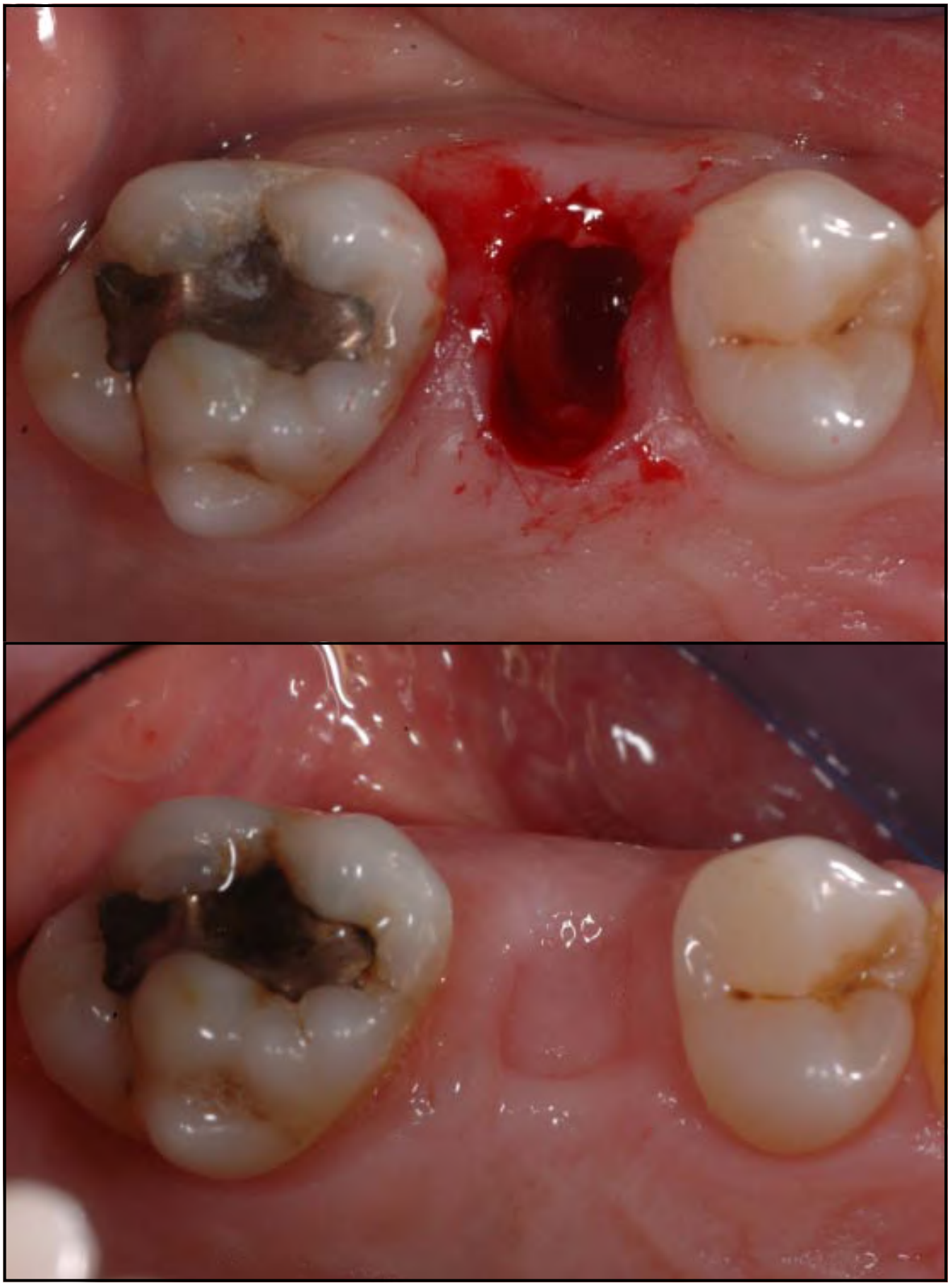

Socket Preservation Using Bovine Bone Mineral and Collagen Membrane: A Randomized Controlled Clinical Trial with Histologic Analysis

