BONE GRAFT ALTERNATIVES

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INTRODUCTION

Surgeons have searched for years for suitable bone replacement materials. In 1920, F. H. Albee injected triple calcium phosphate solutions into bone defects. Experimentation and exploration have continued from this early beginning. Today, there are several bone replacement products available, including hydroxyapatite which is derived from coral, and tricalcium phosphate.

The use of a bone graft substitute offers the advantage of eliminating the need for a second surgical site. The elimination of the donor site also removes the risk of the inherent complications such as increased chance of infection, delayed healing, stress risers in the bone donor site, increased pain, and a delayed return to normal ambulation.

There are three elements of bone healing: osteoconduction, the property of providing a scaffold for bony ingrowth; osteoinduction, the stimulation of new bone growth, and osteogenesis, the actual production and growth of new bone. Holmes et al. demonstrated that Tri-calcium phosphate and hydroxyapatite possess excellent osteoconductive properties, however, they do not possess osteoinductive or osteogenesis properties. Although the ideal bone graft substitute should include all three elements, the absence of osteoinductive and osteogenerative properties has not proven to be a deterrent to the body's acceptance and use of these products.

HYDROXYAPATITES

There are two forms of coralline hydroxyapatite available, coralline hydroxyapatite porites (CHAP), and coralline hydroxyapatite goniopora (CHAG). Each is derived from a different genus of coral.

Coralline Hydroxyapatite Porites

Coralline hydroxyapatite porites, is derived from a common reef-building coral, Genus Porites, found in the South Pacific. CHAP possesses a pore size of 230 micrometers in diameter with interconnecting fenestrations of 190 micrometers in diameter. (Figure 1)

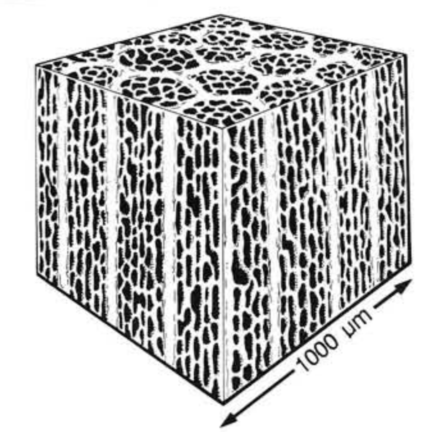

Figure 1. CHAP Coralline Hydroxyapatite Porites

The structure of CHAP is columnar, and the compressive strength is greatest in the direction against the long axis of the columns. This strength has been documented in a study by Piecuch, et al. utilizing CHAP implants in dog mandibles. Peicuch's study showed that CHAP implants gained a three-fold increase in strength in the columnar direction, and an eight-fold increase in strength in the direction perpendicular to the columnar directions. These increases in strength, measured at 24 months, were attributed to the rapid ingrowth of normal bone. CHAP has shown to be nonallergenic and non-toxic. It has also proven to be inert when not in contact with bone.

CHAP is marketed under the trade name of Interpore 200, by Interpore International, Irvine, California and is available in blocks of various sizes and shapes. CHAP is currently marketed for use in orthognathic/maxillofacial surgery, however studies have been performed inserting CHAP grafts into long bones of canines. Recommendations have also been made for its use in filling bone defects such as non-unions, bone cysts, and excised osseous tumors.

Coralline Hydroxyapatite Goniopora

Coralline hydroxyapatite goniopora (CHAG), has also been extensively researched as a bone graft substitute. (Figure 2) GHAG, also found in the South Pacific is from the Genus Goniopora. CHAG has a greater pore diameter than CHAP which makes it similar to cancellous bone. CHAG pore diameters range from 500 to 600 micrometers, with interconnecting fenestrations of 220 to 260 micrometers.

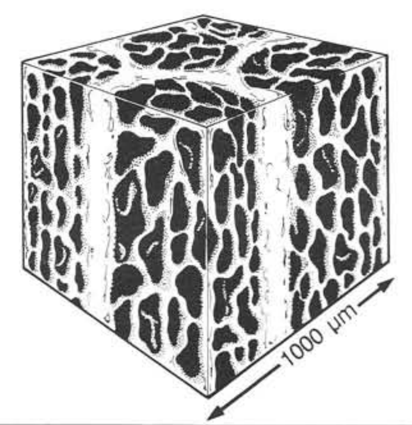

Figure 2. CHAG Coralline Hydroxyapatite Goniopora

As expected, the compressive strength of CHAG is less than that of CHAP. In its free state, CHAG's compressive strength is less than that of cancellous bone, 55% when oriented parallel to its columnar axis. However, Holmes showed CHAG's ultimate strength to be three times that of cancellous bone at six months post-implantation. Implanted cancellous bone only showed a 50% increase in strength at six months post-implantation.

CHAG's lack of elasticity makes it ideal for filling subchondral defects. It provides greater structural support, thus decreasing the chance of damage to the overlying cartilage.

CHAG is marketed by Interpore International, Irvine California under the trade name of Interpore 500. It is currently under investigation and has not yet been approved by the Food and Drug Administration.

TRICALCIUM PHOSPHATE

Tricalcium phosphate is another type of bone graft substitute. Marketed under the name Orthograft by DePuy Company of Warsaw, Indiana, tricalcium phosphate (TCP) is produced by sintering betatricalcium phosphate powder at 2000 degrees Centigrade. The particle size ranges from 0.4 to 2 micrometers and has a pore diameter of 250 to 400 micrometers. Orthograft is currently packaged in a powder form for use as filler, however, blocks and dowel forms are planned for the future.

Synthagraft, a small granular form of TCP by Miter Corporation, is approved for use in filling small periodontal defects. However, due to the larger size of orthopedic defects, research continues to show TCP is an acceptable alternative bone graft substitute.

Various studies have shown TCP to have a compressive strength comparable to cancellous bone. Like CHAP and CHAG, TCP does not possess osteoinductive or osteogenerative properties. It works by providing an osteoconductive scaffold for the ingrowth of new bone.

Clinical and radiographic results from studies using TCP in filling bone defects created by curettage of benign tumors and cysts, have shown it to be comparable to autogenous bone without the detrimental effects of the harvest. TCP is currently indicated for the filling of small and moderate sized defects of cancellous bone. Contact with host bone, good vascular supply, and an infection-free site are a must for the use of TCP, CHAP, and CHAG.

CONCLUSION

Early studies using coralline hydroxyapatite porites coralline hydroxyapatite goniopora, and tricalcium phosphate as bone graft materials have been favorable. All three materials possess osteoconductive properties that allow the ingrowth of new bone. They have proven to be bio-compatible, chemically stable, and stable to sterilization and manipulation. The use of these bone graft materials can spare the patient the inherent complications that can accompany an autogenous graft harvest.

RISK MANAGEMENT CONCERNS

As with any implanted foreign material, the surgeon must be aware of any complications that may arise from the use of these bone graft alternatives. These include, but are not limited to, rejection by the host, failure to incorporate, and, infection. However, as with any other bone graft strict adherence to accepted surgical guidelines can help decrease or eliminate these possible complications.

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