Comparison of an Allograft in an Experimental Putty Carrier and a Bovine-Derived Xenograft Used in Ridge Preservation: A Clinical and Histologic Study in Humans

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Purpose: *The aim of this randomized, controlled, blinded clinical study was to compare ridge dimensions and histologic characteristics of ridges preserved with 2 different graft materials.* ***Materials and Methods:*** *Twenty-four subjects, each requiring a nonmolar extraction and delayed implant placement, were randomly selected to receive ridge preservation treatment with either an allograft in an experimental putty carrier plus a calcium sulfate barrier (PUT) or a bovine-derived xenograft (BDX) plus a collagen membrane. Horizontal and vertical ridge dimensions were determined using a digital caliper and a template. At 4 months postextraction, a trephine core was obtained for histologic analysis.* ***Results:*** *The average ridge width decreased by 0.50 mm for both groups ($P < .05$). The midbuccal vertical change for the PUT group was a loss of 0.3 ± 0.7 mm versus a gain of 0.7 ± 1.2 mm for the BDX group, a difference of 1.0 mm ($P > .05$). Histologic analysis revealed vital bone in the PUT group of about 61% ± 9% versus 26% ± 20% for the BDX group ($P < .05$).* ***Discussion:*** *Greater vital bone fill in the PUT group may be attributable to earlier and greater vascular invasion of the carrier material. The putty material was characterized by ease of handling, simple placement, and enhanced graft particle containment.* ***Conclusions:*** *Allograft mixed with an experimental putty carrier produced significantly more vital bone fill than did the use of a xenograft with no carrier material. Ridge width and height dimensions were similarly preserved with both graft materials.* INT J ORAL MAXILLOFACIAL IMPLANTS 2004;19:491–497

Key words: *allografts, calcium sulfate, carboxymethylcellulose, collagen membrane, ridge preservation, xenografts*

Previous studies have shown that tooth extraction can result in resorption of the bony ridge.[1–6] Resorption occurred primarily on the buccal side of the ridge in these studies. Ridge width was most affected, but ridge height was also compromised. The resorptive response varied substantially between individual patients, and the amount of postextraction ridge resorption varied widely.[1–6]

The extent of the resorption may be affected by numerous factors, including, but not limited to, the number of bony socket walls, bone density, severity of periodontal bone loss, the presence of infection, and the absence of adjacent teeth.[4–8] The sites of extracted terminal teeth are especially vulnerable to ridge resorption. Even relatively normal extraction sockets with no loss of periodontal bone or bony walls can have substantial resorption.[4–6]

The placement of an intrasocket osseous graft minimizes, but does not eliminate, loss of horizontal and vertical ridge dimensions.[6] One study showed that an intrasocket osseous graft combined with an extrasocket graft overlaid on the buccal plate preserved pre-extraction ridge dimensions.[9] Typically a barrier membrane has been used in conjunction with

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an osseous graft; however, osseous graft material can also be used alone.[4–6] Failure to use a membrane, according to the principles of guided bone regeneration, may lead to greater connective tissue invasion and reduced conservation of the graft or bone.

Normal healing of an untreated extraction socket results in fill with vital bone.[6,10–14] Use of a graft, either an autograft, allograft, xenograft, or alloplast, has resulted in retention of nonvital graft particles.[6,14–22] Studies have reported from 5% to 35% residual graft particles and from 30% to 60% vital bone. In general, a higher percentage of residual graft particles has been found with allografts, xenografts, and alloplasts, while a lower percentage resulted when autografts were used.[6,14–16,22] In addition, more vital bone may be present following use of an autograft.[15,16] It is unknown whether the long-term success of implants is compromised by placement into sites containing residual graft particles. Irrespective of what long-term data may show, most clinicians favor placing implants into vital bone when possible. Therefore, a material that will preserve pre-extraction ridge dimensions and also promote vital bone socket fill will produce the most clinically acceptable result.

