Mostly showmanship – or a treatment approach with predictable benefits?

PROFESSOR ANTON FRIEDMANN, WITTEN, GERMANY

Membrane techniques have been successfully used for many years in the context of bone regeneration. They serve to separate the augmented region from the soft tissue of the oral mucosa. This article provides a brief overview of the importance of membrane exposure for the augmentation result. Based on data from animal and clinical studies, factors and membrane material properties are discussed that may contribute to an improved postoperative course following exposed healing. This in turn gives rise to a surgical protocol for the minimally invasive treatment of fresh extraction sockets using appropriate augmentation materials.

Introduction

About 30 years ago, Dahlin and coworkers introduced the membrane technique as a novelty within bone-defect treatment [1,2]. Especially when using a particulate bone substitute for augmenting local alveolar-ridge defects, the combination with a membrane cover has become an international standard. Several animal studies have demonstrated the fundamental effectiveness of a barrier on the regeneration results in standardized defects [3,4]. In these studies, significantly less newly formed bone on particulate bone substitute was regularly found in the control groups without a membranous defect cover than in the test groups where membranes were used to cover the defects.

Two factors ensure the effectiveness of this augmentation technique: the creation of additional space (volume) below the membrane and a dense primary wound seal of the soft tissue above [5,6]. The dense tension-free wound closure is to promote primary healing and to protect the augmentation site as well as the implanted materials from irritation by substances within the oral cavity for the duration of the integration phase.

Influence of membrane materials on degradation time and primary wound healing

The issue of wound healing above the membrane that separates the flap from the underlying bone continues to be controversial. Do the material properties of the membranes play a role in the wound healing processes over and above the tensile force?

While the pioneering work on guided bone regeneration (GBR) was carried out with non-resorbable membranes, the collagen membranes now constitute the most important product class. Those collagens are xenogeneic type I and III collagens in native or in crosslinked form. Collagen membranes are biodegradable, with the degree of crosslinking determining the degradation kinetics. A higher crosslinking rate can extend the degradation time compared to native collagen membranes. This was confirmed in several animal studies where the degradation rates of single- and double-layer crosslinked and non-crosslinked collagen membranes were investigated [7–9]. While native collagen rapidly integrates with the connective tissue and quickly undergoes complete degradation, crosslinked collagen and particularly ribose-crosslinked collagen has a significantly extended degradation profile [8]. The biocompatibility of crosslinked collagen membranes has been called into question in some animal studies [3]. However, the type of crosslinking must be considered in this context – whether it is based on chemical additives such as aldehyde or on the enzymatic action of sugars (ribose). While chemical crosslinking triggered foreign-body and inflammatory reactions in tissue [14], human biopsies of particulate remains of ribose-crosslinked
membranes showed high levels of biocompatibility. Unlike the complete degradation seen with native collagen membranes, they often tend to calcify during the mineralization process [10–2].

**Importance of membrane exposure**
Early wound dehiscence is one of the most frequent complications in GBR and can compromise the treatment outcome, sometimes to the point where the augmentation is lost completely. It was shown in vitro that when the exposed area is contaminated with microorganisms of the oral cavity, periodontal bacteria (Porphyromonas gingivalis, Treponema denticola) cause varying degrees of degradation of the collagen membranes. The bacteria’s own proteolytic enzymes degraded the native collagen more than the crosslinked collagen [13]. This also has a strong influence on the clinical results expected. In a clinical study, the effectiveness of a non-resorbable ePTFE membrane was compared to a non-crosslinked native collagen membrane and a ribose-crosslinked collagen membrane in dehiscence defects around implants [14].

Both this study and a prospective comparative clinical study by my former working group showed that ribose-crosslinked collagen membranes have an advantage over native collagen membranes with regard to the filling of the defect or the gains in height and width. This is especially true in areas where soft-tissue dehiscence and membrane exposure occur in the postoperative period [14,15]. The histological analysis of biopsies from previously dehiscient augmentation areas supports these clinical findings. Inflammatory infiltrates and a higher incidence of multinucleated giant cells – possible indication of an inflammatory response – were found mainly in augmentation materials covered with native collagen membranes. In contrast, former dehiscient defects that were covered with a stable ribose-crosslinked membrane exhibited more pronounced osteoneogenesis [16].

