Current Trends in Bone Grafts

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Abstract

Alveolar bone cavities generated due to congenital deformities, trauma, loss of a tooth, inflammatory conditions, infections as well as cancerous conditions usually call for a destructive resection of infected bone tissue. The concept of bone replacement graft has gained popularity given the filling of the dead space generated due to this aggressive course of action. Being performed throughout the world, the principle of grafting is based on the regeneration abilities of bone tissue. Bone materials from the patient's own body or an equivalent substitute (natural or artificial) are used as replacements for the lost bones.

Objective: To perform the procedure of bone grafting successfully and to achieve the desired results, a thorough understanding of bone biology and its constituents is of utmost importance.

Conclusion: The future of dental bone grafting and dental implants lies in the development of hybrid grafts that combine growth factors and living osteogenic cells, such as bone substitutes that can release bone morphogenic proteins or platelet-derived growth factors in a controlled manner, gene modifying drugs, and science in biochemistry, engineering, and nanotechnology.

***Keywords**:* Bone Grafts, Alveolar reconstruction, bone fillers

1. Introduction

Remodelling alveolar bone is a daunting process in dentistry. Bone grafting has emerged as a possible solution to correct alveolar bone deformities as well as craniofacial/skeletal defects and to minimise bone loss.[1] Bone grafts used as replacement are usually made of natural or synthetic material. To successfully serve the purpose of grafting, a replacement material should be biocompatible, moldable and well-accepted by the recipient.[2] It must have adequate mechanical qualities, ability to merge with native bone and an ideal replacement rate.[3] This article anticipate bone replacement materials for dentoalveolar restorations and also to shed light on their current and future dental trends.

Characteristics of bone grafts

Maintenance of shape, abolish dead space, depletion of postoperative infection are all goals of osseous replacement, which improves healing.[4,5] Bone grafts helps in achieving accurate intermaxillary connections and proper volume and form of bone. Another feature of osseous grafts is to serve as a scaffold to allow the production of new bone, stimulate wound healing, and act as a mineral source to aid in the formation of new bone [6] Bone transplant provide mechanical support and encourage osteoregeneration. In order to properly execute these duties, the four biological qualities of osseointegration, osteogenesis, osteoinduction, and osteoconduction must be present.[7,8] These elementary features permit for new bone creation to proceed in tandem with osseous connectivity.[2] The graft type, preparation site, vascularity, mechanical strength, and pore size of the material all play a role in the successful assimilation of a grafted material. Practically all contemporary bone graft and substitute materials serve solely as a structural framework for osteoregenerative processes to take place, and hence only satisfy the osteoconductivity feature. Bone replacement should be considered based on the site of reconstruction, the extent of the defect, a thorough, healing environment, the patient's wishes and expectations, and the dentist's knowledge.[2]

Bone graft Physiology

Bone grafts should contain three aspects to accomplish bone regeneration: osteoprogenitor mesenchymal cells, growth factors, and a framework capable of supporting cells of adhesion, allowing for their expansion and proliferation.[9] Bone graft represents the skeleton and serves to produce a three-dimensional mechanical structure that hosts and supports cells.[3]

Classification of bone grafts and substitutes

Bone grafts can be classified according to their source of origin and material group into natural bone graft and substitute and synthetic bone substitute.[2]

1.Natural bone grafts and substitute materials

2.Synthetic bone substitute

3.Composite bone substitute

4. Growth factor based bone substitute

5. Bone substitute with living osteogenic cells

Discussion

1. **Natural bone grafts** are procured from living sources, that have not been modified. These are further categorised into autograft, allograft, xenograft and phytogenic materials[2]

a) Where in Autograft is a tissue graft that is transferred from one fragment of the body to another within the same person and is a rich supply of osteogenic bone and marrow cells with all four key biological properties.[10] Autografts can be acquired from mandibular symphysis, ramus, external oblique ridge, iliac crest, proximal ulna, or distal radius.

b) Allografts are bone transplants from one person to another and can be received from a living donor or a corpse. These are the most common alternatives to autografts, however they always perform badly in comparison to autografts. These are available in three different states: fresh, frozen, and freeze dried. Fresh and frozen foods are rarely employed due to their immunogenicity to the host, yet they are osteoconductive in nature. Freeze dried are made by freezing them and then dehydrating them to about 5% water content. Preferable in dental applications since they do not require a second surgical visit and can be used to augment extensive bone abnormalities. However, there are still concerns about the possibility of infectious conditions like HIV and Hepatitis B and C, as well as a failure rate that is substantially higher than that of autografts[11,12].

