Anorganic Bovine Bone Plus Recombinant Human Platelet-Derived Growth Factor-BB in Ridge Preservation: A Pilot Study

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Purpose: To determine clinical parameters, histologic features, and radiographic linear bone width changes of regenerated bone using different biomaterials for ridge preservation following tooth extraction. ***Materials and Methods:*** For this pilot study, five patients were grafted with anorganic bovine bone and collagen plus recombinant human platelet–derived growth factor-BB (rhPDGF-BB), five patients were grafted with anorganic bovine bone and collagen alone, and five patients did not receive any biomaterial (control) after tooth extraction. Clinical, histologic, and radiographic evaluations were carried out 4 months postextraction. ***Results:*** Differences in terms of buccolingual width were found when comparing the control group to the group grafted with anorganic bovine bone and collagen plus rhPDGF-BB ($P = .012$). No statistical differences were observed between the groups in terms of mineralized or nonmineralized tissue formation or in terms of the number of osteoblasts or osteocytes per mm^2 after 4 months of healing. Interestingly, the number of vessels in the grafted area was found to be significantly different among the three groups ($P = .005$). The number of Musashi-1 positive cells was also different among groups, both in the mineralized and the nonmineralized areas of the grafted bone ($P = .024$ and .005, respectively). ***Conclusion:*** Anorganic bovine bone with bovine collagen is an efficient biomaterial to avoid postextraction resorption of the alveolar ridge. The addition of rhPDGF-BB appears to improve the biologic features of the newly formed bone and decrease bone resorption; further studies are needed for confirmation. *Int J Oral Maxillofac Implants 2022;37:356–364. doi: 10.11607/jomi.9022*

Keywords: anorganic bovine bone, rhPDGF-BB, ridge preservation

Teeth extraction is a clinical procedure that leads to anatomical and histologic changes in the alveolar environment.[1] Clinical and preclinical studies have shown that postextraction vertical and horizontal modifications of the alveolar bone are unavoidable, regardless of alveolar ridge preservation procedures.[2] The level of bone loss is modifiable depending on the nature of the biomaterial used to conduct the preservation technique.

For alveolar ridge preservation, the use of low-resorption biomaterials, such as anorganic bovine bone, is considered the gold standard. Bio-Oss, in particular, shows high osteoconduction capacities, and its resorption is mediated by osteoclasts.[3] However, not all biomaterials of a given origin have the same biologic results.[4]

In 2014, BioHorizons launched MinerOss X Collagen,[5] which is structurally very similar to Bio-Oss Collagen. However, to the authors' knowledge, there are no clinical studies that have tested the use of MinerOss X Collagen in postextraction sockets in humans.

Moreover, the activity of a biomaterial for bone regeneration can be modified by growth factors.[6] These growth factors can be either autologous from platelet concentrates[7] or recombinant. The main component of GEM 21S is recombinant human platelet–derived growth factor-BB (rhPDGF-BB), which is intrasurgically mixed with a beta-tricalcium phosphate matrix. GEM 21S has been used previously for postextraction sockets.[8] In addition to the original combination of rhPDGF-BB and beta-tricalcium phosphate,[9] other studies propose that rhPDGF-BB serves as a

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Submitted September 28, 2020; accepted February 17, 2021.

biofunctional activator of other biomaterials, such as xenografts.[10] No studies have combined bovine xenografts with rhPDGF-BB for ridge preservation in postextraction sockets.

The present pilot study proposes combining anorganic bovine bone in a collagen matrix with rhPDGF-BB for ridge preservation after tooth extraction. The outcomes in terms of histologic characteristics and radiographic linear bone changes are compared to those of anorganic bovine bone in a collagen matrix alone and spontaneous healing without any biomaterial.

MATERIALS AND METHODS

This pilot study followed the internationally accepted ethical principles for clinical research established in the Helsinki protocols. All patients were treated in the Periodontics Program of the Universidad Científica del Sur (Lima, Peru). Thus, the study protocol was approved by the Ethics on Research Committee of the School of Dentistry, Universidad Científica del Sur (Lima, Peru) and registered with the protocol no. 000446. Before any study procedures, each patient received detailed information about the study. Then, they signed an informed consent form.

Patient Selection

All included patients were between the ages of 18 and 75 years, in good general health, and in need of an implant-supported restoration after the extraction of an unirradicular tooth in the premolar area with neighboring teeth.

Patients were excluded for inadequate oral hygiene, an acute infection in the extraction area, being a smoker, and the absence of integrity of the cortical bone at the time of clinical or radiologic examination by CBCT. Patients were also excluded if they were pregnant, had hematologic disorders, had diseases that could alter bone metabolism, had cancer, had diabetes, needed radiation therapy in the work area or chemotherapy within 18 months before extraction, were taking anticoagulant or antiplatelet medication that could alter the stabilization of the blood clot, or were taking drugs that altered normal bone function. Extractions never took more than 40 minutes, and no buccal bones were broken during extraction.

