REGENERATION OF THE ALVEOLAR CREST USING TITANIUM MICROMESH WITH AUTOLOGOUS BONE AND A RESORBABLE MEMBRANE

Marco Degidi, MD, DDS
Antonio Scarano, DDS
Adriano Piattelli, MD, DDS

KEY WORDS

Alveolar crest
Guided bone regeneration

Guided bone regeneration (GBR) has been used for the regeneration of bone in conjunction with the placement of oral implants. The aim of the present study was to clinically and histologically evaluate the use of a titanium micromesh and a resorbable membrane in the GBR technique in patients with alveolar crest defects due to periodontitis, trauma, and extractions. Eighteen patients participated in this study, and 50 implants were inserted. The postoperative healing was uneventful, no dehiscences were observed, and all implants were functioning successfully at 7-year follow-up. At reentry, in all cases, the space under the titanium mesh was completely filled by bone. From a clinical point of view, in all patients, no residual bone defects were observed and a significant increase of the alveolar width or height was found. In all cases, a good esthetic result of the restorative procedures was present.

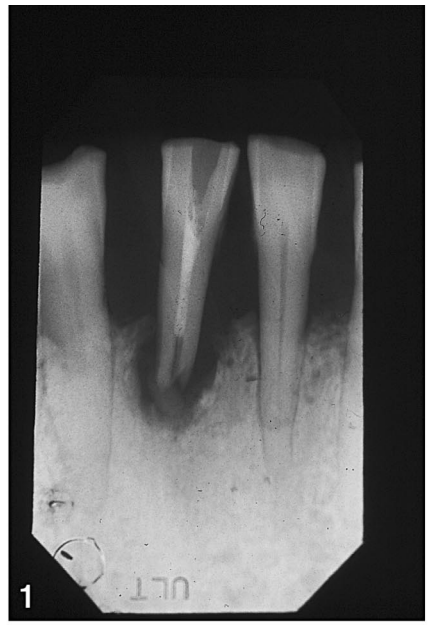
INTRODUCTION

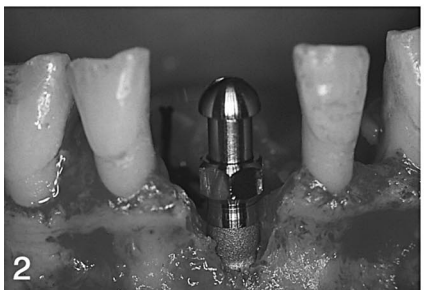
Guided bone regeneration (GBR) has been used in recent years for the regeneration of bone in conjunction with the placement of oral implants, augmentation of resorbed alveolar ridges, and treatment of localized ridge deformities.[1–9] An adequate bone volume for complete circumferential coverage of the implants is important for obtaining long-term success of oral implants.[10] The minimum amount of bone seems to be 4 mm horizontally and 7 mm vertically.[10] The barrier membrane can be used either in a 2-stage technique, where bone is formed before the implantation or directly at the time of implant insertion.[11] One of the most important aspects in obtaining results with membranes for lateral ridge augmentation is the creation and maintenance of a secluded space under the membrane.[9] The development of this space is the prime determinant of the amount of newly formed bone.[2] The sites for localized ridge augmentation are non–space-making defects because they are not supported by the bone walls.[9] In these

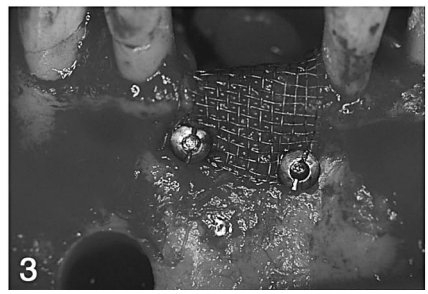
Marco Degidi, MD, DDS, *is in private practice in Bologna, Italy, and is a visiting professor at the Dental School, University of Chieti, Chieti, Italy.*

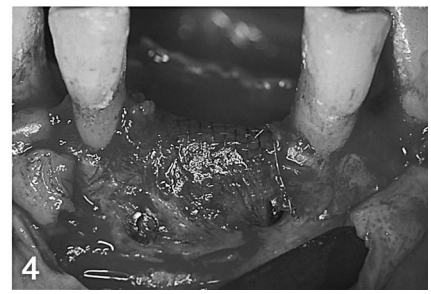
Antonio Scarano, DDS, *is a research fellow at the Dental School, University of Chieti, Chieti, Italy.*