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After tooth extraction, varying amounts of bone resorption occur because of qualitative and quantitative changes at the edentulous site of the alveolar process. The aims of this randomized controlled clinical trial were (1) *to compare the postextraction changes in residual ridge dimensions during spontaneous healing with those during socket preservation,* (2) *to analyze the histologic and histomorphometric aspects of the grafted sockets, and* (3) *to compare probing procket depth (PPD) and clinical attachment level (CAL) changes at teeth adjacent to extraction sites. Forty-eight teeth were extracted from 41 patients referred for extraction of 1 or more maxillary or mandibular premolars or molars. The edentulous sites were randomly assigned to the control (EXT, extraction alone) or experimental groups (SP, extraction and socket preservation). In the SP group, the sockets were filled with bovine bone mineral and covered with porcine collagen membrane. At baseline and after 4 months, PPD, gingival recession (REC), and CAL were measured at teeth adjacent to the edentulous sites. The changes in ridge dimensions from baseline to 4 months were assessed on dental casts. At 4 months, bone was harvested from the grafted areas in the SP group and the edentulous areas in the EXT group. PPD, REC, and CAL were comparable between groups. However, from baseline to 4 months, the SP group showed significantly less reduction in ridge width (1.04 ± 1.08 mm vs 4.48 ± 0.65 mm,* P *< .001) and height (0.46 ± 0.46 mm vs 1.54 ± 0.33 mm,* P *< .001). Histologically, the grafted sockets exhibited various stages of bone maturation and formation without inflammatory responses. No significant difference in the mineralized and nonmineralized fractions was noted between the groups. Socket preservation using bovine bone mineral and porcine collagen membrane considerably limits the amount of horizontal and vertical bone resorption when compared with extraction alone.* (Int J Periodontics Restorative Dent 2012;32:421–430.)

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After tooth extraction, varying amounts of bone resorption occur because of qualitative and quantitative changes at the edentulous site of the alveolar process.[1–8] Scientific evidence has demonstrated the dynamics of tissue alteration after tooth extraction. Histologically and anatomically, alveolar bone is a tooth-dependent structure that develops in conjunction with tooth eruption, and its topography is determined by the formation of teeth and their axes of eruption. In the first phase of remodeling of the buccal or lingual walls of the extraction site, bundle bone is resorbed because of the lack of nutritive support from the periodontal ligament and is replaced with woven bone.[6–8] Consequently, the dimensions of the tooth socket reduce both vertically and horizontally.[5,7] This change may lead to esthetic and functional disadvantages that compromise future implant placement because adequate width of the residual ridge is essential for endosseous implant positioning that is prosthetically guided with a correct crown-to-root ratio and

esthetically maintainable with good soft tissue support.

Both clinical and histologic investigations in studies performed on animals and humans have clearly demonstrated that the buccal bone wall is often composed solely of bundle bone, resulting in considerably greater postextraction resorption on the buccal aspect than on the lingual aspect of the alveolar bone.[5,7] This is true in both the maxilla and mandible. Moreover, the maximal loss of soft tissue contour, which is in the order of 3 to 5 mm, occurs during the first months after tooth extraction[4,5] and stabilizes after 6 months.

In 2003, Schropp et al[5] published a clinical study on 46 patients that investigated bone healing and soft tissue contour changes after tooth removal. They found an approximate 50% reduction in the buccolingual width of edentulous sites after 12 months. Therefore, it is mandatory to preserve the dimensions of the tooth socket after extraction, especially if rehabilitation with an osseointegrated implant is planned. The different approaches presented in the literature to preserve the edentulous site include the use of barrier membranes and bone fillers.[9–16] The filling and covering of the postextraction alveolus with such materials preserves bone volume with greater predictability than that with spontaneous healing.

Socket preservation is a bone regeneration technique used to minimize the dimensional changes in soft and hard tissues after tooth extraction. Similar to the dynamics of spontaneous healing at a postextraction edentulous site, socket preservation enhances the stability of the blood clot, which reorganizes and is subsequently replaced by a provisional connective tissue matrix, woven and lamellar bone, and bone marrow. Barrier membranes are used to create space for the blood clot and exclude soft tissue ingrowth. The prerequisites for an ideal barrier membrane are biocompatibility, cell occlusivity, tissue integration, space-making effect, and clinical manageability.[13,14,16]

The aims of this randomized controlled clinical trial were *(1)* to compare the postextraction changes in ridge dimensions during spontaneous healing with those during socket preservation using bovine bone mineral and collagen membrane, *(2)* to analyze the histologic and histomorphometric aspects of the grafted sockets, and *(3)* to compare probing depth and clinical attachment level changes at teeth adjacent to extraction sites.

