

Guided bone regeneration using a titanium membrane at implant placement: a case report and literature discussion

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Abstract

Reconstruction of the oral supporting tissues lost by disease or trauma is essential to tooth replacement with dental implant therapy. This treatment requires evidence based augmentative procedures combined with up-to-date and current techniques. Guided bone regeneration (GBR) aims to initialize this process of alveolar ridge reconstruction by utilizing biologically active and supportive materials best coupled to the body's healing processes. The use of non-resorbable, titanium membranes can achieve GBR by ensuring graft stability and space maintenance so as to ensure optimal neovascularization. Hereafter is a case report of a ridge defect reconstructed at implant placement, with the rationale and current, evidence-based literature discussed.

Keywords: Guided bone regeneration, titanium membrane, ridge augmentation, dental implant therapy

Background

The management of partially or totally edentulous patients with implant therapy has long since been a literature supported and successful treatment modality.¹⁻³ The implant supported restoration's survival and success is directly related to the health of its supporting tissues and their orientation circumferential to the implant.⁴ Guidelines to ensure long-term bone stability exist, namely positioning an implant at minimum 1.5 mm from an existing tooth, as narrow implant diameter as possible in the aesthetic zone, 3 mm inter-implant space, palatal and deeper implant placement in an immediate protocol, 2 - 3 mm of bone buccofacial and palatolingual to the implant, and so forth.⁵⁻⁹ When the tissues to ensure the long term stability of an ideally prosthodontically planned implant placement are deficient, the site should be augmented, by means of soft tissue procedures and guided bone regeneration (GBR).^{10, 11} Viz the guidelines should not be violated to compensate for the tissue deficit. Alveolar ridge augmentation can be predictably achieved by means of GBR, whereby the clinician constructs a scaffold at the defect site that supports a bone graft or bone substitute material (BSM).¹² A variety of GBR techniques are available to the clinician's augmentation armamentarium, comprising a variety of materials, each with its own properties and clinical indications.

Bone graft materials

These are defined by their osteoinductivity, osteoconductivity and osteogenicity. Albrektson simply describes osteoinduction as the process by which osteogenesis is induced, the ability of the graft material to actively promote bone formation.¹³ Osteoconductivity is the property of a surface that promotes bone formation upon it, a characteristic of a scaffold that may facilitate osteoprogenitor cells and neovascularization of its surface.¹⁴ Osteogenicity is the property of actual bone forming cells within the graft material, specifically pluripotent bone stem cells to form bone.¹⁵ Since autogenous bone contains such undifferentiated mesenchymal cells, precursors for osteoblasts and osteoclasts, monocytes and growth factors, it possesses all these aforementioned qualities and is the literature supported gold standard to promote GBR.¹⁶ In consideration of additional surgery, technique difficulty, and patient morbidity,

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an acceptable compromise would be to select an allograft (human tissue) material or BSM with some of these properties in lieu of an autograft.¹⁷ BSM may be xenograft (animal tissue) or alloplastic (synthetic materials), each having its own biological and mechanical properties.¹⁶

Graft barrier

A barrier membrane is a material that supports and secures the graft material in position.¹⁸ Some reports propose that the periosteum itself is an adequate graft barrier.^{19, 20} Periosteum however is a tissue not in isolation and is contiguous with oral mucosa and muscles thus making it a poor graft stabilizer and space maintainer.²¹ Graft success is strongly dependent on blood supply, nutrition, and immobility.²² The application of a barrier membrane secures the material at the recipient site and separates mucosa and muscle tissues from acting on it.²³ A resorbable membrane material will provide this barrier and secure the graft, though unpredictably and out of the clinician's control. Conversely a non-resorbable membrane is within the clinician's control, but may perforate the tissues and elicit unwanted complications.²⁴ Each membrane type thus similarly has its own biological and mechanical properties, its own pros and cons. Possibly the first report of titanium membranes used in GBR was by Celletti et al, 1994.²⁵ Thus the introduction of these materials into the literature are not altogether new, but their wider commercial availability and use now may be. A titanium sheeting device when adapted to the alveolar ridge provides a semi-permanently rigid scaffold surrounding the graft material and can be fixed to the dental implant itself. The material is biologically inert and its duration of support needed is dictated by the type of bone material placed beneath the membrane, ie. allogeneic, alloplastic, etc. Hereafter is a case demonstrating GBR simultaneous to implant placement and outlines the procedures used to

