BONE GRAFT ASSOCIATED PERIODONTAL REGENERATION : A REVIEW

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Abstract

After periodontal therapy the healing is mainly concerned with two aspects like Regeneration & Repair. Regeneration is by formation of New attachment and Repair may be by formation of Long junctional epithelium or Reattachment or by Ankylosis. The aim and ultimate objective of periodontal therapy is to gain healing of the diseased part, regeneration of lost periodontal structures and return to health with normal form and function of entire periodontium (Melcher 1970). The Key cell for periodontal regeneration is Mesenchymal cell of periodontal ligament as it can synthesize and remodel the three connective tissues of alveolar part of periodontium. Various attempts for periodontal regeneration include, Non-surgical curettage, Flap with thorough debridement, Root biomodification, usage of Growth factors, Enamel matrix proteins, Bone grafts, Guided tissue regeneration Combination of above techniques. The present article reviews various bone replacements grafts that are available for periodontal regeneration.

Keywords: Regeneration; Bone replacement Grafts;Periodontal,;Osseous; Healing.

Introduction

Regeneration refers to the reproduction or reconstitution of a lost/injured tissue. Periodontal regeneration is defined as the restoration of lost periodontium

Or supporting tissues and includes formation of new alveolar bone, new cementum, and new periodontal ligament.

A "GRAFT" is a viable tissue that, after removal from a donor site, is implanted with in a host tissue, which is then restored, repaired (or) regenerated.

The primary types of bone graft materials are,

1. AUTOGENOUS BONE GRAFTS
2. ALLOGRAFTS
3. XENOGRAFTS
4. ALLOPLASTS

Bone graft materials are generally evaluated based on their osteogenic, osteoinductive, or osteoconductive potential.

OSTEOGENISIS refers to the formation or development of new bone by cells contained in the graft.

OSTEOINDUCTION is a chemical process by which molecules contained in the graft convert the neighboring cells into osteoblasts, which in turn form bone.

OSTEOCONDUCTION is a physical effect by which the matrix of the graft forms a scaffold that favors outside cells to penetrate the graft & form new bone

I.AUTOGRAFTS : An Autograft is a tissue transferred from one position to a new position in the same individual.

Autogenous bone grafts can be classified as,

1. Bone harvested from Intra oral sites
2. Bone harvested from Extra oral sites

Intra Oral Autogenous Bone Grafts. (Fig. 1)

Sources for intra oral autogenous bone grafts include, Maxillary tuberosities, Mandibular retromolar area, Extraction wounds, Edentulous ridges, Bone trephined from jaws and Bone removed during Osteoplasty and Ostectomy, etc

Osseous Coagulam (Fig.2)

Robinson in 1969 described this technique using a mixture of bone dust and blood and termed as OSSEOUS COAGULUM. For osseous coagulum, bone fragments are obtained by a carbide bur #6/#8 at speeds between 5000 to 30,000rpm and placed in a sterile dappen dish or amalgam cloth. When coated with patients blood these become a coagulum and used to fill the defect.

Bone Blend (Fig.3)

This technique uses an autoclaved plastic capsule & pestle. Cortical or Cancellous bone is collected from any accessible intra oral donor site, placed in a sterile amalgam capsule with a pestle and triturated for a minimum of 10 seconds. The particle size obtained is approximately 105-210μm.

Cancellous Bone Marrow Transplants (Fig.4)

Cancellous bone can be obtained from the maxillary tuberosity edentulous areas, & healing sockets cancellous bone & marrow are removed with curettes, back action chisels or trephine. Sockets are allowed to heal for 8 to 12 weeks & the apical portion is used as donor material.

Bone Swaging (Fig.5)

This technique requires an edentulous area adjacent to the defect, from which the bone is pushed in to contact with

the root surface without fracturing the bone at its base.

Ramping of Bone (Fig.6)

In this technique cortical bone adjacent to the defect, is pushed in to contact with the root surface without fracturing the bone at its base.

Bone Harvested from Extra Oral Sites

I. Liac Autografts (Fig.7)

Iliac cancellous bone and marrow has highest osteogenic potential. The graft is obtained by a physician from either the anterior (or) posterior iliac crest with a biopsy needle (or) trephine. For short term storage (3hrs to 1 week) the graft is placed in minimal essential medium (MEM) and refrigerated at 40c.for longer storage (1week to 6 months) the graft is placed in MEM with 15% to 25% glycerol and frozen.

Autogenous bone was considered for bone fill because it contained viable cells.

