

Bone Graft Materials: Dental Aspects

¹Jaspreet Singh, ²Rajbir Kaur Takhar, ³Aseem Bhatia, ⁴Asim Goel

^{1,3,4}B.D.S, Gian Sagar Dental College and Hospital, Banur, Punjab.

²B.D.S, Genesis Institute of Dental Sciences and Research, Ferozepur

Abstract: The ultimate goal in periodontal therapy is creation of an environment that is conducive to maintaining patient's dentition in health, comfort, and function. The shift in therapeutic concepts from resection to regeneration has significantly impacted the practice of periodontology in the last two decades. The objective of this review article is to provide an overview of various bone graft materials intended for periodontal reconstructive therapy.

Keywords: Bone Grafts, Periodontics, Autografts, Allografts and Xenografts.

1. INTRODUCTION

The ultimate goal in periodontal therapy is creation of an environment that is conducive to maintaining patient's dentition in health, comfort, and function. The shift in therapeutic concepts from resection to regeneration has significantly impacted the practice of periodontology in the last two decades. The objective of this review article is to provide an overview of various bone graft materials intended for periodontal reconstructive therapy.

2. IDEAL BONE GRAFT MATERIAL

The ideal bone replacement graft should be able to trigger osteogenesis, cementogenesis and formation of a functional periodontal ligament.

A simple classification of bone graft is as follows:

Autogenous bone grafts:

- Bone from intraoral sites
 - Osseous Coagulum
 - Bone Blend
 - Cancellous bone marrow transplants
 - Bone swaging
- Bone from extraoral sites

Bone Allografts:

- Freeze dried bone allograft
- Demineralized Freeze dried bone allograft

Xenografts:

- Calf bone

- Kiel bone
- Anorganic bone
- Bio-Oss

Alloplastic grafts:

- HTR polymer
- Tricalcium phosphate
- Hydroxyapatite
- Bioactive glasses

Autogenous bone grafts:

Autogenous bone grafts, also called autografts, are bone grafts transferred from one site to another site within the same individual. These grafts are the **gold standard** to which all other grafting materials are compared. Autogenous grafts can be cortical or cancellous or a combination of both.[1]

Various types of autografts have been described in following section:-

1. Bone from Intraoral Sites. In 1923, Hegedüs attempted to use bone grafts for the reconstruction of bone defects produced by periodontal disease. The method was revived by Nabers and O'Leary in 1965, and numerous efforts have been made since that time to define its indications and technique [2]. Sources of bone included bone from healing extraction wounds, bone from edentulous ridges, bone trephined from within the jaw without damaging the roots, newly formed bone in wounds especially created for the purpose, bone removed from tuberosity, and the ramus and bone removed during osteoplasty and ostectomy.

a) Osseous Coagulum: Robinson described a technique using a mixture of bone dust and blood that he termed "osseous coagulum." The technique uses small particles ground from cortical bone. The advantage of the smaller particle size is that it provides additional surface area for the interaction of cellular and vascular elements [3].

b) Bone blend: The bone blend technique uses an autoclaved plastic capsule and pestle. Bone is removed from a predetermined site, triturated in the capsule to a workable, plastic like mass, and packed into bony defects. Froum et al found osseous coagulum–bone blend procedures to be as effective as iliac autografts and open curettage [4].

a) Cancellous Bone Marrow Transplants. Cancellous bone can be obtained from the maxillary tuberosity, edentulous areas, and healing sockets. Cancellous bone and marrow are removed with curettes, back-action chisels, or trephine.

b) Bone Swaging. The bone swaging technique requires an edentulous area adjacent to the defect, from which the bone is pushed into contact with the root surface without fracturing the bone at its base. Bone swaging is technically difficult, and its usefulness is limited [5].

2. Bone from Extraoral Sites:-The use of fresh or preserved iliac cancellous marrow bone has been extensively investigated. This material has been used by orthopedic surgeons for years. Data from human and animal studies support its use, and the technique has proved successful in osseous defects.

