Bone into Bone technique: An alternative to horizontal bone regeneration techniques. Retrospective case-control study

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Abstract: Purpose: To evaluate the efficacy of lateral ridge augmentation (LRA) of porcine cortical barriers when placed in a surgical bone gap, buccal to the defect, using the Bone into Bone (BiB) technique compared to a guided bone regeneration (GBR) technique. **Methods:** The study was a retrospective case-control evaluation. A group of 23 subjects (test) underwent horizontal augmentation procedures using the BiB technique. A group of 18 subjects (control) was treated with the guided bone regeneration (GBR) technique, using a resorbable membrane and a mixture of heterologous bovine particles and autologous bone fragments. Radiological and histological analysis of the outcomes were performed. **Results:** Mean ridge width varied from a preoperative value of 3.4 mm to a postoperative value, measured 8 months postoperatively, of 7.1 mm in the Control Group. The mean ridge width varied from a preoperative value of 4.8 mm to a postoperative value, measured 8 months after the procedure, of 7.5 mm in the Test Group. Histological images, after 8 months, showed native, mineralized bone with a lamellar pattern of varying thickness (30.3% ± 5.3). (*Am J Dent* 2024;37:37A-40A).

Clinical significance: This technique (Bone-into-Bone) using resorbable heterologous biomaterials and without the use of retention devices for horizontal bone augmentation may be a viable alternative that is easily reproducible and has reduced morbidity for the patient.

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Introduction

Dental implants need to be placed in a biologically and prosthetically favorable position to achieve long-term success. Alveolar ridge deficiencies, which could be horizontal, vertical or combined, usually impede meeting these requirements. In the lateral ridge augmentation (LRA) the use of allogeneic or autogenous bone blocks and guided bone regeneration (GBR) with bone granules and occlusive membranes demonstrated predictable outcomes in alveolar ridge regeneration.

GBR[1] is based on the use of a membrane over a bone defect filled with osteoconductive material and which, with blood clotting, leads to the formation of new bone, capable of bearing the load of an implant-supported restoration.[2] Non-resorbable polytetrafluoroethylene (PTFE) membranes, which have demonstrated high regenerative capacity,[3] are also used, but even these carry a significant risk of complications, such as exposure and infection, which are also extremely difficult to treat and could compromise the procedure.[4]

Heterologous-derived cortical bone barriers have been studied[5] for their physicochemical properties and compared with various other membranes,[6] and could replace the application of non-resorbable membranes and autologous cortical bone laminae[7] as a means of creating and maintaining a space for the placement of a particulate bone graft. These laminae are resorbable and can be fixed at the surgical site by screws,[8] biological or synthetic adhesives.[9]

This retrospective study assessed the horizontal bone gain achieved with two different GBR techniques: a conventional GBR technique (Control Group) and the Bone into Bone (BiB) technique (Test Group). The effectiveness of the two techniques was compared with an 8-month follow-up, in which histologic and histomorphometric analyses and radiographic assessment of ridge size were performed.

Materials and Methods

Study design - This is a retrospective case-control study. Subjects included in the study gave their consent to surgical therapies and subsequent inclusion in the retrospective analysis of their data. The study subjects were treated between September 2018 and January 2021. The guidelines of the Declaration of Helsinki, revised in 2013, were followed in this investigation (Protocol number 4729).

The study included subjects with a horizontal bone defect measured on preoperative cone-beam computed tomography (CBCT) treated with conventional GBR (Control Group) or with BiB technique (Test Group).

Criteria for inclusion/exclusion to surgery - Inclusion criteria were as follows:. 1. Over 18 years of age; 2. Full mouth bleeding score (FMBS) and full mouth plaque score (FMPS) ≤ 20%; 3. Needing an LRA procedure to provide adequate implant-prosthetic treatment.