Adriano Piattelli, MD, DDS, *is a professor in the Department of Oral Medicine and Pathology, Dental School, University of Chieti, Chieti, Italy. Address correspondence to Prof Adriano Piattelli, Via F. Sciucchi 63, 66100 Chieti, Italy.*









FIGURES 1–4. FIGURE 1. A lower incisor has been lost due to advanced periodontal disease. FIGURE 2. A Twin Plus (3.3 mm diameter and 15 mm length) IMZ implant has been inserted approximately 5 mm above the lowest border of the defect. FIGURE 3. The defect has been filled with autologous bone retrieved from the chin area. A titanium mesh and a resorbable membrane are used to cover the autologous bone. The mesh is fixed with microscrews. FIGURE 4. Reentry procedure after 4 months.

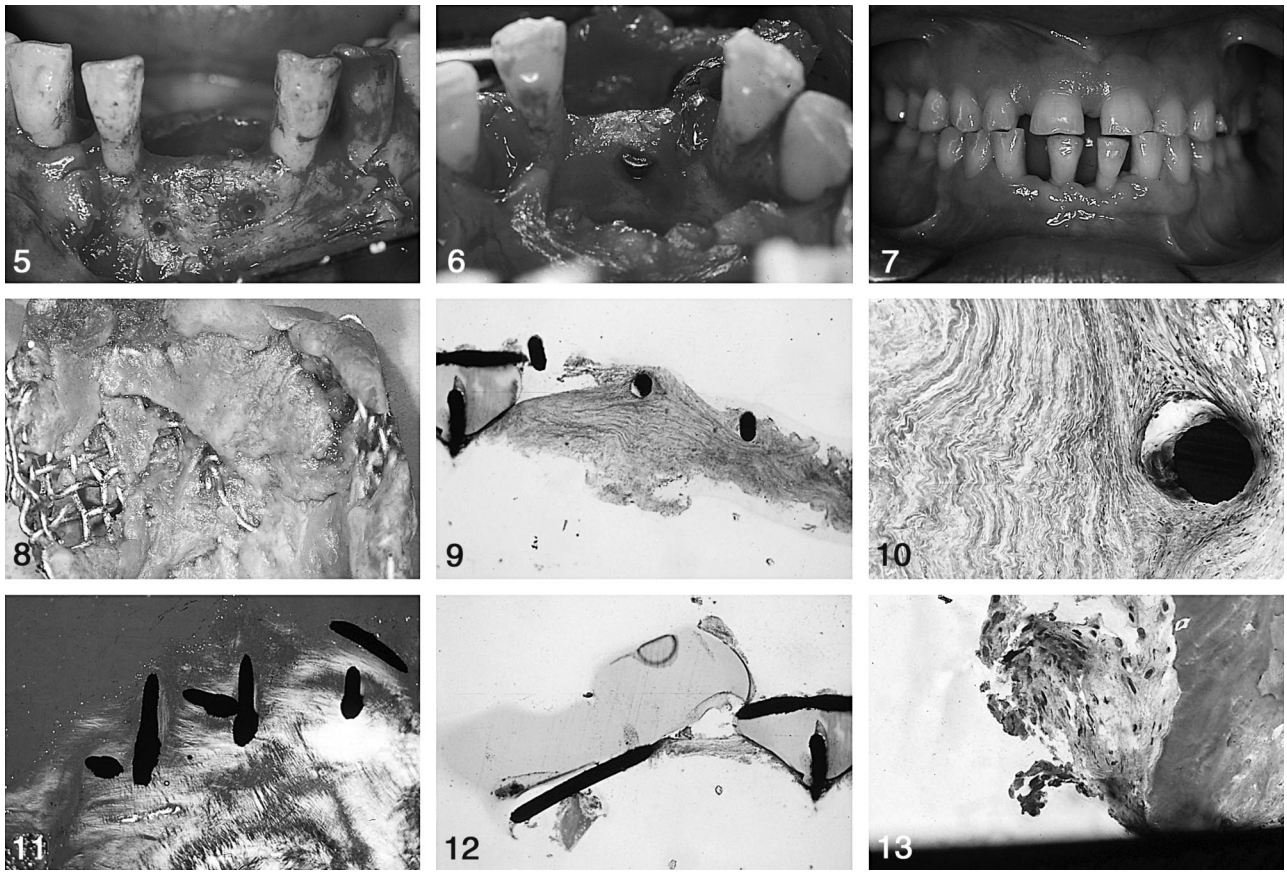
situations, an excessive soft tissue pressure could cause a membrane collapse toward the defect.[2] Possible solutions to avoid the membrane collapse and to increase the regenerative capabilities of the bone in non–space-making situations have been the use of reinforced e-PTFE membranes[2,10] or miniscrews and pins to support the membrane.[9] Recently, the use of self-reinforced polyglycolide membranes has been advocated.[12] However, even with miniscrews, it is possible to have a lateral collapse of the membrane.[9] The use of different types of grafts has been proposed to maintain the space between implant and surrounding defect.[13] Semirigid membranes are especially useful to treat the vertical component of the ridge deformity.[8] Recently, the use of barriers made of titanium micromesh has been advocated.[14–17] The aim of the present study was to clinically and histologically evaluate the results obtained using GBR with a titanium micromesh and a resorbable membrane.

