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Guided Bone Regeneration in Immediate Dental Implants - Review

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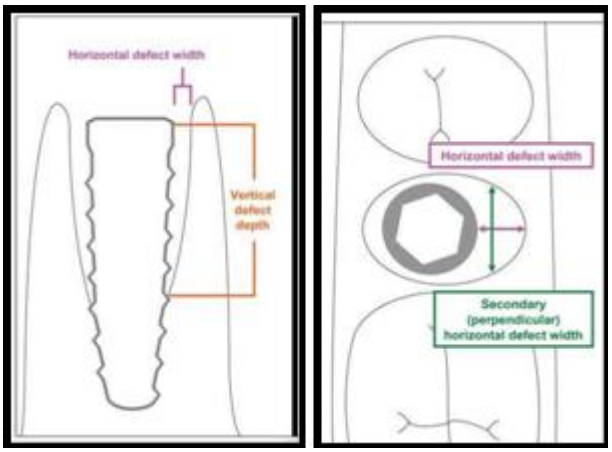
Abstract: ***The need for bone grafting and the use of a barrier after immediate implant placement depend on the thickness of the labial plate and the size of the gap between the implant and the adjacent alveolar bone. A variety of regenerative techniques using combinations of bone grafts and barrier membranes have been suggested promoting bone regeneration in localized defects at implants placed into extraction sockets. GBR is the most frequently used technique for bone regeneration in conjunction with or prior to implant placement. The principal idea of GBR is the use of membranes to exclude epithelial cells with a high turnover and to allow the migration of the desired cells (particularly osteoblasts) in the established wound space.***

Keywords: Immediate dental implant, Guided tissue regeneration, Bone grafts, Membranes

1. Introduction

When a dental implant is placed into a fresh extraction socket, a space between the implant periphery and surrounding bone occurs. A gap can occur on any aspect of an immediately placed implant: Buccal, lingual or proximally. This space between the implant periphery and surrounding bone is called the gap or jumping distance. Bone fill in the gap between the implant and the peripheral bone is important [1]. The buccal aspect of an implant is of great concern, especially in the aesthetic zone, because the buccal bony plate is usually thin and its resorption can result in soft tissue recession. The objective of the surgical management of the buccal gap is optimal bone fill in the gap, most coronal level of bone-to-implant contact and the least amount of buccal bone loss and soft-tissue recession.



Guided bone regeneration - A variety of regenerative techniques using combinations of bone grafts and barrier membranes have been suggested promoting bone regeneration in localized defects at implants placed into extraction sockets (**Schwartz and Chaushu, 1997, Mayfield 1999)**[2] **.** The principal idea of GBR is the use of membranes to exclude epithelial cells with a high turnover and to allow the migration of the desired cells (particularly osteoblasts) in the established wound space **(Ha¨mmerle & Jung 2003)**[3].