c) Xenografts - Xenografts are osteoconductive in nature and has limited resorption potential.[8] procured from species other than human that retain the natural mineral component of bone and are surgically transplanted between different species. Examples are bovine bone and natural coral and Chitosan [13,14]

1) Chitosan – It's a naturally occurring polymer made up of glucosamine and N-acetylglucosamine that comes from the exoskeletons of crustaceans, found in the walls of fungus and yeast, only in trace amounts. It promotes bone deposition by acting as a structural platform for osteoblastic activity, the production of mineralized bone matrix, and the differentiation of MSCs into osteoblasts. It comes in variety of forms, including beads, films, hydrogels, and porous scaffolds. It can be coupled with growth factors to stimulate osteogenesis and neovascularization, as well as other proteins like BMPs to generate osteoinductive potential. It proves to be a viable alternative to autologous bone repair when paired with growth factor. Also used as a coating material for osteointegration on titanium and hydroxyapatite in dentistry.[15,16]

2) Silk- Silk is a crude form (bipolymer) extracted from the silkworm Bombyx mori. Proteins, fibrion, and sericin make up this substance. Silk fibroin is extensively employed as a bone scaffold in sponge, fibres, film, and hydrogel forms only after sericin is removed through degumming. Biocompatibility, degradability, tissue integration, oxygen and water permeability are all relatively good. It's meant to be used as a GBR membrane after extraction of alveolar tooth, cyst or tumor removal, and implant insertion in inadequate alveolar bone. To upgrade the membrane's mechanical strength and stability, HA, SF integrated membrane, and chitosan can be combined.[17] However limitations persist with use of xenograft which is nothing but resorbable nature of graft, lack of viable cells and biological components.[18]

d) Phytogenic material

Materials obtained from plants are phytogenic material. These are mainly gusuibu, coral-based bone substitutes, and marine algae.

1) Gusuibu- Gusuibu (Rhizoma Drynariae) , which is a traditional Chinese medication mainly employed for treatment of bone associated illnesses. It is the dried rhizome of perennial pteridophyte Drynaria fortune. Gusuibu with collagen carrier greatly boosted new bone formation in skull deformities. It generated 24% more new bone than a bone transplant alone, and 90% more new bone than an absorbable collagen sponge alone.[19,20]
2) Algipore- A naturally found mineral obtained from marine algae that with good resorbable characteristics. There is a scarcity of clinical evidence for this biomaterial, known for its high biocompatibility, low immunological reactions, biodegradability, and bone adhesive ability.[21] In clinical practise, Algipore™ has mostly been employed

as a space filler in conjunction with other materials to minimise ridge abnormalities after tooth extraction.[22]

2. **Synthetic Bone Substitute Materials-** These materials were developed to overcome the immunogenicity morbidity associated with previously discussed materials. They almost discloses biological properties of natural bone and includes the following

Hydroxyapatite – It is non resorbable artificial HA is astable, non-toxic, and inert. It has a chemical composition that is quite similar to the inorganic component of bone. Unfortunately, while being moulded or forced into position, HA is fragile and susceptible to fracture. The new bone generated after grafting with artificial hydroxyapatite alone or in conjunction with a polymer was found to be deficient for maintaining alveolar ridge heights for endosseous implant insertion, maxillary sinus elevation, and periodontal osseous defect correction .[24] As a result, the use of HA in dentistry is mostly restricted to implant coatings, external fixator pins, and low-loading sites.[21, 23,24]

Tricalcium phosphate ceramic - α-TCP and β-TCP are the two crystallographic forms of TCP. - α TCP is a totally bioabsorbable, biocompatible, osteointegrative, and osteoconductive substance. It's also low in immunogenicity and disease transmission risk. β -TCP, on the other hand, has a poor mechanical strength under compression due to its interconnected porous structure, making it unsuitable as a bone substitute but useful as a filler in bony defects. It is frequently used to treat periapical and marginal periodontal abnormalities. β -TCP has also been used in investigations that have documented alveolar ridge augmentation in both vertical and horizontal dimensions, with mixed results. β -TCP grafts have been demonstrated to have bone regeneration capability similar to autogenous bone, FDBA, DFDBA, and collagen sponge.[25,26,27,28] c) Metals- Nickel titanium in the form of GBR is widely used due to a number of desirable features such as acceptable mechanical strength, biocompatibility, corrosion resistance, and elastic modulus.[29] The use of Ni-ti with holes ranging from 50 to 125 microns has resulted in vascularization and bone repair. The membrane is designed to act as a physical barrier, preventing epithelial cells and fibroblasts from migrating to the defect site while permitting osteogenic progenitor cells to migrate to the defect location for new bone production. The membrane primarily serves as a structural scaffold, allowing cells to adhere, proliferate, and differentiate, resulting in the formation of new bone. It can be used in conjunction with other bone augmentation procedures and can be implanted simultaneously or afterwards. [30,31]