Disadvantages: The disadvantages of autogenous grafts are the limited amount of available graft material and the morbidity associated with their harvest. Root resorption is associated with the use of fresh iliac grafts.

3. ALLOGRAFTS

It is a graft between genetically dissimilar members of the same species.

Bone allografts are commercially available from tissue banks. They are obtained from cortical bone within 12 hours of the death of the donor, defatted, cut in pieces, washed in absolute alcohol, and deep-frozen. The material may then be demineralized, and subsequently ground and sieved to a particle size of 250 to 750 µm and freeze-dried. Finally, it is vacuum-sealed in glass vials.

Allografts for maxillofacial and periodontal use generally come as demineralized freeze-dried bone allografts (DFDBA) or mineralized freeze-dried bone allografts (FDBA) and in the form of particles, sheets, blocks, or entire preformed bones. Some researchers propose that removal of the mineral component allows greater expression of osteoinductive proteins; however, allografts are predominately space-occupying osteoconductive lattices or frameworks. The osteoinductive capability of these products is minimal because of the low concentration of bone growth proteins as a result of the rigorous processes involved in the removal of potential antigenicity and pathogenicity. Piatell and colleagues found that only the DFDBA particles near the host bone were involved in the mineralization process, whereas in FDBA even particles that were farthest from the host bone were lined by osteoblasts actively secreting osteoid matrix and newly formed bone. No osteoinduction was observed with FDBA or DFDBA. There was an increased osteoconductive effect with FDBA [6].

Disadvantages:

A major concern with allografts in general is the potential for disease transfer, particularly viral transmission, and even more particularly HIV. Tissue banks have adopted rigorous exclusionary techniques, testing for HIV antigen, and HIV antibody and lymph node biopsy in order to reduce this potential risk. Additionally, mere freezing of bone allografts reduces the risk of disease transfer to 1 in 8 million. Treatment of cadaveric bone spike with viral particles and cortical bone procured from a donor who had died of AIDS with a viricidal agent and demineralization in HCl has been found to inactivate HIV in both cases. The probability of HIV transfer following appropriate demineralized freeze-dried bone allograft preparation has been calculated to be 1 in 2.8 billion [7].

4. XENOGRAFTS

Xenografts are grafts shared between different species. Currently, there are two available sources of xenografts used as bone replacement grafts in periodontics; bovine bone and natural coral. Xenografts are osteoconductive, readily available and risk free of disease transmission. The latter point has been questioned with the discovery of bovine spongiform encephalopathy, particularly in Great Britain.

Types of Xenografts:

1. **Calf bone (Boplant)**, treated by detergent extraction, sterilized, and freeze-dried, has been used for the treatment of osseous defects [8].
2. **Kiel bone** is calf or ox bone denatured with 20% hydrogen peroxide, dried with acetone, and sterilized with ethylene oxide.
3. **Anorganic bone** is ox bone from which the organic material has been extracted by means of ethylenediamine; it is then sterilized by autoclaving [9].
4. Currently, an anorganic, bovine-derived bone marketed under the brand name **Bio-Oss (Osteohealth)** has been successfully used both for periodontal defects and in implant surgery. It is an osteoconductive, porous bone mineral matrix from bovine cancellous or cortical bone. The organic components of the bone are removed, but the trabecular architecture and porosity are retained. The physical features permit clot stabilization and revascularization to allow for migration of osteoblasts, leading to osteogenesis. Bio-Oss is biocompatible with the adjacent tissues, eliciting no systemic immune response [10].
5. **PepGen p-15**:- Yukna et al have used Bio-Oss in combination with a cell binding polypeptide (P-15) that is a synthetic analog of a 15–amino acid sequence of type I collagen marketed as PepGen P-15 (Dentsply/CeraMed); this combination seems to enhance the bone regenerative results of the matrix alone in periodontal defects [11].