Presurgical Preparation

A clinical study of the surgical area was performed on each patient, including a periodontal evaluation, a full-mouth teeth cleaning, and appropriate hygiene instructions.

Before starting the surgical procedure, CBCT was performed with the Picasso Master 3D (Vatech).

Surgical Procedures and Intrasurgical Measurements

The tooth extraction was performed, avoiding trauma as much as possible under local anesthesia (2% xylocaine with 1:100,000 epinephrine) by a single oral surgeon (G.M.-A.). The cavities were treated as follows: five patients—no biomaterial (control); five patients—anorganic bovine bone in a collagen matrix (MinerOss X Collagen, Biohorizons) mixed with rhPDGF-BB gel obtained from GEM 21S (Lynch Biologics), and covered with a resorbable collagen membrane (Mem-Lok Resorbable Collagen Matrix, BioHorizons); and five patients—anorganic bovine bone in a collagen matrix covered with a resorbable collagen membrane.

In all cases, interrupted sutures forming a simple X were used to protect the area using an expanded-polytetrafluoroethylene suture (Goretex suture, P5K17, CV-5, W. L. Gore & Associates, Medical Products Division).

Postoperative Care

All patients received detailed information about postoperative care to avoid any type of trauma that could alter the area during the first few weeks. The patients were prescribed antibiotics (amoxicillin 500 mg + clavulanic acid 125 mg every 8 hours for 1 week), analgesics (ketorolac 10 mg every 8 hours for a maximum of 3 days), and anti-inflammatory drugs (dexamethasone 4 mg every 12 hours for 3 days). After 20 days, the sutures were removed.

Surgical Reentry for Implant Placement

After 16 weeks, a second CBCT image was obtained from each patient. A mucoperiosteal incision was made. Then, a full-thickness flap was elevated to expose the bone. Then, a bone tissue biopsy specimen was obtained using a 2 mm internal/3 mm external trephine (Dentium). The space created by the trephine served for implant placement. Tapered dental implants (SuperLine, Dentium) were placed in each prepared site.

Clinical Measurements

At the time of tooth extraction, the buccolingual dimension of the alveolum in its most coronal aspect was measured. At the time of surgical reentry for implant placement, the same measurement was performed to evaluate the dimensional clinical changes at the crestal bone level in its most coronal part.

Tomographic Measurements

The tomographic measurements were taken by drawing a line from the neighboring teeth passing through the cementoenamel junction and a perpendicular line to it. Then, three planes were drawn at 3, 6, and 9 mm from the buccal bone crest. The thickness of the buccal plate and the width of the buccolingual ridge were

Table 1 Demographic Data by Group

	Control	Anorganic bovine bone and collagen	Anorganic bovine bone and collagen plus rhPDGF-BB
Age (mean [minimum–maximum])	44.8 (35–57)	47.5 (39–68)	40.4 (29–53)
Sex (n [%])			
Male	3 (60.0)	0 (0.0)	3 (60.0)
Female	2 (40.0)	5 (100.0)	2 (40.0)

measured. The vertical distance to the cementoenamel junction was also measured to be able to reproduce the process at 16 weeks.

All these measurements were performed by a specialized radiologist, who did not know the treatment that the patients had received.

Histologic and Histomorphometric Evaluation

As explained elsewhere,[7] the collected cores obtained with the trephine were immediately fixed in formalin 10% for 48 hours at room temperature and then transferred to ethanol 70%. Fixed samples were transported to the Laboratory of Pathology (University of Granada) for evaluation. They were decalcified with 10% ethylene diamine tetraacetic acid (Sigma-Aldrich) for 4 weeks. Then, they were embedded in paraffin to create blocks that were then sectioned by the central long axis. Conventional hematoxylin-eosin and Masson trichrome methods were applied to stain the dewaxed and rehydrated sections. Osteoblast and osteocyte cells per mm^2 were counted by visualizing the sections under a microscope equipped with a millimeter scale in the eyepiece and a 40× objective. The results were expressed as number of cells per mm^2.

Bone histomorphometry was performed semiautomatically on Masson trichrome–stained sections. Ten random images per sample captured with 10× objective were evaluated using the ImageJ software (National Institutes of Health). Proportions of mineralized and nonmineralized tissues as well as remnant particles were calculated.

Immunohistochemical Evaluation

Rehydrated 4-µm sections were also heat treated for antigenic unmasking in a pretreatment module (Thermo Fisher Scientific) containing a 1-mM ethylene diamine tetraacetic acid buffer (pH 8) at 95°C for 20 minutes. Primary polyclonal antibody against Musashi-1 was then applied in all the samples and incubated at 1:100 dilution for 1 hour at room temperature. A non-immunospecific immunoglobulin G was used as a negative control. Antibodies were purchased from Master Diagnóstica. Immunostaining was carried out in an automatic immunostainer (Autostainer 480S, Thermo Fisher Scientific) using a peroxidase-conjugated micropolymer and diaminobenzidine (Master Diagnóstica). Immunopositivity was then evaluated quantitatively in mineralized and nonmineralized tissues to count the number of mesenchymal stromal cells per mm^2 as mentioned earlier.

