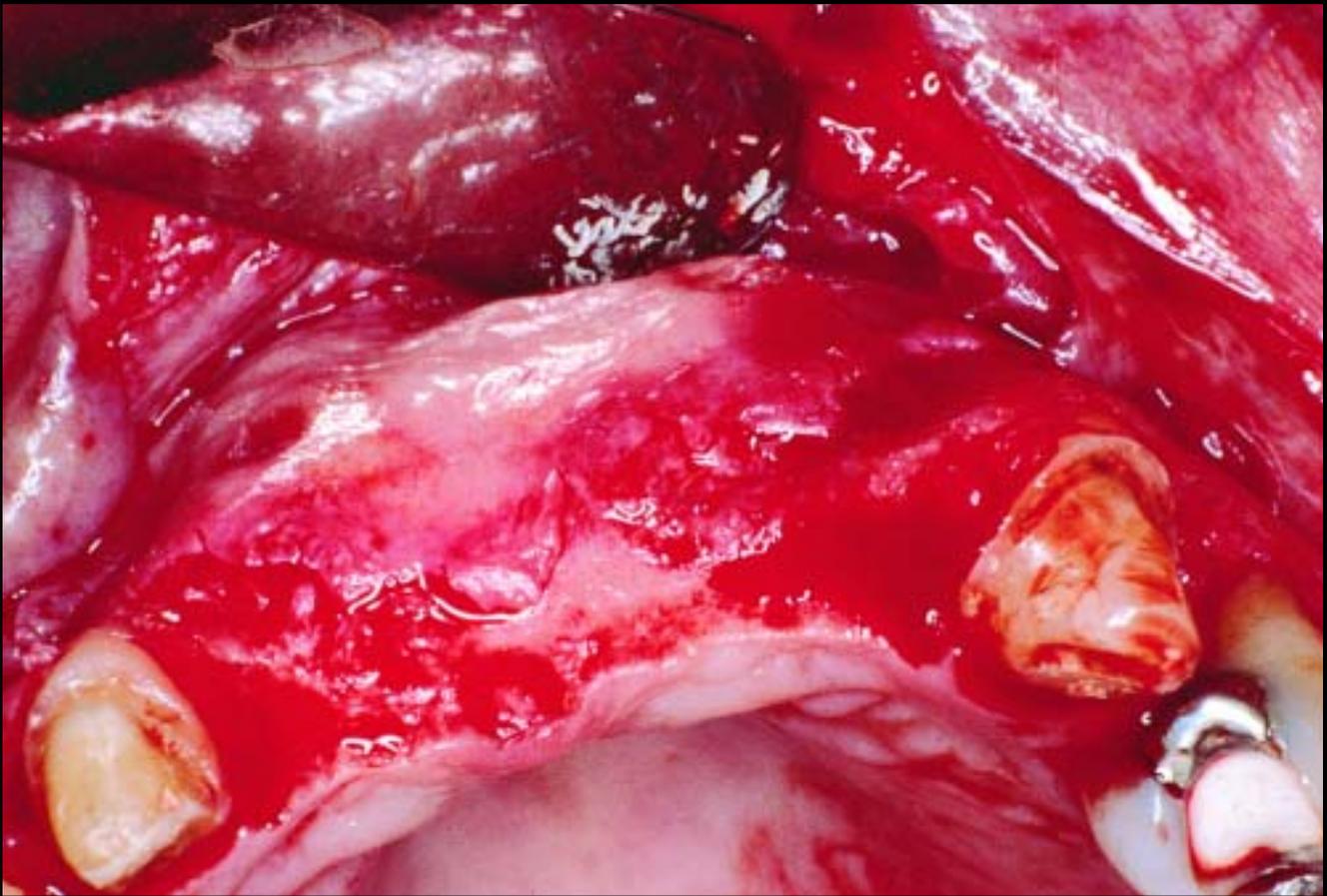