There are many osseous graft materials available for clinical use. Since they are associated with varying amounts of vital bone socket fill, comparison studies are useful to determine the amount that occurs with each material. The first aim of this randomized, controlled, blinded clinical study was to determine the amount of vital bone associated with an experimental osseous graft putty when compared to a commercially available bovine xenograft used as a positive control. The second aim was to assess the horizontal and vertical ridge changes associated with each graft material. The third and final aim was to evaluate how each treatment affected the thickness of the soft tissue overlying the bony ridge.

MATERIALS AND METHODS

Patient Selection

Twenty-four patients (9 men and 15 women, mean age ± SD 56 ± 11 years) were invited to participate in this randomized, controlled, blinded clinical trial. Subjects were included in the study if they were at least 18 years of age and had 1 or 2 nonmolar teeth that required extraction and replacement with a dental implant. All extraction sites were bordered by at least 1 tooth. Exclusion criteria included *(1)* debilitating systemic diseases, *(2)* pregnancy or lactation, *(3)* a known allergy to any of the study materials, *(4)* the need for antibiotic prophylaxis, and *(5)* failure to sign an informed consent approved by the University of Louisville Human Studies Committee. Subjects were withdrawn from the study if they developed any adverse reaction or infection.

Study Population and Design

Using a coin toss, 12 patients were randomly selected to receive ridge preservation treatment with an experimental putty binder composed of carboxymethylcellulose and calcium sulfate (CaS) mixed with a decalcified freeze-dried bone allograft (DFDBA) in a 50:50 ratio and then covered with a CaS barrier (Capset; Lifecore Biomedical, Chaska, MN). These patients were designated the PUT group. The other 12 patients were treated with a mineralized bovine-derived xenograft (BioOss; Geistlich Biomaterials, Wolhusen, Switzerland) and a collagen membrane (BioGide; Geistlich Biomaterials) and were designated the BDX group. At 4 months postextraction, a trephine (H & H, Ontario, CA) was used to remove a core from each site, and an endosseous dental implant placed.

Presurgical Treatment

Customized acrylic resin occlusal templates were fabricated on the diagnostic casts to serve as fixed reference guides for the vertical measurements, and standardized radiographs were taken.[6] All measurements were taken by a calibrated, blinded examiner, who was a different individual from the surgeon and was unaware of the treatment provided.

Presurgical preparation included detailed oral hygiene instructions. Baseline data collected at surgical treatment included Plaque Index, Gingival Index, bleeding on probing, soft tissue thickness, horizontal ridge width, vertical distance from the template to the alveolar crest, and individual socket wall thickness.[6,23–25] Horizontal ridge width was determined by the use of a modified digital caliper measuring to the nearest hundredth of a millimeter at the midpoint of the alveolus; the thicknesses of the buccal and palatal/lingual walls were measured in a similar fashion. Soft tissue thickness was measured with an SDM gingival thickness meter (Dentsply/Austenal, York, PA) that utilized ultrasonic waves.[6] Measurements were taken 3 mm apical to the soft tissue crest, both buccally and lingually. At the 4-month visit, prior to implant placement, an additional thickness measurement was taken at the crest of the ridge. All parameters were measured at the time of extraction and at the time of implant placement.

Surgical Treatment

Full-thickness mucoperiosteal flaps were elevated on the buccal and palatal/lingual sides. Interproximal papillae were reflected in the palatal/lingual flap to

expose both the labial and palatal/lingual aspects of the alveolar ridge. Teeth were extracted atraumatically to avoid loss of alveolar bone, using elevators, periotomes, forceps, or burs when necessary. The extraction socket was then curetted to remove all soft tissue. Horizontal and vertical ridge measurements were taken with the caliper and the template.

