

Osteoconductive Evaluation of Alumina Hydrothermally Treated in CaCl₂ Aqueous Solution

Akari Takeuchi, Abdullah Al-Mahmood Tarique, Kanji Tsuru, Kunio Ishikawa.

Department of Chemistry, Faculty of Science, Shinshu University, Japan

Department of Biomaterial, Faculty of Dental Science, Kyushu University, Japan

Introduction: Alumina ceramics known as a bioinert material has been used as prostheses for many years because of its chemical stability, mechanical strength and fracture toughness. However, alumina ceramics cannot bond to bone directly, that causes loosening between them for a long time. In order to obtain long-term fixation of the materials and bone, surface modification techniques to change it from bioinert to osteoconductive has been awaited.

We previously documented that the hydrothermally treated alumina with CaCl₂ has high possibility to be osteoconductive material [1]. Namely, calcium ions were bound onto the alumina surface after the hydrothermal treatment, and the Ca-bonded alumina formed bone-like apatite on its surface in a simulate body fluid (SBF). To evaluate the osteoconductivity of the Ca-bonded alumina, *in vitro* biological analyses were performed in the present study using bone marrow cells.

Methods: Commercially obtained alumina disks of 10 mm in diameter were used after polishing with 0.25 μm diamond slurry. Alumina disks were immersed in distilled water or 50 mmol/L of CaCl₂ aqueous solution in Teflon vessel with stainless steel jacket. Then, it was kept 125°C for 7 days for hydrothermal treatment. After rinsed with distilled water, one of disks was analyzed by X-ray photoelectron spectroscopy (XPS) to confirm the Ca binding onto the surface. The other disks were sterilized by keeping at 180°C for cell study. Bone marrow cells harvested from rat tibias were cultured in various periods on the surface of alumina disks, and then analyzed in terms of initial cell attachment, proliferation, and bone-like nodule formation. The alumina disks without hydrothermal treatment were denoted as NT, and the alumina disks with hydrothermal treatment in distilled water or 50 mmol/L of CaCl₂aq were denoted as HT0 or HT50. Sintered hydroxyapatite (HAP) disk, that is one of osteoconductive materials, was also examined as a reference sample.

Results: Figure 1 shows XPS spectra of alumina before (NT) and after hydrothermal treatment with distilled water (HT0) or 50 mmol/L of CaCl₂ aqueous solution (HT50). Ca binding was detected only on the surface of HT50 whereas no Ca binding was detected on the other alumina disks. The initial cell attachment rate after 7 hours of culture on the surface of hydrothermally treated alumina disks was almost the same as HAP (Figure 2). The cell number on the surface of HT0 and HT50 was significantly higher than that on NT. Cells on all alumina disks proliferated greatly over 7 days of culture. After 3 days, the cell number on HT50 was significantly higher than other samples. Bone-like nodule formation was observed only on HT50 surface after 9 days culture. In

contrast, there were no differences regardless of the type of the disks after 15 days of culture. These results showed that biological properties of alumina to bone marrow cells could be significantly improved by the surface modification with Ca.

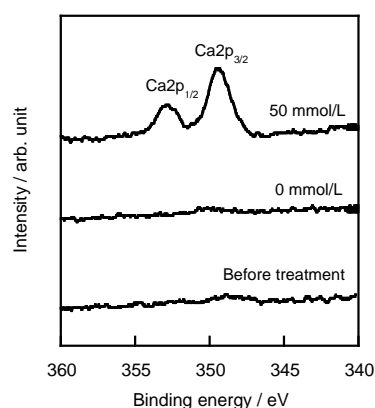


Figure 1. XPS spectra of alumina before (NT) and after hydrothermal treatment with distilled water (HT0) or 50 mmol/L of CaCl₂ aqueous solution (HT50).

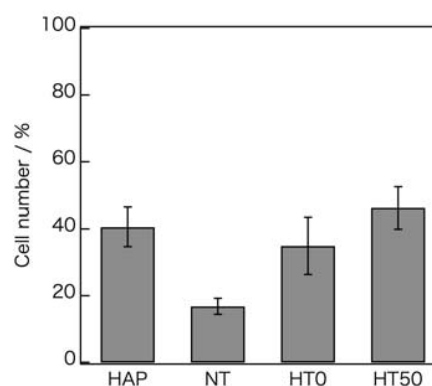


Figure 2. Initial cell attachment rate after 7 hours of culture on the surface of NT, HT0 and HT50 alumina disks. The cell attachment rate on the surface of HAP was also listed for comparison.

Conclusions: Ca-bonded alumina prepared by the hydrothermal treatment with CaCl₂ aqueous solution showed the improved biological properties against bone marrow cells. Therefore, the hydrothermal treatment of alumina with CaCl₂ aqueous solution would be promised technique to change bioinert alumina to osteoconductive material.

References: Tarique AAM, Tsuru K, Maruta M, Takeuchi A, Matsuya S, Terada Y and Ishikawa K, J Ceram Soc Japan 2010;118:512-515.