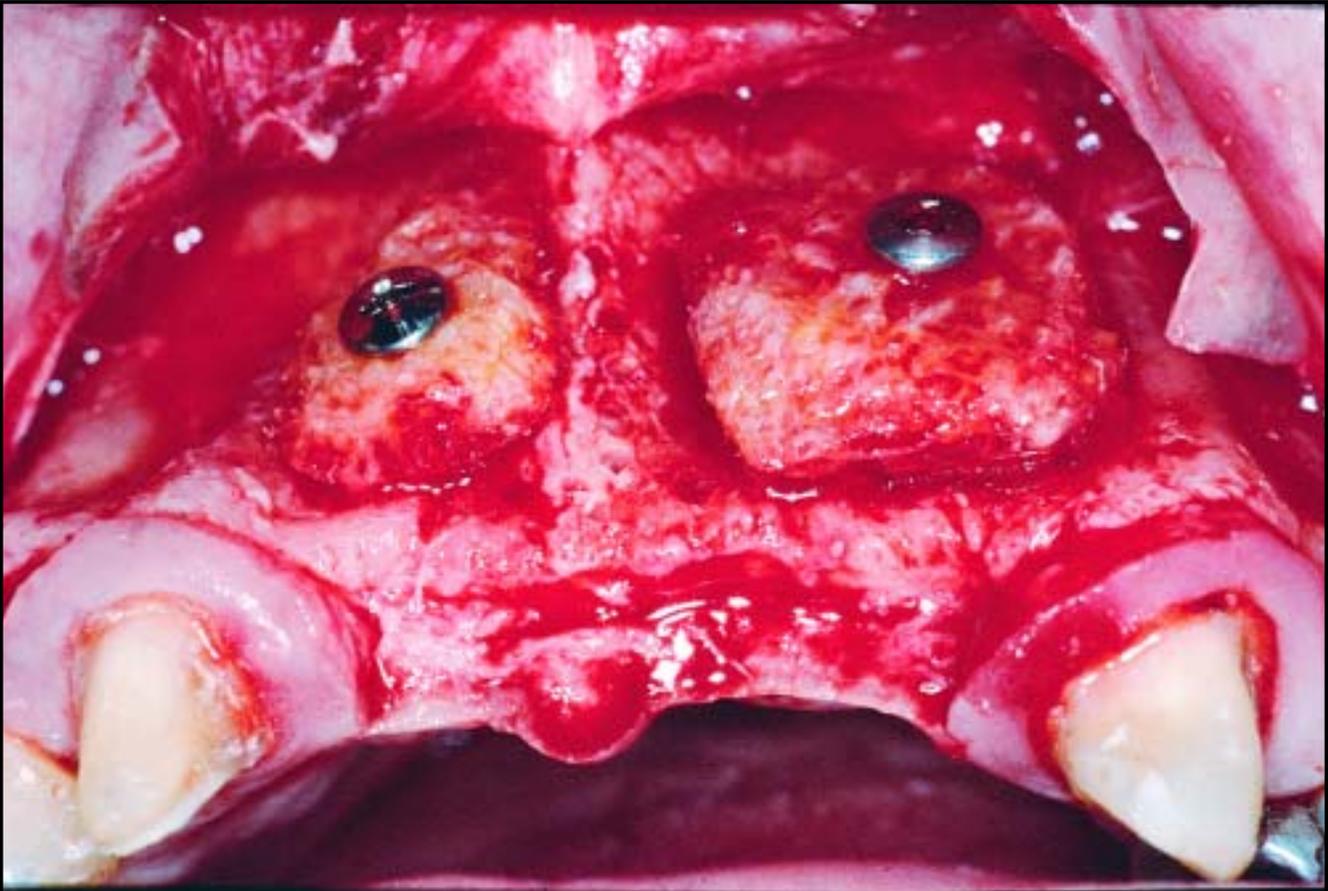


