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# EVOLUTION OF BONE GRAFT MATERIALS IN PERIODONTAL THERAPY: A CHRONOLOGICAL REVIEW

**Vaishali , Neelam Das , Janardhana Amaranath B.J., Shruti Gupta , Lynn Johnson ,**

**Koushik Mukherjee**

Rama Dental College, Hospital & Research Centre, Rama University,

Mandhana, Kanpur (UP) India

## ABSTRACT

Bone replacement in materials had been used in a wide variety of surgical approaches. The use of such bone grafts for reconstructing osseous defects is the choice of periodontist, which significantly improves the clinical outcome in regeneration procedures. It increases the bone formation and quality of vital bone. A wide range of bone grafting materials, have been applied and evaluated clinically, including autografts, allografts, xenografts, and alloplasts. It substitutes as a basic building block for the periodontal reconstruction, by providing clinical application with its biological functions. This review insight various use of bone graft materials and its characteristic features in promoting its bone formation and emphasis on recent advances in this field.

**KEYWORDS**: Graft, regeneration, scaffold, osseous defect, vital bone

## INTRODUCTION

Maintaining the health of teeth and their supporting structures is the goal of modern periodontics. Most periodontal practices focus on the prevention of disease, initial therapy, and corrective surgical treatment to eliminate deep periodontal pockets. However, restoring supporting tissues to their healthy level is a critical area that offers a much more appealing, and in fact, a more desired outcome for the patients.[1] Periodontal regeneration has become one of the primary objectives of periodontal therapy. Regeneration can be defined as the reproduction or reformation of organs or tissue that have been lost or injured as a result of a wound or infection. Periodontal regeneration refers to the restoration of supporting tissues of the teeth such as bone, cementum, and periodontal ligament to their original healthy levels before damage from

  

periodontal bacteria has occurred. Regeneration of supporting tooth structures is a huge step up in managing advanced periodontal disease and preventing tooth loss.[1] Bone grafting is a dynamic phenomenon. A successful bone graft is applied, heals, becomes incorporated, revascularizes, and eventually assumes the form desired. In their early application, bone grafts were considered a mere strap lattice, and the results were measured primarily by the graft's ability to withstand the mechanical stresses that surround them. Today, bone grafts are viewed as biological structures. Of course, mechanical stress, shear stress (extrinsic and intrinsic), contouring, and remodelling are also important in the long term and are part of the healing process of a bone graft.

## DEFINITIONS RELATED TO VARIOUS PERIODONTAL REGENERATION

Bone grafting is a surgical procedure for the replacement of missing bone resulting from bone defects. Various methods have been used to eliminate these defects such as stem cells, bone graft, guided bone regeneration. Grafts help in maintaining normal anatomic outline, aesthetic restoration, eliminating space, and implant placement.[2]

1. **Regeneration** refers to the reproduction or reconstitution of a lost or injured part, in contrast to repair, which describes healing of a wound by tissue that does not fully restore the architecture or the function of the part. [2]
2. **Periodontal regeneration** is defined histologically as regeneration of the tooth's supporting tissues, including alveolar bone, periodontal ligament, and cementum over a previously diseased root surface.[2]
3. **New attachment** is defined as the union of connective tissue or epithelium with a root surface that has been deprived of its original attachment apparatus.[2]
4. **Bone fill** is defined as the clinical restoration of bone tissue in a treated periodontal defect. Bone fill does not address the presence or absence of histologic evidence of new connective tissue attachment or the formation of new periodontal ligament.
5. **Guided tissue regeneration (GTR)** describes procedures attempting to regenerate lost periodontal structures through differential tissue responses.[2]

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## IDEAL CHARACTERISTICS OF BONE GRAFTS (Boyne 1973)

- Nontoxic
- Nonantigenic
- Resistant to infection
- No root resorption or ankylosis
- Strong and resilient
- Easily adaptable
- Readily and sufficiently available
- Stimulates new attachment
- Osteoinductive property
- Non antigenic and biologic compatibility
- Predictability

## INDICATIONS OF BONE GRAFTS

1. To fill bone defects resulting from cysts, tumors, or any neoplasm.
2. For implant placement in aesthetic regions.

## CONTRAINDICATIONS OF BONE GRAFTS

1. The contraindications of bone grafts in periodontal regeneration include factors such as severe periodontal diseases associated with significant bone loss, denudated roots caused by periodontal disease, and the risk of infection through periodontal pockets.

