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ALLOGENEIC AND ALLOPLASTIC BONE GRAFTS IN DENTISTRY

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ABSTRACT

Medical professionals have been using bone grafting methods for more than a century. The nature of the graft, ability to induce bone formation, mechanical strength, and pore size are just a few of the variables that affect how well a grafted material is incorporated. The bone transplant material should have the following four characteristics: osteogenesis, osteoinduction, osteoconduction, and osteointegration. Although autologous bone is the only material to possess all the four characteristics, due to donor site morbidities it has limitations in its use. An alternative to autogenous bone is allogeneic bone, which is obtained from another individual and is frequently processed by tissue banks. It has risk of antigenicity and disease transmission. The advent of synthetic bone substitutes over the past few decades has brought enormous alternatives and possibilities to address these constraints. Biological components and synthetic bone substitutes are rapidly replacing natural grafts in bone grafting techniques. The site, size of the defect, patient factors and availability and cost of the graft materials are all elements that must be considered. In this review various allogenic and alloplastic materials available in use their action advantages and disadvantages have been discussed.

KEYWORDS: Bone substitutes, Bone transplantation, Morbidity, Osteogenesis, Tissue banks

INTRODUCTION

A surgical procedure called “bone grafting” replaces missing bone or bone that is not properly healed. Autologous bone is still regarded as the gold standard among all clinically accessible transplants because it combines all the qualities needed for bone regeneration in terms of osteoconduction, osteoinduction, and osteogenesis. The second higher choice is predominately shared by bone allografts. They are primarily osteoconductive, with reduced osteoinductivity. The advent of synthetic bone substitutes over the past few decades has brought enormous alternatives and possibilities to address these constraints. Biological components and synthetic bone substitutes are rapidly replacing natural grafts in bone grafting techniques [(1)].

BONE BIOLOGY

Biology of bone structure

The bone once formed is maintained dynamically through two different processes, modelling and remodelling, which are also employed in bone fracture recovery. In bone modeling process, the new bone is formed without prior bone resorption, while in the bone remodelling process, bone formation follows bone resorption [(2)].

The biology of bone regeneration

Bone healing unlike other tissues is found to be the biogenesis of the events that take place during embryonic development of the skeleton, which enables the damaged part to be fully restored to

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its pre-injury composition, shape and function (DeLacure, 1994). Bone repair can be studied into two categories. Primary or direct bone healing happens when the gap between the fracture ends is less than 0.1 mm and the fracture site is rigidly fixed. It is suggested that with this procedure, the bone gap is directly filled by continuous Haversian remodelling that follows ossification without any cartilaginous or connective tissue. The more frequent type of bone healing is secondary or indirect bone healing were healing takes place when the fracture ends are under twice the diameter of the broken bone. In secondary remodelling multiple events such as blood coagulation, inflammatory reactions, production of fibro cartilage calluses, endochondral and intramembranous ossification with bone remodelling can occur [3].

PROPERTIES OF BONE GRAFTS

Osteoconduction

It happens when bone graft material acts as a scaffold for the formation of new bone and facilitates the attachment of osteoprogenitor cells and osteoblasts before being replaced by native bone. As a platform for cell migration and angiogenesis, osteoblasts from the defect margin employ the bone transplant material [4].

Osteoinduction

It is the stimulation and activation of mesenchymal stem cells from the surrounding tissue, which differentiate into bone-forming cells called osteoblasts after which begins the formation of new bone[5].

Osteogenesis

It occurs when bone graft material have osteoblasts that contributes to the growth of new bone by bone apposition to the surrounding bone [4].

Osteopromotion

The materials which enhances the osteoinductivity of a material but does not have possession osteoinductive properties on its own [5].

Osseointegration

It refers to the structural and functional adaptation of the graft material to the surrounding bone.