Method and materials

Patients

Forty-one patients (17 women, 24 men; mean age, 47.2 ± 12.9 years; age range, 24 to 71 years) undergoing dental treatment at a private practice in Torino, Italy, were enrolled in this trial. Patients were referred for extraction of one or more maxillary or mandibular premolars or molars and subsequent single-tooth implant treatment, leaving sockets with three intact walls and at least 80% of the fourth wall intact. Reasons for extraction included root fracture, periodontal involvement, endodontic treatment failure, and advanced caries.

Patients with acute periodontal or periapical infections were excluded. The systemic exclusion criteria were existence of metabolic bone disease, current pregnancy, history of malignancy, history of radiotherapy or chemotherapy for malignancy in the past 5 years, history of autoimmune disease, and long-term steroidal or antibiotic therapy. Those who smoked more than 10 cigarettes per day were also excluded, and those who smoked fewer than 10 cigarettes per day were asked to stop smoking before and after surgery.

Patients were provided oral and written information regarding the study, and written informed consent was obtained.

Extracted teeth

Forty-eight teeth were planned for extraction, including 4 first premolars, 12 second premolars, and 32 molars. By using a computer-generated randomization list, the extraction sites were assigned to either the control (EXT, extraction alone) or experimental group (SP, extraction and socket preservation).

Before the surgical procedures, a comprehensive periodontal examination was performed, including assessments of probing pocket

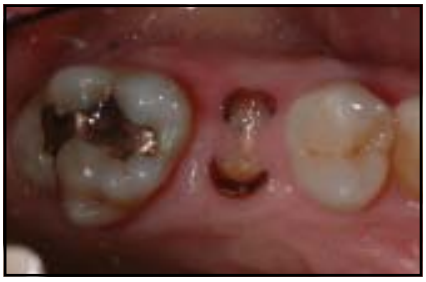
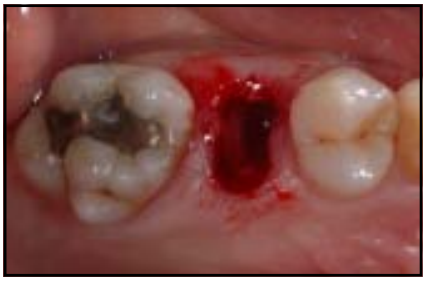


Fig 1a (left) *Test site (SP group) at baseline. The root of a maxillary second premolar was to be extracted and replaced by a delayed postextractive implant.*

Fig 1b (right) *The root was extracted using a flapless technique while preserving the integrity of the socket.*



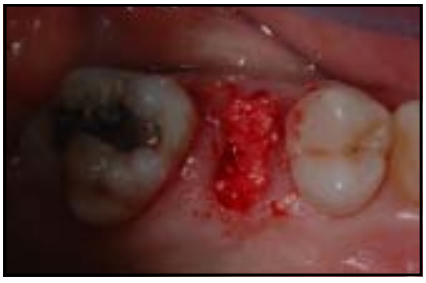


Fig 1c *Socket filled with bovine bone mineral.*

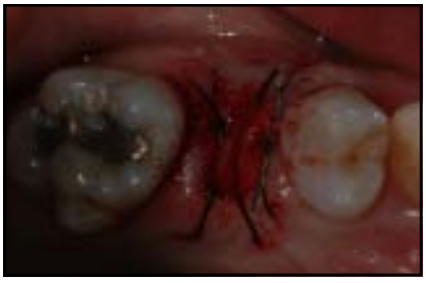


Fig 1d *Bone graft covered by a collagen membrane and secured using a cross matrress suture.*

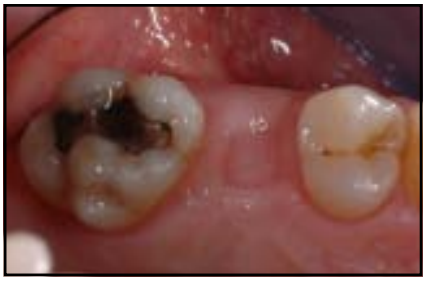


Fig 1e *Four months postextraction, gingival tissue had completely covered the socket.*

depth (PPD), gingival recession depth (REC), clinical attachment level (CAL), Plaque Index (PI), and bleeding on probing (BoP). This examination was followed by oral hygiene instructions and periodontal therapy if indicated, which included scaling and root planing to ensure a healthy periodontal environment. Further, intraoral radiographs of the indicated teeth were obtained using the parallel technique. Irreversible hydrocolloid impressions were registered immediately before tooth extraction (baseline), and dental casts were fabricated.