Magnesium based bone substitute- These substitute material utilising pure Mg (99.9%) and a Mg-30wt percent Sr alloy. The degradability, superior mechanical characteristics, and biocompatibility of pure Mg and Mg-Sr alloys are integrated in this material. Strontium is known to promote the growth of osteoblasts. In addition, the inhibitory effect of Sr on osteoclasts proliferation will be consider in preventing bone resorption.[32,33]

Bioactive glass- It is made of active silicate-based glass and has much stronger strength. It uses hydroxyapatite crystals to generate a sturdy connection between the glass and the host bone.[3]

3. Composite bone substitute materials

Composite materials are bone substitute materials with increased mechanical properties. They are combination of different materials, for example bioglass and polymers. Commonly used materials are Nano bone and Fortoss bone.[34]

- NanoBone TM is a novel combination bone substitute that is made up of 76 percent nanocrystalline HA and 24 percent silicon dioxide.[35] The surface adherence of autologous proteins is mediated by the silicon dioxide component, which mediates bone remodelling. Inspite of porous structure, nanobone retains high fracture toughness and mechanical strength. It can speed up bone regeneration and improve the quality and amount of produced bone after mandibular cyst removal when combined with platelet-rich fibrin. The NanoBone's crystal size is in the nanometre range, whereas holes are only found in the micrometre and millimetre range.[35,36]
- Fortoss VitalTM is a biphasic alloplastic substance consisting of TCP inside a calcium sulphate matrix and is a resorbable composite bone substitute product. It functions as an osteoconductive structural scaffold, with a negative surface charge that attracts positively charged host BMPs and interstitial fluid, guiding osteoblast recruitment to the grafted site and finally improving bone regeneration. Bone augmentation, rehabilitation of implants and socket preservation have all been achieved with Fortoss.[37,38]

4. **Bone Substitutes incorporating growth factors-** Bone morphogenic proteins, Platelet-derived growth factors, and Insulin-like growth factors are all growth factors having osteoconductive characteristics (IGFs). These growth factor-based materials were originally first used to speed up healing in patients with jaw osteonecrosis caused by bisphosphonates in the form of plasma rich in growth factors (PRGF), platelet rich plasma (PRP), and plasma rich in fibrin (PRF).[38]

a) Sticky bone –Sticky bone is a fibrin bone graft that is physiologically solidified and entrapped in a fibrin network. It offers stabilisation to the bone graft, Due to the densely intertwined fibrin network, this sticky bone does not migrate even when shaken, minimising bone loss on the defect throughout the healing phase without the usage of bone tack or titanium mesh. Sticky bone has good moldability, can be tailored to various geometries of bony deficiency, has good structural stability, and requires no biochemical additives.[39]

b) Bone morphogenic proteins- BMP-2 and BMP-7 are USFDA approved growth factors, most commonly used for grafting in dentistry. Several BMPs are thought to play a key role in the chemotactic proliferation and differentiation of osteoprogenitor cells, resulting in bone production. BMPs are active ingredients in InfuseTM and OsigraftTM, two popular commercial products. However, OsigraftTM manufacture has since been suspended, and the usage of InfuseTM has been linked to a slew of life-threatening side effects. Collagen-based bone grafts have been shown to increase bone ingrowth in FDA-approved clinical spine and tibia trauma reasons on numerous occasions.[40,41]

5. Bone Substitutes with Infused Living Osteogenic Cell

Bone substitute materials bioengineered using MSCs have been found to significantly increase bone healing and reconstruction, new bone has notably improved biomechanical properties. Direct ingrain with MSCs can further proliferate bone healing.[42] Bioseed-Oral BoneTM and Osteotransplant DENTTM, which use an autologous source of MSCs with an appropriate matrix, are clinically authorised products used in severely atrophic maxilla sinus augmentation to facilitate predictable implant placement [43].

Conclusion

Autografts are still the gold standard, as they are the only substance that has all four biological qualities. However, because to their scarcity and other drawbacks, another grafting materials with innovative synthetic bone substitutes are being developed. The future of dental bone grafting and dental implants lies in the development of hybrid grafts that combine growth factors and living osteogenic cells, such as bone substitutes that can release bone morphogenic proteins or platelet-derived growth factors in a controlled manner, gene modifying drugs, and science in biochemistry, engineering, and nanotechnology.

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