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Functionally graded titanium implants: Characteristic enhancement induced by combined severe plastic deformation
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Abstract
Commercially pure titanium was processed by equal channel angular pressing (ECAP) and surface mechanical attrition treatment (SMAT) for the purpose of developing functionally graded titanium used for implants and a gradient structure including nanostructured, deformed and undeformed zones were produced on the samples. In particular, it was aimed to design the gradient-structure in the titanium with enhanced properties by applying 4 ECAP passes to form bulk structure of ultrafine-grains and subsequently subjecting SMAT to the surface of ECAPed samples to produce nanostructured surface region. Microstructural examination was made by electron back scatter diffraction (EBSD). Also, microhardness, nanoindentation, topography, roughness and wettability were evaluated. To examine the biological response, human osteosarcoma cells were cultured in contact with the samples in various time periods and morphology change, cell viability and alkaline phosphate activity were conducted also cell morphology was monitored. EBSD showed development of ultrafine-grained structure after 4 passes of ECAP with an average grain size of 500 nm. Applying SMAT resulted in additional refinement in the ECAP samples, particularly in the subsurface regions to a depth of 112 μm. Furthermore, the SMATed samples showed an enhancement in roughness, wettability and hardness magnitudes. Viability enhanced up to 7% in SMATed + ECAPed sample, although the acceptable cell adhesion, improved cell differentiation and mineralization were seen. The combined use of ECAP and SMAT has shown a good potential for optimizing the design of modern functionally graded medical devices and implants. © 2019 Attarilar et al.

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