Surgical procedures

After administration of local anesthesia with 4% articaine plus epinephrine 1:100,000, the indicated teeth were gently luxated with an ultrasonic device (Piezon Master Surgery, EMS) and periotomes, and then carefully extracted with extraction forceps while attempting to minimize trauma to the bone circumscribing the teeth (Figs 1a and 1b). For multirooted teeth, the roots were sectioned first. The tooth sockets were carefully debrided to remove granulation tissue. In all cases, extraction was performed without elevating a mucogingival flap by using a flapless procedure.

In the SP group, the alveolus was then filled with combined bovine bone mineral (Bio-Oss Collagen, Geistlich) (Fig 1c). A porcine collagen membrane (Bio-Gide, Geistlich) was then trimmed to cover the socket and gently inserted under the periodontal sulcus (Fig 1d). Using 4-0 nonabsorbable sutures (Supramid, Resorba), a cross mattress suture pattern was used to secure the membrane in place, allowing open healing because soft tissue primary closure was not intended. In the EXT group, no additional treatment was performed and no sutures were placed after tooth extraction, but spontaneous stabilization of the blood clot with fibrin sponge was attempted (Fig 2a).

In both groups, patients were instructed to apply a gel rich in hyaluronic acid and amino acids (Aminogam, Errekappa) over the wound three times daily until complete gingival closure was noted. Patients agreed not to wear any prostheses during the healing period. In all cases, antibiotic therapy with 1 g amoxicillin plus clavulanate potassium was prescribed every 12

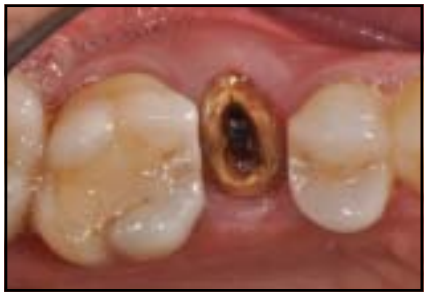


Fig 2a *Control site (EXT group) at baseline. The root of a maxillary second premolar was to be extracted and replaced by a delayed postextractive implant.*

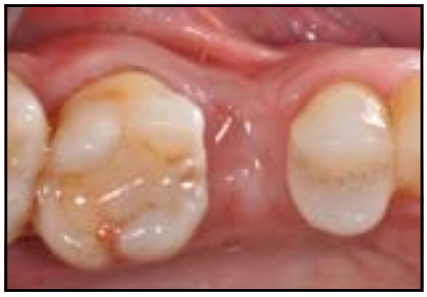


Fig 2b *Control site at 4 months.*

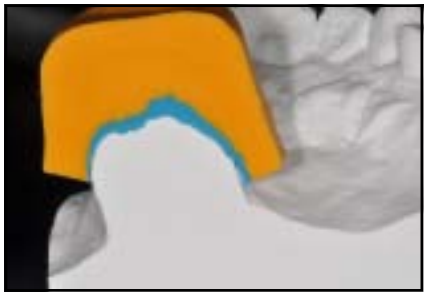


Fig 3 *Silicone template used for the cast measurement. Yellow = soft tissue contour at baseline; blue = soft tissue contour at 4 months.*

hours for 6 days, along with 600 mg ibuprofen every 12 hours for 3 days and 0.2% chlorhexidine gluconate mouthrinse every 8 hours. In the SP group, the sutures were removed after 14 days. Patients were asked to continue the chlorhexidine rinses until complete gingival closure. All patients were monitored weekly during the first month of healing.

Reentry procedure

Four months after extraction, PPD, REC, CAL, PI, and BoP were reassessed buccally, orally, and interproximally (mesially or distally) at the teeth adjacent to the edentulous sites using a calibrated periodontal probe (UNCP-15, Hu-Friedy) (Figs 1e and 2b). Furthermore, irreversible hydrocolloid impressions were registered, and dental casts were fabricated. Under local anesthesia in both the SP and EXT groups, surgical reentry was performed corresponding to the time of implant placement, and tissue samples were harvested from the grafted or edentulous sites using a 2-mm-diameter trephine. To ensure correct positioning of the trephine, a template was fabricated on initial study casts indicating the center of the extraction sites.[8] The template was again positioned before taking the bone biopsy. Subsequently, the implant osteotomy was completed and implants were inserted.