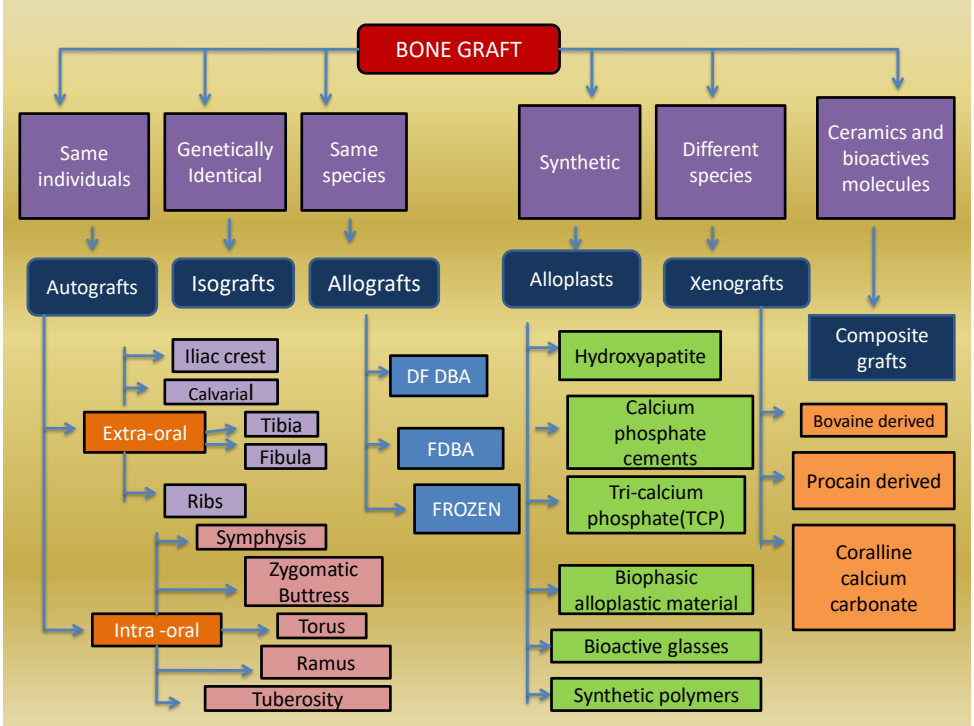
GBR is a surgical procedure that uses barrier membranes with or without particulate bone grafts or/and bone substitutes. Osseous regeneration by GBR depends on the migration of pluripotential and osteogenic cells(e.g. osteoblasts derived from the periosteum and/or adjacent bone and/or bone marrow) to the bone defect site and exclusion of cells impeding bone formation(e.g. epithelial cells and fibroblasts).[4]

After GBR procedures, bone regeneration follows a specific sequence of events. Within the first 24 hours after a bone graft, the graft material/barrier created space is filled with the blood clot which releases growth factors (e.g., platelet derived growth factor) and cytokines (e.g., IL-8) to attract neutrophils and macrophages. The clot is absorbed and replaced with granulation tissue which is rich in newly formed blood vessels. Through these blood vessels, nutrients and mesenchymal stem cells capable of osteogenic differentiation can be transported and contribute to osteoid formation. Mineralization of osteoid forms woven bone, which later serves as a template for the apposition of lamellar bone . This transformation of primary sponge work would eventually constitute both compact and reticular bone with mature bone marrow. These events
occur 3 to 4 months postsurgery .[5]

Grafting Materials
The physiological properties of **osteogenesis, osteoconduction, and osteoinduction** possessed by bone grafts is one of the most important factors that affect the dynamics of bone graft healing. While **osteogenesis** is the ability of graft to produce new bone owing to the presence of viable osteoprogenitor/osteogenic precursor cells, **osteoinduction** is the ability of the graft to induce stem cells to differentiate into mature bone cells owing to the presence of bone growth factors. **Osteoconduction** is just a physical property that enables a graft to serve as a scaffold and allow

the ingrowth of neovasculature and infiltration of osteogenic precursor cells into the graft site.[6]

Several local factors that influence graft incorporation positively are good vascular supply at graft site, large surface area, mechanical stability and loading, growth factors, and electrical stimulation; while radiation, bone disease, infection, mechanical instability, and denervation affect it negatively[7].



