

Vertical Ridge Augmentation with a Collagen Membrane, Bovine Bone Mineral and Fibrin Sealer: Clinical and Histologic Findings



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This study evaluated the treatment of alveolar bone deficiencies combined with dental implant placement. Thirty-five endosseous implants were inserted into 20 patients. After implant placement, the mean height of the supracrestal bone defects measured 4.25 ± 1.34 mm. Bone regeneration procedures were performed using a combination of a bovine bone-derived mineral stabilized with a fibrin-fibronectin sealing system and covered with a bilayered porcine collagen membrane. Healing was uneventful in all instances with maintenance of primary closure throughout the healing period. Stage-two surgery was performed after 6 months, and a hard bonelike tissue was detectable at the defect sites. Histologic examination confirmed the presence of newly formed bone with residual particles of xenograft. The mean bone gain was 3.95 ± 1.47 mm. The positive outcomes in terms of bone regeneration and low complication rate demonstrated the potential of this technique for the treatment of supracrestal ridge deficiencies. Bovine bone mineral combined with a fibrin sealer and protected by a collagen membrane should be considered as an alternative in the treatment of vertical peri-implant bone defects. (Int J Periodontics Restorative Dent 2013;33:583–589. doi: 10.11607/prd.1208)

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Single or multiple tooth extractions due to periodontal disease, peri-apical infection, root fracture, or dental trauma may lead to insufficient bone volume for the insertion of endosseous implants. Augmentation procedures are needed when the pre-existing bone height does not allow for a correct space-related implant insertion, when a proper primary stability cannot be reached, or when the prosthetic rehabilitation will provide an unfavorable crown/root ratio. Bone deficiencies can be classified as bone dehiscences, fenestrations, intraosseous, or postextraction defects. In such situations, bone regenerative techniques are capable of providing positive outcomes with longevity.^{1,2} Severe vertical bone resorptions require supracrestal regeneration, a challenge for clinicians since the external soft tissue pressure is considered to be a major reason for failure of the surgical procedure in nonspace-making bone defects. Autogenous bone grafts, guided bone regeneration (GBR), and distraction osteogenesis have been proposed for vertical bone augmentation.^{3–7} However, these surgical procedures

have negative aspects such as high morbidity for harvesting the autogenous bone, long-term resorption of the autogenous grafts,^{8,9} and membrane exposure with the GBR technique.¹⁰⁻¹³ Moreover, all are technique sensitive and require a highly skilled surgical procedure.

To solve such problems, bone substitutes and resorbable membranes have been used to augment the alveolar ridge. Allografts and xenografts, such as bovine bone mineral, have been used with different results as filler materials in cases of vertical ridge augmentation.¹⁴⁻¹⁷ In the last few years, the use of absorbable collagen membranes for GBR has been proposed.¹⁸⁻²² Moreover, clinical studies have reported on the combination of fibrin seal and calcium carbonate to obtain supracrestal bone regeneration around dental implants.^{23,24}

The aim of this clinical investigation was to evaluate the possibility of obtaining vertical ridge augmentation around osseointegrated implants by using a bovine bone mineral stabilized with a fibrin-fibronectin sealing system and covered by a collagen membrane.

Method and materials

Thirty-five endosseous titanium implants were placed into the atrophic alveolar ridges of 20 partially edentulous patients (8 women and 12 men) aged 34 to 80 years (mean, 57.60 ± 10.82) (Figs 1 and 2). Tapered Osseotite Certain implants (Biomet 3i) were used in

the study. All patients had no systemic contraindication to implant surgery, and written consent was obtained. All of the selected cases showed inadequate height and width of the ridge at both the clinical and radiologic evaluations.

Surgical protocol

Buccal and lingual/palatal local anesthesia was injected using articain 4% plus epinephrine 1/100.000 (Ubistesin, 3M ESPE). Using a 15-C carbon steel surgical blade (KAI), a crestal or paracrestal incision was made connecting the edentulous space to the mesial and distal teeth. Vertical buccal releasing incisions or intrasulcular mesiodistal extensions of the flap were performed if needed. A full-thickness flap was then elevated until the mucogingival junction, followed by a split-thickness flap to achieve a tension-free adaptation of the soft tissues. Implants were inserted in a prosthetically driven position resulting in the implant being placed supracrestally. With a calibrated periodontal probe (PCP15, Hu-Friedy) the extent of the vertical defect was measured. The cortical bone was perforated with a round bur to increase vascularity to the wound. The defects were then filled with granules of a bovine xenograft (Bio-Oss, Geistlich) mixed with a fibrin-fibronectin sealing system (Tissell, Baxter). To reduce the hemostatic capacity of the fibrin sealer and to extend the polymerization time, a 1:10 dilution of the thrombin was performed (nine parts saline solu-

tion and one part thrombin). The graft, stabilized with the fibrin glue, was placed around the implants, and a two-layer porcine collagen membrane (BioGide, Geistlich) was placed over the grafted site.