The experimental putty material was combined with 5 mL of a proprietary liquid solution and 0.5 mL of DFDBA and placed into the extraction socket. The CaS barrier was prepared and placed over the grafted socket. Flaps were replaced without any special effort to achieve primary closure and sutured with a 4-0 synthetic, nonabsorbable, monofilament, polybutester suture (Novafil; Kendall Healthcare, Mansfield, MA). The BDX graft was hydrated in 5 mL of sterile saline and placed in the extraction socket. The collagen membrane was also hydrated in sterile saline for 5 minutes. It was trimmed to completely cover the socket and extend a minimum of 3 mm past the alveolar crest. Flaps were replaced and sutured with Novafil sutures.

Table 1 Clinical Indices for PUT and BDX Sites (Mean ± SD)

	n	Initial	Final	Change
Plaque Index				
PUT	12	0.4 ± 0.2	0.2 ± 0.1	0.2 ± 0.2*
BDX	12	0.4 ± 0.3	0.1 ± 0.2	0.2 ± 0.2*
Gingival Index				
PUT	12	0.6 ± 0.4	0.2 ± 0.1	0.4 ± 0.3*
BDX	12	0.5 ± 0.3	0.2 ± 0.2	0.3 ± 0.2*
Bleeding on probing				
PUT	12	0.2 ± 0.2	0.1 ± 0.1	0.1 ± 0.2*
BDX	12	0.1 ± 0.1	0.1 ± 0.1	0.0 ± 0.1*

*$P < .05$ between initial and final (4-month) values.

Table 2 Horizontal Ridge Width in mm for PUT and BDX Sites (Mean ± SD)

	Initial	Final	Change
PUT	8.9 ± 1.8	8.4 ± 1.5	–0.5 ± 0.8*
BDX	9.7 ± 1.2	9.2 ± 1.2	–0.5 ± 0.8*

*$P < .05$ between initial and final (4-month) values.

Postoperative Care

Patients were seen on a weekly basis until soft tissue closure, then on a biweekly basis until week 8. Patients were given 375 mg naproxen (Geneva Pharmaceuticals, Broomfield, CO) every 12 hours, 50 mg doxycycline hyclate (Warner Chilcott, Rockaway, NJ) daily, 0.12% chlorhexidine (Colgate Oral Pharmaceutical, Canton, MA) twice daily, and analgesics, if needed.

Surgical Re-entry for Implant Placement

Full-thickness mucoperiosteal flaps were elevated and an osseous core was obtained from the center of the filled socket site using a 2.7 × 6-mm trephine with copious chilled irrigation. The cores were placed in a bottle of 10% buffered formalin. A 1-stage dental implant (Stage-1; Lifecore Biomedical) was then placed and flaps were closed using 4-0 silk suture. Patients were again given the previously described postoperative medications.

Histologic Analysis

The trephine cores (2.7 × 6 mm) were decalcified, sectioned, and prepared for histologic analysis using hematoxylin and eosin (H&E) staining. Twelve to 15-step serial sections were taken from the center of each longitudinally sectioned trephine core. Six randomly selected fields, 1 per section if possible, were used to obtain percent cellular bone, acellular bone, and trabecular space using an American Optics light microscope (Burlington, Ontario, Canada) at 150×, with a 10× objective and a Nikon 15× reticle eyepiece (Tokyo, Japan).

Statistical Methods

A 2-way analysis of variance was used to evaluate the statistical significance of the differences between groups and changes from baseline to final examination. Percentages were transformed using an arcsine transformation.

RESULTS

Each of the 24 subjects contributed 1 extraction site. Eight maxillary premolars, 3 mandibular premolars, and 1 maxillary central incisor were extracted from patients in the PUT group. Eight maxillary premolars, 1 mandibular premolar, 1 maxillary canine, 1 mandibular canine, and 1 maxillary central incisor were extracted from patients in the BDX group.

Clinical Indices

Both the PUT and BDX groups demonstrated a statistically significant reduction ($P < .05$) in all indices measured from baseline to final examination (Table 1).

Horizontal Alveolar Ridge Width Changes

Both the PUT and BDX groups lost 0.5 ± 0.8 mm of horizontal ridge width (Table 2), which was statistically significant ($P < .05$).