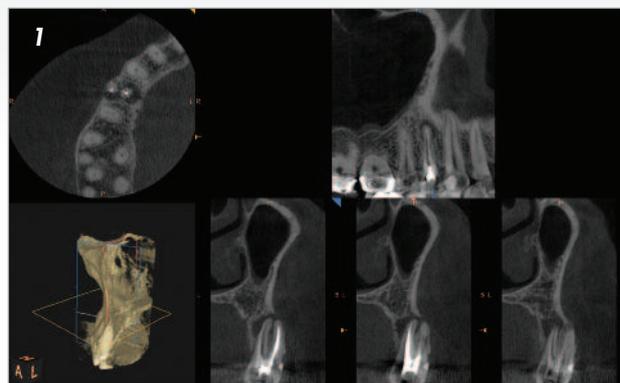


Figure 1: Preoperative CBCT

conform to guidelines for long-term implant tissue stability by using a titanium barrier membrane.

Case Report

A 58-year-old female patient was referred by her general practitioner with the request to extract tooth 14 and for further rehabilitative intervention. Additional social history profiled the patient as a non-smoker, and social drinker. The patient reported an uncomplicated medical history. The dental history indicated endodontic treatment of tooth 14 with a post-core-crown restoration completed several years prior. The tooth demonstrated failure of treatment, periapical pathology, and was symptomatic. Intraoral examination indicated the patient had a thick gingival biotype though with high scalloped, triangular adjacent teeth. Cone beam computed tomography (CBCT) of the site indicated significant pathological resorption of the bony ridge at 14 (Fig. 1). The tooth root was orientated buccally within the ridge and a post-extraction ridge defect was anticipated. Endodontic re-treatment was opted against due the large apical pathology in spite of relatively sound looking, previous endodontic treatment, and extraction with dental implant therapy to follow was planned for.



Figure 2: Minimally traumatic tooth extraction



Figure 3a: Extent of the ridge defect



Figure 3b: Extent of the defect from an occlusal view

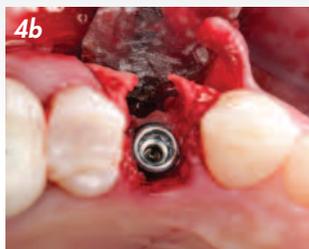


Figure 4a & b: Immediate placement of the implant



Figure 5a & b: Xenogeneic particulate graft combined with A-PRF fragments placed over the implant and defect



Figure 6: iGen titanium membrane



Figure 7a & b: Titanium membrane secured to the implant and over the graft material

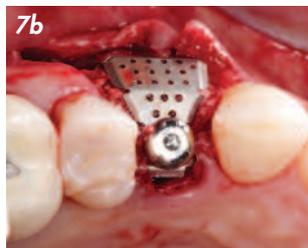


Figure 8: A-PRF membranes positioned over the titanium membrane

The patient's preoperative drug regime consisted of Augmentin 1000 mg twice daily 2 days prior to treatment, to progress 5 days following treatment. The operative site was anaesthetized with a 4% articaine solution containing a 1:100,000 concentration of adrenaline, and was the local anaesthetic administered in all subsequent surgical procedures. The tooth was sectioned and removed by a minimally traumatic extraction technique and the periodontal tissues maximally preserved where possible (Fig. 2). A full thickness flap was raised, and with the site fully exposed, apical pathological and inflammatory tissue was debrided from the socket and the site rinsed with a sterile saline solution. The extent of the ridge defect could be appreciated post-extraction (Fig. 3). A screw retained prosthesis had been planned and for its support a conical connection 4.5 x 11.5 mm endosteal implant (MegaGen AnyRidge) was then immediately placed into the site (Fig. 4). A flat abutment

screw was fixed in place and a combination graft material consisting of particulate xenograft (Gen-Oss) mixed with A-PRF membranes cut into small fragments was placed onto and around the implant, augmenting the buccal and crestal ridge defect (Fig. 5). With the particulate bone in position, a titanium membrane (i-Gen, Megagen) was then positioned over the graft material and secured in place to the neck of the implant by a healing abutment screwed into the flat abutment (Figs. 6, 7). A-PRF membranes were then positioned between the flap and the titanium membrane to assist with soft tissue healing (Fig. 8). The flap was repositioned and passive closure by primary union achieved with 6-0 polypropylene sutures (Fig. 9). A postoperative regime consisting of Myprodol, 2 capsules taken 6 - 8 hourly as required, and a chlorhexidine antiseptic rinse used twice daily was administered for 5 days. A 10 day follow up with suture removal reported healing without incidence, without

