

Fabrication of porous carbonate apatite and its *in vivo* evaluation

Kunio Ishikawa, Nguyen Xuan Thanh Tram, Kanji Tsuru

Department of Biomaterials, Faculty of Dental Science, Kyushu University

Introduction:

B-type CO_3Ap , which is the apatite found in bone, is known to be fabricated based on the compositional conversion using precursors such as calcium carbonate and α -tricalcium phosphate (α -TCP: $\alpha\text{-Ca}_3(\text{PO}_4)_2$). CO_3Ap was found to be resorbed by osteoclast and replaced to bone similar to autograft. Since replacement of CO_3Ap to bone is done by the osteoclastic and osteoblastic cells, interconnected porous CO_3Ap is desired for quicker replacement to bone. We have previously reported that CO_3Ap foam can be prepared using polyurethane foam as template. However, mechanical strength of the CO_3Ap foam was weak due to its too high porosity (95%).

In the present method porous CO_3Ap was fabricated using polyurethane foam as porogen.

Methods:

Polyurethane foam was used as porogen. Some polyurethane foam was coated with polyurethane to regulate the diameter of the polyurethane strut. The polyurethane foams were filled with $\text{Ca}(\text{OH})_2$ and heated at 700°C under CO_2/O_2 atmosphere. Porous CaCO_3 thus prepared was then immersed in Na_2HPO_4 solution for compositional transformation based on dissolution-precipitation.

Composition was analyzed using XRD, FT-IT and CHN analysis. Mechanical strength was evaluated by means of compressive strength. Structure was confirmed by SEM and $\mu\text{-CT}$.

The cylindrical shaped porous CO_3Ap and hydroxyapatite (HAp) foams were implanted in the tibia of 17wks rabbits, and evaluated by means of $\mu\text{-CT}$.

Results and discussion:

Strut of the polyurethane foams became larger with polyurethane coating as shown in Fig. 1. As a result, the pore size of porous CO_3Ap became larger when polyurethane coated polyurethane foam was employed.

Composition of the porous CaCO_3 was found to convert to CO_3Ap keeping its macroscopic structure by immersing in Na_2HPO_4 solution. FT-IR spectra confirmed the formation of B-type CO_3Ap in which PO_4 is replaced by CO_3 , and is the CO_3Ap found in bone. Carbonate contents of the CO_3Ap was approximately 11mass%, and was independent to the presence and absence or the number of polyurethane coating. The compressive strength of the porous CO_3Ap (5MPa for non coating) was much higher than CO_3Ap foam and decreased with the increase in the strut diameter as shown in Fig. 2.

Fig. 3 summarizes the μCT images when porous CO_3Ap and HAp were implanted in rabbit tibia. In the case of porous HAp, no significant change in its structure was observed at least within 12 months. In contrast, porous CO_3Ap was resorbed gradually with time and replaced to bone.

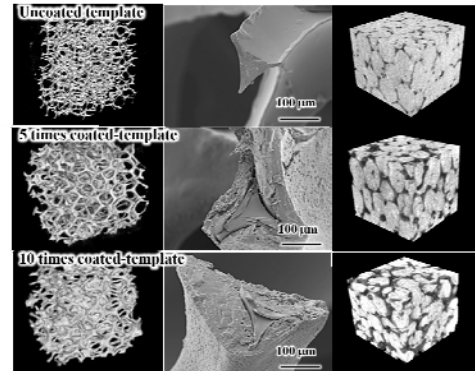


Fig. 1 SEM images of the polyurethane foam and porous CO_3Ap fabricated using the polyurethane foams as porogen.

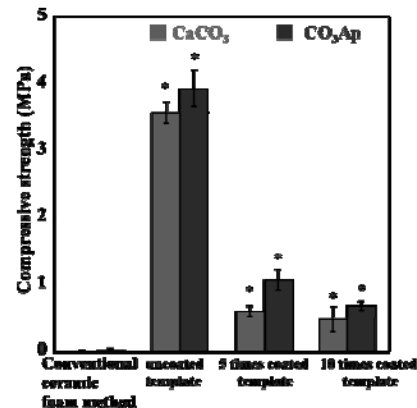


Fig. 2 Compressive strength of CO_3Ap foam and porous CO_3Ap along with their precursor CaCO_3 .

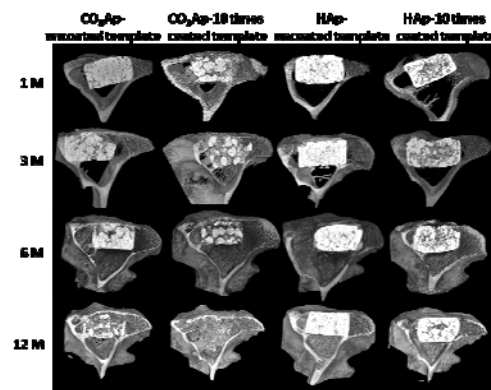


Fig. 3 The μCT images of the porous CO_3Ap and HAp with different pore size when implanted in rabbits tibia for up to 12 months.

Conclusion: CO_3Ap will be replaced with bone whereas HAp keep its structure in bone. Porous structure was found to be an important factor for the replacement of CO_3Ap to bone.