Table 3 Vertical Ridge Height Changes in mm for PUT and BDX Sites

	PUT		BDX	
	Mean ± SD	Range	Mean ± SD	Range
Midbuccal	–0.3 ± 0.7	–1.0 to 1.0	0.7 ± 1.2	–0.5 to 2.5
Midlingual	–0.5 ± 0.7*	–1.5 to 1.0	–0.1 ± 0.8	–1.5 to 1.5
Mesial	–0.2 ± 0.6*	–1.5 to 0.5	–0.5 ± 0.5*	–1.3 to 0.3
Distal	–0.1 ± 0.7*†	–1.5 to 0.8	–0.7 ± 0.8*†	–1.7 to 0.7

*$P < .05$ between initial and final (4-month) values.
†$P < .05$ between PUT and BDX groups.

Table 4 Histologic Data at Implant Placement (4 Months Postextraction) for PUT and BDX Sites (Mean ± SD)

	n	% Vital	% Graft	% Trabecular	% Amorphous	Osteoblasts
PUT	12	61 ± 9*	3 ± 3*	32 ± 10*	4 ± 4	3 ± 2
BDX	12	26 ± 20*	16 ± 7*	54 ± 15*	5 ± 6	2 ± 2

*$P < .05$ between PUT and BDX groups.
Vital = vital bone; Graft = residual graft particles; Trabecular = trabecular spaces; Amorphous = amorphous organic matrix.

Vertical Ridge Height Changes

The difference between groups was greatest on the midbuccal side of the ridge; the PUT group lost 0.3 ± 0.7 mm, while the BDX group gained 0.7 ± 1.2 mm (Table 3), for a mean difference of 1.0 mm. This difference was not statistically significant ($P > .05$). The differences between groups were small on the midlingual, mesial, and distal sides (Table 3); however, on the distal side the mean difference of 0.6 mm was statistically significant ($P < .05$).

Histologic Evaluation

The percentages of vital bone, residual graft particles, and trabecular space (Table 4) found were significantly different between groups ($P < .05$). The greatest difference was in the percentage of vital bone; the PUT group had 61% ± 9%, whereas the BDX group had only 26% ± 20% ($P < .05$). The amount of amorphous organic matrix and the number of osteoblasts were not significantly different between groups ($P > .05$). Representative photomicrographs are shown in Figs 1 and 2.

Soft Tissue Changes

The changes in soft tissue thickness found were minimal (Table 5), and no statistically significant differences were noted ($P > .05$).

DISCUSSION

This 4-month randomized, controlled, blinded clinical study compared ridge preservation with an experimental putty mixed with a DFDBA graft and a CaS barrier (the PUT group) to the use of a BDX and a collagen membrane (the BDX group). Although ridge preservation was similar for the 2 groups, from a histologic standpoint, the PUT group was associated with significantly greater vital bone fill in the socket. Implants were successfully placed in all sites and retained for at least 4 months postplacement.

The PUT consisted of a binder, carboxymethylcellulose and CaS, that was mixed with DFDBA in a 50:50 ratio. In previous studies, a substantial amount of nonvital DFDBA particles were retained in grafted sockets.[14,15] In the PUT group in the present study, the graft sites were only 3% nonvital DFDBA particles after 4 months, while 61% vital bone was present for (Table 4, Fig 1). This is in contrast to 16% nonvital particles with only 26% vital bone for the BDX group (Table 4, Fig 2). The reasons for this substantial difference are unknown; however, the loose, porous consistency of the carboxymethylcellulose and CaS may have favored more rapid vascular and cellular ingrowth, which would have facilitated vital bone formation and resorption of DFDBA particles.