Exclusion criteria were: 1. General contraindications to surgery; 2. Under long-term treatment with non-steroidal anti-inflammatory, corticosteroid, bisphosphonate or immune-suppressant drugs; 3. Radiotherapy, malignancy or chemotherapy history in the head and neck area in the past 5 years; 4. Uncontrolled metabolic diseases, that might impair wound healing (i.e. diabetes); 5. Blood-related diseases; 6. Pregnancy and nursing period; 7. Uncontrolled periodontal disease; 8. Presence of sites with acute inflammation that cannot

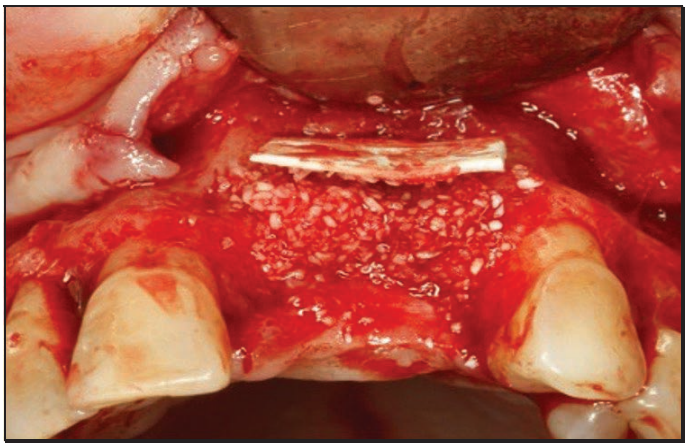

Fig. 1. The lamina in the vestibular slot and the gap filling with a mix of autologous and heterologous bone.

be solved at the time of extraction (e.g., abscess, phlegmon); 9. Smoking habits > 10 cigarettes/day; 10. Low compliance to undergo follow-up visits.

Pre-treatment - Data on the subjects' age, gender, medical history and dental status were obtained. All patients underwent mechanical debridement before the surgical procedure. Patients also received antibiotic prophylaxis 1 hour before surgery with 2 g amoxicillin + clavulanic acid tablets (Augmentin[a] 875 mg/125 mg) and a 1-minute mouthwash with 0.20% chlorhexidine digluconate directly before the procedure.

Surgical procedure

Test group - After administering local anesthesia, a crestal incision was executed in the edentulous area, continuing with an intrasulcular incision on the adjacent teeth mesial and distal to the defect; then a full-thickness vestibular flap and a lingual flap were lifted. Utilizing a 0.6 mm-diameter bur mounted on a surgical handpiece or a piezosurgery combined with a piezoelectric tip dedicated to "osteotomy" (Mectron[b]); a 2-3 mm-deep slit was made in the vestibular wall of the defect (Fig. 1) to insert and stabilize the lamina, in a position to recreate adequate volume of the defect. To allow for the formation of blood clots, small perforations were made in the cortical of the bone to be regenerated. The sterile blister of the cortical lamina (OsteBiol Lamina[c] soft) was used to shape the appropriate final shape of the lamina subsequently cut with surgical scissors. The Lamina soft has a thickness of 0.6 mm and a semi-rigid consistency; therefore, it should not be hydrated before its application to facilitate insertion into the fissure and direct imbibition with blood from the site (Fig. 2). A mixture of heterologous porcine collagenic cortico-cancellous bone mix (OsteoBiol GTO[c]) and particulate autologous bone, retrieved with a bone scraper from the apical area to the bone defect, was inserted into the space between the lamina and the lingual wall of the defect. A resorbable collagen membrane (OsteoBiol Evolution[c]) covered the grafted area without rigid fixation; then, the flaps were sutured with interrupted sutures, which were removed 7 days after surgery. After 8 months, a full-thickness minimal flap was lifted, and implants were placed with submerged healing protocol. Hard tissue samples were collected with a 3 mm diameter trephine drill at the implant site with the augmented bone. Subjects were given postoperative antibiotics