Statistical Analysis

All data are presented as mean (standard deviation). The differences among groups were evaluated by the Kruskal-Wallis nonparametric test. Pairwise comparisons were further analyzed by the Dunn multiple comparisons test. Comparisons between histologic data from grafted and pristine areas, mineralized and nonmineralized tissues, as well as between clinical and radiographic data before and after surgical procedures were conducted by the Student *t* test. The association between the buccal plate thickness and the reduction of the radiographic width of the alveolar bone was analyzed with the Spearman rho correlation coefficient. Statistical significance was set at a *P* value of .05. Prism 7.0a for Mac OS X was used for the analyses.

RESULTS

The demographic data of the included patients are presented in Table 1.

Analyses of clinical data are presented in Table 2. The analysis of clinical measurements of the buccolingual width (Fig 1) demonstrated no statistically significant differences between groups at baseline ($P = .295$, Kruskal-Wallis test). Although differences at reentry were significant globally ($P = .045$, Kruskal-Wallis test), no pairwise comparison was found to be significant. Interestingly, when evaluating the change from baseline to reentry, significant changes were found ($P = .009$, Kruskal-Wallis test), specifically when comparing the control group to the anorganic bovine bone and collagen plus rhPDGF-BB group ($P = .012$, Dunn post hoc multiple comparison test). In fact, the only groups that changed significantly from baseline to reentry were the control ($P < .001$, Student *t* test) and the anorganic bovine bone and collagen plus rhPDGF-BB ($P = .028$, Student *t* test). When looking at the radiographic measurements, similar outcomes were found. Statistical differences, however, were not so

Table 2 Clinical Buccolingual Width of the Socket

	Control	Anorganic bovine bone and collagen	Anorganic bovine bone and collagen plus rhPDGF-BB	*P* value[#]
Before	9.60 (0.89)	9.60 (1.52)	10.40 (0.55)	.295
After	6.40 (0.89)	7.20 (2.17)	9.20 (0.84)	.045
P value[##]	< .001	.077	.028	
Difference	3.20 (0.84)	2.40 (0.89)	1.20 (0.45)	.009 *

Unless otherwise noted, the pairwise comparison did not demonstrate any statistical significance. *P = .012 for the pair comparison control vs anorganic bovine bone and collagen plus rhPDGF-BB. [#]Kruskal-Wallis test; [##]Student t test.

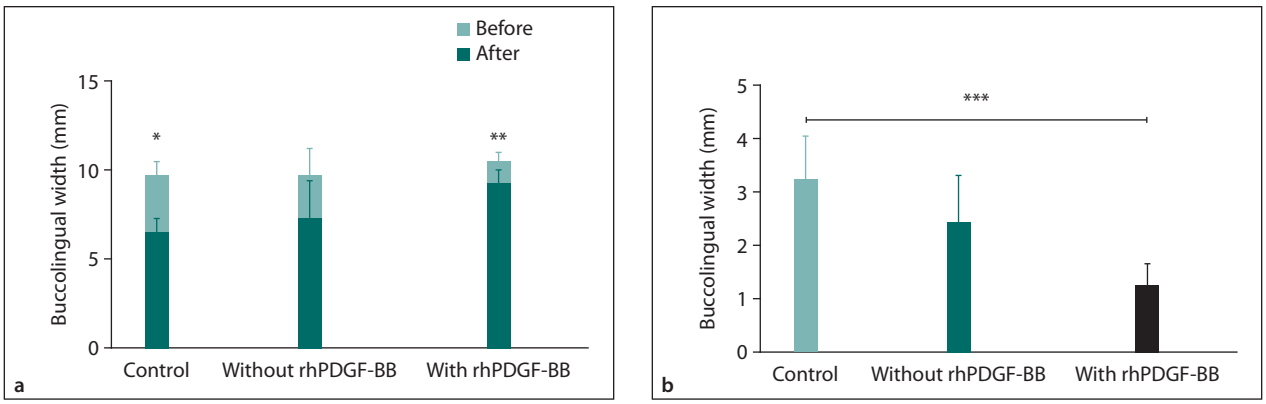

Fig 1 Graphical representation of the data from clinical measurements of the *(a)* buccolingual width and *(b)* the differences between baseline and reentry. *P < .001; **P = .028; t test comparing before and after within groups; ***P = .012; Dunn multiple comparison test between control and anorganic bovine bone and collagen plus rhPDGF-BB.