Previous studies have shown increased bone formation with calcium sulfate ($CaSO_4$),[26] with histologic results similar to those achieved with the use of an autogenous graft[27] and increased formation of bone morphogenetic proteins-2 and -7, transforming growth factor-beta, and platelet-derived growth factor.[28] CaS has also been shown to increase angiogenesis relative to an autogenous bone graft[29] and, in general, to improve clinical results.[30–37] Irrespective of the reason, the fact that the sockets grafted with putty

Fig 1a Vital bone surrounded by vascular channels and amorphous organic matrix. PUT group (original magnification ×150).

Fig 1b Large area of vital bone interspersed with several areas of amorphous organic matrix. PUT group (original magnification ×150).

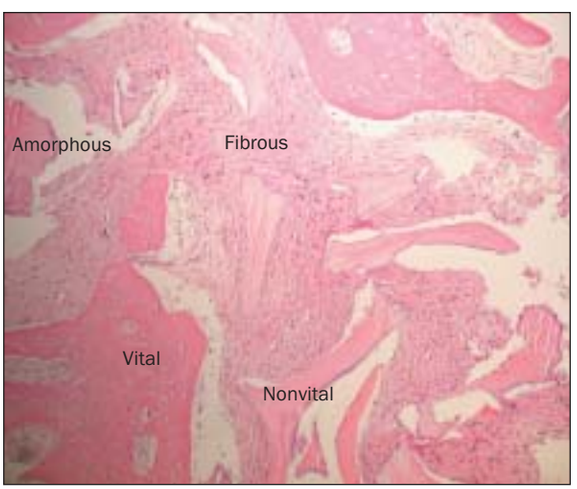

Fig 2a Fibrous encapsulated nonvital BDX particles with vital bone and a small area of amorphous organic matrix (original magnification ×150).

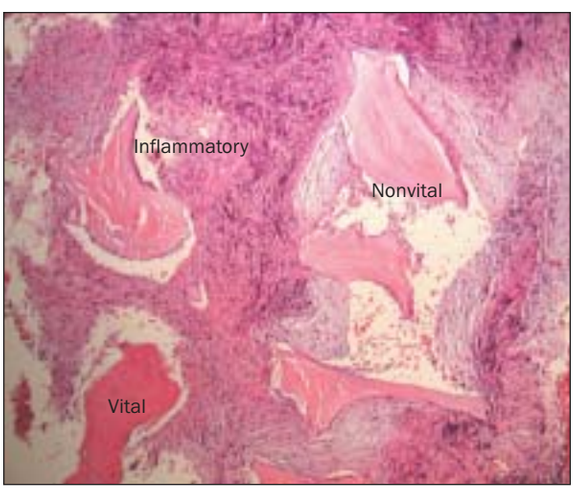

Fig 2b Fibrous encapsulated nonvital BDX particles with an area of vital bone and dense inflammatory infiltrate (original magnification ×150).

were filled primarily with vital bone at 4 months is a clinically significant finding. Iasella and associates[6] showed that untreated extraction sites healed with 58% vital bone at 4 months, which is very similar to the 61% vital bone found in this study for the sites grafted with putty.[6] Thus the histologic result of grafting can be similar to that achieved with ungrafted socket healing, but with the advantage of preserving pre-extraction ridge dimensions.

Three of 12 BDX sites showed some histologic inflammation, primarily polymorphonuclear neutrophils in the trabecular spaces, at 4 months (Fig 2b). Since histologic examinations were conducted at only 1 time, it was impossible to know the extent of inflammation during the early healing process. There was no clinical inflammation, and all sites

Table 5 Soft Tissue Thickness Changes in mm for PUT and BDX Sites (Mean ± SD)

	Initial	Final	Change
PUT			
Buccal	1.2 ± 0.5	1.3 ± 0.4	0.1 ± 0.6
Lingual	2.1 ± 0.8	2.0 ± 0.8	–0.1 + 0.7
Occlusal		1.9 ± 1.0	
BDX			
Buccal	1.5 ± 1.5	1.2 ± 0.3	–0.2 ± 1.5
Lingual	2.7 ± 0.8	2.7 ± 0.9	0.0 ± 0.7
Occlusal		1.9 ± 0.5	

had complete soft tissue closure by 3 weeks. The cause of the inflammation is unknown, but it may have been related to resorption of the graft particles. The inflammation had no clinical effect on implant placement, and only the histologic examination indicated its presence.