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## Clinical Evaluation of Freeze-Dried Block Allografts for Alveolar Ridge Augmentation: A Case Series



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*Various grafting materials have been used in guided bone regeneration procedures to augment alveolar ridges deficient in horizontal or vertical dimensions or both. Autogenous block grafts from intraoral and extraoral sites have been used for ridge augmentation with encouraging results. However, the risk of vascular and neurologic injury at the donor site as well as postoperative patient morbidity have been reported following these surgical procedures. The use of a cancellous block allograft could be one alternative to avoid potential donor site complications. Five deficient alveolar ridges in three patients were each grafted with a freeze-dried cancellous block allograft and a resorbable barrier membrane. Ridge measurements taken at baseline, graft placement, and a 6-month reentry surgery demonstrated an increase in alveolar ridge width from 2 to 4 mm. These gains in ridge width compare favorably with other guided bone regeneration studies, suggesting that a freeze-dried cancellous block allograft in conjunction with a resorbable membrane may be an acceptable alternative to the autogenous block graft in the treatment of compromised alveolar ridge deficiencies. (Int J Periodontics Restorative Dent 2003;23:417-425.)*

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The reconstruction of alveolar ridges through guided bone regeneration (GBR) techniques has been performed to increase bone volume in horizontal or vertical dimensions or both.<sup>1-14</sup> GBR procedures are generally reported as being performed prior to or during dental implant placement, but they may also be used to meet functional and/or esthetic demands of conventional removable or fixed dental prostheses. They involve the use of a physical barrier to exclude soft tissue cells, aid in maintaining a space, protect the blood clot, and stabilize the wound.<sup>15-18</sup> Both nonresorbable<sup>1-9,11-14</sup> and resorbable<sup>7,10,18</sup> barrier membranes have been successfully used in regenerating new bone on deficient alveolar ridges. However, by themselves, most membranes are not capable of creating and maintaining a wound space that would be adequate for ridge augmentation. To help create this space and support the membrane, various grafting materials,<sup>8,19</sup> tenting pins,<sup>3,4,8</sup> rigid titanium plates,<sup>20</sup> and dental implants<sup>12,13</sup> have been used either alone or in combination.

Among bone grafting materials, autogenous bone is still considered the gold standard. In addition to serving as a superior osteoconductive scaffold, autogenous bone can express osteoinductive properties that may be mediated through viable bone-forming cells retained within the graft and/or various soluble growth factors released during healing.<sup>17</sup> For larger-volume defects, intraoral sites such as the mandibular symphysis<sup>14,21-27</sup> and mandibular ramus<sup>14,28,29</sup> have been used as a source for either cortical or corticocancellous blocks as well as particulate graft material. Extraoral donor sites commonly used include the iliac crest<sup>30,31</sup> and the head of the tibia.<sup>32,33</sup> Often-quoted disadvantages of harvesting bone from these donor sites are the need for a secondary surgical site, risk of vascular and neurologic injury, and postoperative morbidity.<sup>34-38</sup>

Allografts are one alternative source of bone grafting material that may be used to avoid most of the aforementioned disadvantages. These materials have been successfully used in GBR procedures to expand small volumes of autogenous bone, used alone, or used in combination with xenografts or alloplasts.<sup>8,19,39,40</sup> Additional advantages include a ready availability of large volumes of material, extremely low antigenic potential, and unblemished safety record in dentistry.<sup>41-44</sup> Allografts are primarily considered to be osteoconductive, providing a scaffold for migrating cells, but they also possess a family of bone-inductive proteins des-

ignated bone morphogenetic proteins (BMP). BMPs are expressed following demineralization during processing of the allograft, ie, demineralized freeze-dried bone allograft (DFDBA).<sup>41,43</sup> Freeze-dried bone allografts also contain BMPs, but they are bound to calcium and therefore provide no immediate bone-inductive effect.<sup>41</sup>

The purpose of this case series was to clinically evaluate the potential of a freeze-dried cancellous block allograft combined with a resorbable barrier to increase alveolar ridge width. The rapid revascularization and creeping substitution of cancellous bone, along with the ability to shape and stabilize a relatively large block of bone into a rigid support for a barrier membrane, may make it a useful alternative to autogenous block grafts and their potential complications.

## Method and materials

Three partially edentulous patients, two women and one man (age range 55 to 60 years), with a total of five localized alveolar ridge defects (four maxillary, one mandibular), were included in this case series. Edentulous sites to be augmented had from one to four missing teeth. A comprehensive evaluation of each patient was performed to assess his/her systemic health and the periodontal status of all remaining teeth. Each patient was determined to be in good health, and none reported a positive history of smoking. Based on probing depths, attachment levels, percentage of sites bleeding on probing, and mobility, all remaining teeth were considered to be in good periodontal health. Panoraphic and periapical radiographs, diagnostic casts, and clinical examination were used to determine the extent of the ridge defects. Pending successful augmentation, these sites were treatment planned to receive dental implants (three sites) or to serve as ovate pontic beds (two sites) for fixed partial dentures (FPD). Written informed consent was obtained from each patient using a form previously approved by the Institutional Review Board at the University of Texas Health Science Center at San Antonio.