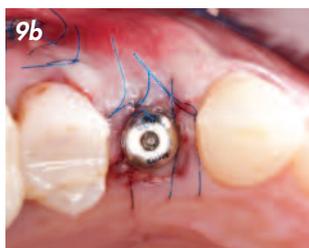


Figure 9a & b: Final closure of the site



Figure 10a & b: 1 Week postoperative



Figure 11a & b: 1 Month postoperative



Figure 12: Mini flap to expose membrane to crestal fold only

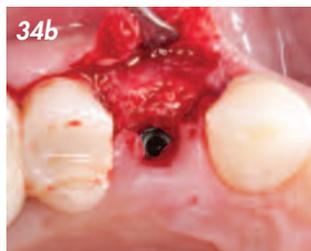


Figure 13a & b: Membrane removal and view of the augmented ridge



Figure 14: Membrane after removal

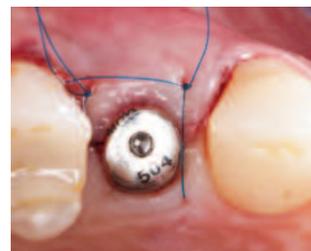


Figure 15: Site closure with healing abutment in place

untoward pain, signs of infection, oedema, nor perforation of the soft tissue (Fig. 10). The site was left to heal for a period of 4 months, whereafter the patient was recalled for removal of the membrane. The site was inspected and demonstrated no signs of tissue perforation by the titanium material (Fig. 11). With the site anaesthetized, an incision was made from the healing abutment's buccal aspect to the membrane's crestal fold only (Fig. 12), the healing abutment was removed, and the membrane retrieved with micro forceps (Figs. 13, 14). The flat abutment was also removed and a standard healing abutment then repositioned and the site again sutured closed (Fig. 15). An impression was taken of the implant for the fabrication of a lab manufactured provisional which was fitted 2 days later and the site was left to heal for an additional 2 months of soft tissue healing and development.

After the additional 2 months the ISQ readings demonstrated osseointegration of the implant, at 80B and 82P respectively. Postoperative CBCT evaluation demonstrated successful augmentation of the site with abundant bony tissue on the buccal aspect (Fig. 16) demonstrating a buccal ridge augmentation contour consistent with the anterior and posterior ridge and with good tissue stability. The patient was satisfied with the form

and function re-established with the graft procedure and the final healing (Fig. 17).

Discussion

Soft tissue aesthetics and long-term stability of the peri-implant tissues buccofacial to the implant supporting the restoration are largely dependent on the health and quantity of the bone. Grunder and Spray notably proposed the guidelines of bone ≥ 2 mm buccal and palatally to ensure long-term tissue stability.^{8, 9} An alveolar ridge deficient in volume to accommodate the dental implant whilst providing

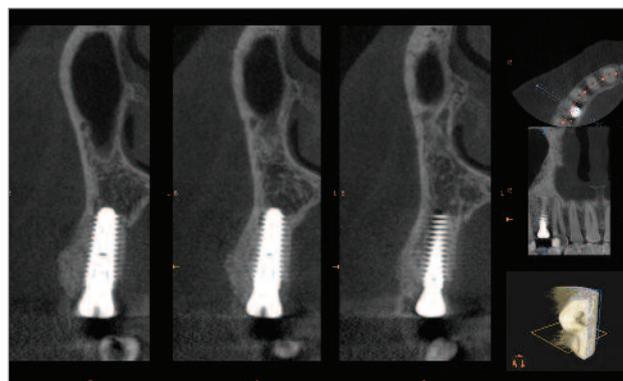


Figure 16: 3 Months postoperative CBCT



Figure 17a & b: The provisional restoration in place after a total of 6 months of healing