Structure of Grafts

Cortical bone grafts are used essentially for providing structural support. Since all or most of the cellular components in cortical grafts die and are gradually replaced, bone regeneration occurs via creeping substitution, with the graft merely serving as a scaffold for the growth of new bone. Replacement of hard cortical bone occurs at a far slower rate than spongy or cancellous bone. Osteogenesis uses bone grafts made from leftover material. Although cancellous bone has a greater potential for osteogenesis, it lacks the strength to effectively support structures.

Type and Tissue Sources

Autograft: Autogenous bone graft involves bone obtained from same individual who is receiving the graft. Bone can be harvested from areas adjacent to the defect. Some of the sites are ribs, femur bone, iliac crest, mandibular symphysis region, and anterior mandibular ramus region. It is an ideal material for grafting with osteoinductive, osteogenic and osteoconductive property with less graft rejection. Need for an additional surgical site and postoperative pain and complications are possible disadvantages of autologous grafts. [6]

Allografts: Both autogenous and allograft bone come from humans, with the difference being that allograft is taken from a person other than the recipient of the graft. It is obtained and stored in a bone bank [6].

Xenograft - Bone transplants from animals such as bovine, are known as xenografts. They are widely accessible, and in addition to other grafts, they can be employed as supporting or carrier materials [6].

Synthetic alloplastic variants: The synthetic bone graft substitutes should be biocompatible,

show minimal immunogenic reaction and support new bone formation. Artificial bone can be obtained from materials such as ceramics, calcium carbonates, sulphates and phosphates, bioglass, silicon which are made biologically active by altering the solubility and physical properties [6,7]. In addition to the above materials Growth factors, silicone-based bone graft substitutes, Polymer-based bone graft substitutes are also available.

Allografts

Allografts are bone grafts that are extracted from one person and transplanted to another. Orthopedics, craniofacial surgery, and dentistry all employ bone allografts often. Allograft bone are available in numerous configurations, including powder, cortical chips, cancellous bone etc. Antigenicity and the chance of disease transfer are the two main issues with the use of bone allografts. Freeze dried bone allograft (FDBA) and demineralized freeze dried bone allograft (DFDBA) are the two kinds that are commonly employed. While DFDBA has both osteoconductive and osteoinductive potential, FDBA possesses osteoconductive property and acts as a scaffold for bone formation.

Allografts have the benefits of being readily available and eliminating the need for a second donor site operation. Host incompatibility and potential disease transmission from donor to recipient are two drawbacks of allografts [8].

The Proceedings from the State of Art Workshop held in 1982 stated "a principal concern with allografts is the problem of graft rejection." due to Human leukocyte antigen (HLA) incompatibility[9]. Detection of donor specific anti-HLA antibody formation in a patient receiving allografts is an important measure of the clinical immunogenicity of the respective graft material [10]. One significant risk connected with the use of bone allografts is the potential for disease transmission, notably viral transmission and even more specifically Human Immuno Deficiency (HIV) [8,9]. Additionally, when cells in tissue are killed during processing, whether it is after aseptic procurement or after terminal sterilisation, the potential for an immunological reaction is greatly reduced [8]. Processing methods include physical debridement to remove soft tissue and reduce the cellular load, ultrasonic or pulsatile wash to remove most of the remaining cells and blood, ethanol treatment to denature cellular proteins and provide some viral deactivation, an antibiotic wash to kill bacteria, milling to create the final geometry, terminal sterilization for lot release (principally gamma irradiation, ethylene oxide, or other methods) or pre-treatment with gamma irradiation to reduce the initial microbial load, freeze-drying, and conventional freezing. Donor screening and processing of the specimen under aseptic protocols are important during the procurement of the allograft [11].

Alloplastic Materials

Alloplastic bone graft materials are synthetic, inorganic, biocompatible, and bioactive bone substitutes. Osteoconduction and osteointegration, two of the four qualities of the ideal graft, have been demonstrated in these materials. Allografts have two benefits over autografts: they don't require a donor site during surgery, and they are widely available. However, drawbacks such transplant rejection, infection, and extended recovery times exist.