(A) Autografts

The gold standard of bone grafting materials is autografts. Autografts are obtained from the same patient, taken from one site and placed in another site and forms bone by the process of osteogenesis and osteoinduction. Osteogenesis is defined as bone growth from viable bone cells known as osteoblasts, osteoinduction is the process that involves materials that are capable of inducing cells to differentiate into osteoblasts[8]. Autograft materials are obtained intraorally form edentulous areas, tuberosity mandibular symphysis and mandibualr ramus. Extra oral autografts are obtained from iliac crest, rib, tibia and calvarium . Autogenous bone provides proteins, bone enhancing substrates, minerals, and vital bone cells to the recipient site, which enhance the overall success of the grafting procedure, resulting in high success rates. However, there are downsides associated with autogenous bone: 1) the necessity of harvesting from a secondary surgical site and the possible resultant patient morbidity; 2) possible root resorption and ankylosis with the use of fresh iliac bone graft when placed near the roots and 3) the difficulty of obtaining a sufficient amount of graft material, especially from intraoral sites. These limitations led to the development of allografts and alloplasts as alternative or supplemental grafting materials. Autogenous bone can be harvested as block autograft or particulate graft. High or slow speed handpieces, chisels, trephines, piezosurgical instruments, rongeurs, or bone scrappers may be used to harvest bone from donor sites. Grafted autogenous bone can be trabecular (cancellous), cortical or corticotrabecular. In general, cancellous bone has more osteogenic potential than cortical bone due to presence of hematopoietic marrow and a greater amount of pleuripotential cells in cancellous bone[9]. Brugnami et al. 1996 and Dealemans et al. 1997 recommended the use of autografts instead of allografts, due to the absence of immune reactions associated with the former. In this sense, the general impression appears to be that autologous grafts are the best choice for osseoinductive purposes[10].

(B) ALLOGRAFTS

Allograft bone is obtained from individuals of the same species, derived from human-cadaver bone that has been selected and tested to be free of HIV and transmitted diseases. The most common allograft used is dematerialized freeze dried bone allograft (DFDBA), provide type I collagen, which comprises most of the organic component of bone (Scahalhorn, 1972). In addition, allograft contains BMPs, which stimulate osteoinduction. There are thirteen proteins have been identified (BMP1-BMP13) which are osteoinductive compounds and stimulate new bone formation (Hoexter, 2002). Allografting was introduced by Sir William MacEwen in 1879.[8]

The main benefit of allograft bone is the avoidance of a secondary donor site, reduced surgical time, decreased blood loss, decreased host morbidity and unlimited supply of graft material. However, allografts are not osteogenic and bone formation usually takes longer and results in less regeneration than autogenous grafts. Freeze-dried bone can be used in two forms, demineralized freeze-dried bone allograft (DFDBA) or mineralized freeze-dried bone allograft (FDBA). Since FDBA is mineralized, it elicits slower resoprtion than DFDBA and provides an osteoconductive scaffold when implanted in mesenchymal

tissues. For DFDBA, the demineralization process removes the mineral phase of the graft[9]. **Fugazzatto (2004)** demonstrated that, a combination of osseous coagulum collected during preparation and freeze-dried bone allograft placed at immediate implant insertion and loading. After six months from surgery there was no probing depth exceed than 3mm an any aspect of the implant[11] .

(C) Xenografts

Xenografts are graft materials derived from the inorganic portion of animal bones; the most common source is bovine the removal of the organic component are processed to remove their antigenicity, while the remaining inorganic components provide a natural matrix as well as an excellent source of calcium. The first documented xenograft was done by Job van Mee'kren in 1600.[8] The disadvantage of xenografts is that they are only osteoconductive and the resorption rate of bovine cortical bone is slow. In addition, patients may have anxiety to mad cow disease or bovine spongiform encephalitis . (**Berlungh and Lindhe, 1997**).[12] According to **Artzi et al.2000, 2001**; **Carmagnola et al. 2003** the disadvantages of the use of bovine bone include its slow resorption and healing with fibrous encapsulation that leads to very protracted or even no remodelling in the central part of the augmented socket.[13]

(D) Alloplasts

Alloplastic bone grafts are synthetic materials that have developed to replace human bone to avoid transmitted diseases such as HIV, bovine spongiform encephalitis (BSE), or hepatitis. They are biocompatible and osteoconductive materials. The most common types of alloplasts used are calcium phosphates, bioactive glasses and biocompatible composite polymers. Moreover, the main disadvantage of alloplasts is that they are unpredictable in allowing bone formation; therefore, particles can be uncounted within the grafted site **(Knapp et al., 2003)[8].**

2. Barrier Membranes

Guided tissue regeneration is a barrier technique used for the treatment of periodontal bone defects. Guided bone regeneration is used to enhance bone growth of the alveolus for implant placement and around peri-implant defects.Studies by **Dahlin *et al.*** showed that if a barrier membrane was placed in direct contact with the surrounding bone surface and a space was created, only cells from the neighboring bone or bone marrow can migrate into this bone defect, without in-growth of competing soft tissue cells from the overlying mucosa[14].