2 mm or more of residual bone, or implants not positioned 3-dimensionally correct, viz excessively buccofacial, will see tissue recession, loss of aesthetics, and treatment failure. Following Grunder and Spray's guidelines, stability can be achieved by applying the GBR technique demonstrated here. Positioning bone or a BSM with a barrier membrane locally applies bioactive materials and / or supports the body's own, aiming to sculpt a scaffold that will eventually be occupied by autogenous bone.²³ To achieve successful GBR the clinician needs to select techniques and materials that will create these three essential factors: 1. Graft stability, 2. Space maintenance, 3. Support the blood supply. Neovascularization of a healing wound is paramount to its recovery and rehabilitation.²⁴ A supported blood supply into graft material, be it autogeneic, alloplastic, xenogeneic, is critical for populating the site with osteoprogenitor cells, fibroblasts and leukocytes with their associated growth and chemotactic factors, and for an uninterrupted oxygenation and nutrient supply to the healing tissues.²⁶ To ensure neovascularization the graft must be stable, protected, and remain immobile, critically so during the first phases of wound healing. Mammoto et al proved that initial tissue regeneration is dependent on blood vessel ingrowth and is extremely mechanosensitive: the greater the graft immobility during the regenerative period the greater this vascular ingrowth.²² This factor is of paramount importance in oral tissue grafting. While some authors purport the periosteum as an adequate barrier, the use of implanting a barrier membrane device cannot be discarded.²⁷ Mucoperiosteum is continuous with other oral tissues and mobility will disturb the graft.²¹ Connective tissue and epithelium has a growth rate and turnover that far exceeds bone, and will grow into

and populate a graft particulate faster than an immature blood supply can introduce cells that secrete osteoid which then requires significant time to mature and mineralize.²⁸ Moreover, suturing the mucoperiosteum directly over the graft material without a barrier to achieve primary union may place tension on the underlying material that has increased the ridge volume. This scenario does not maintain space. Moreover, if primary union is not achieved, the graft material may spill from the site, defeating the purpose of the procedure, and as such it could be argued that the use of a barrier membrane is indispensable to maintain space and protect the graft. The use of barrier membranes for GBR around titanium implants has been reported in the literature for more than 25 years.²⁹ Resorbable membranes, typically of xenogeneic collagenous material could contribute to achieving temporary stability, as a barrier between healing soft tissue and graft material, but do not provide any space maintenance, and the clinician cannot ensure its duration within the tissues and thus is wholly unsure of the procedure's predictability.^{12,23} This is owed to variation in tissue collagenase pH among patients, to variability in material resorbability, and to the membrane strength itself.³⁰ Jason porcine pericardial membranes (Botiss) for example claim a stability for 12 - 24 weeks, while Altis porcine tendonous membranes (Altis Biogenics) state complete degradation at 16 weeks.^{31,32} These materials are organic and their infiltration by oral microbiota cannot be entirely prevented. Studies show that bacterial adherence to collagen membranes is higher than any other type of membranes, introducing a radical risk of graft infection and failure.³³⁻³⁵ By comparison, non-resorbable membranes are biologically inert. The materials may theoretically harbour microbes but

do not provide a nutritional source promoting graft infection. Of the more widely known materials, dense polytetrafluoroethylene (dPTFE) can provide separation between soft tissue and the grafted bone, can assist in sealing the wound when primary union will not be achieved, and if secured properly can stabilize the graft to support ingrowth of new vessels.^{36,37} dPTFE is malleable though and has no structural strength. dPTFE membranes modified by titanium for structural resilience are however commercially available and may provide the necessary space maintenance and aid graft stability.³⁸ Adjunct to these are membranes wholly manufactured of titanium.³⁹ The case demonstrated here utilized such a membrane of titanium sheeting that was fixed over the graft, secured in place by the implant fixture component itself, and it created the three essential factors needed for the graft's success. Being structurally the most resilient in the membrane armamentarium the clinician is assured of it protecting the graft, supporting angiogenesis and cell ingrowth, and the maintenance of space is controlled by the clinician until its removal. If the GBR technique is applied correctly and the bone given adequate time to develop, the implant tissues' stability and ultimately the long term aesthetic stability can be better assured.

The discussion would however be incomplete without noting the material's disadvantages. These titanium membranes incur increased treatment cost, whereas suturing with the mucoperiosteum for example as a graft membrane incurs none. The material's greatest advantage being its resilience, is also its greatest disadvantage. There is risk of perforating of the overlying soft tissues.⁴⁰ Thus the use of titanium membranes may be best suited in thick gingival biotypes, or their use in thin biotypes should possibly be with an adjunctive connective tissue graft, or with A-PRF as in this case to support the soft tissue healing. As with any technique and material selection, the clinician is to be well informed of each to make best practice clinical decisions.

Conclusions

To achieve predictable long term aesthetic results around restored dental implants, the bone supporting the soft tissues requires volume. GBR when successful can provide the 2 mm or more required. The critical factors for GBR success are graft stability, space maintenance, and supporting the blood supply. Proper case selection coupled with the use of titanium membranes can produce positive results when grafting around dental implants.

Declaration

No conflicts of interest are declared.

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