Table 3 Radiographic Buccolingual Width of the Socket and Thickness of the Buccal Plate at Different Distances from the Crest

	Control	Anorganic bovine bone and collagen	Anorganic bovine bone and collagen plus rhPDGF-BB	*P* value[#]
Buccolingual width of the socket (mm)				
At 3 mm				
Before	9.30 (0.45)	9.36 (0.83)	9.54 (0.78)	.776
After	6.02 (1.11)	7.74 (1.25)	8.12 (1.06)	.036
P value[##]	< .001	.042	.042	
Difference	3.28 (0.88)	1.62 (0.80)	1.42 (1.09)	.027
At 6 mm				
Before	9.76 (0.54)	9.52 (1.35)	9.80 (0.42)	.956
After	7.10 (0.87)	8.76 (1.43)	8.82 (0.80)	.041
P value[##]	< .001	.413	.041	
Difference	2.66 (0.87)	0.76 (0.51)	0.98 (0.62)	.006*
At 9 mm				
Before	10.42 (0.22)	10.48 (2.28)	10.38 (0.70)	.852
After	8.98 (0.47)	9.46 (1.66)	9.88 (0.44)	.070
P value[##]	< .001	.442	.214	
Difference	1.44 (0.38)	1.02 (1.01)	0.50 (0.32)	.020**
Thickness of the buccal plate (mm)				
At 3 mm	0.85 (0.09)	0.81 (0.02)	0.86 (0.16)	.714
At 6 mm	0.90 (0.07)	0.86 (0.17)	0.84 (0.11)	.845
At 9 mm	0.88 (0.16)	0.94 (0.08)	0.92 (0.08)	.693

Unless otherwise noted, the pairwise comparison did not demonstrate any statistical significance. *P = .021 for the pair comparison control vs anorganic bovine bone and collagen; **P = .026 for the pair comparison control vs anorganic bovine bone and collagen plus rhPDGF-BB. [#]Kruskal-Wallis test. [##]Student t test.

obvious in the width of the socket at 3, 6, and 9 mm from the cementoenamel junction, both at baseline and reentry (Table 3 and Fig 2). Buccal bone thickness was not different between groups (Table 3 and Fig 3). Buccal bone thickness did not correlate with socket width reduction in any measurement at any depth (P = .263, P = .838, and P = .584; 3, 6, and 9 mm from the cementoenamel junction, respectively).