The flap was then sutured with 5.0 nonabsorbable polyvinylidene difluoride (PVDF) sutures (Resopren, Resorba) using a combination of simple sutures and horizontal mattress sutures. Postoperatively, patients were prescribed the oral antibiotic amoxicillin/clavulanate potassium (1 gram twice a day for 6 days) as well as the nonsteroidal analgesic nimesulide (100 mg twice a day for 5 days), and rinsed with chlorhexidine 0.2% (three times a day) until suture removal.

Two weeks after surgery the sutures were removed, and the patients were followed every 4 weeks until re-entry. Stage-two surgery was performed after 6 months of healing. At this time, a new recording of the residual peri-implant defects was made to evaluate the amount of tissue regeneration. In five cases, a biopsy specimen of the regenerated tissue was taken for histologic evaluation. The bone biopsy specimens were fixed in 10% neutral buffered formalin, dehydrated in ethanol, and embedded in methyl-methacrylate resin. After polymerization, blocks were sectioned using a diamond saw microtome. The sections were ground and polished and stained with azure II and pararosaniline (Fig 3).



Fig 1a Periapical radiograph at baseline of a representative site showing vertical bone loss in the posterior maxillary area.



Fig 1b Intrasurgical view of the site showing vertical ridge deficiency.



Fig 1c Two implants are inserted into the atrophic ridge, presenting the need for supracrestal regeneration. The implant inserted in the distal site is located 6.5 mm above the bone crest.



Fig 1d The bone defect is augmented with a mixture of bovine hydroxylapatite and fibrin glue and covered with a porcine-derived collagen membrane.



Fig 1e After an uneventful healing period of 6 months, a new ridge volume can be detected with regenerated tissue around the implants.



Fig 1f Intraoral view of the final restoration after 12 months of function.



Fig 1g Periapical radiograph after 12 months of function.

Results

Implants were inserted in 2 maxillary incisor, 2 maxillary canine, 6 maxillary premolar, 4 maxillary molar, 4 mandibular incisor, 6 mandibular premolar, and 11 mandibular molar sites.

Soft tissue healing was uneventful in all cases, and complete closure was recorded at the 4-week evaluation. At the 6-month re-entry surgery, a hard bonelike tissue was detectable at the defect sites. In three cases, a thin layer of firm connective tissue, approximately

0.5 to 1.0 mm thick, was noted above the hard tissue.

The mean initial defect height was 4.25 ± 1.34 mm, while mean final defect height was 0.3 ± 0.54 mm. Mean values of bone regeneration amounted to 3.95 ± 1.47 mm, corresponding to 92% of the initial

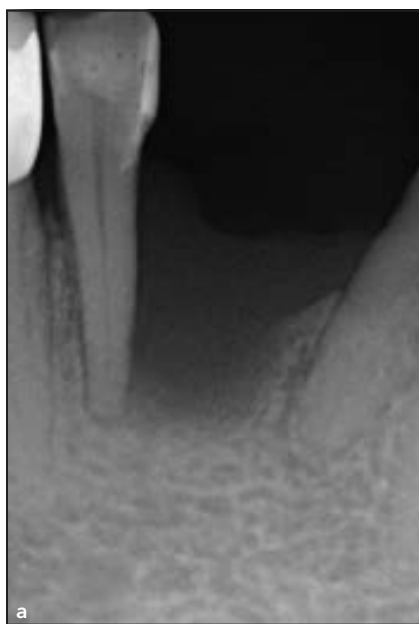


Fig 2 (a) Periapical radiograph at baseline of a representative site showing vertical bone loss in the anterior mandibular area. (b) Two implants are inserted, leaving a number of threads exposed. The implant placed in the mandibular right central incisor site is 7 mm above the bone crest. (c) Bovine bone mineral and fibrin-fibronectin sealing system are placed around and above the implants, and a bilayered absorbable collagen membrane covers and protects the bone graft. (d) Six months after surgery, the implants are completely covered by newly formed hard tissue. (e) Periapical radiograph after 12 months of function.



value. Twenty-four cases showed complete coverage of the exposed implant threads by newly formed tissue with the aspect of bone, and no xenograft particles were visible clinically in the newly generated tissue. In the 11 cases of incomplete regeneration, bone gain varied from 40% to 90% of the initial defect.