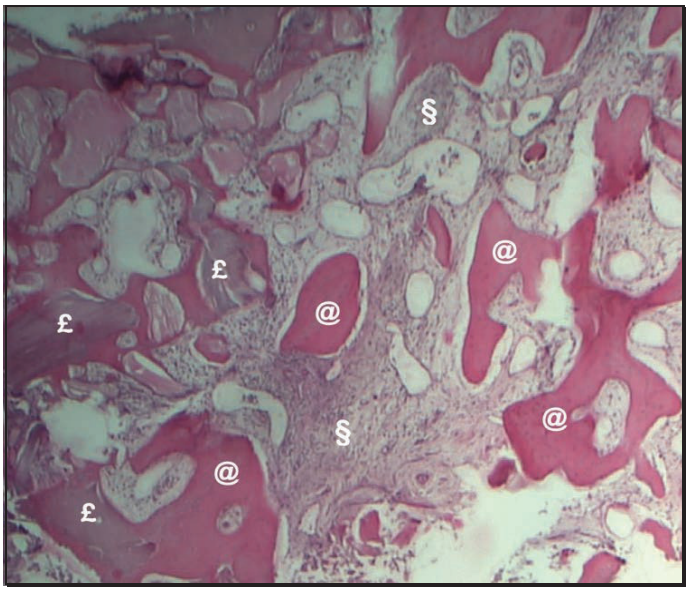

Fig. 2. 5 µm-thick histological sections prepared and stained with hematoxylin/eosin. After 8 months, the sample shows biomaterial not yet resorbed integrated in new mature bone. Legend: £ Residual biomaterial, & Vital bone, § Soft tissue. 10×.

for 6 days (amoxicillin 0.75 g + clavulanic acid 0.25 g 2/day) and anti-inflammatory therapy (Ibuprofen 400 mg 3/day days 1-2, 2/day, 400 mg 2/day days 3-4). After a 3-month healing time, the implants were exposed and healing abutments were placed, striving for a torque of at least 25 N/cm.

Control group - After administration of local anesthesia, a full-thickness flap was raised with a crestal incision and two vertical buccal incisions distant from the surgical site. Cortical perforations were performed, and a resorbable collagen membrane (Geistlich Bio-Gide[d]) was fixed using lingual or palatal pins (SMARTACT PIN evo[e]). The defect was filled with a 1:1 mixture of particulate autograft taken with bone scrapers in the contiguous areas and DBBM (Bio-Oss,[d] 1-2 mm), and then the membrane was placed on the graft and fixed with pins. The buccal flap was passivated with a periosteal release incision between the two vertical incisions. The flaps were sutured with horizontal mattress sutures, and single interrupted sutures to seal the everting portions of the flaps.

After 8 months, a full-thickness minimal flap was lifted, and implants were placed (Straumann BLT[f]) with submerged healing protocol. Subjects were given postoperative antibiotics for 6 days (amoxicillin 0.75 g + clavulanic acid 0.25 g 2/day) and anti-inflammatory therapy (Ibuprofen 400 mg 3/day days 1-2, 2/day, 400 mg 2/day 3-4). After a 3-month healing time, the implants were exposed and healing abutments were placed, striving for a torque of at least 25 N/cm.

Histological and histomorphometric analysis - Considering the effective biointegration and tissue maturation of conventional GBR, biopsy examination was performed only for Test Cases to demonstrate proper biological maturation.

During the implant surgery, bone samples were collected from the implant sites with a 3-mm diameter trephine drill. Each biopsy sample was given a unique identification number and then fixed in 10% phosphate-buffered formalin, then followed by decalcification in a hydrochloric acid/formic acid solution

(4/5%). After decalcification, specimens were dehydrated in a sequence of alcohol baths and then embedded in paraffin. Histological sections of 5 µm thickness were then cut and stained with hematoxylin/eosin.

The slices were digitally scanned at various magnifications. Histomorphometric examinations were performed with ImageJ[g] software to assess the presence and patterns of newly formed bone, residual graft material, and its integration. The percentages of bone, residual biomaterial, and soft tissue (bone marrow or nonmineralized connective tissue) were recorded on each slide.