Cast-based measurements

Changes in the residual ridge dimensions were assessed on the dental casts obtained at baseline and 4 months by a clinician blinded to the type of treatment. A stent of yellow polyvinyl siloxane (Elite HD, Zhermack) was fabricated on each baseline cast to duplicate the contour of the edentulous site, with

perfect three-dimensional mapping of the ridge. The stent included at least one tooth anterior and posterior to the edentulous site to provide stability during repositioning. The stent was then adapted on the corresponding cast obtained at 4 months, and the difference in volume of the healed ridge was indicated with blue polyvinyl siloxane. The stent outlined the most prominent points of the ridge buccally and lingually and was cut at the midpoint of the edentulous site (Fig 3).

For each edentulous site, the ridge width (horizontal dimension) was measured as the distance between the buccal and lingual sides of the stent at baseline (yellow) and 4 months (blue). Similarly, the ridge height (vertical dimension) was assessed as the perpendicular distance between the midpoint of the edentulous site and the line connecting the most occlusal and buccal surfaces of the adjacent teeth at baseline (yellow) and 4 months (blue). The measurements were conducted using a calibrated lens at 7× magnification (Peak Scale Loupe, Tekno Optik) and rounded to the nearest 0.5 mm.

Histologic and histomorphometric analyses

The harvested bone tissues were fixed in 10% neutral buffered formalin, dehydrated in ethanol, and embedded in methyl methacrylate resin. After polymerization, the blocks were sectioned using a diamond saw microtome. The sections were ground, polished, and stained with Azure II and pararosaniline and with fast green and acid fuchsin.

Histomorphometric analysis was performed under optical microscopy with image analysis software. The sections were analyzed by a single examiner blinded to the type of treatment. The following parameters were measured as percentages of the total sample area: proportion of new bone (stained dark magenta), proportion of residual graft material (stained light magenta), mineralized fraction, and proportion of connective tissue plus bone marrow (stained blue).

Statistical analysis

A power calculation before the trial revealed that a sample size of 24 was necessary to detect a difference in bone width of 1 mm after 4 months, assuming a maximal standard deviation of 0.6 mm using a paired *t* test with 80% power and .05 level of significance. A preliminary analysis of data to evaluate the normal distribution of the values (Shapiro-Wilk test) and homoscedasticity (Barlett test) was performed. All clinical results were treated as ordinal data, and histomorphometric results were treated as continuous data. Each parameter was evaluated at baseline and 4 months per group by the paired *t* test. Intergroup comparisons at baseline and 4 months were made using the *t* test for independent data.

Results

Postextraction changes in ridge dimensions

All patients completed the study and all surgical procedures were performed successfully as planned without complications. The postsurgical healing phase was uneventful, although pain and swelling were commonly reported.

Table 1 shows the changes in PPD, REC, and CAL adjacent to the edentulous sites. The baseline clinical parameters were comparable between groups, with no significant differences. PPD was significantly reduced (approximately 0.3 to 0.5 mm) in both groups at 4 months compared with baseline ($P < .001$). Furthermore, at 4 months, REC values had significantly increased in both groups (approximately 0.3 mm, $P < .001$). A slight gain in CAL was measured in both groups at 4 months (0.19 mm in the SP group, 0.10 mm in the EXT group), but no significant difference was noted between baseline and 4 months or between groups.

The cast-based measurements are shown in Table 2. The SP group demonstrated a significant reduction in ridge width between baseline (range, 11 to 18 mm) and 4 months (range, 10 to 18 mm), corresponding to a 7.70% horizontal loss (range, 0 to 3 mm; $P < .001$). Similarly, the EXT group had a significant reduction in ridge width between baseline and 4 months, corresponding to a 33.48% horizontal loss (range, 3 to 5.5 mm;

Table 1 PPD, REC, and CAL (mm) at baseline (T0) and 4 months (T4) in the SP and EXT groups*

	T0 (mean ± SD)	T4 (mean ± SD)	Difference (mean ± SD)	*P*
PPD				
SP	2.92 ± 0.93	2.43 ± 0.83	−0.49 ± 0.96	.001
EXT	2.88 ± 0.85	2.54 ± 0.83	−0.34 ± 0.79	.001
Difference	0.04 ± 0.46	−0.11 ± 0.94		NS
REC				
SP	0.90 ± 0.99	1.20 ± 0.92	0.30 ± 0.67	.001
EXT	0.86 ± 0.90	1.11 ± 0.90	0.24 ± 0.57	.001
Difference	0.03 ± 0.30	0.09 ± 0.69		NS
CAL				
SP	3.82 ± 1.49	3.63 ± 1.32	−0.19 ± 1.20	.001
EXT	3.75 ± 1.39	3.65 ± 1.29	−0.10 ± 1.01	NS
Difference	0.08 ± 0.54	−0.02 ± 1.18		NS

PPD = probing pocket depth; REC = gingival recession depth; CAL = clinical attachment level; SD = standard deviation; NS = not significant.
*Intragroup analysis by two-tailed paired *t* test; intergroup analysis by *t* test for independent data. Significance set at $P < .05$.

