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Review Article

Alloplastic bone grafts in maxillofacial surgery – An overview

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A B S T R A C T

Bone grafting techniques have been used by medical practitioners for over a century. A few factors that influence how successfully a grafted material is assimilated are its mechanical strength, pore size, ability to stimulate bone growth, and type of the graft. The four properties that the bone transplant material should possess are osteogenesis, osteoinduction, osteoconduction, and osteointegration. Despite being the only material with all four qualities, autologous bone has limited applications because of morbidities at the donor site. Allogeneic bone, which is taken from a different person and is commonly processed by tissue banks, is an alternative to autogenous bone. It carries a danger of spreading illness and being antigenic. Over the past few decades, the development of synthetic bone substitutes has opened up a wide range of options and opportunities to solve these limitations. In bone grafting procedures, synthetic bone replacements and biological components are quickly taking the place of natural grafts. Considerations include the patient's characteristics, the location, the extent of the lesion, and the cost and availability of the graft materials. This review has covered a variety of commonly used alloplastic materials.

1. Introduction

A mineralized tissue that provide structural support is called bone. It can fully renew, but it needs some kind of scaffold to do so. A graft is a surgically transplanted portion of living tissue, organ, etc., according to the Oxford Dictionary. The Graft is a live tissue that is inserted into a recipient and then restored, repaired, or regenerates after being removed from a donor location. During a surgical technique called "bone grafting," new bone or replacement material is inserted into a bone defect or fracture to promote healing. Another definition of bone grafting is a surgical process that uses the patient's own tissue to replace lost bone with an artificial, synthetic, or natural equivalent.[1] Depending on their reasons, several sites are used for bone grafts. They support bone growth and facilitate healing by serving as a scaffold and filler. The following phases are involved in integrating grafts to the recipient site: inflammation, revascularization, osteoinduction, osteoconduction, and remodeling.[2]

As an alternative to xenograft, alloplastic materials have been developed. They come in an infinite number of shapes, sizes, and configurations. No immune response or disease transmission is brought on by alloplastic materials. Because of state-of-the-art technology that improves surface texture, mineral production, and biocompatibility, they resemble natural bone quite a bit. Alloplastic materials can be osteoinductive or osteoconductive, depending on the situation.[3] The most commonly utilized alloplastic substance is beta-tricalcium phosphate (β-TCP). Its resorption occurs by enzymatic, phagocytic, and hydrolysis processes, and its compressive strength is comparable to that of cancellous bone.[4] Bioactivity is the chemical connection that occurs between the bone graft and

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the host bone. Bioactivity characteristics of calcium sulfate (CS) include slow resorption and eventual replacement by new bone. An alloplastic compound biomaterial that attaches to the host bone and hardens in place is generated by combining CS with β-TCP. This complex biomaterial acts as a stable scaffold and aids in maintaining the enhanced site's dimensions and shape. Typically, the ideal grafting material should act as a substrate for the ingrowth of bone into the hole, with host bone eventually replacing it entirely at a rate of resorption that is acceptable in relation to new bone formation.[5]

Osteoprotegrin is a soluble secretory glycoprotein primarily produced by osteoblast lineage cells that belongs to the tumor necrosis factor receptor (TNFR) class. By binding the receptor activator of NF-kB ligand (RANKL), it functions as a soluble decoy receptor that inhibits osteoclast differentiation, activation, and apoptosis induction. Because it controls osteoclast activity and changes in bone density, osteoprotegrin has long been regarded as a vital component of bone repair. The RANKL/OPG ratio indicates whether the tissue response is more likely to promote bone resorption with an increase in RANKL or bone creation with a predominance of OPG.[6]

2. Synthetic Bone Substitute/ Alloplastic Materials

These artificial materials are utilized in the process of bone grafting to correct periodontal osseous deformities. The artificial materials listed below are utilized to treat human periodontal osseous deformities. TCP, or tricalcium phosphate, is a commonly utilized graft. The ratio of calcium to phosphate is 1:1.5. These crystals are crystals of beta-whitlockite. They come in two varieties: ceramics and cement. Cement comes in paste form, which hardens at flaw sites when applied. Because they undergo a heat process called sintering, ceramic grafts are both solid and porous.

2.1. Advantages

1. Biocompatible
2. Strong osteoconductivity
3. Enables bone regeneration, vascularization, and phagocytosis
4. Unaffected by compressive loads

2.2. Disadvantages

1. Inadequate mechanical stability
2. Reduced resistance to shear and tensile stresses
3. Fragile
4. Absence of osteogenic and osteoinductive characteristics
5. It has little resorbability

2.3. Hydroxyapatite

One of the primary inorganic elements that makes up bone and teeth is hydroxyapatite. They are composed of calcium and phosphate as well, but in a 1:1.67 ratio.

2.4. Advantages

1. They have osteoconductive qualities.
2. Not usually resorbable.
3. Outstanding transporter of osteogenic and osteoinductive growth factors.