The description of the surgical protocol that follows was similar for all patients (Figs 1 and 2). Prior to the start of the procedure, the patient rinsed with 15 mL of a 0.12% chlorhexidine digluconate solution for 30 to 60 seconds as a



**Fig 1a** Measurement of the alveolar ridge width with a caliper in the right maxilla prior to graft placement.



**Fig 1b** Ridge width measures 4 mm.



**Fig 1c** One-centimeter cube of cancellous freeze-dried block allograft prior to trimming for placement.



**Fig 1d** Block allograft is trimmed to the defect dimensions and secured into place with a titanium bone screw.



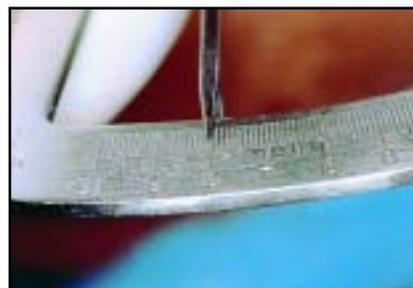
**Fig 1e** Collagen barrier is secured into place over the block graft with two nonresorbable bone tacks.



**Fig 1f** Six-month reentry demonstrates an increase in ridge width. The barrier has resorbed.



**Figs 1g and 1h** Measurement of ridge width indicates an increase of 4 mm from the baseline.





**Fig 2a** Localized deficient alveolar ridge. A periodontal probe indicates extent of bone loss.



**Fig 2b** Intramarrow penetration in multiple sites is used to enhance bone formation.



**Fig 2c** Freeze-dried allograft blocks are trimmed and fixed firmly in place.



**Fig 2d (left)** Particulate freeze-dried cortical bone fills the voids surrounding the block allografts.

**Fig 2e (right)** Nonresorbable barrier is used for GBR.



**Fig 2f (left)** Labial view indicates the extent of ridge augmentation.

**Fig 2g (right)** Occlusal view shows new bone formation. The new bone is covered by 1 to 2 mm of dense connective tissue.



presurgical disinfectant. The patient was then attached to an automated vital signs monitor for continuous monitoring of blood pressure, pulse rate, electrocardiogram, blood oxygen saturation, and respirations. An open intravenous line was established with a 24-gauge plastic catheter (Angiocath, Becton Dickinson Infusion Therapy Systems) with a continuous infusion of

5% dextrose and water. Midazolam, diluted to a concentration of 1 mg/mL, was slowly titrated until a suitable level of conscious sedation was reached. Maintenance doses of midazolam were delivered throughout the procedure as needed. Block and infiltration anesthesia for pain control was achieved using 2% lidocaine with 1:100,000 epinephrine.

A midcrestal incision was made at the one mandibular site, while for maxillary sites, a beveled incision was made slightly palatal to the crest of the alveolar ridge. Buccal (labial) vertical releasing incisions were used when indicated to facilitate access. Mucoperiosteal flaps were gently elevated to allow complete visualization of the defect and surrounding bone. A UNC-15 probe (Hu-Friedy)

was placed horizontally across the buccal (labial) surface parallel to the crest of the ridge to locate the most deficient aspect on the bone. At this point, the width of the ridge was measured using crown calipers (Iwanson, Interpore Dental) (Figs 1a, 1b, and 2a). A 1-cm cube of freeze-dried cancellous block graft (LifeNet) was then shaped with a fissure bur in a high-speed handpiece with copious irrigation. The endpoint was a block graft that closely approximated the recipient bed and provided adequate width to accomplish the restorative treatment plan (Fig 1c). The block graft and recipient bed were predrilled to accommodate a 1.2 mm × 8 mm bone screw (OsteoMed). Prior to graft fixation, multiple perforations were made through the cortical plate with a 1/2 round bur to ensure the broadest communication possible between grafted bone and the bone marrow cavity and to enhance bone neogenesis (Fig 2b).<sup>45</sup> The head of the bone screw was slightly recessed so that it would not protrude above the outer surface of the block allograft (Figs 1d and 2c). Freeze-dried allograft particulate (LifeNet) was placed around the perimeter of the block graft to fill any voids between it and native bone (Fig 2d). A resorbable bovine collagen barrier (BioMend Extend, Calcitek) or a nonresorbable barrier (Gore-Tex Augmentation Material, 3i/WL Gore) was trimmed to extend at least 3 mm beyond the grafted area. The nonresorbable membrane was hydrated for 1 minute in sterile saline prior to placement and stabilized at its vestibular