AUTOGENOUS GRAFTS were considered as GOLD STANDARD among all graft materials. But the disadvantages of autogenous bone graft included the need for a second surgical site to procure donor material and the frequent lack of intra oral donor sites to obtain sufficient amount of autogenous bone for multiple or deep osseous defects.

II. Allografts

An ALLOGRAFT is a tissue graft between individuals of same species but with non identical genes.

They are commercially available from tissue banks. They are obtained from cortical bone within 12hrs after 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 250-750mm and freeze dried. Finally, it is vacuum sealed in glass vials.

Allografts have OSTEOCONDUCTIVE and possibly OSTEOINDUCTIVE properties.

Various types of Allografts available are,

1. Frozen Iliac Bone Marrow : They are procured from donors following brain death. Extensive cross matching between donor and recipient is necessary to reduce antigenecity. To prevent this, iliac allografts were irradiated with 6 mega rads of gamma radiation.

2. Merthiolated Bone: Cancellous bone removed during hip surgery or from amputated limbs or ribs and is stored in merthiolate solution. It should be noted that the merthiolate is toxic to host tissue.

3. Demineralized Dentin

4. Lyophilized Allogenic Duramater

5. Freeze Dried Bone Allografts (FDBA) : Freeze dried bone allograft is bone that has been frozen, with water removed by sublimation in a vacuum. After procuring the bone under sterile conditions processing is begin within 24 hours of death. Cortical bone is removed and frozen in liquid Nitrogen. Then the bone is freeze dried. The freezing process takes approximately 14 days, during which 95% of the total water content is removed. The final product is nonviable. As a result the freeze dried allograft function as a passive scaffold which is progressively replaced by new host bone. Its mode of action is through osteoconduction.

6. Decalcified Freeze Dried Bone Allografts (DFDBA) : Demineralization and freeze drying of a cortical bone graft induce new bone formation & greatly enhance its osteogenic potential. Demineralization exposes component of bone matrix, bone morphogenic protein, which is a hydrophobic glycoprotein, composed of a group of acidic polypeptides, it induces the differentiation of mesenchymal cells into osteoblasts. Cortical bone contains more bone matrix and therefore more BMP than cancellous bone.Thus DFDBA stimulates new bone formation by OSTEOINDUCTION.

7. Osteogenin : It is a Bone inductive protein isolated from the extracellular matrix of human bones, termed as OSTEOGENIN or BMP 3

The possibility of disease transfer, immunogenicity and need for cross matching still remains with allografts. Despite the success demonstrated with transplants of osseous materials, their use is frequently either impractical (or) impossible.

III. Alloplasts

An ALLOPLAST is an inert foreign body used for implantation into tissues. Alloplast materials are available in a variety of textures, sizes and shapes.