Radiographic analysis - Eight months after the regenerative procedure, postoperative CT scans were performed for all treated cases before implant placement; preoperative and postoperative CT scans were superimposed, using other anatomical structures (e.g., adjacent teeth, hard palate) as reference. Taking preoperative sagittal cuts (T0), the presurgical crestal width (W0) was linearly calculated near the ideal implant insertion site. Maintaining the same palatal/lingual and apical landmarks, the postsurgical (T1) crestal width (W1) was calculated linearly on the postoperative CT. Horizontal bone gain (WG) was then recorded as the discrepancy between W1 and W0.

All linear measures were carried out with coDiagnostiX[h] software, rounded to the nearest 0.1 mm. Pre- and postoperative CT scans were performed with the CBCTNewtom 5G XL.[i]

Statistical analysis - The primary endpoint was to radiographically observe the stability and augmentation of regenerated bone at an 8-month follow-up; the secondary endpoint was to examine the histological appearance of these tissues and analyze their composition. Continuous variables were presented as mean ± standard deviation, while qualitative variables were described as absolute and relative frequencies.

In the statistical analysis, the bone defect was considered as a statistical unit. A comparison of width differences T0 and T1 (8 months) was made. Given their non-normal distribution (Shapiro-Wilk test) and non-homogeneity (Levene's test) of variance, Wilcoxon's paired-samples signed ranks test was used for intra-group comparison; the difference between the two groups was analyzed by Mann-Whitney U test; the significance threshold was set at $P< 0.05$. Statistical analysis was performed with R statistical software.[j]

Results

Subjects - A total of 23 subjects (45% men 55% women) were included in the test group, and 18 subjects (44% men 66% women) were included in the control group. Six subjects of the test group were cigarette smokers (< 10) and one subject was an occasional cigar smoker. Two subjects of the control group were cigarette smokers.

Reasons for the bone defects included alveolar resorption following extraction, implant failure, and dental pathology. Baseline classification of bone defects according to Misch et al[10] is shown in the Table.

Four subjects in the control group reported swelling in the first week after surgery and two in the test group with no symptoms or signs of surgery impairment. Three sites in the test group and one in the control group showed membrane exposure with complete re-epithelialization at about 4 weeks. At 4 weeks, all subjects recovered without signs of graft failure.

Table. Baseline Misch classification for bone defects.

Misch classification	Test group	Control group
B	13 (56.5%)	10 (55.6%)
Bw	6 (26.1%	3 (16.7%)
Cw	4 (17.4%)	5 (27.8%)

Histomorphometric evaluation - Eleven biopsy samples were obtained and processed. The higher percentage of new bone was found near the apical portion of the defect rather than near its coronal part. Mature mineralized bone composed 30.3% ± 5.3 of the samples, while the percentage of remaining biomaterial, not yet resorbed, was 7.4% ± 7.2. The residual fraction of the specimens was composed of soft tissue (bone marrow or nonmineralized connective tissue), which represented 60.5% ± 10.9 of the tissues.

Bone gain - The mean ridge width in the Test Group ranged from a preoperative value of 4.8 mm (T0) to a value, 8 months after surgery, of 7.5 mm (T1). The mean ridge width ranged from a preoperative value of 3.4 mm (T0) to a value measured 8 months after surgery of 7.1 mm (T1) in the Control Group.

The mean horizontal bone gain obtained after 8 months was 2.6 mm (SD = 0.8 mm) in the test group and 3.8 mm (SD = 0.5 mm) in the control group, and were considered statistically significant differences ($P< 0.05$).

Discussion

This retrospective study aims to compare the "BiB" technique with a GBR technique using a resorbable membrane and particulate graft, a technique that has been proven effective.[11] The main role of membranes is to prevent epithelial and connective tissue cells from invading the wound area and to create and maintain space in which pluripotent and osteogenic cells can regenerate.[12]

As a possible alternative choice in regenerative surgery, resorbable cortical laminae demonstrated their effectiveness both in lateral and vertical augmentation.[5,13]

Villa et al,[13] in a case study of 15 subjects, evaluated the efficacy of a xenogenic cortical bone sheet used for a heterologous "shell technique" fixed on the buccal aspect of alveolar ridges resorbed for horizontal bone augmentation with titanium screws, and filled with a mixture of autologous particulate bone and porcine hydroxyapatite. The mean horizontal bone gain from CBCT scans was 4.8 ± 1.6 mm at landmarks 1 mm apical to the buccal bone ridge.

