

# An in Vivo Study of a Locally-Manufactured Hydroxyapatite-based Material as Bone Replacement Material

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## Introduction

Synthetic HA has excellent biocompatibility, but it has limited application due to its low toughness and flexural strength. In order to improve the mechanical properties (impact resistance, and tensile strength), metals and other elements were added to HA. The properties of the powder precursors have been studied by controlling important parameters such as particle size and shape, particle distribution and agglomeration<sup>1</sup>. The tissue response to different materials will vary with the chemical composition and micro-and macro-structure of the synthetic material. Composites formed by HA ceramic in combination with zirconia have been proven not to produce any local or systemic adverse reactions or any cytotoxic effects in various in vivo studies<sup>2</sup>. The objective of this study is to evaluate the biocompatibility, osteoconductive and osteoinductive properties of a locally produced dense value-added HA in a rabbit model.

## Materials and Methods

The test material was a value-added dense HA in the form of blocks measuring 6mm x 6mm x 6mm

prepared by the School of Materials and Mineral Resources Engineering, Universiti Sains Malaysia. The experimental models were eight New Zealand White rabbits. Defects were created in the mandible whereby the right side was implanted with HA while the left side was left empty to act as control. Both the implant and control sites were evaluated macroscopically and histologically at 4, 12, 20, 22 weeks interval. Decalcified sections were studied under confocal laser scanning microscope.

## Results

There was no incidence of extrusion of the implanted material throughout the study period in all operated sites, neither was there superficial nor deep infection. Macroscopic examination showed that at 4 weeks the HA implant appeared fixed to the host bone edges. By 12 weeks, the margins of the HA implant appeared resorbed in some areas. By 22 weeks, the HA block was not visible. Bone formation and maturation in the implant site was ahead of the control site at all the time intervals of 12, 20 and 22 weeks. Bone deposition was found at the bone implant interface with the earlier and

less mature stages of bone development being found towards the centre of the implant. At 22 weeks, the implanted defect showed mature bone formation filling almost the whole field.

## Discussion

Chemical composition, physical form, and appropriate application are good starting points when evaluating any new biomaterial for potential use<sup>3</sup>. The material under investigation is a locally produced dense HA zirconium ceramic. The present study is therefore a preliminary study into the biocompatibility and the ability of this material to induce bone formation. The study demonstrated that the dense HA blocks exhibit excellent biocompatibility comparable to the published results. Enhancement of osteoconduction in the implant group was evident by the presence of abundant capillaries, perivascular tissue and osteoprogenitor cells of the host accounting for the new bone filling the gap and remodelling taking place. Bone ingrowth into the implant was evident as early as

4 weeks, when the specimen was viewed by topography. The pattern of new bone growth beginning with an ingrowth of cellular loose connective tissue, which is replaced later by a dense connective tissue and matured bone, indicates the osteoconductive property of the implant material. However, it is difficult to confirm osteoinduction, which would be better studied in undecalcified sections. Some researchers suggest that a more desirable bioresorbable implant would be one that would allow for initial permeation and maturation of bone, followed then by resorption and replacement of the implant on the assumption that this type of pattern would allow for increased strength and/or stability at the implant site during the longer healing period<sup>4</sup>. The material in this study showed similar characteristics and this would probably indicate its use in load-bearing clinical situations. From this preliminary in vivo histological study, it appears that this locally manufactured dense HA block has the potential to be a valuable replacement material.

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