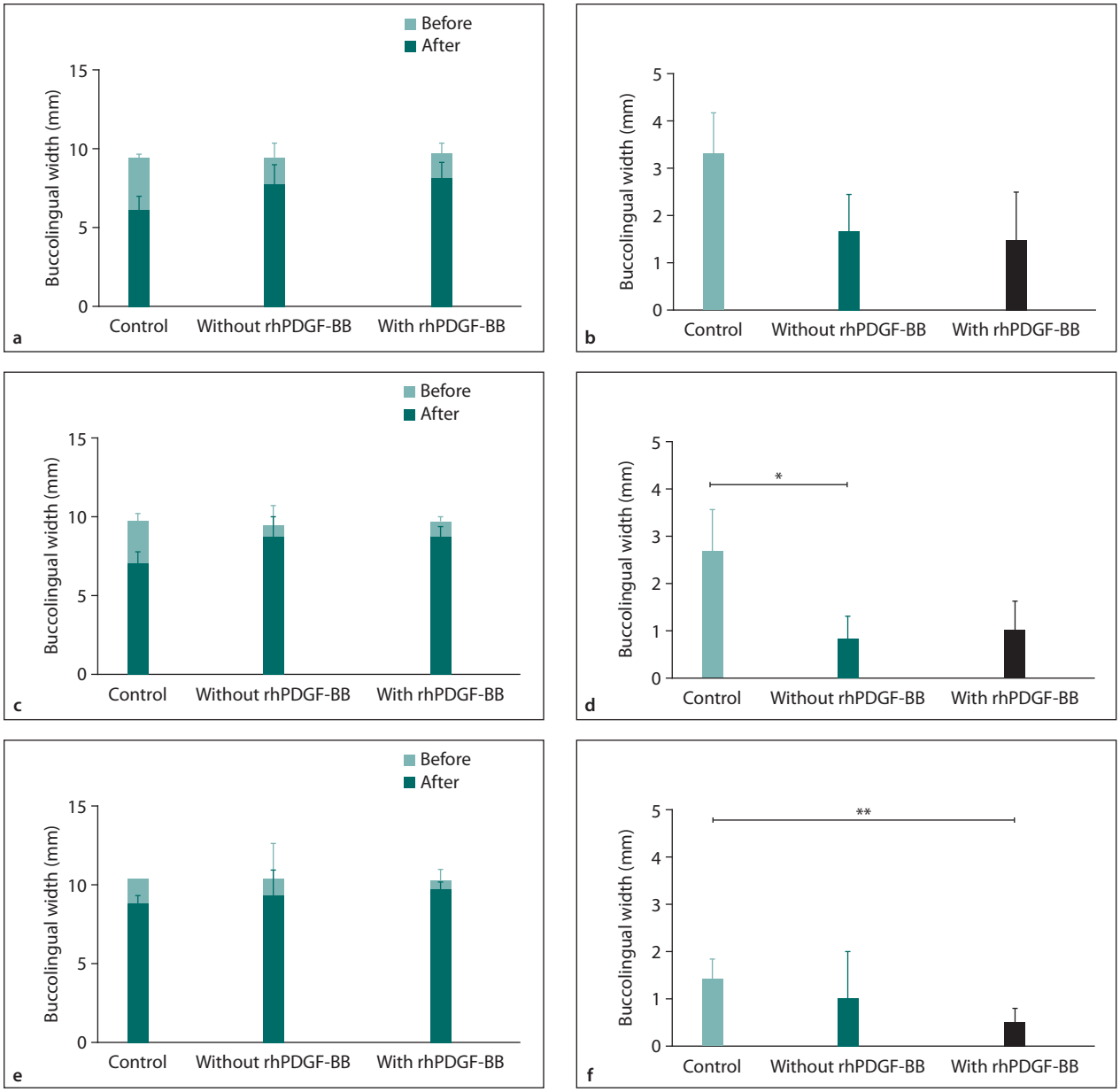

Fig 2 Graphical representation of the buccolingual width of the socket from CBCT measurements at *(a)* 3, *(c)* 6, and *(e)* 9 mm from the cementoenamel junction and *(b, d, and f)* the differences between baseline and reentry. *P = .021, Dunn multiple comparison test between control and anorganic bovine bone; **P = .026; Dunn multiple comparison test between control and anorganic bovine bone and collagen plus rhPDGF-BB.

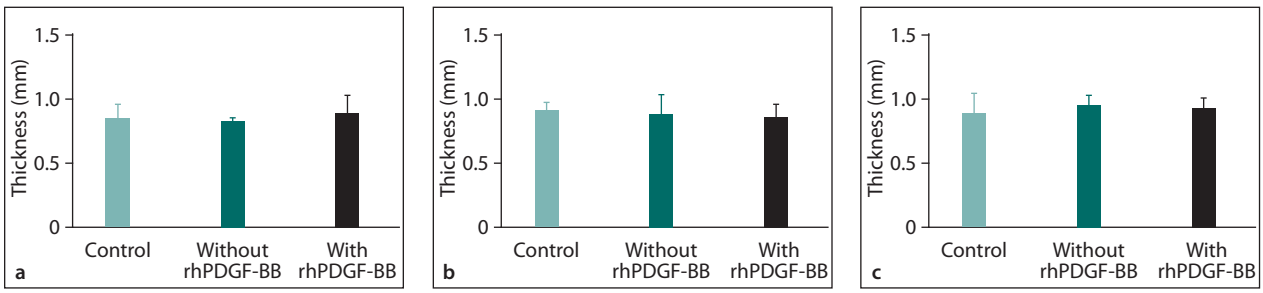

Fig 3 Graphical representation of the thickness of the buccal bone plate at *(a)* 3, *(b)* 6, and *(c)* 9 mm from the cementoenamel junction. No statistically significant differences were found for any of the measurements.

Table 4 Histologic and Histomorphometric Data

		Control	Anorganic bovine bone and collagen	Anorganic bovine bone and collagen plus rhPDGF-BB	*P* value[#]
Histologic outcomes					
Osteocytes per mm^2	Grafted area Pristine bone *P* value[##]	204.16 (155.05)	149.42 (112.51) 196.45 (142.29) 0.604	212.71 (142.74) 260.19 (138.03) 0.600	.760 .809
Osteoblasts per mm^2	Grafted area Pristine bone *P* value[##]	6.45 (14.43)	12.90 (13.50) 48.13 (87.31) 0.243	39.55 (38.96) 47.26 (56.84) 0.795	.204 .194
Vessels per mm^2	Grafted area Pristine bone *P* value[##]	12.84 (6.15)	37.42 (19.17) 35.45 (27.60) 0.899	41.90 (7.01) 26.84 (16.97) 0.104	.005* .188
Musashi-1 positive cells mm^2	Mineralized Nonmineralized *P* value[##]	35.99 (4.93) 29.26 (2.96) .031	22.58 (10.94) 56.13 (20.48) .012	16.77 (11.72) 73.87 (21.52) < .001	.024** .005***
Histomorphometric outcomes (% of total area)					
New mineralized tissue		58.68 (35.02)	46.75 (33.45)	36.06 (16.70)	.703
Nonmineralized tissue		41.32 (35.02)	46.98 (29.95)	58.75 (17.43)	.761
Biomaterial		0.00 (0.00)	6.27 (5.79)	5.19 (4.36)	.017

Unless otherwise noted, the pairwise comparison did not demonstrate any statistical significance. *P = .017, **P = .022, and ***P = .004 for the pair comparisons control vs anorganic bovine bone and collagen plus rhPDGF-BB. [#]Kruskal-Wallis test; [##] Student *t* test.