margin with two titanium tacks (IMZ, Interpore Dental) (Figs 1e and 2e). Mucoperiosteal flaps were reapproximated, and periosteal releasing incisions were made when necessary to achieve tension-free primary closure. The nonresorbable barrier was used whenever periosteal releasing or vertical incisions were not needed to achieve complete wound closure. Horizontal mattress sutures using 4-0 expanded polytetrafluoroethylene (e-PTFE) suture material (Gore-Tex, 3i/WL Gore) were placed to slightly evert flap margins. Standard interrupted sutures using 5-0 chromic gut (Ethicon/Johnson & Johnson) were placed as needed to ensure complete flap closure.

Patients were asked to rinse twice daily for 30 seconds with 15 mL of a 0.12% chlorhexidine digluconate mouthrinse and were placed on a daily regimen of 100 mg of doxycycline HCl for 10 days. A methylprednisolone dose pack (Medrol, Pharmacia) was also prescribed to help control postoperative inflammation and swelling. Patients were instructed to take 800 mg ibuprofen three times per day as needed for discomfort. Patients returned at 1, 2, 4, 6, 12, and 16 weeks for evaluation and debridement of remaining teeth. Sutures were removed at the 4-week appointment.

At 6 months, all patients returned for reentry surgery at the grafted site. A midcrestal incision was made, and mucoperiosteal flaps were elevated to allow measurement of the alveolar ridge width (Figs 1f

and 2f) as described previously (Figs 1g and 2g). The bone screw and tacks were located and removed. Primary flap closure was obtained using 5-0 chromic gut in an interrupted fashion. Postoperative appointments were scheduled at 1, 2, and 4 weeks, and as needed thereafter prior to dental implant surgery or restorative treatment.

## Results

During the entire 6-month healing period, no membrane became exposed, nor did any other adverse event occur. At reentry, no remnants of the membrane could be observed in any of the five sites. In two maxillary augmentation sites, the top of the bone screw was completely level with newly formed bone-like tissue, but it appeared to partially protrude in the other three sites. The latter finding suggests that some surface resorption of the graft material had occurred. The maximum net gain in ridge width was 4 mm, which was found in one maxillary posterior site. Of the remaining four sites, one maxillary anterior site demonstrated a net increase of 3 mm, and three sites (two maxillary, one mandibular) had gains of 2 mm (Table 1). The resulting increase in ridge width at each site was sufficient for the original restorative treatment plan to be implemented (Fig 1h). Four 4.0 mm × 11.5 mm dental implants (3i/Implant Innovations) were subsequently placed in three of the sites without any need for additional bone augmentation. At phase 2, all

implants had successfully integrated and were eventually restored with single crowns in two cases and an FPD in the third case. Two remaining maxillary anterior sites were treated with conventional FPDs and ovate pontics.

## Discussion

To the best of our knowledge, this is the first published report of a cancellous block allograft being used for alveolar ridge augmentation in humans. The results of this case series demonstrate that a freeze-dried cancellous block allograft may be used in conjunction with a resorbable barrier membrane for alveolar ridge augmentation. Although this report includes a small number of sites, the 2- to 4-mm gain in alveolar ridge width obtained falls within the range of 1 to 6 mm reported in other studies using either nonresorbable or resorbable barrier membranes.<sup>1,7,9-11</sup>

Buser et al<sup>1</sup> treated maxillary and mandibular ridge defects in 12 patients with e-PTFE membranes supported by tenting screws to cover pieces of collagen soaked in the patients' blood. After 6 to 10 months of healing, membranes were removed, and gains in ridge width of 1.5 to 5.5 mm were found. Others<sup>11</sup> reported gains in ridge width from 0.82 to 6.2 mm after 6 months of healing in maxillary and mandibular edentulous sites in 12 patients treated with autogenous chin blocks, with or without e-PTFE membranes. Resorption was approximately seven times greater when membranes were not used, even though there were no statistical differences in mean gain with or without membrane use. Chiapasco et al<sup>9</sup> found increases in alveolar ridge width from  $2.7 \pm 1.22$  mm to  $4.0 \pm 0.8$  mm after 6 to 8 months of healing when using autogenous particulate or block grafts with e-PTFE membranes. The particulate grafts were obtained from intraoral sites only,

whereas the block grafts were taken from both intraoral and extraoral sites.

