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IN VIVO OSTEOINTEGRATION OF POROUS HYDROXYAPATITE PRODUCED BY THE GELCASTING OF FOAMS

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ABSTRACT

Development of materials for bone repair has stimulated a wide field for research in the recent decades. This work describes manufacturing methods of porous ceramics which can provide suitable porous structures for tissue regeneration. Emphasis is given to foaming of ceramic suspensions and gelcasting setting with organic monomers, which yields materials of a wide range of porosity and enhanced mechanical strength. The interconnected network of macropores in foams provides the means of access for tissue in-growth while the intricate framework enables cell attachment and supports the organisation of the growing tissue. The in vivo osteointegration results of hydroxyapatite foams are presented.

Key-words: porous hydroxyapatite; gelcasting of foams; biocompatibility; rabbit tibia; bone grafts.

INTRODUCTION

Many calcium-phosphate compounds are known to be osteoconductive and can establish a physico-chemical bond to bone during the tissue regenerative process.[1] In addition, macro-porosity in these materials can promote penetration of osseous tissue and restoration of vascularity throughout the repair site, improving fixation and healing rates.[2] However, an intrinsic compromise between mechanical strength and porosity limit the extensive application of macroporous ceramics to this field. Recently, the method of gelcasting foams has shown suitability to manufacture strong and reliable macro-porous ceramics that have potential properties for bone graft applications.[3,4] The ability of a foamed structure in providing a network for tissue regeneration is shown herein through the results of *in vivo* evaluation of hydroxyapatite foams.

MATERIAL AND METHODS

Macroporous bodies of biomedical-grade hydroxyapatite (Plasma Biotal Ltd., U.K.) were produced by the gelcasting of foams method.[4] The procedure involves dispersion of the ceramic powder in aqueous medium, foaming by agitation in the presence of surfactants and

setting by the *in situ* polymerisation of acrylic monomers. The gelled bodies were dried and then sintered for matrix consolidation. Scanning electron microscopy (SEM) and mercury porosimetry were carried out for evaluation of the porous structure produced. Cylinders of 3 mm diameter of sintered HA foams were sterilised and implanted in the tibia of albino New Zealand rabbits under general anaesthetic conditions and antibiotic protection.[5] The implants were removed after a period of 8 weeks to observe the bone regenerative potential of the foams.

RESULTS AND DISCUSSION

The process of gelcasting foams is known to yield non-cytotoxic materials with optimised strength and open spherical pores, and can be applied to many raw-materials as shown in previous works.[3,4] A representative specimen of the hydroxyapatite foams tested in this work containing approximately 85% porosity is shown in Figure 1. The structure is highly porous and thoroughly interconnected. The large spherical pores of 100-500 μm and interconnecting windows of 30 and 120 μm (as measured by mercury porosimetry) are enclosed by a compact framework of polycrystalline hydroxyapatite.

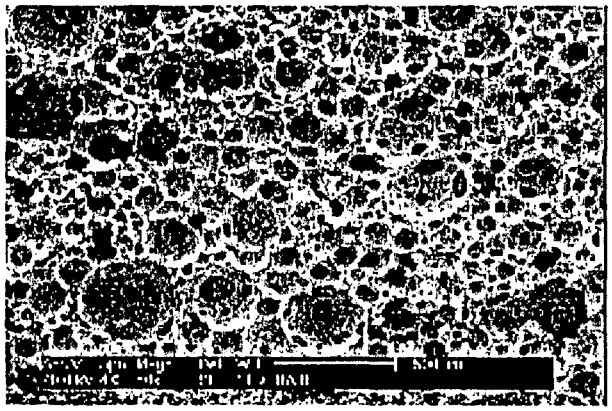

Figure 1. SEM micrograph of macro-porous hydroxyapatite manufactured by the gelcasting of foams method.

The suitability of the foam network produced with HA to promote tissue regeneration was verified by *in vivo* studies. All animals survived the 8 weeks study period without evidence of inflammation or infection at the implantation site. The results revealed that the HA foam structure was filled almost entirely with newly formed trabecular bone within the implantation period. Figure 2 illustrates bone-implant integration, with new bone filling the foam structure progressively, from areas of neighbouring old bone towards the inner part of the implant. Newly formed bone tissue at various stages of maturation were detected, with osteoids mainly present within larger pores in the foams, indicating that vascularisation is improved when interconnecting windows are larger, as expected.

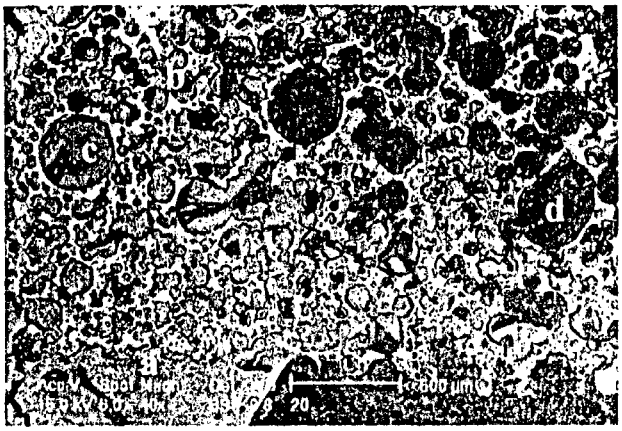

Figure 2. Cross-section showing original old bone (in a) in contact with a HA foam (in b) after 8 weeks of implantation. Healing is shown from the stage of pores filled with collagen (in d) at the outermost zones of the implant towards pores completely filled with trabecular bone and osteoids (in c).

CONCLUSIONS

The framework of ceramic foams provides an ideal scaffold for extensive bone ingrowth allowing good osteointegration, in this case associated with the high osteoconductive potential and high biocompatibility of hydroxyapatite compositions. The results demonstrate that the foams provide a potential structure for bone repair, and can be applied to a wide variety of compositions to suit different applications.

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