A) Based on POROSITY they can be classified as,

a) Dense

b) Macro porous

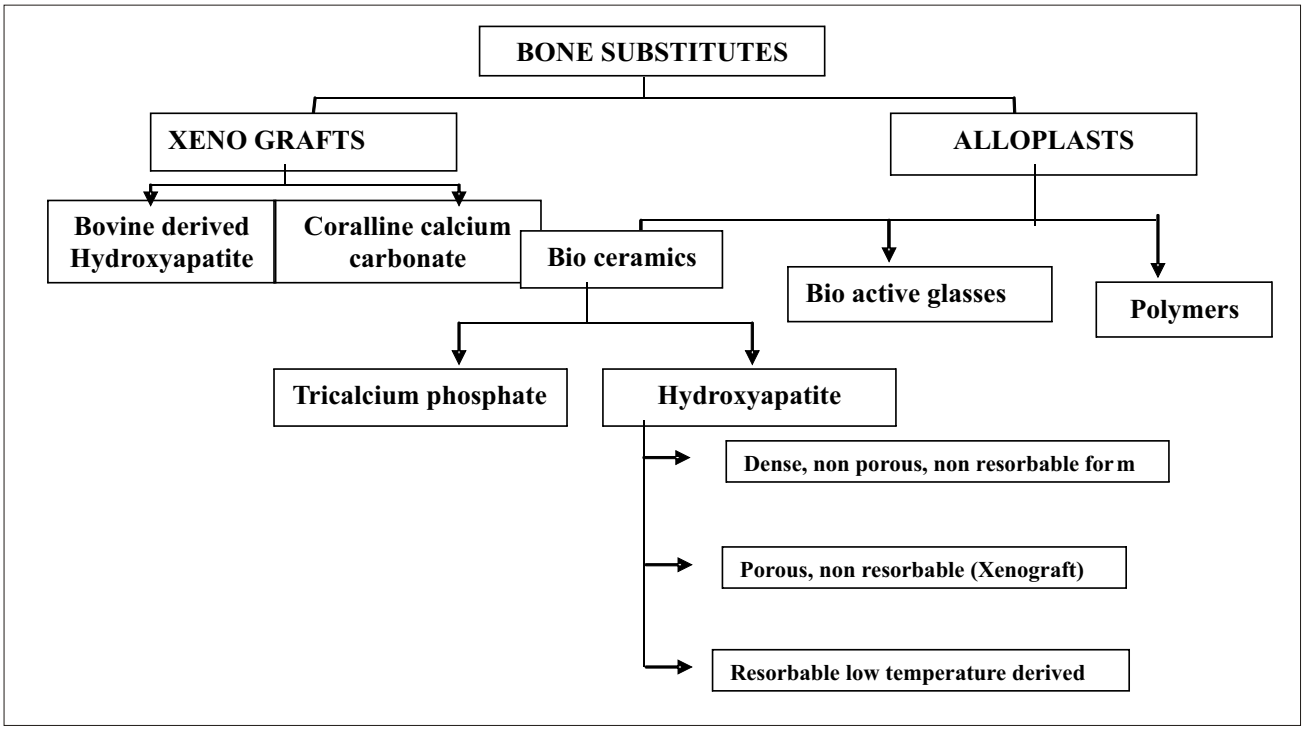
c) Micro porous

B) They can be either CRYSTALLINE (OR) AMORPHOUS

C) The available alloplastic materials can be classified generally as RESORBABLE (OR) NON RESORBABLE.

Classification of alloplastic graft materials by Yukna R.A.

a) RESORBABLE	b) NON RESORBABLE
. Plaster of Paris	. Polymers
. Calcium carbonate	. Dense Hydroxyapatite
. Tricalcium phosphate	
. Resorbable Hydroxyapatite	



D) Yukna et al proposed the classification of Bone substitutes as follows (1998, Dental clinics of North America, Vol. 42, Number 3 July 1998).

Several bone substitutes have been used in clinical periodontal therapy to encourage bone formation. They may be synthetically derived (or) processed from skeletal structures of other species, are bio compatible and are non organic.

Bioceramics

Bio ceramics are defined as "Specially designed ceramics for the repair, reconstruction and replacement of diseased (or) damaged parts of the body." Bio ceramic alloplasts are primarily comprised of calcium phosphate with the proportion of Ca and P similar to bone.

Tricalcium Phosphate

Tricalcium phosphate is a porous form of calcium phosphate. The calcium to phosphate ratio is 1.5, is mineralogically β-Whitlockite i.e β $Ca_3(PO_4)_2$ and is partially resorbable.

In body, Tricalcium phosphate is converted in part to HA. The rate of resorption of Tricalcium phosphate varies and appears to depend greatly on the material's chemical structure, porosity and particle size. Tricalcium phosphate is osteo conductive and is intended to provide a physical matrix that is suitable for the deposition of new bone.

Hydroxyapatite

Hydroxy apatite $Ca_{10}(PO_4)_6(OH)_2$ is the primary mineral component of bone. It is extremely bio-compatible and bonds readily to adjacent hard and soft tissues. Hydroxyapatite has a calcium-to-phosphorous ratio of 1.67, Primarily three forms of HA are used,

1. Dense, nonporous, non resorbable HA
2. Porous, non resorbable, HA
3. Porous, non ceramic, resorbable form of HA

Properties of the material will be dictated by the processing as follows:

1. Dense, Nonporous, Non resorbable Hydroxyapatite:

When prepared at high temperature (Sintered), Hydroxyapatite is non resorbable, nonporous, dense and has a large crystal size. Dense Hydroxyapatite grafts are osteophilic, osteo conductive and at primarily as inert biocompatible filters.

2. Porous Non resorbable form Hydroxyapatite

It is obtained by 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 200µm, which allows bone in growth into the pores and ultimately within lesion itself.

3. Nonceramic resorbable, particulate Hydroxyapatite

This material is processed at low temperature. This resorbable form is a Non-sintered (Non ceramic) precipitate with particles measuring 300-400µm.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 a scaffold for bone replacement.