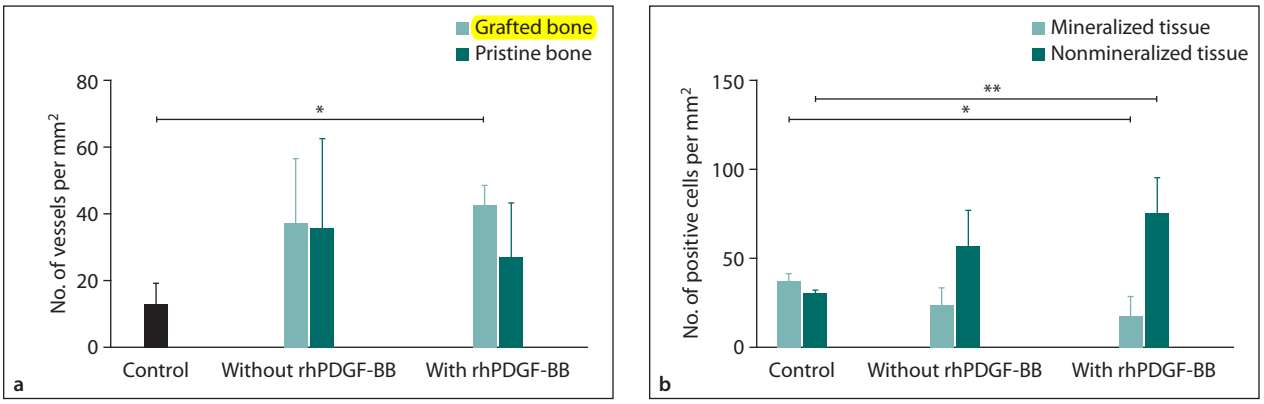

Fig 4 *(a)* Number of vessels per mm^2 in control and grafted and pristine areas of anorganic bovine bone and anorganic bovine bone and collagen plus rhPDGF-BB groups. *P = .017; Dunn multiple comparison test between control and grafted area of anorganic bovine bone and collagen plus rhPDGF-BB. *(b)* Number of Musashi-1 positive cells per mm^2 in mineralized and nonmineralized tissues. *P = .022 and **P = .004; Dunn multiple comparison test between control and anorganic bovine bone and collagen plus rhPDGF-BB.

The analysis of the cellularity, histologic, and histomorphometric data of each area of the biopsy specimen is also presented in Table 4. As shown, no differences were found between any of the groups and areas of the biopsy specimen in terms of osteoblasts or osteocytes. Interestingly, the number of vessels in the grafted area was found to be significantly different among groups (P = .005, Kruskal-Wallis test), particularly when comparing the control group to the anorganic bovine bone and collagen plus rhPDGF-BB group (P = .017, Dunn post hoc multiple comparison test [Figs 4a and 5]). Similarly, the number of Musashi-1 positive cells was also different among groups, both in the mineralized and the nonmineralized areas of the graft (P = .024 and .005, Kruskal-Wallis test, respectively). Again, the pairwise comparison showed differences between the control group and the anorganic bovine bone and collagen plus rhPDGF-BB group in the mineralized and the nonmineralized areas of the graft (P = .022 and P = .004, Dunn post hoc multiple comparison test; Figs 4b and 5). Within-group comparison between the number of Musashi-1 positive cells in the mineralized and nonmineralized tissues showed significant differences in all groups (P = .031, P = .012, and P < .001, Student *t* test for control, anorganic bovine bone and collagen, and anorganic bovine bone and collagen plus rhPDGF-BB groups, respectively). In those comparisons, Musashi-1 positive cells were higher in the nonmineralized tissue except in the control group, where Musashi-1 positive cells were higher in the mineralized tissue.

Finally, no statistical differences were observed between experimental groups and the control group in