Subjective assessment of bone quality revealed that PUT sites gave the "feel" of slightly greater bone density.[38] Two of the 12 PUT sites were considered type 1 bone, while the remaining 10 were judged to be type 2 bone. Seven of the 12 BDX sites were judged type 2 bone, while 5 of 12 were judged type 3 bone.[38] Irrespective of treatment or bone density, implants were placed at all sites, and none have been lost so far. One BDX site required grafting at the time of implant placement, but this has not had an adverse impact on implant success.

Both treatments were effective in the preservation of horizontal and vertical ridge dimensions. Typically, extraction without preservation results in substantial dimensional loss, with the greatest amount occurring buccally and leading to diminished ridge width and height.[1–6] In this study, both treatments resulted in a net loss of 0.5 ± 0.8 mm ridge width. Vertical loss was greatest midbuccally, where the PUT group experienced a 0.3 ± 0.7 mm loss, while the BDX group gained 0.7 ± 1.2 mm in height—a 1-mm difference between treatment groups. Both grafts were placed in an identical manner to completely fill, but not overfill, the socket. The reason for the difference in ridge height is unknown but the difference in barriers may be responsible. The CaS membrane used to cover the putty may have resorbed more quickly, permitting connective tissue ingrowth and causing a loss of graft and/or bone. Loss of vertical ridge height was similar for both treatments on the mesial, distal, and midlingual sides, and there were no clinically significant differences between treatments. There was a statistically significant difference between treatments on the distal sides; however, the mean difference between treatments was only 0.6 mm, and the range was similar for each treatment.

Iasella and colleagues[6] showed that an intrasocket osseous graft covered by a membrane prevented most postextraction bone loss; however, there was a slight loss of ridge width. Simon and coworkers[9] showed that use of an intrasocket graft in combination with an extrasocket graft overlying the buccal plate preserved or even augmented pre-extraction ridge dimensions. In esthetic areas where it is imperative to preserve full ridge dimensions, including the convexity of the root prominences, the additional buccal overlay graft may be essential. Posterior areas, however, where esthetics may be of less concern, were adequately preserved with an intrasocket graft alone.[6]

From a clinical standpoint the experimental putty was characterized by ease of handling. It had a doughy consistency and could be rolled into small spheres that were easily placed in the socket. The putty contained DFDBA, which prevented particle scatter. The handling characteristics of the BDX were similar to other particulate grafts, and the collagen membrane was needed to contain the graft within the socket.

Previous studies have shown that use of a barrier membrane produces a loss of the soft tissue thickness overlying the bony ridge, while extraction alone results in a gain of soft tissue thickness.[6,39] In the present study, there was a slight loss of soft tissue thickness on the lingual or palatal surface in the PUT group and on the buccal surface in the BDX group, which is consistent with previous reports.[6,39] When ridge preservation is performed primarily for esthetic reasons, rather than to maintain bone dimensions for implant placement, the thickness of both the soft and hard tissues is important in determining the final ridge width and height. A loss of either tissue type can compromise the final result. Therefore, when a membrane is used, a buccal overlay osseous graft may be needed in addition to the intrasocket graft to augment the hard tissue dimension and compensate for the anticipated loss of soft tissue thickness.

CONCLUSIONS

Ridge preservation using an intrasocket graft of carboxymethylcellulose and CaS with DFDBA covered by a CaS barrier produced a significantly higher percentage of vital bone fill at 4 months than BDX with a collagen membrane, while BDX with a collagen membrane was associated with more residual graft particles and less vital bone. From a clinical standpoint, both treatments preserved ridge dimensions in a similar fashion.

ACKNOWLEDGMENTS

This study was sponsored in part by Lifecore Biomedical, Chaska, MN.

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