**Use of ribose-crosslinked membranes for preservation of the alveolar ridge using a minimally invasive treatment protocol**
Because of the high biocompatibility of ribose-crosslinked collagen membranes and their superior stability in wound dehiscence, it may be possible in certain clinical situations to waive the requirement of complete primary closure. This is important, for example, for the immediate treatment of extraction sockets, because here the mucogingival junction is displaced by the preparation of an advancement flap for complete wound closure. This displacement causes a loss of keratinized tissue on the vestibular side of the alveolar ridge. If the implants are to be surrounded entirely by keratinized mucosa, the keratinized tissue must be regenerated later.

In an ongoing clinical study by my working group, extraction sockets are always covered – without regard to the preservation status of the residual bone walls – with a ribose-crosslinked membrane (Ossix Plus; Regedent, Dettelbach, Germany). No mobilization of the flap to complete primary coverage is attempted. Rather, the flap edges are elevated vestibularly and orally by 2 to 3 mm in order to move the membrane edges to below the periosteum for subsequent fixation of the wound edges with in-situ sutures. If major parts of the defect walls are missing and the defect cannot be classified as self-sustaining, the residual socket is filled with bone substitute before covering it.

Postoperative healing is usually without complications. It generally takes three weeks for secondary epithelialization of initially exposed membrane surfaces to be completed. The filling of the alveoli with bone substitute as appropriate had no noticeable effect on healing. After the healing period, the length of which depends on the bone substitute material used, implants with a standard diameter can be placed in the alveolar ridge segments thus pre-treated. No additional augmentation to create additional bone volume is necessary.

**Case No. 1: Ridge preservation in the posterior maxilla**
The patient (female, 53 years) had been receiving periodontal treatment at our clinic for years. Following the unsuccessful treatment of a perio-endodontic lesion on tooth 16 (Fig. 1), it was decided to extract the tooth and replace it with an implant-supported restoration. Figure 2 shows the extracted tooth fragments. On the palatal root we found a massive periapical granuloma. Due to the distinct apical
and palatal bone defect without a mouth-antrum connection, implant placement was postponed until after the healing of the defect. Given the good bony delimitation of the extraction defect on the buccal side and the classification of the defect as self-sustaining, it was decided not to fill the socket with bone substitute material.

The socket was covered with a membrane tucked in below the slightly elevated mucoperiosteal flaps both palatally and buccally. The long-lasting barrier effect of the membrane permits this minimally invasive treatment protocol without the preparation of a coronal advancement flap. Flap fixation and stabilization of the membrane were performed with cross sutures (Fig. 3).

Postoperatively, the patient was instructed to rinse her mouth with 0.2% chlorhexidine digluconate solution three times a day until complete wound closure over the membrane was achieved, as well as to avoid mechanical trauma to the wound area (10 to 14 days). At each control visit, topical wound disinfection with 3% H₂O₂ and cotton pellets was additionally performed. These prophylactic measures prevent permanent contamination of the membrane surface. Figure 4 shows the completely inflammation-free situation, with secondary granulation already setting in three days postoperatively. The sutures were removed after seven days (Fig. 5). The membrane body was still completely intact at that point, and the soft tissues continued to be non-inflammatory with advanced granulation.

At the 21-day recall, the socket above the membrane had been completely closed with soft tissue
(Fig. 6). The rest of the healing process was uneventful. The implant was placed after six months. The soft tissue was still healthy, with newly formed keratinized gingiva at the former site of tooth 16 (Fig. 7). In addition, the former extraction defect exhibited complete bony consolidation and no evidence of vertical loss, while the ridge width appeared reduced by the proportion of bone that formerly covered the palatal root (Fig. 8). Membrane residues were found on the buccal aspect of the augmented site. As they were already partially integrated into the alveolar ridge, they were removed only superficially for a histological examination.

The implant could be inserted in the new, vital bone in its entirety. The bone quality was D2 according to Lekholm and Zarb. A large circular volume was available for the bone bed. Its apical dimension towards the sinus region was sufficient to accept an 8-mm WN implant (Straumann, Freiburg, Germany) with good primary stability in an optimal prosthetic position (Figs. 9 and 10).