MATERIALS AND METHODS

Eighteen patients (14 women and 4 men), with a mean age of 47.5 years (range, 20–63 years), participated in this study. All patients gave their informed consent. In all patients, alveolar crest defects due to advanced periodontitis, trauma, or extractions were present (Figure 1). Fifty Frialit 2 or IMZ Twin Plus implants (Friadent, Mannheim, Germany) were inserted, usually 4 to 5 mm above the lower borders of the defects (Figure 2), and the defects were filled with autologous bone obtained from intraoral sites (usually the chin area). The defects were then covered with a titanium micromesh (Cortical Mesh, Micronova, Bologna, Italy) (Figure 3) above which was positioned a resorbable membrane (Biogide, Geistlich, Wohlhusen, Switzerland) or a polyurethane membrane. The micromesh was fixed with 3-mm titanium microscrews. After a healing period of 4 months in the mandible and 6 months in the maxilla, the mesh with the surrounding and underlying tissues was removed.

Specimen processing

All specimens and surrounding tissues were washed in saline solution and im-



FIGURES 5–13. FIGURE 5. Underneath the mesh, it is possible to observe the presence of a tissue with the macroscopic features of mature bone; this tissue cannot be entered with a dental probe. FIGURE 6. Lingual view after removal of the mesh. It is possible to observe the amount of the vertical regeneration (about 3 mm of newly regenerated bone is present on top of the implant). FIGURE 7. A single crown has been placed on the implant and the restoration is completed. FIGURE 8. Macroscopic view of the mesh: the mesh is surrounded by dense connective tissue. FIGURE 9. At low magnification, dense connective tissue is present around the mesh (acid fuchsin-toluidine blue, original magnification ×50). FIGURE 10. At higher magnification, no inflammatory cells are visible (acid fuchsin-toluidine blue, original magnification ×100). FIGURE 11. Under polarized light, the connective fibers run in a parallel way around the titanium (acid fuchsin-toluidine blue, original magnification ×50). FIGURE 12. In some areas, it is possible to observe the remnants of the resorbable polyurethane membrane and newly formed bone in tight contact with the membrane (acid fuchsin-toluidine blue, original magnification ×50). FIGURE 13. At higher magnification, newly formed bone with wide osteocyte lacunae is in close contact with the titanium (acid fuchsin-toluidine blue, original magnification ×200).

mediately fixed in 4% paraformaldehyde and 0.1% glutaraldehyde in 0.15 M cacodylate buffer at 4°C and pH 7.4 to be processed for histologic analysis. The specimens were processed to obtain thin ground sections with the Precise 1 Automated System (Assing, Rome, Italy). The specimens were dehydrated in an ascending series of alcohol rinses and embedded in a glycolmethacrylate resin (Technovit 7200 VLC, Kulzer, Wehrheim, Germany). After polymerization, the specimens were sectioned along their longitudinal axis with a high-precision diamond disk at approximately 150 μm and ground down to approximately 30 μm with a specially designed grinding machine. The slides were stained with acid fuchsin and toluidine blue. The slides were observed in normal transmitted light under a Leitz Laborlux microscope (Leitz, Wetzlar, Germany).

