison using standardized treatment outcomes. In this study, the Block group had 70% of patients with ridge width ≥ 6 mm of bone while the DBM group had 80%. The Block group had 0% that were ≤ 4 mm and the DBM group had 10%. This indicates that both treatments showed similar predictability of achieving defined ridge width categories. A second method for determining predictability is the frequency of placing the planned implant completely within bone, which considers the planned implant size. In other words, if all planned implants had a reduced diameter, the ridge-width requirement would be less than that needed if all planned implants had a wide diameter. In this study, 90% of implants were placed as planned for both treatment groups. Thus, using two predictability criteria, both treatments used in this study would be classified as predictable procedures.

**Conclusions**

Within the limitations of this study, both the cancellous block allograft and the DBM allograft with verified osteoinductive capabilities provided similar and significant gains in mean ridge width. Histologically, a high percentage of vital bone was found at the site of implant placement, most likely due to the cancellous nature of the graft, which favors...
vital bone formation. Additional studies with a larger sample size are recommended to determine the generalizability of the data.

Acknowledgments

The authors declare no conflicts of interest.

References