A case of localized ridge augmentation from using a titanium membrane: A pilot study

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Abstract: The aim of this investigation was to histologically compare the effects of new titanium membranes with those of proven expanded polytetrafluoroethylene (ePTFE) membranes on alveolar ridge augmentation. The study was carried out using a canine mandible where the right and left premolar teeth were previously extracted. At the second month of healing following extraction, a total of seven similar defects were created on both sides of the mandible. Three defects received the titanium membrane, one of which was in the right side of the mandible. Two defects, one on each side, received the ePTFE membrane. The remaining two defects, both on the right side, served as control. Fixation and stabilization of the membranes were accomplished by using the Frios Augmentation System. After three months of healing, the animal was sacrificed, block sections were taken and processed for histological examination according to the cutting and grinding technique. The results revealed that the ePTFE and titanium-treated defects, and the controls, showed complete bone fill with the exception that there was a more pronounced and thicker connective tissue formation in titanium-treated sites as compared to the ePTFE treated and control sites. (J. Oral Sci. 42, 133-138, 2000)

Key words: ridge augmentation; titanium membrane; guided-bone regeneration.

Introduction

Reconstruction of alveolar ridge deformities has begun to be widely performed as a result of the great improvements that have taken place in dental material technology. Alveolar ridge deformities have an appearance that is not aesthetic and also have insufficient bone architecture for the purpose of prosthetic restorations in general and implantation procedures in particular (1). Because of this, guided-bone regeneration (GBR), which evolved from guided-tissue regeneration (GTR), has started to be used for the formation of new bone in order to reconstruct defective alveolar ridges, which are caused by numerous reasons such as systemic diseases, mechanical forces, periodontal diseases and trauma (2,3).

The GTR technique has continuously improved since the 1980's, with a variety of new materials having been developed. The validity of the clinical use of expanded polytetrafluoroethylene (ePTFE) membranes has been supported by experimental and clinical studies (4,5). Some investigators have been using resorbable membranes for GBR, but variability of resorption among individuals and the quality of new bone might cause controversial results (6,7). In recent years, titanium, which is biocompatible with oral tissues, has begun to be manufactured in the form of a periodontal membrane. The use of titanium membranes with immediate implants has already been reported (8), however there is very little information in the literature concerning their use in reconstructing alveolar ridge deformities. Therefore, the use of titanium in a similar way as ePTFE membranes in GBR may be a matter that deserves further research. Recently, Von Arx et al. used titanium mesh with autogenous bone grafts in vertical ridge augmentation (9) and in the treatment of peri-implant bone defects (10). They found that a micro titanium mesh...
(but not a membrane) in combination with autogenous bone grafts was effective for the treatment of peri-implant bone defects (10). Moreover, they concluded that loaded dental implants, which were placed in the titanium mesh-treated sites, had clinical and radiographic characteristics similar to implants placed into a pristine ridge (11).

The aim of this study was to make a histological comparison between the effects of new titanium membranes and those of ePTFE membranes on alveolar ridge augmentation on experimentally-created defects.

**Materials and Methods**

An extracted canine mandible lacking the right and left premolar teeth was used in this study. Two months following extraction, the animal was anesthetized with an i.m. injection of Ketalar and Rompun. A midcrestal incision was made and full mucoperiosteal flaps were elevated to the labial and palatal aspects. Four defects on the right mandibular premolar region and three defects on the left mandibular premolar region were prepared under saline irrigation by using a 2.2 mm diameter bur. The transcortical defects were 'U' shaped and 5 mm in depth, and extended buccally and lingually (Fig. 1). Out of a total of seven defects, three received a titanium membrane, one of which was on the right side. Two defects, one on each side, received a ePTFE (GTAM, oval-6 WL Gore) membrane while the remaining two defects on the right side served as controls (Figs. 2 and 3). The membranes were placed in such a way that complete coverage of the defects was maintained both from the vestibule and lingual aspect of the alveolar ridge. Fixation and stabilization of the membranes were accomplished by using mini screws (Frios Augmentation system, Friadent) (Fig. 4). Titanium membranes (Frios Bone Shield, Friadent) used in this study were 0.025 mm thick and perforated at every 0.25 mm. During the three month postoperative period, the dog was fed with a soft diet and plaque control was maintained by a weekly application of 0.2 % Chlorhexidine solution. After three months of healing, the dog was sacrificed by an overdose of pentothal and block sections were obtained. The specimens were fixed in 10 % formaldehyde and processed according to the cutting and grinding technique described by Donath and Breuner (12). The 10 μm serial sections were prepared and stained with Masson-Gold Trichrome and histological examination was carried out under light microscopy.

**Results**

The healing period was complication free with no signs of infection or exposure of the membranes. The ePTFE and titanium membranes were tolerated well and an inflammatory response, including the appearance of multinuclear foreign body cells, was virtually absent. In the midcrestal coronal sections, all of the defects, including...

![Fig. 1](image1.jpg) Similar "U" shaped transcortical defects were prepared.