RESULTS

The postoperative healing was uneventful in all patients, and no incision dehiscences were observed. All implants were functioning successfully at 7-year follow-up. At the reentry procedure, the titanium micromesh appeared to be surrounded by a dense connective tissue with no clinical signs of inflammation (Figure 4). The micromesh appeared to adhere to the newly formed tissues, and, after its removal, a whitish soft tissue was present underneath; this tissue was carefully removed with a curette, and it was possible to observe that the space under the titanium mesh and the resorbable membrane was completely filled by a tissue with the macroscopic features of newly formed bone (Figure 5). It was not possible to enter this tissue with a dental probe. From a clinical point of view, in all patients, no residual bone defects were observed, and a significant increase of the alveolar width or height was found (Figure 6). In all cases, it was possible to observe a good

esthetic result of the restorative procedure (Figure 7). From a macroscopic point of view, the mesh was surrounded by dense connective tissue (Figure 8). Histologic analysis showed that in all specimens the resorbable membrane was still present and fragmented and tended to surround, in many fields, the titanium mesh. Few macrophages were visible near the membrane, but no multinuclear giant cells were present. The resorbable membrane and the titanium mesh were surrounded by a dense connective tissue with few cells (Figure 9); no inflammatory infiltrate was present (Figure 10). In a few areas, capillaries were visible near the membrane. Under polarized light, connective tissue fibers were seen running in a parallel way around the titanium (Figure 11). In some specimens, it was possible to observe newly formed bone under the resorbable membrane. In only a few areas under the titanium mesh was it possible to see newly formed bone with wide osteocyte lacunae in tight contact with the metal (Figures 12 and 13); this bone was lined by osteoblasts.

Discussion

One of the main problems in using occlusive membranes is their lack of stiffness, which can produce a collapse of the barrier toward the bone defect, reducing the space needed for the bone regeneration.[15–18] This problem can be, in part, overcome with the use of grafts beneath the membrane, but the influence of the overlying soft tissues in collapsing the membrane could still be present. For this reason, we decided, in patients with deficient ridges in the lateral and vertical dimensions, to use a titanium micromesh to try to eliminate in a more complete way the negative influence of the soft tissues. The higher the stiffness of a material, the lesser the tendency to collapse. However, we also have to take into consideration the need to adapt a barrier to the bone contours.[16] In all our patients, the titanium micromesh was easy to handle, was ductile, and appeared to have excellent space-making capabilities. No inconveniences (dehiscences, infections) were observed in the healing of the soft tissues. On the contrary Celletti et al,[19] in an experimental study in dogs using titanium membranes, found that at 3 weeks all these membranes were slightly exposed. These different results could be due to the fact that our barrier was made by a micromesh with pores where the surrounding tissue could grow, whereas Celletti et al[19] used a membrane without pores. The high biocompatibility of the titanium micromesh used is attested to by the presence, in some specimens, of newly formed bone in close and tight contact with the metal.[20] In all our patients, the use of grafts under the mesh and the membrane appeared to have a beneficial effect on the amount of bone regeneration in non–space-making defects. The dense connective tissue that we found under the titanium mesh and the resorbable membrane could be due to different factors, such as insufficient peripheral healing between material and bone, ingrowth of connective tissue through the pores of the barrier, and insufficient stability of the wound area.[7]

These findings are in contrast to the study by Lundgren et al,[5] where, with the use of a completely occlusive titanium barrier, no presence of connective tissue was found under the membrane. In our cases, the connective tissue under the mesh was probably caused by an insufficient adaptation of the mesh to the contours of the bone defects due to the stiffness of the material. Regarding this issue, Zellin et al[21] found that, in a histologic comparison of 10 different types of membranes in rats, a 50-μm membrane made of a titanium foil had the least tendency to collapse, but problems were present concerning the adaptability of the material. In conclusion, the clinical and histologic results of the present study show that most certainly the space for the bone regeneration is one of the most critical factors in the success of the regenerative techniques and that the primary closure of the mucoperiosteal flap has a relevant role in the protection of the blood clot and in the prevention of infection.[8,22,23] The use of a bioresorbable membrane and of grafting material under the barrier membranes is certainly helpful and beneficial.

Acknowledgments

This work was supported in part by the National Research Council, Rome, Italy, and the Ministry of Education, University, and Research, Rome, Italy.

References

1. Jovanovic SA, Nevins M. Bone formation utilizing titanium-reinforced barrier membranes. *Int J Periodontics Restorative Dent.* 1995;15:57–69.

2. Jovanovic SA, Schenk RK, Orsini M, Kenney EB. Supracrestal bone formation around dental implants: an experimental dog study. *Int J Oral Maxillofac Implants.* 1995;10:23–31.

3. Jensen OT, Greer RO, Johnson L, Kassenbaum D. Vertical guided bone graft augmentation in a new canine mandibular model. *Int J Oral Maxillofac Implants.* 1995;10:335–344.

4. Hardwick R, Hayes BK, Flynn C. Devices for dentoalveolar regeneration: an up-to-date literature review. *J Periodontol.* 1995;66:495–505.

