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Guided Bone Regeneration

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Abstract

Guided bone regeneration (GBR) is a reconstructive procedure of alveolar ridge using membranes with or without particulate bone grafts or/and bone substitutes. This procedure is indicated when insufficient bone for implantation is there, or in case of optimal implant placement for esthetic or functional needs. GBR can be performed before placement of implant, when there is insufficient bone for initial stability of implants and less predictable outcomes (staged approach), or performed simultaneously with implantation (combined approach). Vertical and horizontal ridge augmentations can be done by the use of GBR technique with acceptable results. This literature review discusses the background, the materials used in GBR (types of membranes and bone grafts), principles of GBR, factors affecting successful regeneration and determinants for implant site augmentation.

Keywords: Guided Bone Regeneration, Barrier membranes, Titanium mesh.

Introduction

Melcher[1] in 1976 described the concept of selective cell repopulation of defects to enhance healing. Exclusion of fast-growing epithelium and connective tissue from a periodontal wound for 6-8 weeks allows the slower growing tissues including osteoblasts, cement oblasts, and periodontal ligament cells, occupy the space adjacent to the tooth. The concept of GBR is based on the same principles of specific tissue exclusion but was not associated with teeth. Thus the term applied to this technique was GBR. **Dahlin et al.**[2] in 1988 introduced the term Guided bone regeneration (GBR) as a therapeutic modality aiming to achieve bone regeneration, via the use

of barrier membranes. Guided bone regeneration (GBR) in the oral cavity is defined according to the American Academy of Periodontology as "procedures attempting to regenerate lost periodontal structures through different tissue responses typically referring to bone or ridge augmentation.[3] Oral implantology has evolved into an accepted, predictable treatment for restoring lost teeth. Often in clinical practice, the bone volume deficiency is shown to be the primary reason for avoiding the treatment of implant. The solution lies in reestablishing the ridge volume consistent with prosthetic design and with suitable load-bearing lamellar bone for long-term stability of the implant therapy.[4] To promote bone growth and regeneration many predictable therapies are recently introduced in implant dentistry, including distraction Osteogenesis, only bone grafting, and guided bone regeneration (GBR). **Buser et al.**[5] in 1993 introduced the principle of "guided bone regeneration", applied in clinical dentistry to promote bone regeneration using a barrier membrane allowing the re-population of the osseous wound space. Since then, membrane barriers and bone grafting materials in GBR technique have been extensively investigated in periodontal regenerative medicine and dental implant therapies to enhance new bone formation for the placement of implants.[6,7]The concept of creating a secluded anatomic site with the aim to promote healing was first introduced 50 years ago, when cellulose acetate filters were experimentally used for the regeneration of nerves and tendons.[8] Experimental studies have provided significant evidence that bone regeneration is significantly enhanced when the invasion of soft tissue into osseous defects is mechanically impeded.[9]

Principles of guided bone regeneration

The concept of GBR treatment was developed on the basis of the GTR principle. Hence, the GBR biological rationale advocated the mechanical exclusion of undesirable soft tissues from growing into the osseous defect, thereby allowing only osteogenic cell populations derived from the parent bone to repopulate the osseous wound space.[1] (Figure1)

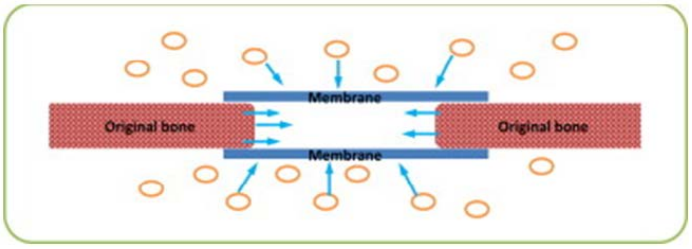

Figure1: Principle of GBR

Again in 2006**,** Wang and Boyapati[8] proposed the PASS principles for predictable bone regeneration. To attain horizontal and/or vertical bone augmentation beyond the envelope of skeletal bone, four principles are needed to be met: Primary wound closure, Angiogenesis, Space creation/maintenance, and Stability of both the initial blood clot and implant fixture (PASS).