2. Additionally, bone quality and quantity play a crucial role in determining the success of bone grafting procedures, with considerations for different classes of bone quality and jaw shapes affecting the outcome.

## ADVANTAGES OF BONE GRAFTS [3]

1. Regeneration of the attachment apparatus is possible. Reconstruction of lost bone, cementum, and periodontal ligament has been adequately documented with autogenous and allogeneic graft materials.

  

2. By reconstructing the periodontium, it is possible to reverse the disease process.

## DISADVANTAGES OF BONE GRAFTS [3]

1. Bone graft therapy involves additional treatment time. Because of graft procurement and /or preparation, as well as placement, the time allotted to the surgical procedure must be lengthened. For the clinician inexperienced in regenerative periodontal therapy, the learning curve and the subsequent increase in treatment time will be significant.

2. Autograft requires the removal of host donor tissue. Unless bone can be removed from within the primary surgical site, a secondary surgical site, either extraoral or intraoral, is necessary. The risks of any surgical procedure will apply here as well. In addition, the quantity of intraoral bone to fill multiple or deep defects is often lacking. Root resorption and ankylosis are problems encountered only with fresh iliac cancellous bone and marrow.

## THE POSSIBILITIES OF BONE GRAFTING

- Actively forms new bone
- Induces bone formation
- Creates passive surface for bone formation
- Provides mechanical obstruction

## BIOLOGY OF BONE HEALING [2]

**Osteogenesis** is the formation of new bone by the cells contained within the graft materials such as cancellous bone/bone marrow that contain living cells that are capable of differentiation and formation of bone.

**Osteoinduction** is a chemical process in which molecules contained within the grafts such as DBM (bone morphogenetic proteins [BMPs]), that provide a biologic stimulus which induces the progression of mesenchymal stem cells and other osteoprogenitor cells toward the osteoblast lineage convert.

**Osteopromotion** involves the enhancement of osteoinduction without the possession of osteoinductive properties.

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**Osteoconduction** is a physical effect by which the matrix of the graft forms a scaffold on which cells in the recipient site can form new bone (osteogenesis) in a closed environment. [2]

**CLASSIFICATION OF BONE GRAFTS [4]**

(A). **BONE GRAFTS CAN BE BROADLY CLASSIFIED INTO HUMAN BONE AND BONE SUBSTITUTES** [4]

1.Human bone Autografts or autogenous grafts

- Extraoral
- Intraoral Allografts or allogenic grafts
- Fresh frozen bone
- Freeze-dried bone allografts (FDBA)
- Demineralized freeze-dried bone allografts (DFDBA)

2. Bone substitutes Xenografts or xenogenic grafts

- Bovine-derived hydroxyapatite
- Coralline calcium carbonate alloplasts or alloplastic grafts
- Absorbable

**MECHANISM BEHIND PERIODONTAL REGENERATION [5]**

The process of regenerating periodontal tissue relies on the presence of stem cells, particularly within the periodontal ligament surrounding the tooth root. Studies have shown that these ligament-derived stem cells possess the potential to differentiate into various cell types crucial for tissue regeneration, including osteoblasts and cementoblasts. Despite their presence, conventional periodontal treatments often fail to induce successful tissue regeneration. Therefore, there is a need to develop methods specifically targeting these stem cells to promote regeneration effectively.

