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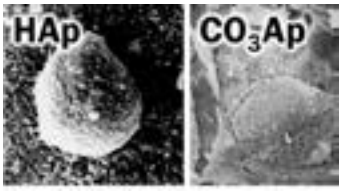
Carbonate apatite: Next generation artificial bone replacement

Although bone apatite is the carbonate apatite (CO_3Ap) that contains 6-9 wt% carbonate in apatitic structure, hydroxyapatite (HAp) has been used as one of typical artificial bone substitute since CO_3Ap powder start to decompose at 400°C, thus cannot be sintered. We have found that CO_3Ap block can be fabricated by compositional transformation though a dissolution–precipitation reaction using precursors such as calcium carbonate and tricalcium phosphate. Although HAp is not resorbed by osteoblasts, CO_3Ap thus fabricated was resorbed by osteoclasts similar to bone. As a result of osteoclastic resorption, CO_3Ap is replaced by bone whereas HAp remained as it is at the bone defects. CO_3Ap up-regulate differentiation of osteoblasts even when compared to HAp. Figure 3 show the typical Villanueva Goldner staining of HAp and CO_3Ap when used for the reconstruction of bone defect made at the beagle dog mandible. Both HAp and CO_3Ap demonstrated excellent tissue response. However, amount of the bone formed at the bone defect was much larger in the case of CO_3Ap when compared to HAp.



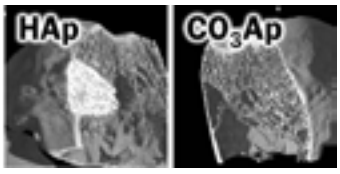


Figure 1: SEM images of HAp and CO_3Ap when osteoclastic cells were incubated on their surfaces.

Figure 2: Micro-CT images of HAp and CO_3Ap when used for the reconstruction of rabbit femur bone defect. 24 months after implantation.

Figure 3: Villanueva Goldner staining of HAp and CO_3Ap when used for the reconstruction of bone defect at the beagle dog mandible. Three months after implantation

Recent publications

1. Ishikawa K, Kawachi G, Tsuru K and Yoshimoto A (2017) Fabrication of calcite blocks from gypsum blocks by compositional transformation based on dissolution–precipitation reactions in sodium carbonate solution. Mater Sci & Eng C, 51:389–393.
2. Shariff K A, Tsuru K and Ishikawa K (2017) Fabrication of dicalcium phosphate dihydrate-coated β-TCP granules and evaluation of their osteoconductivity using experimental rats. Materials Science and Engineering C, 75:1411-1389–393.

3. Fukuda N, Tsuru K, Mori Y and Ishikawa K (2017) Effect of citric acid on setting reaction and tissue response to β-TCP granular cement. Biomed Mater, 12(1):15027.

4. Arifta T I, Munar M L, Tsuru K and Ishikawa K (2017) Fabrication of interconnected porous calcium-deficient hydroxyapatite using the setting reaction of α tricalcium phosphate spherical granules. Cerams Int, 43:11149-11155.

5. Sugiura Y, Tsuru K and Ishikawa K (2017) Fabrication of arbitrarily shaped carbonate apatite foam based on the interlocking process of dicalcium hydrogen phosphate dihydrate. J Mater Sci: Mater Med, 28:122.

Biography

Kunio Ishikawa graduated from Osaka University, Japan in 1985 and got a PhD in 1990. After he worked at Tokushima University as an Assistant Professor he then moved to Okayama University as Associate Professor. In 2001, he became Chairman and Professor of the Department of Biomaterials, Faculty of Dental Science, Kyushu University, Japan. He is also working as a Senior Special Advisor, National Institute of Science and Technology Policy, Ministry of Education, Culture, Sports, Science and Technology, Japan. His interest is in biomaterials aimed for hard tissue regeneration and reconstruction. He was awarded "The Award of Japanese Society for Biomaterials".

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