Table 2 Cast-based measurements (mm) of changes in ridge dimensions between baseline (T0) and 4 months (T4) in the SP and EXT groups*

	T0 (mean ± SD)	T4 (mean ± SD)	Difference (mean ± SD)	*P*
Width				
SP	13.50 ± 1.82	12.46 ± 2.08	1.04 ± 1.08	.001
EXT	13.38 ± 1.51	8.90 ± 1.53	4.48 ± 0.65	.001
Difference	0.12 ± 2.39	3.56 ± 2.98		.001
Height				
SP	6.88 ± 1.42	7.33 ± 1.54	0.46 ± 0.46	.001
EXT	7.46 ± 0.91	9.02 ± 0.90	1.54 ± 0.33	.001

SD = standard deviation; NS = not significant.
*Intragroup analysis by two-tailed paired *t* test; intergroup analysis by *t* test for independent data. Significance set at $P < .05$.

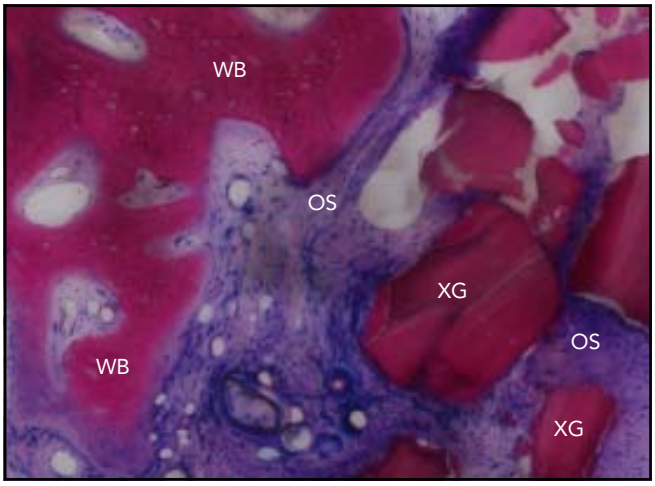


Fig 4a *Section from a test site specimen at 4 months. The mineralized part is composed of newly formed woven bone* (WB) *and xenograft granules* (XG) *surrounded by osteoid* (OS)*. No signs of acute inflammatory response were observed (Azure II and pararosaniline, original magnification ×100).*

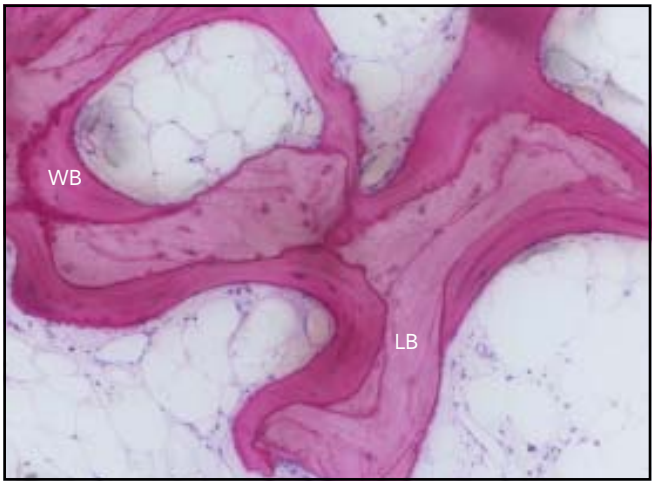


Fig 4b *Section from a control site specimen at 4 months. Newly formed woven bone* (WB)*, lamellar bone* (LB)*, blood vessels, and adipocytes were present (Azure II and pararosaniline, original magnification ×100).*

$P < .001$). Although no significant difference in ridge width was detected between groups at baseline, the intergroup difference was statistically significant at 4 months ($P < .001$). Furthermore, both groups showed significant increases in ridge height between baseline and 4 months ($P < .05$). The intergroup analysis revealed no significant difference in ridge height at baseline but a statistically significant difference between groups at 4 months ($P < .05$).

