

BONE GRAFTS IN DENTISTRY

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ABSTRACT

In clinical practice, bone grafts are frequently utilized as a structural scaffold and filler material to promote bone regeneration and improve wound healing. Usually, these materials are bioresorbable, which means that over time, natural bone progressively replaces them. Crucially, they don't cause antigen-antibody interactions and are biologically compatible. Apart from their structural function, bone grafts act as a storehouse of vital minerals that stimulate and encourage the growth of new bone tissue.

KEY WORDS: Allograft, autograft, bone reconstruction, bone repair, calcium sulphate, ceramic, hydroxyapatite, implant, polymer

Surgical treatments, trauma, infections, or congenital anomalies are some of the causes of ridge deformities. Maintaining the natural shape of the bone, removing dead space, lowering the risk of postoperative infection, and enhancing both hard and soft tissue healing are the basic objectives of bone replacement treatments. Tooth loss is one of the most frequent causes of bone insufficiency. The lack of stimulation from periodontal ligament (PDL) fibers causes the alveolar bone to resorb quickly after extraction. Bone volume and density are reduced as a result of this lack of stimulation. The pneumatization of the maxillary sinus after tooth loss, which further decreases the amount of bone accessible for operations like dental implants, is a common case.

Using material from the patient's own body, another human donor, an animal source, or synthetic alternatives, bone grafting is a surgical procedure used to restore missing or insufficient bone. The ability of bone tissue to fully regenerate given enough room and the right biological conditions is one of its special qualities. Newly generated bone gradually replaces the transplant material over time, creating a completely integrated and functional bone structure.

Grouping Bone Grafts according to Material Types

Based on the kind of material utilized, bone transplants can be divided into multiple groups:

- a. Bone grafts derived from allografts: These human donor-derived grafts can be utilized either by themselves or in conjunction with other substances. They are frequently processed and kept in banks of bones. Products like OrthoBlast and Grafton are two examples.
- b. Bone grafts based on factors: Natural or recombinant growth agents that promote bone development are used in these transplants. Transforming growth factor-beta (TGF- β), platelet-derived growth factor (PDGF), fibroblast growth factors (FGF), and bone morphogenetic proteins (BMPs) are significant examples.
- c. Bone grafts based on cells: These create new bone tissue by using living cells, especially mesenchymal stem cells. To improve bone regeneration, the cells can be employed either by themselves or sown into a scaffold.
- d. Ceramic-based alternatives to bone grafts: These consist of substances like bioactive glass, calcium phosphate, and calcium sulfate. They can be taken on their own or in combination with other drugs. OsteoGraf, ProOsteon, and OsteoSet are a few examples.
- e. Bone grafts made of polymers: These may involve natural or manufactured polymers that are either non-biodegradable or biodegradable. To enhance their qualities, they are frequently mixed with other materials. Porous polylactic acid is one example.

Bone Grafting's Biological Mechanisms

Three primary biological processes are necessary for bone grafting to be successful:

Osteoconduction

When the graft material serves as a scaffold to promote the development of new bone, osteoconduction takes place. New bone is formed along the graft surface by osteoblasts that migrate from

the surrounding bone. For any graft material, this is the most fundamental prerequisite

Osteoinduction

In osteoinduction, undifferentiated progenitor cells are stimulated to develop into osteoblasts, which subsequently create new bone. Important mediators of this process are bone morphogenetic proteins (BMPs). Osteoinductive grafts speed up bone integration and repair.

Osteopromotion

Without actually causing the production of new bone, this procedure improves osteoinduction. Derivatives of the enamel matrix, for instance, can improve the efficacy of osteoinductive grafts but are unable to promote bone development on their own.

Osteogenesis

Osteogenesis is the process by which living osteoblasts found in the graft material directly create new bone. Autografts are very effective because of this characteristic.

Types and Sources of Tissue

Autograft

Autografts come from the same recipient. The mandibular ramus, mandibular symphysis, and iliac crest are typical donor locations. Because of their osteoconductive, osteoinductive, and osteogenic qualities, these grafts are regarded as the gold standard. There is also little chance of immunological rejection. However, the risk of complications and discomfort following surgery is increased when a second surgical site is required.