Factors affecting successful regeneration

A number of factors have been implicated or shown to adversely influence periodontal regeneration therapy.[9] These include: Bacterial Contamination, Smoking, Diabetes, Defect Morphology and Tooth Anatomy, Membrane Exposure, Gingival Thickness, Space Maintenance

The Biology of Particulate Bone Grafting in Implant Dentistry: Regenerative Materials of Choice

Bone grafting and bone graft substitute

There is a broad variety of bone grafts that can be considered for implant site preparation. These include[10]: Auto grafts, Allograft, Xenografts, Allopath

Selection of bone graft and bone substitute materials

There is a wide variety of literature regarding the selection of graft materials for implant site preparation. Bone regeneration for implant placement can be accomplished through three different mechanisms[8]: Osteogenesis,

Osteoinduction, Osteoconduction. All grafting materials have one or more of these three mechanisms of action and mechanisms by which the grafts act are normally determined by their origin and composition.

Barrier Membranes

In the GBR procedure, the barrier membrane role is crucial for proper bone regeneration. It can prevent in-growth of soft tissue to the bone defect and helps in maintaining the defect space during bone tissue regeneration. Scantlebury[11] described five main criteria that membrane should fulfill which are: biocompatibility, the ability to create space, cell occlusiveness, tissue integration and easy – handling[12] According to **Wang and Caroll (2001)**, to achieve better clinical outcomes, the GBR barrier should possess the following properties:

1. **Cell exclusion:** In GBR, the barrier membrane is used to prevent gingival fibroblasts and/or epithelial cells from gaining access to the wound site and forming fibrous connective tissue.
2. **Tenting:** The membrane is carefully fitted and applied in such a manner that a space is created beneath the membrane, completely isolating the defect to be regenerated from the overlying soft tissue.
3. **Scaffolding:** This tented space initially becomes occupied by a fibrin clot, which serves as a scaffold for the in-growth of progenitor cells. In GBR, the cells will come from adjacent bone or bone marrow.
4. **Stabilization:** The membrane must also protect the clot from being disturbed by movement of the overlying flap during healing. It is therefore often, but not always, fixed into position with sutures, mini bone screws, or bone tacks.
5. **Framework**: Where necessary, as in nonspace maintaining defects such as dehiscences or fenestrations, the membrane must be supported to prevent collapse.[13]Currently,

Barrier Membranes are of two types: 1. Non-Resorbable, 2. Resorbable

Non-Resorbable Membranes - Non-resorbable membranes include Polytetrafluoroethylene (PTFE) and titanium mesh. In critical size defects non-resorbable devices have better abilities to achieve successful regeneration for their stiffness, controlled time of barrier effect and lack of resorption process. The main limitations of non-resorbable is the need for an additional surgery for their removal and wound dehiscence because of incomplete coverage during healing. With the development of resorbable materials and the increasing evidence of their effectiveness the use of ePTFE and titanium mesh has become limited to specific indications.[14]

i. **Expanded Polytetrafluoroethylene** - Expanded Polytetrafluoroethylene (e-PTFE) was originally developed in 1969 and it became the standard for bone regeneration in the early 1990s. The e-PTFE membrane is sintered with pores between 5 and 20 µm in the structure of the material. The most popular commercial type of e-PTFE was Gore-Tex®. The e-PTFE membrane acts as a mechanical hindrance. Fibroblasts and other connective-tissue cells are prevented from entering the bone defect so that the presumably slower migrating cells with osteogenic potential are allowed to repopulate the defect. [10]

ii. **Dense Polytetrafluoroethylene** - In high density-PTFE (d-PTFE) membranes, the risk of bacterial colonization is less than of e-PTFE even after exposure. The primary soft tissue closure is not required because of this high density and submicron pore sizes thus enhancing vertical and/or horizontal bone regeneration and soft tissue healing.[15]

iii. **Titanium Mesh** - Guided bone regenerative membranes can help in treating moderate to severe

osseous defects, but the inherent physical property of the membrane to collapse towards the defect due to the pressure of the overlying soft tissues (thus reducing the space required for regeneration) makes the overall amount of regenerated bone questionable. The use of titanium mesh which can maintain the space can be a predictable and reliable treatment modality for regenerating and reconstructing a severely deficient alveolar ridge.[16] The main advantages of the titanium mesh are that it maintains and preserves the space to be regenerated without collapsing and it is flexible and can be bent. It can be shaped and adapted so it can assist bone regeneration in non-space maintaining defects. Due to the presence of holes within the mesh, it does not interfere with the blood supply directly from the periosteum to the underlying tissues and bone grafting material. It is also completely biocompatible to oral tissues.[16] The main complication related to the use of titanium membrane is the dehiscence of soft tissues with the consequent exposure of the mesh. Nonetheless, titanium meshes are able to tolerate a certain degree of exposure.