Histologic and histomorphometric evaluation

The specimens from the grafted sites exhibited various stages of bone maturation and formation without any inflammatory response or fibrous encapsulation of the graft particles (Fig 4a). All sections showed osteoblasts adjacent to areas of osteoid tissue, woven bone, and mature bone. Residual graft particles were embedded in new bone. All sockets demonstrated complete bone fill with interindividual variation in the mineralized fraction (Fig 4b).

Table 3 shows the results of the histomorphometric analysis. No significant difference in the mineralized and nonmineralized fractions was noted between groups.

Discussion

The placement of osseointegrated implants requires adequate bone volume, but tooth extraction leads to different patterns of bone remodeling and resorption. Accordingly, the residual bone volume should be estimated before tooth extraction so that clinicians can use different techniques to preserve the alveolar bone and ensure ideal anatomy of the implant site. Such estimation is also important because bone-augmentation procedures increase the morbidity associated with implant placement.

In this randomized controlled clinical trial, edentulous sites allowed to heal spontaneously (EXT group) were compared with edentulous sites preserved with bovine bone mineral and collagen membrane (SP group), and the major dimensional changes in the extraction sockets were evaluated 4 months after tooth removal. The residual ridge width was reduced by approximately 35% in the EXT group but

Table 3 **Histomorphometric data expressed as percentages of the total sample area in the SP and EXT groups***

	New bone (mean ± SD)	Residual graft material (mean ± SD)	Mineralized fraction (mean ± SD)	Connective tissue + bone marrow (mean ± SD)
SP	26.34 ± 16.91	18.46 ± 11.18	44.80 ± 11.45	55.19 ± 11.45
EXT	43.82 ± 12.23		43.82 ± 12.23	56.17 ± 12.23
Difference			0.98 (NS)	−0.98 ± 13.55 (NS)

SD = standard deviation; NS = not significant.
*Intergroup analysis by *t* test for independent data. Significance set at $P < .05$.

remained nearly stable (only a 7.26% reduction) in the SP group. The horizontal loss at EXT sites is in accordance with the results of previous studies that observed considerable ridge volume loss after root removal.[6,7] Schropp et al[5] reported a 50% reduction in alveolar ridge width, corresponding to a mean 6.1-mm loss over an observation period of 12 months, and approximately two-thirds of the width reduction occurred within the first 3 months after extraction. In a controlled study, Iasella et al[17] found a 29% decrease in ridge width at nongrafted sites in the premolar and anterior areas. Furthermore, Botticelli and coworkers[18] reported a mean 56% width reduction at untreated extraction sockets with immediate implant placement. In 2008, Barone et al[14] evaluated the healing of incisor, canine, and premolar extraction sockets at 7 to 9 months and reported a mean ridge width reduction of 4.5 mm, corresponding to a 42% horizontal loss.

In the present study, the sockets in the SP group were augmented with composite bovine bone mineral (Bio-Oss Collagen) and the grafted sites were covered and protected with a resorbable membrane (Bio-Gide). Bio-Oss Collagen is a blend of deproteinized bovine bone granules (90%) and porcine type I collagen fibers (10%). The postextraction socket can be filled and packed easily with this graft material. Bio-Gide is a bilayered porcine-derived collagen membrane that tends to absorb blood and easily covers and adheres to the underlying bone graft.[19]

Bio-Oss Collagen has been tested as a graft material for augmentation of both experimentally created and postextraction defects.[12,15,20,21] Recently, Araújo et al[20] evaluated the dynamics of Bio-Oss Collagen incorporation in extraction wounds in dogs. The authors found that the biomaterial was first entrapped in the fibrin network of the coagulum, and then neutrophilic leukocytes migrated to the surface of the graft particles. In the second phase, the polymorphonuclear cells were replaced by multinuclear TRAP-positive cells (osteoclasts) that apparently removed material from the surface of the xenograft. After 1 to 2 weeks, osteoclasts disappeared from the grafted site and were replaced by osteoblasts, which lay bone mineral in the collagen bundles of the provisional matrix. In this third phase, the Bio-Oss particles became osseointegrated.