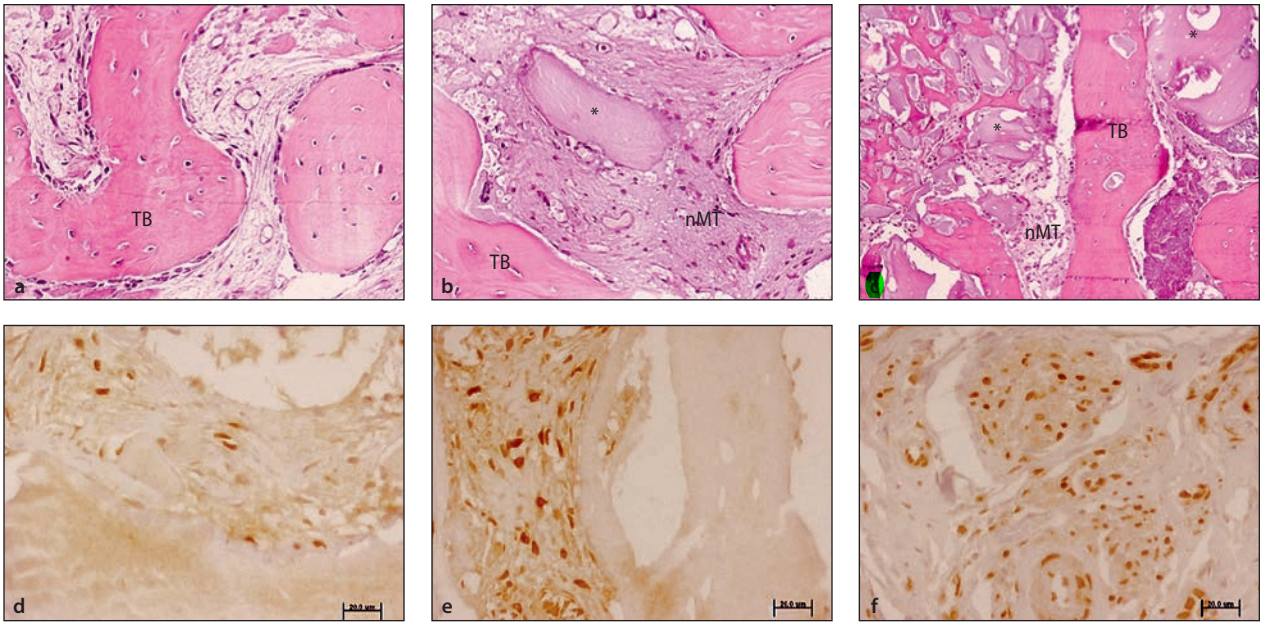

Fig 5 Representative photomicrographs of bone samples after 4 months of healing. Note the mineralized (trabecular bone, TB) and the nonmineralized areas (nMT) of the graft with remnant biomaterial (*). *(a)* Control group, *(b)* anorganic bovine bone group, *(c)* anorganic bovine bone and collagen plus rhPDGF-BB group (hematoxylin-eosin, original magnification ×20). See also the different number of Musashi-1 nuclear positive cells in the nonmineralized areas of the graft. *(d)* Control group, *(e)* anorganic bovine bone group, *(f)* anorganic bovine bone and collagen plus rhPDGF-BB group (peroxidase-conjugated micropolymer method). Scale bar: 20 µm.

terms of mineralized and nonmineralized tissue formation after 4 months of healing. The amount of remnant biomaterial particles was quite similar in both experimental groups as well.

DISCUSSION

The present results show, in summary, less reduction of the buccolingual dimensions of the alveoli after 4 months of healing in the grafted groups, especially in the most coronal part. Adding rhPDGF-BB to the anorganic bovine bone and collagen graft may induce better cellularity and microvascularity, resulting in better clinical results. Statistical significance was only found for the pairwise comparison control vs anorganic bovine bone and collagen plus rhPDGF-BB. The apparent advantage of the combination with rhPDGF-BB requires further confirmation. In any case, the present main outcomes are in line with previous meta-analyses, both in terms of clinical[11] and histologic outcomes.[12]

Limited quantities of remnant biomaterial were found in both experimental groups. This was surprising because the biomaterial used in the present study is 95% anorganic bovine bone, a similar composition to that of Bio-Oss Collagen. Numerous studies conducted with Bio-Oss Collagen show a persistent presence of biomaterial even for years.[13,14] This is due to the slow remodeling rate of anorganic bovine bones.[3] The differences might be explained by specific differences between the biomaterial used in those previous studies and the biomaterial used here. The main differences are in the source of the collagen component, percent of each, and manufacturer processing, among others. As Monje and coworkers reported with allografts,[4] differences in the manufacturing procedures can lead to different biologic behavior.

Tirone and coworkers analyzed the outcomes in four maxillary premolars and six molars,[15] while Cardaropoli and coworkers evaluated 12 superior anterior teeth.[16] Both reported similar average histomorphometric outcomes to those in the present study. More surprising were the results by Schulz and coauthors,[17] who reported only 0.36% ± 0.46% of remnant Bio-Oss Collagen. A possible explanation could be that the location and dimension of the socket may promote different outcomes. The present study was conducted exclusively in maxillary premolars. Heberer and coworkers analyzed 16 patients after 6 weeks of healing using Bio-Oss Collagen in alveolus from each location in the mouth.[18] Tissue compartments were different depending on the area where the samples were obtained (anterior vs posterior, mandible vs maxilla). Heberer and coworkers also indicated that the biomaterial was not distributed homogenously along the alveolar defect; there was a higher quantity of biomaterial in the most coronal section of the alveoli. Thus, the higher percentage of new mineralized tissue was located in the apical portion of the alveoli.[18] This could also be due to the confined nature of the apical part of the alveolus, surrounded by bone, more than, for example, the most coronal part.