Resorbable Membrane

In an effort to overcome the need for a second operation for membrane removal, barrier membranes are also constructed from biodegradable materials. Using resorbable synthetic membranes additionally decreases the need for surgical intervention from inflammation of membranes as well.[17] Currently there are two kinds of resorbable membranes: Polymeric (oraGRAFT®, Lifenet) and Collagen (Bio-Gide®, Geistlich) derived from different animal sources.

Emerging Natural Materials in Barrier Membranes

Hybrid and multiphasic barrier membranes, Multi Anti-infective membranes, phasic membranes, "Sweet" Manuka honey advancements for barrier membranes

Clinical Applications of Barrier Membranes

The choice of the type of membrane to be used depends substantially from the characteristics of the bone defect. They can be: Fenestrations, Dehiscence, Horizontal defects, and Vertical defects

The different techniques for bone augmentation are: Graft and membrane, Only grafts, Maxillary sinus lift using lateral approach

Complications Following GBR Procedure

Soft tissue complications are common during guided bone regeneration with a mean complication rate of 16.8%. Membrane exposure and acute infection are the most common complications. If not managed properly, this can result in infection of regeneration site and failure of GBR procedure.[18]

Indications

1. Small to medium size bone defect
2. Peri-implant socket spaces in cases of immediate implant in fresh extraction socket
3. Ridge splitting with simultaneous implant placement
4. Sinus grafting with simultaneous implant placement
5. Adequate bone volume to engage the implant
6. Implant placement is possible within the osseous envelope of the defect
7. Adequate amount of thick, stable, and keratinized soft tissue is available to cover the graft site.
8. Adequate blood supply for the graft from the host site.[14]

Tenting & fixation screws- The tenting screw technique (TST) is an alternative to these procedures and is as effective in promoting new bone formation, localized to the site that is highly predictable, time efficient, cost effective, with less patient morbidity. It is based on the

basic principles of GBR utilizing resorbable barrier membranes. This technique provides and maintains space, allowing stabilization of the blood clot during healing.[19] A tenting screw osteotomy was created with the tenting screw kit drill. The tenting screw was placed vertically, horizontally, or diagonally depending on where augmentation was needed. Titanium tenting screws are available in different sizes of 4mm, 6mm, 8mm, 10mm, 12mm, and 15mm in length and 1.5mm to 2mm in diameter. If primary stability is difficult, a longer screw can be used. The lingual/buccal plate can be perforated to get bicortical stabilization.[19] The vertical height of the screw is determined by proximal height of the adjacent bone. The screw head can be placed 1–2mm above this height if required. Single or multiple screws can be used based on the size of defect. (Figure2)

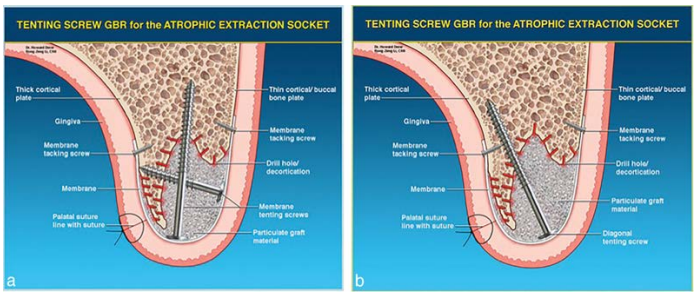

Figure2: Tenting Screw GBR

Determinants for implant site augmentation

Given the wide variety of graft materials, biologics, and regenerative membranes, materials selection can be confusing. With clinical experiences, each clinician will develop their personal decision algorithm for implant site preparation. It should be noted here that not all bone defects need to be augmented. Small and narrow defects with adequate buccal and lingual walls will normally regenerate without manipulation.[20] As the defect becomes larger and the bony walls become more compromised, a variety of graft materials as well as biologics should be considered. When a "regenerative wall" is needed, one should consider the addition of a GBR membrane. The absorbable membranes are convenient to use but as the defect becomes larger, the need for a non-absorbable GBR membrane becomes more prevalent. Should a positive architecture be required, titanium-reinforced non-absorbable GBR membrane should be considered. It important for each clinician to understand the defect requirements, material cost, and necessary healing time and convey this information to the patient.[20] In a study done by Hammerle et al[20] reported that the alveolar ridge undergoes a mean horizontal reduction in width of 3.80mm and a mean vertical reduction in height of 1.24mm within 6 months after tooth extraction without ridge preservation therapies.

Conclusion

Guided bone regeneration is one of the several surgical techniques that have been introduced in the last two decades for bone regeneration prior or at the time of implant placement. The rationale of this technique is the positioning of a barrier membrane between the bone and the connective tissue to create a secluded space and to enhance the proliferation of bone forming cells.

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