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CURRENT SCENARIO OF BONE GRAFTS IN PERIODONTAL THERAPY.

Dental Science

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ABSTRACT

Bone replacement grafts are widely used to promote bone formation and periodontal regeneration. Bone grafting, placing bone or bone substitutes into defects created by the disease process, acts like a scaffold upon which the body generates new bone. A wide range of bone grafting materials, including bone grafts and bone graft substitutes, have been applied and evaluated clinically, including autografts, allografts, xenografts, and alloplasts. To Date, histologic evidence in humans indicates that bone grafting is the only treatment that leads to the regeneration of bone, cementum, and a functionally oriented new periodontal ligament coronal to the base of a previous osseous defect.

KEYWORDS

Periodontal Regeneration, Autograft, Allograft, Xenograft

INTRODUCTION

Bone replacement grafts are widely used to promote new bone formation and periodontal regeneration therapy, especially in intra-bony defects. Bone grafting materials function as structural scaffolds and matrices for the attachment and proliferation of anchorage-dependent osteoblasts. Various types of grafting materials have been introduced in reconstructive periodontal treatment based on their ability to facilitate the reconstruction of the lost supporting apparatus through the following mechanisms.[1]

1. Osteogenesis (contain bone-forming cells)
2. Osteoconduction (serves as a scaffold and space provision for bone formation)
3. Osteoinduction (contain bone-inducing substances).

Historical Background

The use of bone grafts for reconstructing intra-osseous defects produced by a periodontal disease goes back to Hegedus in 1923. He reported success in six cases by transplanting autogenous bone from the tibia to the jaws to treat "advanced pyorrhea". After Hegedus, it was revived in 1965 by Nabers and O'leary, they used shavings of cortical bone removed by hand chisels during osteoplasty and ostectomy and they were used to treat one, two-wall defect.[2] Schallhorn et al.[3] used Allografts of iliac bone and marrow. Rivault et al in 1971 laid down the requirements of successful grafting. Froum et al in 1975 reported a 73% fill with osseous coagulum and 60.7% fill with hip marrow. Richardson et al in 1999 used Bio-Oss a bovine bone from which all inorganic components are removed and used for regeneration.

The objective of Bone Graft Therapy

The objectives of bone graft therapy as stated by Schallhorn et al.[3] in 1970 include:

- Probing depth reduction
- Clinical attachment gain
- Bone fill of the osseous defect
- Regeneration of new bone, cementum, and periodontal ligament.

Criteria for evaluation of Graft Success for Periodontal Regeneration[4]

For any graft material to be considered a successful regenerative material, it should have clear histological, clinical and radiographic evidence of the following criteria:

1. Biologic acceptability
2. Resorbability
3. Regeneration
4. Defect fill
5. Stability

Classification

Autogenous Bone Grafts

It is harvested from the patient's own body which is an ideal material because of its osteoconductive and osteoinductive properties as it contains a source of osteoprogenitor cells. The autogenous bone can be derived from both intraoral and extraoral sites. It is still considered the "Gold Standard" by which other grafting materials are compared.[5]

Sources

Autogenous bone can be harvested from intraoral donor sites (mandibular symphysis and ramus, maxillary tuberosity, edentulous areas, tori) or extraoral sites (iliac crest, tibia, calvaria). represents the sources of autogenous grafts.[6] Several types of autogenous grafts have been proposed in the literature. They include cortical bone chips, osseous coagulum, bone blend, intraoral and extraoral cancellous bone, and marrow.

1. Cortical Bone Chips [7]
2. Osseous Coagulum [8]
3. Bone Blend [9]
4. Intraoral Cancellous Bone and Marrow [10]
5. Extra-oral Cancellous Bone and Marrow [11]

Allografts

The most commonly used forms of allografts in Periodontal Practice are:

1. Fresh-frozen bone allografts (FFB) [12]
2. Freeze-dried bone allografts (FDBA) [13]
3. Demineralized freeze-dried bone allograft (DFDBA) [14]

Xenografts

A xenograft is a tissue transferred between genetically dissimilar members of different species. It is osteoconductive, biocompatible, and structurally similar to human bone. There are two sources of xenografts used for bone replacement in periodontics: Bovine bone and Natural coral.

1. Bovine-derived bone replacement graft [15]
2. Coralline calcium carbonate [16]

Alloplastic materials

In addition to bone graft materials, many alloplastic materials have been tried for the restoration of the periodontium. These include plaster of Paris, Polymers, ceramics, Calcium carbonate, Calcium Phosphates, Hydroxyapatite, and Bioactive Glass. Alloplastic materials can be manufactured in various forms and with varying physicochemical properties. They can be made available in both resorbable and non-resorbable forms and can be customized with varying levels of porosity and pore sizes.[17]

Hydroxyapatite

Hydroxyapatite (HA) is one of the most widely used CaP graft biomaterials in both the research and clinical fields. HA has a similar composition and structure to natural bone minerals. Synthetic HA ($Ca_{10}(PO_4)_6(OH)_2$), is available and used in various forms.[18]

1) Porous non-resorbable
2) Solid non-resorbable
3) Resorbable (non-ceramic, porous)