There may be additional benefits to the use of a membrane, such as protection of the wound from mechanical disruption and salivary contamination. A barrier membrane should satisfy the following conditions: tissue adhesion without mobility, block soft tissue in-growth, east to use, maintains a space, and biocompatibility. Currently, barrier membranes are of two types, non-resorbable and resorbable[15].

(A) Resorbable Membrane- Currently there are two kinds of resorbable membranes: polymeric and collagen derived from different animal sources. The advantages of bioresorbable membranes include, the elimination of the need for membrane removal, greater cost-effectiveness and decreased patient morbidity[16].

Problem with membranes, especially resorbable ones, is that they may become compressed into the defect during healing. **(Dahlin et al. 1991; Jovanovic et al. 1992; Zitzmann et al. 1996).** Additional graft materials are sometimes applied under the membrane in orderto prevent the material from collapsing[17].

Polymeric Membranes - Polymeric membranes are valuable in preserving alveolar bone in extraction sockets and preventing alveolar ridge defects, as well as ridge augmentation around exposed implants. Polymeric membranes are made up of synthetic polyesters, polyglycolides (PGAs), polylactides (PLAs), or copolymers. A clinical advantage of PGA, PLA, and their copolymers is their ability to be completely biodegraded to carbon dioxide and water *via* the Krebs cycle, thus they do not need to be removed at a second surgery[18].

Collagen Membranes - Most of the commercially available collagen membranes are developed from type I collagen or a combination of type I and type III collagen. The source of collagen comes from tendon, dermis, skin or pericardium of bovine, porcine or human origin.[19]

Advantages

There are several advantages of collagen materials for use a barrier membrane to include [20]:

- Hemostasis
- Chemotaxis for periodontal ligament fibroblasts and gingival fibroblasts
- Weak immunogenicity
- Easy manipulation and adaption
- A direct effect on bone formation
- Ability to augment tissue thickness
- Does not require surgical removal
- Cost effective,only one surgery
- Does not have to remove if exposed.

Collagen is degraded through the enzymatic activities of macrophages and polymorphonuclear leukocytes to carbon dioxide and water. Since spontaneous re-epthelialization can occur within 2 to 4 weeks and no secondary surgery is necessary for their removal. Several physical or chemical cross-linking methods, such as ultraviolet light, hexamethylene diisocyanate (HMDIC), glutaraldehyde (GA), diphenylphosphorylazide (DPPA), formaldehyde (FA) plus irradiation and enzymatic cross-linkage have been used to modify the biomechanical properties of the collagen fibers. Studies have shown that cross-linking is associated with prolonged biodegradation as well as reduced epithelial migration, decreased tissue integration,and decreased vascularization. The higher the degree of cross-linking, the longer the resorption rate. Because prototype cross-linking makes the collagen membrane resorb slower severe inflammation and resorption of the grafted area has been reported [21].

it consists of collagen cross-linked with a native metabolite that ensures functional integrity for 6 months in unexposed

membranes. This property of collagen membranes gives the ability to withstand bacterial collagenolytic degrada- tion even when prematurely exposed, thereby enabling soft tissue healing over the exposed membranes[22].

Disadvantages [20] -

- Uncertain duration of barrier membrane function.
- Difficult to tack down.
- Inflammatory response from tissues may interfere with healing and GBR.
- Slightly less bone filling compare to non resorbable membrane.
- Can be technique sensitive.

Cornelini et al.,evaluated the use of a porous bone mineral matrix xenograft (Bio-Oss) as an adjunct to a biodegradable barrier membrane (Bio-Gide) to support healing following the immediate placement of transmucosal implants into extraction sockets. They concluded that the use of deproteinized bovine bone mineral as a membrane support at immediately placed transmucosal implants may offer an advantage in areas with high esthetic demands in terms of soft tissue support[21].

