



BONE GRAFT MATERIALS: A REVIEW

Dental Science

**Bikramjit Singh
Sekhon**

BRS Dental College and Hospital Panchkula, Haryana, India

**Tarndeeep Kaur
Sekhon***

BRS Dental College and Hospital Panchkula, Haryana, India*Corresponding Author

ABSTRACT

Bone grafting is a surgical procedure that replaces missing bone with material from patient's own body, an artificial, synthetic, or natural substitute. Bone grafting is possible because bone tissue has the ability to regenerate completely if provided the space into which it has to grow. As natural bone grows, it generally replaces the graft material completely, resulting in a fully integrated region of new bone. This article briefly reviews various types of bone grafting material available.

KEYWORDS

Bone grafts, Autografts, Allografts, Alloplastic material

Bone grafting is a surgical procedure that replaces missing bone with material from patient's own body, an artificial, synthetic, or natural substitute. Bone grafting is possible because bone tissue has the ability to regenerate completely if provided the space into which it has to grow. As natural bone grows, it generally replaces the graft material completely, resulting in a fully integrated region of new bone. This article briefly reviews various types of bone grafting material available.

Classification of bone grafts based on material groups: [1]

1. Autograft
2. Allograft
3. Xenografts
4. Alloplastic materials

Autograft

Autologous or autogenous bone grafting involves utilizing bone obtained from same individual receiving the graft. Bone can be harvested from nonessential bones, such as from iliac crest, mandibular symphysis (chin area), and anterior mandibular ramus (coronoid process). When a block graft will be performed, autogenous bone is the most preferred because there is less risk of graft rejection as the graft is originated from the patient's body. [2] It would be osteoinductive and osteogenic, as well as osteoconductive. Disadvantage of autologous grafts is that additional surgical site is required, another potential location for postoperative pain and complications. [2] All bones require blood supply in the transplanted site.

Allografts

Allograft is derived from humans. The difference is that allograft is harvested from an individual other than the one receiving the graft. Allograft bone is taken from cadavers that have donated their bone so that it can be used for living people who are in need of it; it is typically sourced from a bone bank.

There are three types of bone allograft available: [3]

1. Fresh or fresh-frozen bone
2. FDDBA
3. DFDBA

The use of allografts for bone repair often requires sterilization and deactivation of proteins normally found in healthy bone. Contained in the extracellular matrix of bone tissue are the full cocktail of bone growth factors, proteins, and other bioactive materials necessary for osteoinduction and successful bone healing; the desired factors and proteins are removed from the mineralized tissue by using a demineralizing agent such as hydrochloric acid. The mineral content of the bone is degraded, and the osteoinductive agents remain in a demineralized bone matrix (DBM).

Xenograft

Xenografts are bone grafts from a species other than human, such as bovine and are used as a calcified matrix.

Alloplastic grafts

Alloplastic grafts may be made from hydroxyapatite, a naturally occurring mineral (main mineral component of bone), made from bioactive glass. Hydroxyapatite is a synthetic bone graft, which is the most used now due to its osteoconduction, hardness, and acceptability by bone. Some synthetic bone grafts are made of calcium carbonate, which start to decrease in usage because it is completely resorbable in short time and makes breaking of the bone easier. Finally used is the tricalcium phosphate in combination with hydroxyapatite and thus giving effect of both, osteoconduction and resorbability.

Synthetic variants

Flexible hydrogel-hydroxyapatite (HA) composite which has a mineral to organic matrix ratio, approximating that of human bone. Artificial bone can be created from ceramics such as calcium phosphates (e.g., HA and tricalcium phosphate), bioglass, and calcium sulphate are biologically active depending on solubility in physiological environment. [4] These materials combine with growth factors, ions such as strontium or mixed with bone marrow aspirate to increase biological activity. The presence of elements such as strontium can result in higher bone mineral density (BMD) and enhanced osteoblast proliferation.

Growth factors

Growth factors enhanced grafts are produced using recombinant DNA technology. They consist of either human growth factors or morphogens (BMPs in conjunction with a carrier medium, such as collagen). The factors and proteins that exist in bone are responsible for regulating cellular activity. Growth factors bind to receptors on cell surfaces and stimulate intracellular environment to act. Generally this activity translates to a protein kinase that induces a series of events resulting in transcription of messenger ribonucleic acid (mRNA) and ultimately into the formation of a protein to be used intracellularly or extracellularly. The combination and simultaneous activity of many factors results in controlled production and resorption of bone. These factors, residing in extracellular matrix of bone, include TGF-beta, insulin like growth factors I and II, PDGF, FGF, and BMPs. [5,6] Cell-based bone graft substitutes: Stem cells are cultured in the presence of various additives such as dexamethasone, ascorbic acid, and b-glycerophosphate to direct the undifferentiated cell towards osteoblast lineage. The addition of TGF-beta and BMP-2, BMP-4, and BMP-7 to the culture media can also influence the stem cells towards osteogenic lineage. Mesenchymal stem cells have also been seeded onto bioactive ceramics conditioned to induce differentiation to osteoblasts.

Ceramic-based bone graft substitutes

Majority of bone grafts available involve ceramics, either alone or in combination with another material (e.g., calcium sulfate, bioactive glass, and calcium phosphate). The use of ceramics, like calcium phosphates is calcium hydroxyapatite which is osteoconductive and osteointegrative; and in some cases, osteoinductive. They require high temperatures for scaffold formation and have brittle properties.

Bioactive glass (bioglass) is a biologically active silicate-based glass, [7] having high modulus and brittle nature; it has been used in combination with polymethylmethacrylate to form bioactive bone cement and with metal implants as a coating to form a calcium-deficient carbonated calcium phosphate layer which facilitates the chemical bonding of implants to the surrounding bone. Different types of calcium phosphates are tricalcium phosphate, synthetic hydroxyapatite, and coralline hydroxyapatite; available in pastes, putties, solid matrices, and granules.

Such calcium phosphates products include Bio-Oss and OsteoGraft. Both products use hydroxyapatite, either as a particulate (Bio-Oss) or as blocks and particulates (OsteoGraft). Pro-Osteon is a unique product based on sea coral, which is converted from calcium carbonate to calcium hydroxyapatite. The advantage of this material is that the structure of coral, which is similar to that of trabecular bone.

Polymer-based bone graft substitutes

This can be divided into natural polymers and synthetic polymers. Subclassified into degradable and nondegradable types. Polymer-based bone graft substitutes include the following:

Healos is a natural polymer-based product, a polymer-ceramic composite consisting of collagen fibers coated with hydroxyapatite and indicated for spinal fusions.

Cortoss is an injectable resin-based product with applications for load-bearing sites

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