The histologic analysis of the harvested tissues showed the presence of newly formed woven bone with osteocytes and many vascular medullary spaces. Bone activity was evidenced by the presence of bone resorption areas alternating

with areas of bone deposition. Unresorbed graft particles embedded in mineralized bone were in direct contact with the bone matrix, with osteoblasts and osteoclasts in direct contact to the xenograft surface, and no signs of inflammation or incapsulation. The analysis also revealed the presence of vascular spaces and macrophages. A histomorphometric evaluation of the five specimens revealed a mean percentage of new bone formation of $30.46\% \pm 11.50\%$ and a mean presence of residual granules of $17.06\% \pm 13.29\%$.

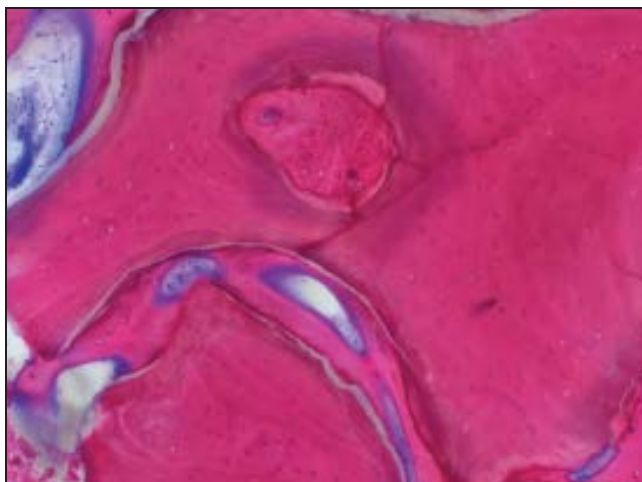


Fig 3a Section from a biopsy specimen taken from one of the regenerated sites. The mineralized fraction consists of newly formed bone and Bio-Oss particles partially embedded in new bone. Newly formed bone is stained light magenta, Bio-Oss dark magenta, and soft tissue blue (original magnification $\times 100$).

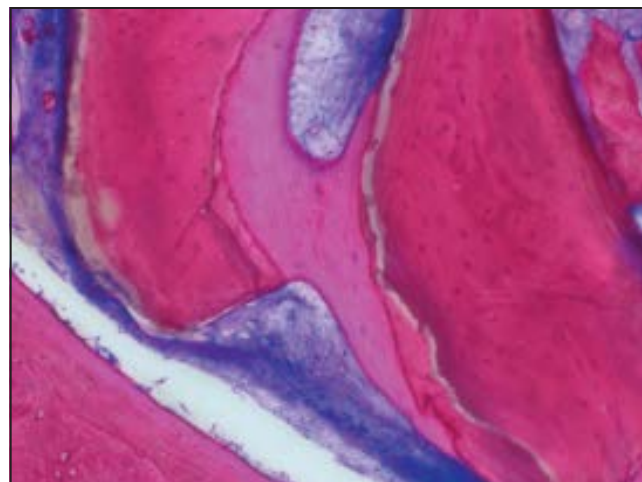


Fig 3b Newly formed bone deposits on residual granules of Bio-Oss (original magnification $\times 100$).

Discussion

Previous studies have shown that the three-dimensional restoration of a resorbed ridge can be achieved using sensitive techniques. In 1994, Simion and coworkers¹⁰ inserted 15 osseointegrated implants with vertical defects measuring 4 to 7 mm into five patients. The implants were covered with an expanded polytetrafluoroethylene (e-PTFE) titanium-reinforced barrier membrane. After 9 months of healing, supracrestal bone regeneration of 3 to 4 mm was reported, with a mean bone-to-implant con-

tact of 42.5%. In all cases, a layer of connective tissue was detected between the membrane and the regenerated bone.