Despite the differences reported between all these studies in terms of time of surgical reentry (from 6 weeks to 6 months), alveoli location and dimensions, the use of covering membranes, how the biopsy specimens were taken, dimensions of the trephines, or differences in the specific composition of the biomaterials, the present results are quite similar in general to those reported earlier, although using a different combination of anorganic bovine bone and collagen.

Regarding the use of rhPDGF-BB, the literature in alveolar preservation is scarce. In fact, according to a systematic review,[19] few studies have been published to warrant the effectiveness of rhPDGF-BB in socket preservation. McAllister and coworkers used a combination of anorganic bovine bone (Bio-Oss Collagen) and rhPDGF-BB in six patients and after 3 months of bone healing found approximately 20% new mineralized tissue.[20] Similarly, Nevins and coworkers analyzed eight patients whose alveoli were grafted with the same aforementioned combination and analyzed the outcomes after either 4 or 6 months. They found similar outcomes between time points, while differences were not significant.[21] The same research group in a later study reported a final bone formation of 39.6% ± 11.3%.[22] The present study has found a similar percentage of mineralized tissue (36.06% ± 16.70%). The differences can be attributed, as explained earlier, to the differences between both anorganic bovine bone commercial presentations.

Although no histomorphometric differences were found, differences were clearly noted when structural resorption was studied. The collapse of the ridge in control cases was very pronounced with respect to the other groups. This clinical advantage of using biomaterials, expressed as a desired space maintenance, is a translation of the maturation of the alveoli. In particular, the number of osteoblasts is lower in the control group compared with the grafted portion of the other groups. This is also supported by a higher number of Musashi-1 positive cells in the group with rhPDGF-BB. This indicates a clear transformation from the mesenchymal stromal cell pool to osteoblasts.[23–28] These results show a pattern similar to that reported by Nahles and coworkers.[29] Using Bio-Oss Collagen, they demonstrated that the apical region of the extraction socket is where the active zone of bone formation is found during the early healing phase. This shifts to the coronal region after 12 weeks. Interestingly, they found less Cbfa1/Runx2 positive cells in grafted sockets, but they were more abundant in the apical portions of those grafted sockets.

Vascular microdensity was higher and statistically significant in the anorganic bovine bone and collagen plus rhPDGF-BB group compared with the control. This result reflects the potential effect of platelet-derived growth factor-BB in angiogenesis by stimulating the vascular endothelial growth factor.[30] Again, Nahles and coworkers[29] also reported that after 4 weeks, endothelial cells were more frequent in the apical region of the defect. However, such differences were not observed when comparing anorganic bovine bone and collagen plus rhPDGF-BB to anorganic bovine bone and collagen.

Besides the histologic knowledge reported in this study, alveolar ridge preservation is clearly superior to the control, whatever biomaterial is used, in terms of clinical and radiographic outcomes.[2,11,31–33] In the present study, this premise was fulfilled: The grafted alveoli showed a smaller reduction of the buccolingual dimension at the different heights compared with the control alveoli. Classical studies by Araújo and coworkers and Cardarapoli and collaborators reported an overall 25% reduction and 40.6% vertical reduction, respectively, in alveoli in the control group, without treatment, compared with the test group, grafted with Bio-Oss Collagen.[16,34]

Besides the interesting findings of the present study and similarities to other studies, this work also has some limitations. First, the sample size is small, although it has to be kept in mind that this study was intended to be a pilot study. In any case, the number of patients included is similar to others, and even higher in some cases. Secondly, despite performing a delicate technique of atraumatic extraction of the tooth, it is known that there are factors that could play an important role in the outcomes of the study, such as the thickness of the buccal bone, which directly influences the final volumetric changes.[35] In the present series, the thickness of the buccal bone was not different between groups. It did not show any influence on the reduction of the width of the socket either. This is most likely because the buccal bone plate was present after the extraction in all cases, as required for inclusion in the study. Furthermore, the thickness of the buccal bone was approximately 1 mm in all cases, which is reported to be a cutoff value for worse outcomes.[36] It would also have been interesting to standardize the sampling of bone for histologic analyses so that clinical and radiographic data could be precisely correlated.

CONCLUSIONS

Within the limitations of this study, it can be concluded that after 4 months, anorganic bovine bone in combination with bovine collagen is an efficient biomaterial to avoid the resorption of the alveolar ridge. The addition of rhPDGF-BB may improve the biologic features of newly formed bone in terms of proportions and cellular composition of mineralized and nonmineralized tissues. Future randomized clinical studies with higher numbers of patients need to be conducted to confirm the present preliminary findings.

ACKNOWLEDGMENTS

The authors thank J. Davis for his assistance with the English translation and Natividad Martin-Morales for her support in conducting the histologic techniques. No author has any type of financial interest in this article or any of the biomaterials used. The authors of this manuscript are partially supported by Research Groups #CTS-138 (FO) and #CTS-1028 (PG-M, MP-M; Junta de Andalucía, Spain). Grafting materials were generously provided by BioHorizons.

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