HA is non-osteogenic, not conclusively osteoinductive, but rather functions as an osteophilic and osteoconductive graft material. The resorptive potential of HA is dependent upon the temperature at which it is processed. When prepared at higher temperatures the HA produced is dense, non-resorbable, and has a larger crystal size.[19]

Other forms of Hydroxyapatite available include: -
A) The coralline porous non-resorbable hydroxyapatite
B) The resorbable non-ceramic hydroxyapatite
C) Nano-crystalline hydroxyapatite

Advantages of using hydroxyapatite are: -
(1) Immunoreaction can be ignored.
(2) Postoperative morphologic changes and volume decreases do not occur if small blocks and chips are adequately packed during surgery.
(3) Post-operative adsorption of hydroxyapatite, if any, is slight and slow and is replaced by bone.
(4) Cement fixation performed on a layer of hydroxyapatite particles prevents the harmful influence of polyethylene wear particles of cement interface.

Disadvantages: -
Particles don't tend to stay in place in a bleeding site, and there is a relatively slow restoration of bone within the assemblage of particles.[20]

Tricalcium phosphate (TCP)
TCP is a porous form of calcium phosphate. TCP has two crystallographic forms; α-TCP and β-TCP.[21] Alpha and beta-tricalcium phosphate are produced similarly, although they display different resorption properties. β- TCP shows the characteristics of good biocompatibility and osteoconductivity. Physiochemically, β-TCP is a resorbable material with 99% phase purity, total microporosity, and a homogeneous ceramic sinter structure. Thus, the optimal matrix for the formation of new bone is available immediately after implantation.[22] β- TCP exhibits degradation kinetics comparable to the rate of new bone growth and regenerative properties similar to those of autologous bone grafts. Resorption of TCP grafts is thought to be dependent on dissolution by biological fluids in the absence of osteoclasts around the materials and by the presence of osteoclast-mediated resorption based on the osteoclast-like giant cells in defect areas in many studies.[23] TCP biomaterials have been used in human clinical studies to repair periapical and marginal periodontal defects, alveolar bony defects, and alveolar ridge augmentation in vertical and horizontal dimensions.[24]

Biphasic calcium phosphates
β- TCP is mostly used in association with HA. The balance between HA and β-TCP is crucial to obtaining adequate mechanical strength, suitable degradation kinetics, and osseointegration in biphasic calcium-phosphate ceramics. The resorption of β-TCP is faster than the resorption of HA, but the mechanical properties of HA are slightly better than β- TCP's (average compressive resistances are, respectively, 160 and 100 MPa). Thus, the association of β-TCP and HA enables a faster and higher bone growth rate than using HA alone.[25] while offering better mechanical properties than β-TCP alone.[26] HA and β-TCP ceramics form a strong direct bond with the host bone.[27] They can be found with different HA/β-TCP ratios and can be associated with bone marrow aspirate which then provides enhanced osteogenic properties to the material.[28] HA and β-TCP ceramics form a strong direct bond with the host bone. The mechanical properties of grafting materials are controlled by the amount of β-TCP and HA of the biphasic material in particular, a material with a high percentage of β-TCP shows poor mechanical properties. Morra et al. developed a biphasic granulate bone filler with a HA/β-TCP weight ratio of 75/25; after being implanted in rabbits, this graft elicited an excellent new bone formation without any inflammatory response.

Bioactive glass
Developed for the first time by Hench et al in the 1970s, bioactive glasses (or bioglasses) are originally silicates that are coupled to other minerals naturally found in the body (Ca, Na2O, H, and P).[29] Heat treatment of a MgO-CaO-SiO2-P2O5 glass gave a glassceramic containing crystalline apatite [Ca10 (PO4)6O, F2)] and β-wollastonite (CaO.SiO2) in a MgO-CaO-SiO2 glassy matrix, and this CaO, SiO2-based glass is called bioactive glass (BG). The particle sizes of bioactive glasses (Bio-Glass®) range from 90 to 710 μm to 300– 355 μm.[30] In bone tissue engineering, a bioactive material has been traditionally defined as a material that undergoes specific surface reactions in vitro and in vivo, promoting the formation of an HA-like layer that allows a strong bond between host bone and grafting material to occur. This ability was also referred to as osteo-stimulation by Schepers & Ducheyne. Bioactive glasses are osteoinductive materials, too, as they can induce osteoprogenitor cells to migrate into the structure of the graft and can promote cell differentiation by affecting the gene expression of undifferentiated cells.[31] The use of bioglasses does not induce an inflammatory response, and their resorption is complete in 6 months for silica-based bioglasses.[32]

There are two forms of bioactive glass currently available: [Perioglas & Biogran]

Disadvantages: - Bioactive glass undergoes no resorption, and limited true periodontal regenerative outcomes based on histological analysis have been demonstrated.[33]

CONCLUSION
Although complete periodontal regeneration is unpredictable with any regenerative therapy currently used, periodontal bone grafts show strong potential. The regeneration of supporting periodontal tissue in humans is possible in selected sites and patients with the use of autografts, allografts, or xenografts. The addition of autograft or growth factors to allograft seems to enhance the regenerative potential of these materials. The clinician should make an effort to select graft material and a technique based on scientific evidence, the type, and size of the defect, the resorbability of graft material, cost, and patient acceptance.

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