Synthetic Hydroxyapatite has been marketed in a variety of forms. The physical (i.e Ca:P surface area and forms of the product, porosity and crystallinity) and Chemical (i.e Ca:P ratio, Elemental impurities, ionic substitution in HA and pH of surrounding area) properties of a particular material (HA) affect the rate of resorption and determine the clinical application of the graft.

Various commercially available HA preparations are,

1. CALCITE- Non resorbable HA particle size 420-840µm
2. OSTEOGRAF - Resorbable HA (bovine derived), Non ceramic form particle size 250-420µm
3. PERIO GRAF: Dense, ceramic, Non resorbable HA
4. ALVEOLOGRAF: Dense, ceramic, Non resorbable HA
5. INTERPORE: Synthetic, non resorbable, porous HA (form coral Origin)
6. OSTEOGEN: Synthetic, porous non ceramic, Resorbable, HA Particle size 300-400µm.

Biphasic Calcium Phosphate Ceramic

Combinations of two primary forms of calcium phosphate have been studied to take advantage of the rapid resorption of β-Tricalcium phosphate and the inert scaffold of dense Hydroxy apatite synergistically. Biphasic calcium phosphate grafts are advantageous because resorption of β-Tricalcium phosphate triggers macrophages, which may affect cell differentiation of soft tissue cells into osteoblasts.

The 85 HA /15 βTCP ratio appears to demonstrate greater gain in attachment level and bone regeneration in the treatment of periodontal osseous defects

Bio-Active Glasses

They are compounds, containing mainly CaO, SiO_2, and P_2O_5, with (or) without additives such as Na_2O, MgO, NaF etc. The directly bonding with the host bone is through Si-OH groups. The function of silica is to provide a low solubility molecular matrix and acts as a container for their ions as Na, P and Ca etc. These ions dissolve into the surrounding body fluid; thereby activating the bio chemical environment leading to the formation of hydroxy carbonate apatite (HCA) layer.

There are three forms of bioactive glasses commercially available,

1. Bio glass 2. Perioglas 3. Bio Gran

Bioglass

Bioglass is composed of calcium salts and phosphate in similar proportions as found in bone and teeth, as well as sodium salts and silicon. The graft is an amorphous and non porous material.

Perioglas

PerioGlas is a synthetic, particulate from of Bioglass. It is composed of calcium and phosphorous, plus silicon and sodium. It is bioactive and is indicated for the treatment of infra bony defects, the repair and maintenance of extraction sockets and ridge augmentation. It has a particle size ranging from 90-710µm, By bonding to both bone and connective tissues, Perio Glas achieved improved grafting results.Perio Glas has demonstrated two favorable characteristics, they are Ease of compactability and Ability to promote Hemostasis.

Biogran

Bio Gran is a resorbable bone Graft material made of bioactive glass granules (300-355µm size) that are composed of calcium, phosphorous, silicon and sodium. This material is hydrophilic and slightly haemostatic; when wetted with sterile saline (or) the patient's blood, a cohesive mass is formed that can be shaped to fill the defect. Bone transformation and growth occur within each granule. This osteogenesis, guided by bioactive glass particles, occurs at multiple sites, rapidly filling the osseous defect with new bone that continuously remodels in the normal physiologic manner.

Polymers

There are two polymer materials that have been used:

HTR POLYMER (Hard Tissue Replacement Polymer): HTR is a biocompatible micro porous composite of polymethyl methacrylate (PMMA), poly hydroxyl ethyl methacrylate (PHEMA) and calcium hydroxide. It is a osteophilic and osteo conductive alloplastic bone substitute.

Polymethyl methacrylate (PMMA) beads of 550-880µm diameter with pores of 50-300µm form the core of this material. These are coated with liquid PHEMA without the addition of any catalysts (or) inducers. The composite beads are then coated with calcium hydroxide (or) calcium carbonate. Thus, the actual surface interface with bone is the calcium surface layer, and both fibrous tissue and bone can form on and attach to this layer. The composite is provided in a fine granular form for use in periodontal intra bony defects. It has been reported to be effective in situations like Ridge augmentation and Repair of periodontal and other bony defects.

PLA-PGA Co-Polymer

A new polymer, PLA-PGA co-polymer is a totally

synthetic co polymer based on poly lactic and poly glycolic acid. It is bio compatible and well tolerated due to the fact that it is reabsorbed and degraded in the KREB'S CYCLE. PLA-PGA co polymer has a lower molecular weight which permits a more rapid biological degradation estimated to be between a minimum of 3-4 months to a maximum 6-8 months.PLA-PGA co polymer is commercially available as "FISIOGRAFT". It is available in gel, sponge and powder form, as a regenerative bone graft material.