Successful results have also been reported with the use of resorbable barrier membranes. Zitzmann et al<sup>7</sup> grafted 84 ridge defects in 25 patients with anorganic bovine bone in a split-mouth design to compare resorbable and nonresorbable membranes. The mean bone fill was 92% for the resorbable membrane sites and 78% for the nonresorbable sites. The lower bone fill at nonresorbable membrane-covered sites may have been due to a 44% incidence of wound dehiscences and/or premature membrane removal in this group. Another study<sup>10</sup> used bone-sounding techniques at 12 months to measure bone gain in 12 patients at 12 localized edentulous sites augmented with an alloplast-allograft combination and polylactide resorbable membrane. Even though reentry was not performed for direct measurement, a mean gain in bone width of  $3.27 \pm 3.73$  mm was reported.

One disadvantage of resorbable membranes is their variable and unpredictable rate of degradation. Depending on their chemical composition and physical characteristics, the resorption rate can vary from 4 weeks to 8 months.<sup>17,18</sup> The cross-linked bovine type I collagen barrier used in this study is reported by the manufacturer to provide barrier function for 16 to 18 weeks.<sup>18</sup> Since reentry was to be performed at 6 months, we did not expect to observe any membrane remnants, and none

were found. However, it is possible that barrier dissolution occurred too early in three of our five study sites, where 1 to 2 mm of surface resorption was found. Although the optimal time for barrier function is still unknown,<sup>18</sup> larger-volume bone grafts may require longer periods of sequestered healing for graft incorporation.<sup>17</sup>

Autogenous block grafts have been very successful in augmenting deficient alveolar ridges.<sup>21-31</sup> Besides the obvious biologic advantages of grafting host bone, block autografts can provide a large volume of bone that can be rigidly stabilized to prevent micromovement. It is also strong enough to resist deformation under pressure from the soft tissue flap.<sup>17</sup> However, the risk of injury and morbidity associated with harvesting blocks from the mandibular symphysis, mandibular ramus, iliac crest, or tibial head is an important concern that must be addressed with the patient during treatment planning and the consent process.<sup>34-38</sup> Cancellous block allografts also provide similar advantages of shaping a large volume of bone into a rigid support for a membrane without creating a secondary surgical site, increasing the risk for potentially significant patient morbidity, and adding surgical time and costs.

Autogenous block grafts taken from the mandible, iliac crest, or tibia will generally consist of either cortical bone or corticocancellous bone, depending on the thickness of the cortical plate at the donor site and/or the volume of bone harvested. There are important differences in

the repair process between autogenous cancellous bone grafts and autogenous cortical bone grafts that affect initial healing and graft maturation.<sup>46</sup> Cancellous grafts are revascularized earlier than cortical grafts and undergo "creeping substitution," which involves an appositional phase followed by a resorptive phase. In contrast, cortical grafts undergo "reverse creeping substitution," which means that they remain an admixture of necrotic and viable bone for prolonged periods, even years. The mechanical strengths of cancellous and cortical grafts have also been correlated to the repair process, in that cancellous grafts tend to be strengthened first, whereas cortical grafts are weakened.<sup>47</sup> These differences suggest that cancellous bone grafts may provide some advantage over purely cortical grafts during the early stages of wound healing and possibly into the longer maturation period. Like cancellous autografts, cancellous allografts undergo early revascularization and repairs predominantly by creeping substitution. This implies that the early healing events are similar, at least in principle. Randomized controlled studies comparing block autogenous grafts to cancellous block allografts will need to be done to fully appreciate the potential of the latter in GBR procedures.

## Conclusion

The present clinical case series has demonstrated that it is possible to increase alveolar ridge width using a cancellous block allograft in combination with a resorbable membrane. It is our experience that patients desire to reduce the extent, time, and costs of surgical procedures if at all possible. The cancellous block allograft may provide one such alternative treatment that meets the clinical requirements while satisfying the patient's expectations.

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