The healing of the implant placed, using a transgingival protocol with a healing abutment, was uneventful (Fig. 11). Thanks to the minimally invasive surgical protocol, the keratinized gingiva at site 16 could be optimally preserved (Fig. 12). The treatment plan called for a screw-retained all-ceramic crown on a Variobase abutment. Figure 13 shows the situation after insertion of the definitive crown restoration. An optimal aesthetic and functional result had been achieved.
Case No. 2: Reconstruction of the alveolar ridge in the upper premolar region

The patient (male, 56 years) had been receiving periodontal treatment at our clinic since 1997. Despite attempted regenerative therapy with enamel matrix proteins and endodontic treatment, the resorptive processes around tooth 14 could not be halted. It was planned to provide an implant-supported restoration.

Following elevation of a flap, massive bone resorption was seen around tooth 14 (Fig. 14). The extent of the resorption became evident once the tooth had been extracted. Because of the patient’s dental history, the buccal lamella was almost completely resorbed (Fig. 15), which necessitated the reconstruction of the ridge contour with a combination of a fast-resorbing bone substitute material and a membrane. The defect on the buccal side was first covered with the membrane (Fig. 16). The bone replacement material used was a synthetic bone cement based on a biphasic calcium sulphate (3D Bond; Regedent, Zurich, Switzerland). These materials are known for their rapid absorption, especially when treating extraction sockets [17–19]. The pasty form of presentation greatly facilitates the introduction of the material into the defect. Figure 17 shows the application of the pasty synthetic bone replacement material. A further advantage of calcium sulphate is that the material cures in situ and provides the best possible stabilization for the primary defect (Fig. 18).

The treatment protocol then called for the same steps as in case No. 1: Closure of the augmented alveolus by placing the membrane over the alveolus and below the full flap on the palatal side with fixation of the flap edges with modified mattress sutures according to Laurell (Fig. 19). The postoperative follow-up consisted of multiple daily mouth rinses for persistent decontamination of the membrane surface. Full secondary wound closure was again achieved after about three weeks. Further healing was uneventful. Due to the rapid absorption pro-
After closure of the socket with a membrane and after repositioning the flap using cross sutures.

The control radiograph at four months shows good bony consolidation. No residue of the bone substitute is visible.

Four months postoperatively. Optimally recovered keratinized gingiva.

After elevation of the flap, an adequately consolidated alveolar ridge was visible (Fig. 22). The former buccal defect was sufficiently regenerated by the augmentation technique used, providing a large circular and apical bone site for implant placement. Figures 23 and 24 show the situation after placement of an 8-mm RN SP implant. No additional augmentation in the region of the peri-implant soft tissue was required.

The control radiograph at four months shows good bony consolidation. No residue of the bone substitute is visible.

Single-tooth control radiograph taken after insertion, showing correct bone dimensions around the implant.

After closure of the socket with a membrane and after repositioning the flap using cross sutures.

The control radiograph at four months shows good bony consolidation. No residue of the bone substitute is visible.

Four months postoperatively. Optimally recovered keratinized gingiva.

Sufficiently consolidated alveolar ridge, with no visible residue of the augmentation material, visible after elevating the flap.

Adequate bone supply in buccal dimension for an 8-mm RN SP implant, provided with a healing cap for transmucosal healing.

Summary
Ribose-crosslinked collagen membranes have an extended degradation profile that has advantages over native collagen membranes especially in wound dehiscence. Being at the same time highly biocompatible, no complete primary closure is required when treating fresh extraction sockets with ribose-crosslinked membranes. Depending on the defect situation, the membrane may be used either alone or in combination with a suitable bone-graft material. Preservation of the ridge width seems to have a safe prognosis. An additional positive effect of this treatment strategy is the preservation of the mucogingival junction, since the flap is not coronally displaced and because secondary epithelialization results in a gain in keratinized gingival tissue.

Contact address
Professor Anton Friedmann
Witten/Herdecke University
Chair for Periodontology
Alfred-Herrhausen-Straße 44
58455 Witten · Germany
anton.friedmann@uni-wh.de

The references are available at www.teamwork-media.de/literatur