(B) Non-Resorbable Membranes

Advantages[20] -

- Remain intact until removal.
- Greater bone fill if membrane not exposed.
- Minimum tissue reaction if membrane not exposed.

Disadvantages[20] -

- Require second surgery for removal.
- Increase patient morbidity.
- If exposed then must be remove.
- Can be technique sensitive.
- Due to the rigidity of the non-resorbable membranes, extra stabilization of the membrane with miniscrews and tacks are often required.
- Wound dehiscence because of incomplete coverage or gingival recession during the healing processes.

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. The e-PTFE membrane has been shown to produce bone predictably in localized bony defects around implants with or without bone grafts. Guided bone regeneration while using e-PTFE barriers has a high predictability, but the membrane often becomes exposed. This leads to a fast plaque build-up and early removal of the material and a reduced amount of bone fill **(Gher et al. 1994a; Dahlin et al. 1995; Becker et al. 1994b; Lekholm et al. 1993)**. Survival rates were 79.4% for implants with dehiscence/ fenestration defects treated with e-PTFE membranes and 93.9% for implants in extraction sites treated with e-PTFE membranes **(Becker et al. 1999)** and 100% for implant streated with e-PTFE membranes **(Buser et al.1996)**[23] **.**

High-Density Polytetrafluoroethylene – A high density PTFE membrane (d- PTFE) with a nominal pore size of less than 0.3 µm was developed in 1993, the most popular Cytoplast®. The increased efficacy of d-PTFE membranes in guided tissue regeneration has been proven with animal and human studies. The increased efficacy of d-PTFE membranes in guided tissue regeneration has been proven with animal and human studies[24].

Titanium Mesh- 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 bonegrafting material. It is also completely biocompatible to oral tissues and reliable treatment modality for regenerating and reconstructing a severely deficient alveolar ridge[25] .

Titanium-reinforced PTFE - The e-PTFE membrane and d-PTFE membrane are also available as titanium-reinforced e-PTFE or d-PTFE. The embedded titanium framework allows the membrane to be shaped to fit a variety of defects without rebounding and provides additional stability in large, non-space maintaining osseous defects[25].

3. Conclusion

Guided bone regeneration can be achieved with using particulate autogenous bone grafts, allografts, xenografts, or alloplasts grafting materials and resorbable or non-resorbable barrier membranes techniques in 1-2 tooth defects that may allow for dental restoration.

4. Conflict of Interest

The authors confirm that this article content has no conflict of interest.

References

[1] Botticelli D, Berglundh T, Buser D, Lindhe J. The jumping distance revisited An experimental study in the dog. Clin Oral Implants Res 2003;14(1)35-42.
[2] Kalash S, Aboelsaad N, ShoKRy M, Choukroun J. The efficiency of using advanced PRF-xenograft mixture around immediate implants in the esthetic zone a randomized controlled clinical trial. Journal of Osseointegration. 2017 .
[3] Schwartz-Arad D, Chaushu G. Immediate implant placement a procedure without incisions. Journal of periodontology. 1998 Jul;69(7)743-50.
[4] Cutrim ES, Peruzzo DC, Benatti B. Evaluation of soft tissues around single tooth implants in the anterior maxilla restored with cemented and screw-retained