Allografts

Allografts come from a different human donor, typically a corpse. They undergo processing that preserves vital proteins while eliminating cells and lowering immunogenicity. Fresh-frozen bone, freeze-dried bone allograft (FDBA), and demineralized freeze-dried bone allograft (DFDBA) are examples of allograft types.

Demineralization increases osteoinductive potential by removing the mineral component while leaving growth factors in the matrix.

Xenografts

Xenografts are obtained from animals, typically bovine sources. They serve primarily as a scaffold and are widely used due to their availability and similarity to human bone structure.

Alloplastic

Alloplastic grafts are synthetic materials such as hydroxyapatite, tricalcium phosphate, calcium carbonate, and bioactive glass. Hydroxyapatite is particularly popular because of its biocompatibility, hardness, and osteoconductive properties. Some materials are fully resorbable, while others provide long-term support.

Synthetic

Advanced materials that closely mimic the nature of natural bone, such as hydrogel-hydroxyapatite composites, are used in synthetic bone grafts. Because of their biological activity and compatibility, ceramics like calcium phosphates and bioactive glass are frequently utilized. To increase their efficacy, these substances might be mixed with bone marrow aspirate, growth factors, or ions like strontium. For instance, adding strontium can boost osteoblast activity and enhance bone mineral density.

Growth

Recombinant DNA technology is used to create growth factor-enhanced grafts. Collagen and other carrier materials are mixed with proteins like BMPs in these grafts. By attaching to cell surface receptors and starting internal processes, growth factors are critical for controlling cellular activity. Gene expression, protein synthesis, and eventually bone production are the results of these processes. TGF- β ,

PDGF, FGF, and insulin-like growth factors are important growth factors.

Cellular Alternatives to Bone Grafts

In stem cell-based grafts, mesenchymal stem cells are cultured with chemicals such as β -glycerophosphate, ascorbic acid, and dexamethasone to guide their development into osteoblasts. This process is further improved by the inclusion of growth factors like BMP-2, BMP-4, and BMP-7. To enhance bone regeneration, these cells can be mixed with bioactive ceramic scaffolds.

Ceramic-Based Alternatives to Bone Grafts

One of the most popular materials for bone grafts is ceramics. Because of their osteoconductive and occasionally osteoinductive qualities, calcium phosphates, such as hydroxyapatite and tricalcium phosphate, are utilized extensively. They must be processed at high temperatures because they are brittle. Plaster of Paris, or calcium sulphate, is biocompatible and resorbable in 30 to 60 days. Nevertheless, it is not appropriate for load-bearing applications and loses mechanical strength as it deteriorates. Bone flaws can be filled with products like OsteoSet, and Allomatrix is an injectable paste made of calcium sulfate and demineralized bone matrix. Another significant substance that creates a chemical interaction with bone and is frequently utilized as an implant covering or in bone cements is bioactive glass.

Polymer-Based Alternatives to Bone Grafts

Both synthetic and natural materials are used in polymer-based grafts. While synthetic polymers like polylactic acid can be designed for controlled breakdown, natural polymers like collagen are very biocompatible. Healos, a collagen-based

composite, and Cortoss, an injectable resin utilized in load-bearing regions, are two examples.

One benefit of degradable polymers is that the body absorbs them gradually, enabling full healing without leaving any foreign substance behind.

Applications

When using dental implants to replace the edentulous portion of a missing tooth, bone grafting is most frequently utilized. In order to better fit a deficiency, bone grafts are typically either particulated or used in blocks (such as from the chin or the ascending ramus area of the lower jaw). The grafted, vascularized fibulas have been used to replace bone segments following trauma or malignant tumor invasion, as well as to restore skeletal integrity to long limb bones with congenital bone abnormalities. In order for the graft to survive and thrive when transplanted into a new host site, the periosteum and nutrient artery are typically removed with a portion of bone.

The transplanted bone usually restores the blood flow to the bone it was linked to once it is firmly in place. In addition to its primary application in dental implants, bone grafting is used to mend fractured bones that have not yet healed, fuse joints to stop movement, and fix shattered bones that have lost bone.

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