IV. Xenografts

A Xenograft is a tissue graft between members of differing species. Xenografts were formerly called Heterografts.

Various xenografts include,

1. BO Plant: Calf bone that is detergent extracted with chloroform methanol, sterilized in propiolactone and Freeze dried.

2. OS-PURAM: Cow bone soaked in potassium hydroxide acetone and salt solution.

3. AN-ORGANIC BONE: Cow bone extracted by means of ethylene diamine and sterilized by autoclaving.

4. BOILED BONE: Cow bone that is boiled and autoclaved.

5. KIEL BONE: Cow bone denatured with hydrogen peroxide dried with acetone and sterilized with ethylene oxide.

6. BIO OSS: Bio Oss is anorganic bovine that has been chemically treated to remove its organic component. Bio Oss is highly osteoconductive, there by allowing bone regeneration to occur.

Recently, a natural, anorganic, micro porous bovine derived hydroxy apatite bone matrix, in combination with a cell-binding polypeptide that is a synthetic clone of the 15 amino acid sequence of Type I collagen is available. The addition of cell binding polypeptide was shown to enhance the bone regenerative results of the matrix alone in periodontal defects.

7. CORALLINE CALCIUM CARBONATE: Bio coral is a resorbable, porous coralline, calcium carbonate graft material. It is a natural coral in the form of aragonite {>98% calcium carbonate}. Its pore size is of 100-200µm similar to the porosity of spongy bone. Its porosity, at >than 45%, provides a large surface area for resorption and replacement by bone. It is a osteoconductive material.

V. NON-BONE GRAFT MATERIALS

In addition to bone graft materials, many non bone graft materials have been tried for restoration of periodontium.

1. SCLERA: Sclera was originally used in periodontal procedures because it is a dense fibrous connective tissue with poor vascularity and minimal cellularity. This affords a low incidence of antigenicity and other untoward reactions. In addition, sclera may provide a barrier to apical migration of the junctional epithelium and serve to protect the blood clot during the initial healing period.

2. CARTILAGE: It can serve as scaffolding

3. CEMENTUM-DENTIN PARTICLES

4. PLASTER OF PARIS: It is a biocompatible and porous, there by allowing fluid exchange, which prevents flap necrosis. Plaster of paris resorbs completely in 1-2 weeks.

VI. COMPOSITE GRAFTS

Combining different graft materials to improve the outcome of the grafting procedures. The composition of the grafting mix used should correspond to the

1) Mechanism of action of the materials

2) Number of walls of host bone that remain in contact with the graft. i.e,

a) Addition of autogenous bone to hydroxy apatite particles could stimulate osteogenesis within the grafted area, rather than relying on the osteoconduction produced by the hydroxyl apatite.

b) Alloplasts alone (or) in combination with allografts can be used for small defects and three to five walled defects.

c) Autogenous bone must be added to the graft for one, two (or) three wall defects (or) relatively large defects.

The larger the defect, the greater the amount of autogenous bone required.

ADVANTAGES OF COMPOSITE GRAFTS:

1) Combining synthetic materials with autogenous bone, decreases the amount of harvested bone necessary for oral and periodontal grafting procedures.

2) It results in a denser new bone formation.

3) It prevents premature resorption of the augmented site.

FUTURE RESEARCH AND NEWTRENDS

With source limitations for Autogenous bone and patient concerns regarding allogenic bone, the role of bone substitutes will probably increase. Alloplastic graft materials may have their greatest usefulness as autograft extenders, being added to available autogenous bone to provide a sufficient total volume graft material. They may also be used as carriers for growth factors (biologic modulators), antibiotics and other substances. Bone substitutes are finding increasing use in conjunction with guided tissue barriers to try to improve results with a

combined technique. Growing interest in periodontal and other bone regeneration will encourage the development of improved materials. Bone substitutes will play a pivotal role in the future of periodontal regeneration.

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Legends:

Fig. 1: Intraoral Autograft
Fig. 2: osseous Coagulum.
Fig.3: Bone Blend.
Fig. 4: Cancellous bone Marrow Transplant.
Fig. 5: Bone Swaging.
Fig. 6: Ramping of Bone
Fig. 7: Iliac Autograft.
Figu. 8: Xenograft Bio-oss.
Fig. 9: Xenograft Oteogen
Fig. 10: Perioglas.
Fig. 11: Biogran.