5. ALLOPLASTIC GRAFTS (ALLOPLASTS)

Alloplasts are the synthetic bone substitutes. . These synthetic materials are inert with no or little osteoinductive activity, with the exception of P-15, which is claimed to stimulate the differentiation of mesenchymal cells into osteoblasts [12]. The advantages of alloplastic grafts include an absence of antigenicity, no potential for disease transmission, and unlimited supply. These materials can be treated to be resorbable or nonresorbable, are provided in various particle or pore sizes, are combined with various carriers to improve handling characteristics, or are combined with bioactive

proteins to provide osteoinduction.

Types Of Alloplasts:

1. Polymers: HTR polymer

HTR Synthetic Bone (Biopiant, Norwalk, CT) is a biocompatible microporous composite of polymethylmethacrylate, polyhydroxyethylmethacrylate and calcium hydroxide. Favorable clinical results have been achieved with HTR™ (the acronym stands for hard tissue replacement) in the treatment of intrabony and furcation defects. Its hydrophilicity enhances clotting, and its negative particle surface charge allows adherence to bone. It appears to serve as a scaffold for bone formation when in close contact with alveolar bone [13].

2. Bioceramics

Bioceramic alloplasts are comprised primarily of calcium phosphate, with the proportion of calcium and phosphate similar to bone. The two most widely used forms are tricalcium phosphate and hydroxyapatite.

I. Tricalcium phosphate

Tricalcium phosphate is a porous form of calcium phosphate, the most commonly used form of which is β -tricalcium phosphate. It serves as a biological filler which is partially resorbable and allows bone replacement. Conversion of the graft is pivotal to periodontal regeneration; first, serving as a scaffold for bone formation, and then permitting replacement with bone [14].

II. Hydroxyapatite

Hydroxyapatite, is the primary mineral component of bone. Synthetic hydroxyapatites have been marketed in a variety of forms, primarily as a porous nonresorbable, a dense or solid nonresorbable, and a resorbable (non-ceramic, porous) form.

Various form of hydroxyapatite are briefly discussed in the following section:

a) Sintered hydroxyapatite: When prepared at high temperature (sintered), hydroxyapatite is nonresorbable, nonporous, dense, and has a larger crystal size. Dense hydroxyapatite grafts are osteophilic, osteoconductive and act primarily as inert biocompatible fillers. They have produced clinical defect fill greater than flap debridement alone in the treatment of intrabony defects [15].

b) Porous hydroxyapatite: Porous hydroxyapatite (Interpore 200, Irvine, CA) is obtained by the hydrothermal conversion of the calcium carbonate exoskeleton of the natural coral genus *Porites* into the calcium phosphate hydroxyapatite. It has a pore size of 190 to 200 μm , which allows bone ingrowth into the pores and ultimately within the lesion itself [16].

c) Non ceramic hydroxyapatite: Another form of synthetic hydroxyapatite is a resorbable, particulate material processed at a low temperature (OsteoGen, Implants, Holliswood, NY; OsteoGraf LD, CeraMed Dental, LLC, Lakewood, CO). This resorbable form is a non-sintered (nonceramic) precipitate with particles measuring 300 to 400 μm . It has been proposed that non-sintered hydroxyapatite resorbs acting as a mineral reservoir inducing bone formation via osteoconductive mechanisms. Its reported advantage is the slow resorption rate, allowing it to act as a mineral reservoir at the same time acting as a scaffold for bone replacement [17].

3. Bioactive glasses: There are two forms of bioactive glass currently available. PerioGlas (Block Drug Co., Jersey City, NJ) and Biogran™ (Orthovita, Malvern, PA).

a) PerioGlas has a particle size ranging from 90 to 710 μm , which facilitates manageability and packing into osseous defects. In surgically created defects in nonhuman primates, 68% defect repair was achieved as new attachment [18]. Compared to tricalcium phosphate, hydroxyapatite and unimplanted controls, Fetner et al. showed that PerioGlas produced significantly greater bone and cementum repair.

b) Biogran has a particle size range from 300 to 355 μm which has been reported to be advantageous for guiding osteogenesis.

6. CONCLUSION

Bone replacement grafts will play a continuing role in periodontal and other regenerative therapy. Several choices are available to the clinician including autogenous, allogeneic, xenogeneic and a variety of alloplastic materials.

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