crowns. Journal of Oral Implantology. 2012 Dec;38(6)700-5.
[5] Salama H, Salama M. The role of orthodontic extrusive remodeling in the enhancement of soft and hard tissue profiles prior to implant placement: a systematic approach to the management of extraction site defects. International Journal of Periodontics & Restorative Dentistry. 1993 Aug 1;13(4).
[6] Hämmerle CH, Jung RE, Feloutzis A. A systematic review of the survival of implants in bone sites augmented with barrier membranes (guided bone regeneration) in partially edentulous patients. Journal of clinical periodontology. 2002 Dec;29:226-31.
[7] Brugnami F, Then P, & Moproi H. (1996). Histological evaluation of human extraction sockets treated with demineralized freeze-dried bone allograft and cell occlusive membrane. J Periodontol 67821-5.
[8] Hassan KS, Alagl AS. Immediate dental implants and bone graft. Implant Dentistry The Most Promising Discipline of Dentistry, IntechOpen. 2011 Oct 3:173-82.
[9] Liu J, Kerns DG. Mechanisms of guided bone regeneration: a review, Open Dent. J. 2014;8:56-65.
[10] Brugnami F, Then P, & Moproi H. (1996). Histological evaluation of human extraction sockets treated with demineralized freeze-dried bone allograft and cell occlusive membrane. J Periodontol 67821-5.
[11] Fugazzotto PA. (2004). Guided bone regeneration at immediate implant insertion and loading A care report. Implant Dent 13 223-227.
[12] Botticelli D, Berglundh T, Lindhe J. Resolution of bone defects of varying dimension and configuration in the marginal portion of the peri-implant bone. An experimental study in the dog. J Clin Periodontol. 2004;31309-317.
[13] Artzi, Z., Tal, H., Dayan, D., 2000. Porous bovine bone mineral in healing of human extraction sockets. Part 1 histomorphometric evaluations at 9 months. J. Periodontol. 71, 1015–1023.
[14] Dahlin C. Scientific Background of guided bone regeneration. In Buser D, Dahlin C, Schenk R, Eds. Guided bone regeneration in implant dentistry. Chicago, IL Quintessence Publ; 1994.
[15] Lazzara RJ. Immediate Implant Placement Into Extraction Socket Sites Surgical And Restorative Advantages. 1989; 9(5)332-43.
[16] Hammerle CH, Jung RE. Bone augmentation by means of barrier membranes. Periodontology 2000. 2003; 33 36-53.
[17] Dahlin, C., Andersson, L. & Linde, A. (1991) Bone augmentation at fenestrated implants by an osteopromotive membrane technique. A controlled clinical study. Clinical Oral Implants Research 2 159–165.
[18] Hutmacher D, Hürzeler MB, Schliephake H. A review of material properties of biodegradable and bioresorbable polymers and devices for GTR and GBR applications. International Journal of Oral & Maxillofacial Implants. 1996 Sep 1;11(5).
[19] Bunyaratavej P, Wang HL. Collagen membranes a review. J Periodontol 2001; 72 215-29.
[20] Irinakis T. Rationale for socket preservation after extraction of a single-rooted tooth when planning for future implant placement. Journal of the Canadian Dental Association. 2006 Dec 1;72(10)
[21] Saadoun AP, LeGall M, Touati B. Selection and ideal tridimensional implant position for soft tissue aesthetics. Pract Periodontics Aesthet Dent. 1999 Nov-Dec;11(9)1063-72.
[22] ArRejaie A, Al-Harbi F, Alagl AS, Hassan KS. Platelet-Rich Plasma Gel Combined with Bovine-Derived Xenograft for the Treatment of Dehiscence Around Immediately Placed Conventionally Loaded Dental Implants in Humans: Cone Beam Computed Tomography and Three-Dimensional Image Evaluation. International Journal of Oral & Maxillofacial Implants. 2016 Mar 1;31(2).
[23] Becker W, Dahlin C, Lekholm U, Bergstrom C, van Steenberghe D, Higuchi K, Becker BE. Five□year evaluation of implants placed at extraction and with dehiscences and fenestration defects augmented with ePTFE membranes: results from a prospective multicenter study. Clinical implant dentistry and related research. 1999 Jul;1(1):27-32.
[24] Bartee BK, Carr JA. Evaluation of a high-density polytetrafluoroethylene (n- PTFE) membrane as a barrier material to facilitate guided bone regeneration in the rat mandible. The Journal of oral implantology. 1995;21(2):88-95.
[25] Malvin E . Dentistry: an illustrated history. 2nd ed. Abradale Press 1985. Maggiolo: Manuel de l'art dentaire [Manuel of dental art], Nancy, France, 1809, C. Le Seure.