Non-ceramics:

OsteoGen is a synthetic bioactive resorbable graft (SBRG) [12] .It is an osteoconductive, non-ceramic graft material indicated for contouring and improving alveolar ridge deformities; filling extraction sockets; using around dental implants and in sinus grafts and repairing marginal, periapical, and periodontal alveolar bony defects.

Ceramics:

Due to its excellent biocompatibility, osseointegration, and osteoconduction, the family of calcium phosphate and calcium sulphate materials known as

ceramics are frequently used in the area of bone regeneration. Calcium phosphate is used in a variety of ceramic goods today, including hydroxyapatite (HA), tricalciumphosphate (TCP), calcium sulphate, or their compounds [13].

Hydroxyapatite (HA)

Hydroxyapatite, Ca_{10} $(PO4)_6(OH)_2$ a stable, non-toxic and inert material is the primary mineral component of bone. The calcium to phosphate ratio for HA is 1.67. The chemical composition closely resembles the inorganic component of bone, which facilitates it to be used as a bone grafting material. Recent developments in materials based on HA have considered creating nanoscale HA, which improved biomechanical characteristics that more closely resemble the composition of organic bone [14].

Tricalcium phosphate

Tri-calcium phosphate is osteoconductive calcium phosphate and has the most similar chemical composition to human bone. It has better absorption than hydroxyapatite. It has a greater degree of porosity than HA, poor mechanical strength, and rapid absorption. Six weeks after being inserted into the bone defect, it begins to biodegrade. Other derivatives with calcium like calcium sulphate and calcium carbonate also have been used [13, 14].

Synthetic Absorbable Polymers

The most readily used polymers for bone regeneration include polylactic acid, polyglycolic acid, poly-caprolactone and their copolymers and derivatives, collectively these are known as aliphatic polyesters. The main advantages exhibited by this group of materials include their availability in customised forms, less immunogenicity, controlled resorption, porosity, and physiochemical composition [15]. Absorbable GBR (Guided bone regeneration) membranes, HTRM (Hard tissue replacement polymer) have been used extensively in oral surgery and may have application in long bone procedures.

Bioactive glass ceramics

Bioactive glass is a non–resorbable material in addition to being osteoconductive, bonds directly to bone tissue. Bioactive glass ceramics have two properties that contribute to the successful results observed with its use: (1) a relatively quick rate of reaction with host cells, and (2) an ability to bond with the collagen found in connective tissue. Some of the commercially available bioactive glass ceramic materials are Bioglass, PerioGlas and Biogran [16].

Metals

Role of metallic ions, such as magnesium (Mg), strontium (Sr), zinc (Zn) and silicon (Si) in the maintenance of bone and stimulation of osteogenesis are identified in recent research. Since nickel-titanium materials have so many desirable qualities, such as strong mechanical strength, good biocompatibility, corrosion resistance, and elastic modulus, they have been investigated for usage in dentistry for bone regeneration [15, 17].

Recombinant human growth factors

Bone healing occurs as the result of interactions between local and systemic regulatory factors. The chemical messengers include BMPs, TGFs, platelet-derived growth factors, fibroblast growth factors, insulin-like growth factors, and vascular endothelial growth factor. Recombinant techniques can provide such purified growth factors [18].

The demineralization process improves the bioavailability of the BMPs. Cheng et al suggests that BMPs 2, 6, and 9 induce osteoblastic lineage-specific differentiation of MSCs at a greater level, whereas most BMPs can effectively promote the terminal differentiation for committed osteoblastic precursors [19].

CONCLUSION

Even though many different bone-grafting materials have been developed, autografts are still the only substance that possesses all four crucial biological characteristics, making them the gold

standard. However, due to their scarcity and other restrictions, substitute grafting materials have developed. The many forms of bone grafts that are currently used as well as the novel bone graft alternatives that have been developed have been covered in this review article. The site, size of the defect, patient factors and availability and cost of the graft materials are all elements that must be considered.

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