In an experimental study in dogs, Cardaropoli et al[21] noted that this graft material minimized wound shrinkage compared with that of nongrafted defects. Although Araújo et al[12] reported that the placement of Bio-Oss Collagen in fresh extraction sockets in dogs failed to inhibit the modeling and remodeling of the ridge walls after tooth extraction because bundle

bone gradually disappeared, the biomaterial apparently promoted de novo hard tissue formation, particularly at the margins of the edentulous sites. Further, Araújo and Lindhe[15] concluded that the placement of Bio-Oss Collagen in postextraction tooth sockets can modify remodeling and counteract marginal ridge contraction, as evidenced by a mean relative reduction in surface area of 35% at nongrafted edentulous sites compared with an only 12% reduction at grafted edentulous sites.

In the present study, socket preservation enabled the maintenance of most of the original ridge dimensions (92.74% preservation of ridge width and vertical loss of only 0.46 mm) and allowed implant placement without the need for bone augmentation. In terms of the periodontal findings adjacent to the edentulous sites, PPD reduction was greater than REC increase from baseline to 4 months, leading to a 0.25- to 0.3-mm gain in CAL during the 4 months of healing. Despite the lack of significant differences between the study groups, the results indicate that the periodontal health of teeth adjacent to an extraction site tends to improve during the healing period.

The observation that the placement of a graft in a fresh extraction socket prevented considerable horizontal ridge loss is in agreement with the results of Iasella et al.[17] The authors found that the use of hydrated freeze-dried bone allograft maintained 84% of the original horizontal ridge dimension. Further, Nevins et al[11] evaluated the fate of the buccal socket wall of 36 maxillary anterior teeth including 19 sockets grafted with bovine bone mineral on the basis of computed tomography scans obtained after tooth extraction and 30 to 90 days of healing. The authors reported that 15 of 19 grafted sockets showed a reduction in the buccal plate of less than 20%, whereas 12 of 17 control sites suffered a reduction of more than 20%. Barone et al[14] reported a mean 24% bone width reduction after 7 to 9 months using a porcine-derived xenograft. In 2011, Engler-Hamm et al[16] reported an approximate 30% ridge width reduction after 6 months using demineralized freeze-dried bone allograft plus bovine-derived hydroxyapatite matrix with cell-binding peptide P-15 (ABM/P-15) and a combination of full- and split-thickness flaps. Cardaropoli and Cardaropoli[13] used porcine bone mineral to fill postextraction sockets with a flapless surgical technique and reported a mean 85% bone width preservation after 4 months.

The minimal vertical remodeling in the present study is also in agreement with the findings of other studies. Cardaropoli et al[21] showed a mean vertical invagination of only 0.1 mm in defects grafted with Bio-Oss Collagen. Barone et al[14] reported a mean 0.7-mm vertical resorption at the buccal sites of preserved sockets. Moreover, Vance et al[22] reported a gain of 0.7 mm in vertical ridge dimension by using bovine-derived xenograft for ridge preservation.

The positive outcomes of the present study may be related to the use of a graft material with a low resorption rate, enabling the maintenance of the grafted site and promoting hard tissue formation by acting as a scaffold with osteoconductive characteristics.[12,15,20] Moreover, the use of a collagen membrane left exposed intentionally may have increased the potential to maintain the socket volume, as previously reported by other studies in which resorbable membranes were left exposed on postextraction sockets to act as self-contained four-wall defects.[13,16]

The histologic findings reported here show that bovine bone mineral can be used to promote socket preservation. No signs of inflammation surrounding the graft particles were detected, and these particles contacted both newly deposited woven bone and osteoid tissue. This observation is in accordance with published data showing that this bovine-derived xenograft is slowly eliminated.[10,12,15,20,21] The grafted sites showed the typical dynamics of bone formation in postextraction sockets.[6–8] The almost complete incorporation of the bovine-derived particles in new bone created a dense and hard tissue network acting as a natural scaffold for further bone deposition. Once the graft particles are embedded in mineralized bone, they probably act similarly to the host bone and provide a biologic support for dental implants.[23,24]

The histomorphometric analysis revealed a comparable mineral-

ized fraction between SP and EXT sites (44.80% and 43.82%, respectively). Furthermore, most of the grafted material was replaced by new bone in the first few months of healing.[12,15,20,21] The proportion of residual Bio-Oss material (18.46%) was substantially lower than the established limit (40%) for successful implant placement.[24]

Conclusions

Socket preservation using bovine bone mineral and porcine collagen membrane considerably limits the amount of horizontal and vertical bone resorption when compared with tooth extraction alone. Histologically, the xenograft material ensures a large mineralized fraction with the formation of new bone.

Acknowledgment

Geistlich Pharma supplied the biomaterials (Bio-Oss Collagen and Bio-Gide) used in this research.

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