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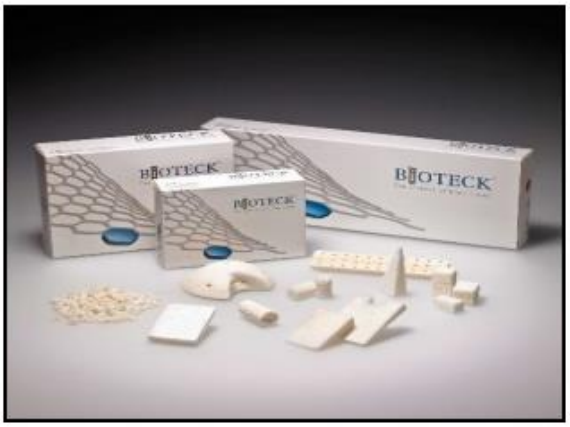


Biotech Block Grafts


Sterile Collagen Sheet Membranes


Bio-Gide Membranes

SyboGraf™ Plus Grafts


Amniotic Membranes

**Figure 1: Commercially Available Bone Grafts & Barrier Membranes Utilized in Various Periodontal Regenerative Procedures**

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## SURGICAL STEPS FOR VARIOUS BONE GRAFTS MATERIALS & BARRIER MEMBRANES USED IN PERIODONTAL & IMPLANT SURGERIES

### USING AMNIOTIC MEMBRANE AS A GTR MEMBRANE IN ISOLATED GINGIVAL RECESSION DEFECT

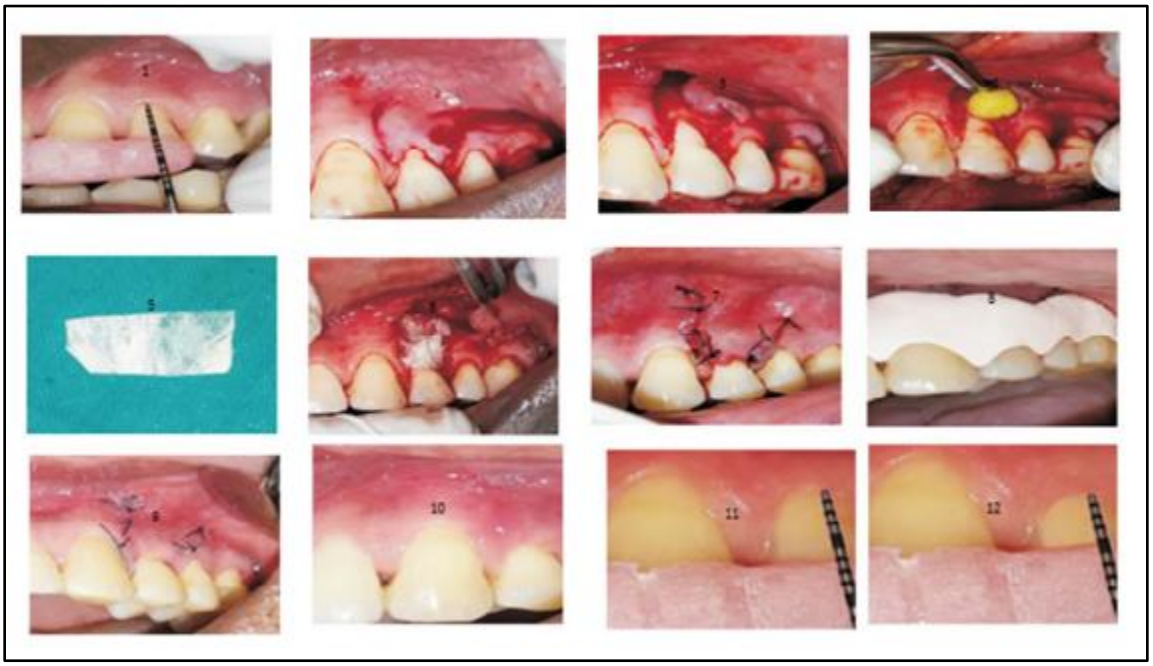

**Figure 2: Using Amniotic Membrane as a GTR Membrane in Isolated Gingival Recession Defect**

**STEPS INCLUDE**: 1. Pre operative view 2. Trapezoidal flap followed by two vertical incisions extending into the alveolar mucosa 3. Trapezoidal full thickness flap reflection 4. Root biomodification using tetracycline HCL (10%pH 2.2) 5. Amniotic membrane trimmed to the size of treatment size 6. Amniotic membrane placement 7. Sutures placed advancing the gingival margin coronally 8. Coe pac placed 9. 10 th day post operative view 10. 1 month post operative view 11. 3 months post operative view 12. 9 months post operative view [6]