In 1996, Tinti et al¹¹ placed 14 autogenous bone implants with vertical defects measuring 4 to 7 mm under a barrier membrane in six patients. In their study, the healing period was 12 months. In 1998, Simion et al¹² evaluated the effects of using autogenous bone graft or demineralized freeze-dried bone allograft along with the barrier membrane technique. They inserted 58 implants with initial vertical defects varying from 1.5

to 7.5 mm in 20 patients. After 7 to 11 months of healing, the new bone-to-implant contact formed was 39.1% to 63.2%. Tinti and Parma Benfenati¹³ reported similar findings; they placed 48 osseointegrated implants in 18 patients who required vertical augmentation. The augmentation procedure was performed using autogenous bone grafts in combination with an e-PTFE titanium-reinforced membrane.

From these studies, vertical GBR appears to be an effective reconstruction technique. However, the use of autogenous bone graft increases the operating time and

postoperative morbidity because of the need for a donor site for the graft (either intraoral or extraoral), limited amount of graft available, and possibility of resorption of the graft. In addition, the use of nonresorbable barrier membranes increases the risk of exposure. According to the literature, early exposure of the membrane may cause infection that can compromise the final outcome of rehabilitation; furthermore, early exposure of membranes during healing hinders the effectiveness of guided tissue regeneration (GTR) in peri-implant tissues. In a study by Tinti and coworkers,¹¹ tissue regeneration did not occur in only one patient where the membrane was exposed and subsequently removed. Bone substitutes and resorbable membranes may represent reliable alternatives for GBR in the augmentation of the alveolar ridge. Moreover, the importance of wound stabilization to obtain tissue regeneration suggests the possibility of using the combination of a space-making material and a stabilizing medium.

Corrente and coworkers^{23,24} used a fibrin-fibronectin sealing system together with calcium carbonate in cases of supracrestal defects and obtained interesting clinical and radiologic outcomes and histologic evidence of bone regeneration. In this study, peri-implant vertical bone defects were corrected using an osteoconductive bovine bone mineral that had been proven effective in both periodontal and bone regeneration. To ensure the stabilization of the clot

and isolation of the regeneration space from the non-osseous compartment, the xenograft was mixed and stabilized with biologic fibrin glue that imparted good mechanical stability and high biocompatibility to the xenograft. The graft material was subsequently covered by a collagen membrane that had previously been used in GTR and GBR. The collagen membrane greatly reduces the risk of infection in case of membrane exposure, has good mechanical properties that protect the graft beneath it, and enhances soft tissue closure.

The results of the present study showed the possibility of achieving supracrestal bone regeneration using an alternative surgical technique that is associated with low morbidity. The mixture of bovine bone mineral and fibrin glue showed good mechanical stability around the treated implants. Soft tissue healing was uneventful, complete closure was observed within 4 weeks of surgery, and no signs of membrane infection were observed. Complete supracrestal bone regeneration was achieved in 24 of the 35 treated implants. In a few cases, a thin layer of soft tissue above the regenerated bone was identified at the re-entry site. The formation of this soft tissue could have been the result of micro-movement and pressure over the site during the remodeling phase.

Histologic analysis of a cylindrical specimen of the newly formed tissue showed that the application of inorganic bovine bone as filler material resulted in new bone formation at various stages of remodeling

and maturation. At the 6-month follow-up, a small portion of the xenograft was found to be embedded in the bone tissue and bone marrow connective tissue, which is in accordance with other findings about the low resorption rate of Bio-Oss. Bone remodeling behavior is the result of a combined activity of osteoclasts and osteoblasts that carry out bone resorption and deposition, respectively. Examination of the specimen showed that bone cells were present on or near the Bio-Oss particles, indicating the biocompatibility and good stability of the material. Moreover, the medium-term stability of the bovine bone substitutes used seems to enhance the osteoconductivity of the material. Vertical ridge augmentation allowed prosthetically correct implant positioning, a correct root/crown ratio, and an axial implant placement, thereby improving esthetic and biomechanical outcomes. The behavior of the regenerated bone under occlusal loading has not been evaluated at this time, necessitating an additional longitudinal study. Presently, encouraging results have been obtained in two systematic reviews on the long-term follow-up of patients with implants placed into regenerated bone.^{1,2}

Conclusion

This study showed the predictability of a new surgical procedure associated with low morbidity in achieving regeneration of peri-implant bone defects.

Acknowledgment

The authors reported no conflicts of interest related to this study.

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