5. Lundgren D, Lundgren AK, Sennerby L, Nyman S. Augmentation of intramembranous bone beyond the skeletal envelope using an occlusive titanium barrier: an experimental study in the rabbit. *Clin Oral Implant Res.* 1995;6:67–72.

6. Schmid J, Hammerle CHF, Olah AJ, Lang NP. Membrane permeability is unnecessary for guided generation of new bone: an experimental study in the rabbit. *Clin Oral Implant Res.* 1994; 5:125–130.

7. Schenk RK, Buser D, Hardwick R, Dahlin C. Healing pattern of bone regeneration in membrane protected defects: a histologic study in the canine mandible. *Int J Oral Maxillofac Implants.* 1994;9:13–29.

8. Cortellini P, Bartolucci E, Clauser C, Pini Prato GP. Localized ridge

augmentation using guided tissue regeneration in humans: a report of nine cases. *Clin Oral Implant Res.* 1993;4:203–209.

9. Buser D, Dula K, Belser UC, Hirt HP, Berthold H. Localized ridge augmentation using guided bone regeneration, II: surgical procedure in the mandible. *Int J Periodontics Restorative Dent.* 1995;15:11–29.

10. Simion M, Trisi P, Piattelli A. Vertical ridge augmentation using a membrane technique associated with osseointegrated implants. *Int J Periodontics Restorative Dent.* 1994;14:497–511.

11. Augthun M, Yildirim M, Spiekermann H, Biesterfeld S. Healing of bone defects in combination with immediate implants using the membrane technique. *Int J Oral Maxillofac Implants.* 1995;10:421–428.

12. Ashammakhi N, Makela EA, Vihtonen K, Rokkanen P, Tormala P. Effect of self-reinforced polyglycolide membranes on cortical bone: an experimental study in rats. *J Biomed Mater Res.* 1995;29:687–694.

13. Becker W, Schenk R, Higuchi K, Lekholm U, Becker BE. Variations in bone regeneration adjacent to implants augmented with barrier membranes alone or with demineralized freeze-dried bone or autologous grafts: a study in dogs. *Int J Oral Maxillofac Implants.* 1995;10:143–154.

14. Von Arx T, Cochran DL, Hermann JS, Schenk RK, Higginbottom FL, Buser D. Lateral ridge augmentation and implant placement: an experimental study evaluating implant osseointegration in different augmentation materials in the canine mandible. *Int J Oral Maxillofac Implants.* 2001;16:343–354.

15. Maiorana C, Santoro F, Rabagliati M, Salina S. Evaluation of the use of iliac cancellous bone and anorganic bovine bone in the reconstruction of the atrophic maxilla with titanium mesh: a clinical and histologic investigation. *Int J Oral Maxillofac Implants.* 2001;16:427–432.

16. Von Arx T, Wallkamm B, Hardt N. Localized ridge augmentation using a microtitanium mesh: a report on 27 implants followed from 1 to 3 years after functional loading. *Clin Oral Implant Res.* 1998;9:123–130.

17. Von Arx T, Kurt B. Implant placement and simultaneous peri-implant bone grafting using a microtitanium mesh for graft stabilization. *Int J Periodontics Restorative Dent.* 1998;18:117–127.

18. Fritz ME, Malmquist J, Koth D, et al. The use of guided bone regeneration to fill large mandibular defects in monkeys: a pilot study. *Int J Oral Maxillofac Implants.* 1994;9:644–652.

19. Celletti R, Davarpanah M, Etienne D, et al. Guided tissue regeneration around dental implants in immediate extraction sockets: comparison of e-PTFE and a new titanium membrane. *Int J Periodontics Restorative Dent.* 1994;14:243–253.

20. Paquay YCGJ, de Ruijter JE, Van Der Waerden JPCM, Jansen JA. Wound healing phenomena in titanium fibre mesh: the influence of the length of implantation. *Biomaterials.* 1997;18:161–166.

21. Zellin G, Gritli-Linde A, Linde A. Healing of mandibular defects with different biodegradable and non-biodegradable membranes: an experimental study in rats. *Biomaterials.* 1995;16:601–609.

22. Sandberg E, Dahlin C, Linde A. Bone regeneration by the osteopromotion technique using bioabsorbable membranes: an experimental study in rats. *J Oral Maxillofac Surg.* 1993;51:1106–1114.

23. Becker W, Becker BE, McGuide MK. Localized ridge augmentation using absorbable pins and e-PTFE barrier membranes: a new surgical technique: case reports. *Int J Periodontics Restorative Dent.* 1994;14:49–61.