### SURGICAL STEPS FOR BONE GRAFTING IN IMPLANTS [7]

The surgical procedure is performed according to established guidelines for implant placement.

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**FIRST SURGICAL STAGE**: After anesthetizing the surgical site using infiltration anesthesia, a full thickness (mucoperiosteal flap) is elevated following a horizontal incision on the palatal aspect of the alveolar ridge. The flap is reflected to the labial surface to expose the underlying bone. Occlusal opening in the prefabricated surgical stent allows the surgical burs to be placed and angled correctly in the implant recipient site. The point of insertion on the bone is marked with the help of a round bur inserted through the occlusal opening of the stent. This is followed by the use of a 2mm spiral drill at a bur speed of 800rpm to 1000 rpm with copious irrigation with normal saline. The depth stop of all instruments is placed at 13 mm corresponding to the selected implant length. The 2mm spiral drill is taken to the predetermined depth followed by a 3 mm spiral drill which enlarged the opening along the angulations determined by the previous spiral drill. The recipient site is prepared to the final diameter (4.5 mm) by using sequential drills of successive increase in diameters. The implant is removed from the sterile packaging and placed in the prepared cavity with finger pressure & a mallet is used to gently tap the inserting instrument and the placement head until the implant fitted snugly and could be rotated into place. The placement head is removed and the placement instrument for the implant into the inter hexagon of the implant and the rachet is placed into position. The implant is established into its final position by three full turns of the rachet. After implant insertion, the corresponding color-coded covering/healing screw is threaded into position and placement is verified with the surgical stent. Cover screws are used to protect the inner aspect of the implant during the healing period and they were placed in level with the surrounding crestal bone.

**BONE GRAFTING**: If buccal dehiscence defect at the most coronal aspect of the implant exposing a few threads of the implant was noted. After decorticating the labial bone with hand instruments, the graft mixed with blood from the recipient site is placed covering the dehiscence. The flap is closed over the graft and implant sutured interrupted sutures. An immediate post-operative radiograph of the surgical site showed correct angulation and bone support around the implant is taken. A temporary restoration is fabricated and used during the transitional period i.e. period of healing.

  

**SECOND SURGICAL STAGE** After a healing period of 5 months as advised in the classical Branemark 2 stage submerged protocol, a tissue punch is used to uncover the implant. The titanium covering screw is removed and replaced with a gingiva former which would enable the gingival margin to form properly during the healing period and ensure an ideal emergence profile around the future crown abutment. The gingiva former is removed after healing of the gingiva (after 2 weeks) and replaced with a transfer coping, placed with a coping screw used for transferring the position of the implant exactly and reliably to the master model. Corresponding color-coded transfer cap is placed over the coping. This allows for the better transfer of the impression coping back into the impression. [7]

**MAKING OF THE IMPRESSION** [7]

Impression is obtained with syringe material around the transfer coping and a heavy body material is placed in the tray for the rest of the dentition. The gingiva former is threaded back into the implant till the seating of the fabricated crown is to be done. The implant analogue is united with the implant coping and secured with fastening screw. A good fit is verified by lining up the flats of the impression coping with the corresponding flats in the impression, the assembly is rotated and snapped into position in the impression and the master cast is poured and sent to the laboratory for crown fabrication. The abutment screws are threaded into position in the implant after removing the gingiva former and the final restoration is cemented to the abutment. The patient is kept on regular maintenance appointments during which the aesthetics & functioning of the restoration was found satisfactory. Post-operative radiograph is taken for adequate bone level and density around the implant.[8]