![Fig. 2](image2.jpg) Right mandibular premolar region. The titanium and the ePTFE membranes were placed to cover the defects entirely from the vestibule and lingual aspects of the alveolar ridge. Control defects were left uncovered.

![Fig. 3](image3.jpg) Left mandibular premolar region.
controls, showed complete bone fill (Figs. 5, 6 and 7). The new bone formations under both of the membranes demonstrated similar healing patterns. Interestingly, the connective tissue formation under the titanium membranes was more dense and thicker when compared to those under the ePTFE membranes (Figs. 5 and 6). The titanium membrane used in this study was manufactured with perforations at every 0.25 mm. Connective tissue flow through these perforations was observed clearly (Fig. 8). Furthermore, there was connective tissue ingrowth at the membrane periphery in one of the sections (Fig. 9).

**Discussion**

Localized alveolar ridge deformities resulting from tooth removal, periodontal diseases, developmental defects and systemic diseases jeopardize the placement of fixtures and prosthetic restorations. In the past years, reports on the treatment of such alveolar ridge deformities usually focused on the techniques of de-epithelialized connective tissue grafts, subepithelial connective tissue grafts, and ridge augmentation with hydroxyapatite and similar materials (13–15). However, when implant placement becomes the choice of treatment, another treatment approach gains more importance. Currently, the guided-bone regeneration (GBR) technique with a barrier membrane is being used extensively either to augment deficient alveolar ridges for prosthetic restorations or to promote bone growth around the exposed implant threads. The ePTFE membrane is the one that has attracted comparatively more attention among membranes. With the exception of the study performed by Celleti et al. (8), there is not much research on the use of recently manufactured titanium membranes. Celleti et al. demonstrated in an animal study that titanium membranes placed around exposed implant threads were not able to enhance bone regeneration as compared with ePTFE membranes. Other studies used titanium either in a dome or mesh form rather than a membrane (10, 11, 16). Von Arx (10) found that micro titanium mesh was effective for treatment of peri-implant bone defects. Moreover, they found that loaded implants, which have been inserted into micro titanium mesh, augmented successful alveolar ridge outcome (11). Recently, in an experimental study in rabbits,
Lundgren et al. (16) reported that the use of a prefabricated titanium dome with total occlusiveness, sufficient stiffness, stability and reliable peripheral sealing, resulted in bone augmentation beyond the skeletal envelope.

In our study, the spaces under the ePTFE and titanium membranes were completely filled with bone without any exposure of the membranes. Achievement of infection-free zones during the entire study period was one of the criteria that predicted success in the regeneration of the experimental defects.

The overall tissue under the membranes was similar, with the exception that there was more dense and thicker connective tissue in the titanium-treated sites. The only possible explanation for this is that the porous titanium membrane was not able to interfere with the connective tissue flow through the microholes. This finding emphasizes the importance of pore size in the outcome of the regenerative procedure.

There was also connective tissue ingrowth at the titanium membrane periphery in one of the sections. This may indicate that the part of the membrane apical to the fixation screw could not have established a seal to the bone surface that was tight enough to prevent ingrowth of soft tissue. Similar findings related to soft tissue ingrowth from membrane peripheries despite the fixation screws were also observed in other studies (2,17). Taking the above findings into account, the titanium membrane might not offer a good alternative to the ePTFE membrane in cases of implant procedures where an intact, mature bone tissue without soft tissue interventions is a prerequisite, since the bulky connective tissue under the titanium membrane may jeopardize the success of implant therapy.

The highly regenerative potential of the tissue in the dogs was again documented in this study with the observation that complete bone fill also occurred in control defects. However, this study was important in that it showed the differences in healing pattern between the newly manufactured titanium and the ePTFE membranes. Although the ePTFE membranes serve as a gold standard among various barrier membranes, it has some drawbacks such as membrane collapse and risk of infection in the case of membrane exposure. These risk factors were eliminated.

**Fig. 6** Bone fill under the titanium membrane (Ti). CT: Connective tissue. Masson Gold trichrome staining, magnification: ×25.

**Fig. 7** Bone fill in the control defect. Masson Gold trichrome staining, magnification: ×25.
with the incorporation of titanium reinforcements and improvement of the flap closure techniques, respectively. However, the titanium membrane might have one advantage over the ePTFE membrane, that is, it allows less plaque accumulation on the membrane. Quirynen (18) stated that the surface roughness and the surface free energy play a key role in supragingival plaque formation, maturation and adhesion of bacteria. Thus, it may be possible that the titanium membrane, with its smooth surface texture when compared to the porous ePTFE membrane, might possess a lower surface free energy, thereby reducing the occurrence of gingival inflammation. Our unpublished clinical data regarding plaque accumulation on titanium membranes also verifies the findings of the present study. However, this issue should be further clarified.

In conclusion, the titanium membrane might become an alternative to the ePTFE membrane, however, further studies are needed to quantitatively examine bone regeneration and amount of connective tissue associated with these membranes. Moreover, future research should focus on the improvement of handling, pore sizes and rigidity of the titanium membrane.

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References