In terms of bone gain, in our study the horizontal increase of the ridge was 2.6 mm (SD = 0.8 mm) in the test group and 3.8 mm (SD= 0.5 mm) in the control group, with a statistically significant difference ($P< 0.05$). The slight difference between the two techniques may be explained by the greater filling capacity due to the elasticity of the resorbable membrane in the control group compared to the rigidity of the Lamina in the test group. Nevertheless, the BiB technique performed favorably in terms of average horizontal ridge width, increasing from a preoperative value of 4.8 mm to a postoperative value of 7.5 mm, which may allow for implant placement.

The lamina, although stabilized only by the buccal slot, was able to provide the stability needed for the graft, which allowed the defects to regenerate; at implant placement after 8 months, it could not be distinguished clinically, being completely resorbed or integrated.

Histologic findings also confirmed the integration of the lamina with the surrounding bone, rendering it unrecognizable after 8 months of healing, as identified by Rossi et al.[14] Few residual granules, which were mainly resorbed (7.4%), could be distinguished in the histological slides. There were no signs of infection, and the biomaterial was fully integrated. Mature, mineralized bone with a lamellar structure was evident in the specimens. In addition, around the newly formed bone, non-mineralized soft tissue, especially bone marrow, was evident.

The histomorphometric result showed a percentage of viable bone of 30.3%, lower than the rates, around 50%, found by Pagliani et al.[15]

Advantages of this technique include ease of performance compared to other regenerative techniques, particularly those requiring a second surgical site for autologous bone harvesting, making this procedure accessible to a wider range of surgeons.

In addition, because the lamina is an integral part of the graft, it reduces bulk compared to titanium mesh and non-resorbable membranes or the overfilling required with GBR.

Therefore, this technique significantly reduces the morbidity associated with other regenerative techniques involving donor sites, non-resorbable membranes, or fixation screws, while limiting the need to over-extend the flap apically to the defect.[5] It also reduces the need for re-intervention in cases of dehiscence and exposure of non-resorbable materials. In fact, even with exposure of the lamina, removal is not necessary except in cases of obvious infection of the graft, since its consistency and integration capacity allow complete healing by secondary intention of the wound.

However, this study has several limitations: our small sample size, short follow-up and lack of randomization reduce the statistical evidence of the collected, albeit valid, clinical data. It would also be interesting to assess volumetric differences using dedicated software.

Future studies with larger samples should evaluate these results and compare with other regeneration techniques.

a. GSK, London, UK.
b. Carasco, Genoa, Italy.
c. Tecnoss, Giaveno, Italy.
d. Geistlich Pharma AG, Wolhusen, Switzerland.
e. Meta Technologies S.R.L, Reggio Emilia, Italy.
f. Straumann, Basel, Switzerland.
g. U.S. National Institutes of Health, Bethesda, MD, USA.
h. Dental Wings, Chemnitz, Germany.
i. Cefla s.c., Verona, Italy.
j. Foundation for Statistical Computing, Vienna, Austria.

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Dr. Lopez is Adjunct Professor; Dr. Passarelli is Professor and Master Director; Dr, Netti is Resident; Dr. C. Cavalcanti is Resident; Dr. Wychowański is Adjunct Professor; and Dr. D'Addona is Head and Full Professor, Department of Head and Neck and Sensory Organs, Division of Oral Surgery and Implantology, Fondazione Policlinico Universitario A. Gemelli IRCCS - Università Cattolica del Sacro Cuore, Rome, Italy. Dr. R. Cavalcanti is Adjunct Professor, Department of General Surgery and Surgical-Medical Specialties, School of Dentistry, University of Catania, Catania, Italy.

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