**BIOLOGIC GROWTH FACTORS, MMPs, PLATELET CONCENTRATION AND BONE MORPHOGENS IN PERIODONTAL REGENERATION** [9]

**PLATELET - DERIVED GROWTH FACTOR**: PDGF is one of the principal wound healing hormones. It plays several important roles in bone formation and regeneration. Including 1) increasing the number of healing cells (including osteoblasts) present at the wound site 2) transforming endothelial mitoses into functioning capillaries 3) debriding the

  

wound site and 4) providing a second phase source of growth factors for continued bone regeneration".

**INSULIN-LIKE GROWTH FACTOR:** There are two types of IGF, IGF-I and IGF II that function similar but are independently regulated. As their name indicates, IGFs are biochemically and functionally similar to insulin. They are primarily produced by the liver and circulate in the vascular system. Although it's direct or indirect effects on bone remodeling are not fully understood. IGF- I appears to stimulate bone formation by increasing cellular proliferation and differentiation as well as bone matrix production. Some evidence suggests IGF-I may mediate the ability of parathyroid hormone to stimulate osteoprogenitor cell proliferation within bones. [10]

**FIBROBLAST GROWTH FACTOR**: FGFs received their name because of their general growth promoting effects on most fibroblastic cell types. This growth factor which occurs in both acidic and basic forms and is stored in bone-also stimulates angiogenesis for vascular invasion of bone, wound healing, and cell migration. Both forms of FGF stimulate bone cell replication, but they can also inhibit matrix synthesis by bone cells under some conditions and they have no stimulatory effects on mature osteoblasts. [11]

**TRANSFORMING GROWTH FACTOR - BETA:** TGF-B is a multifunctional growth factor synthesized by many cell types and almost every cell type can be stimulated by at least one of the various TGF-B molecules. It is one of the major growth factors present in bone (as well as platelets) and is structurally related to, but functionally different from the BMPs. Generally, TGF-B isa weak mitogen for osteoblasts. It has been shown to be chemotactic for bone cells and may increase or decrease their proliferation depending on various conditions. It has also been shown to stimulate type -1 collagen synthesis. Several in vivo studies have shown that TGF-B can induce new cartilage and bone, but only if it is planted in proximity to a bony site. [11]

**PLATELET CONCENTRATE** Platelets were discovered by Giulio Bizzozero in 1882 and was first described as Spherules piastrine' (little plates) as small cell fragments that clumped together at an injured blood vessel site. He also showed that these blood elements did not

have a nucleus. Circulating anucleate platelets are now described as dynamic specialized cells, formed in an elaborate style from their precursor cell, the megakaryocyte. [12]

## FUTURE PERSPECTIVE

Though, a number of unknowns still remain to be answered, with the continued development of improved methods for gene delivery to cells, as well as advances in our knowledge of the molecular basis of periodontal homeostasis, it is reasonable to anticipate that a simple chairside protocol could be developed in the future. This might involve either the direct delivery of the DNA of interest to the periodontal tissue, or the isolation of a small amount of gingival tissue from the patient, transduction/transfection of the DNA at chairside, and reimplantation of the gene enhanced cells into the tooth or periodontal ligament space, which might dramatically improve patients' quality of life by providing accurate therapies with fewer side effects, shorter treatment times, and optimal predictability. Further investigation with recombinant growth factors and live cell therapy needs to be conducted to support these methods for everyday clinical practice.

## CONCLUSION

Complete and predictable regeneration of periodontal tissues lost due to trauma or disease presents a major challenge. Periodontal regeneration requires consideration of many factors that parallel periodontal development, including the use of optimal progenitor cell population, signalling molecules and matrix scaffold in an orderly temporal and spatial sequence. The periodontal ligament is now known to be a rich source of MSCs, and while this tissue appears to have high regenerative potential, it is difficult to harness and utilize this capacity for clinical utility.[13]

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