2.5. Disadvantages

1. Fragile
2. More brittle

Biphasic Calcium Phosphate (BCP) is a mixture of tricalcium phosphate and hydroxyapatite that is used to increase mechanical qualities and overcome drawbacks.[7] Calcium sulfate: Also referred to as Paris gypsum or plaster of Paris. These grafts are widely utilized in situations of dentoalveolar defects, periodontal disease, and tooth extraction.[8] It is resorbed completely in 1-2 weeks.

2.6. Advantages

1. Allow fluid exchange hence prevent flap necrosis
2. Highly Biocompatible
3. Osteoconductivity
4. Good handling property
5. Available in both cement as well as granular form
6. Good tolerating properties

2.7. Disadvantages

1. More prone to fracture when a mechanical load is applied
2. Rapid resorption
3. Minimal structural support

3. Discussion

Synthetic, inorganic, biocompatible, and bioactive bone substitutes are known as alloplastic bone transplant materials. These materials exhibit two of the four characteristics of the perfect graft: osteoconduction and osteointegration. Compared to autografts, allografts have two advantages: they are more readily available and don't need a donor site during surgery. However, there are disadvantages include infection, transplant rejection, and prolonged recovery periods.

3.1. Non-ceramic

A synthetic bioactive resorbable graft (SBRG) is called OsteoGen.[9] This osteoconductive, non-ceramic graft material is recommended for treating marginal, periapical, and periodontal alveolar bone deficiencies as well as for filling extraction sockets, contouring and enhancing alveolar ridge abnormalities, and employing in sinus grafts and around dental implants.

3.2. Ceramics

Ceramics, a class of materials consisting of calcium phosphate and calcium sulphate, are widely employed in the field of bone regeneration due to their outstanding biocompatibility, osseointegration, and osteoconduction. These days, calcium phosphate is found in many ceramic products, such as calcium sulphate, tricalciumphosphate (TCP), hydroxyapatite (HA), or their derivatives.[10]

3.3. Hydroxyapatite (HA)

The main mineral in bone is hydroxyapatite, or Ca10 (PO4)6(OH) 2, a stable, non-toxic, and inert substance. For HA, the ratio of calcium to phosphate is 1.67. Its ability to function as a bone grafting material stems from its chemical composition, which is very similar to the inorganic component of bone. Nanoscale HA has been created in recent HA-based material advancements, improving biomechanical properties that more nearly mirror the makeup of organic bone.[11]

3.4. Tricalcium phosphate

Tri-calcium phosphate is the calcium phosphate that is osteoconductive and most closely resembles human bone chemically. Compared to hydroxyapatite, it has superior absorption. It absorbs quickly, has weak mechanical strength, and is more porous than HA. It starts to biodegrade six weeks after it's been put into the bone deficiency. There have also been uses for other calcium derivatives, such as calcium carbonate and calcium sulphate.[10,11]

3.5. Synthetic absorbable polymers

Polylactic acid, polyglycolic acid, poly-caprolactone, and their copolymers and derivatives collectively referred to as aliphatic polyesters are the most often utilized polymers for bone regeneration. This set of materials' primary benefits include their physiochemical composition, controlled resorption, immunogenicity, porosity, and availability in customized forms.[12] Long bone operations may benefit from the use of absorbable GBR (guided bone regeneration) membranes and HTRM (hard tissue replacement polymer), which have been widely employed in oral surgery.

3.6. Bioactive glass ceramics

In addition to being osteoconductive and non-resorbable, bioactive glass forms a direct bond with bone tissue. Two characteristics of bioactive glass ceramics—(1) a comparatively fast rate of response with host cells, and (2) the capacity to form a link with the collagen present in connective tissue—contribute to the positive outcomes seen in their application. Bioglass, PerioGlas, and Biogran are a few of the bioactive glass ceramic materials that are sold commercially.[13]

3.7. Metals

Recent studies have identified the role of metallic ions, including silicon (Si), magnesium (Mg), strontium (Sr), zinc (Zn), and zinc (Zn), in the promotion of osteogenesis and maintenance of bone. Nickel-titanium materials have been researched for use in dentistry for bone regeneration because they offer so many desirable properties, including excellent mechanical strength, good biocompatibility, corrosion resistance, and elastic modulus.[12,14]

3.8. Recombinant human growth factors

Regulation variables that are both local and systemic interact to cause bone healing. BMPs, TGFs, fbroblast growth factors, platelet-derived growth factors, insulin-like growth factors, and vascular endothelial growth factor are some of the chemical messengers. Such purified growth factors can be obtained by recombinant approaches.[15] The BMPs' bioavailability is enhanced by the demineralization process. While various BMPs can successfully encourage the terminal differentiation of committed osteoblastic precursors, Cheng et al. show that BMPs 2, 6, and 9 stimulate osteoblastic lineage specific differentiation of MSCs at a larger level.[16]

4. Conclusion

Ongoing research has been done to enhance bone transplant properties such mechanical strength, compatibility, degradation capacity, and other features. Even with current developments, the ideal material for bone restoration has not yet been created. The area of bone regeneration has expanded due to the development of many materials that may regenerate bone, including engineering, cells, and nanotechnology. While there have been significant advancements in the field of dental bone transplantation, the search for the perfect graft material continues.

5. Source of Funding

None.

6. Conflict of Interest

None.

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