Cell activity on the alumina microgroove fabricated by micro-molding process

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Statement of Purpose: Osseointegration and cell proliferation between biomaterials and cells mainly depend on surface characteristics of biomaterials, including surface topography, charges, component and chemical state[1]. Among the surface characteristics, the topography of a surface, e.g., its micro-, submicro-, or nano-scale roughness, has been reported to significantly influence cell behavior[2-3]. And, the microgroove studies at the range of micro-scale has also been found to influence the cell behavior such as cell adhesion, alignment, morphology, proliferation, differentiation and gene expression. But these studies on microgrooved surface have been conducted mostly on titanium, silicon, glass and polystyrene. However, there have been few reports on microgrooves on ceramics and their effect. And, various techniques for fabrication of microgrooved surfaces have been developed by such as micromaching, laser cutting and photolithography. However, ceramics are generally difficult to process without cracks while keeping a high accuracy on surface detail. In this study, alumina microgroove was fabricated by the micro-molding technique via polydimethylsiloxane (PDMS) mold. By analyzing the surface characteristics and *in-vitro* test for each specimen, the relationship between the alumina microgroove created by micro-molding and the activity of MSCs was examined.

Methods: In order to manufacture the alumina slurry, alumina powder, polyvinyl alcohol (PVA), dispersant and antifoamer were mixed in D.I water and ball-milled using zirconia balls for 24hr. After ball-milled alumina slurry, the primary deformation process was performed using stirrers and a vacuum pump. Then, the alumina slurry was cast into PDMS mold which was prepared by photolithography and impression process. The secondary defoamation process was carried out to remove the pore trapped between the slurry cast and the surface of mold. The drying process was carried out in a temperature/humidity chamber maintained at a temperature of 40°C with the relative humidity of 80% for 25hr. The dried slurry was then detached from PDMS mold. The alumina specimen was sintered at 1650°C for 1hr. The surface characteristics of each specimen were analyzed using FE-SEM, CLSM, XPS and water contact angle. The activity of mesenchymal stem cells (MSCs) on microgrooved specimen was analyzed using cell adhesion, ALP activity and cell proliferation. And the relative mRNA expression of five osteo-related genes was analyzed in MSCs using quantitative real-time PCR.

Results: Figure 1 shows CLSM images of the alumina microgroove formed by the micro-molding process. Microgroove and ridge fabricated by using the micro-molding process were observed on the alumina surface with uniform width and pitch.

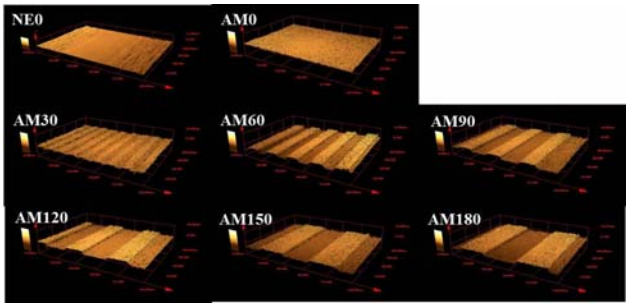

Figure 1. 3D images of the alumina microgroove created by the micro-molding process.

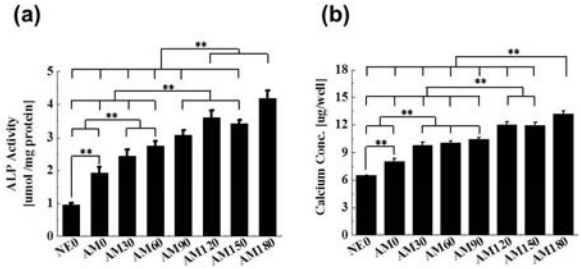

Figure 2. The results of ALP activity (a) and Ca concentration (b) for alumina microgroove created by the micro-molding process.

Figure 2 shows the results of ALP activity and Ca concentration for each specimen created by the micro-molding process. In ALP activity result (Fig-2(a)), cell activity was increased as increasing microgroove size. Especially, cell activity of AM180 surface was increased significantly than that of AM0 and NE0 surface. The results of Ca concentration were similar to the tendency of ALP activity. Ca concentration was increased as increasing microgroove size.

Conclusions: The alumina microgroove was fabricated by micro-molding process. Cell activity was increased as increasing microgroove size. This research demonstrated that cell activity was affected and improved by micro-scale grooves and theirs dimension on the alumina surface.

References:

1. Jansen JA, Adv Dent Res, 1999;13:57-66
2. Curtis A, Biomaterials, 1997;18:1573-83
3. Flemming RG, Biomaterials. 1999;20:573-88