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Investigation of Alumina Membrane Coated Titanium Implants on Osseointegration

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Abstract : In order to obtain an effective integration between an implant and a bone, implant surfaces should have similar properties to bone tissue surfaces. Especially mimicry of the chemical, mechanical and topographic properties of the implant to the bone is crucial for fast and effective osseointegration. Titanium-based biomaterials are more preferred in clinical use, and there are studies of coating these implants with oxide layers that have chemical/nanotopographic properties stimulating cell interactions for enhanced osseointegration. There are low success rates of current implantations, especially in craniofacial implant applications, which are large and vital zones, and the oxide layer coating increases bone-implant integration providing long-lasting implants without requiring revision surgery. Our aim in this study is to examine bone-cell behavior on titanium implants with an aluminum oxide layer (AAO) on effective osseointegration potential in the deformation of large zones with difficult spontaneous healing. In our study, aluminum layer coated titanium surfaces were anodized in sulfuric, phosphoric, and oxalic acid, which are the most common used AAO anodization electrolytes. After morphologic, chemical, and mechanical tests on AAO coated Ti substrates, viability, adhesion, and mineralization of adult bone cells on these substrates were analyzed. Besides with atomic layer deposition (ALD) as a sensitive and conformal technique, these surfaces were coated with pure alumina (5 nm); thus, cell studies were performed on ALD-coated nanoporous oxide layers with suppressed ionic content too. Lastly, in order to investigate the effect of the topography on the cell behavior, flat non-porous alumina layers on silicon wafers formed by ALD were compared with the porous ones. Cell viability ratio was similar between anodized surfaces, but pure alumina coated titanium and anodized surfaces showed a higher viability ratio compared to bare titanium and bare anodized ones. Alumina coated titanium surfaces, which anodized in phosphoric acid, showed significantly different mineralization ratios after 21 days over other bare titanium and titanium surfaces which anodized in other electrolytes. Bare titanium was the second surface that had the highest mineralization ratio. Otherwise, titanium, which is anodized in oxalic acid electrolyte, demonstrated the lowest mineralization. No significant difference was shown between bare titanium and anodized surfaces except AAO titanium surface anodized in phosphoric acid. Currently, osteogenic activities of these cells on the genetic level are investigated by quantitative real-time polymerase chain reaction (qRT-PCR) analysis results of RUNX-2, VEGF, OPG, and osteopontin genes. Also, as a result of the activities of the genes mentioned before, Western Blot will be used for protein detection. Acknowledgment: The project is supported by The Scientific and Technological Research Council of Turkey.

Keywords : alumina, craniofacial implant, MG-63 cell line, osseointegration, oxalic acid, phosphoric acid, sulphuric acid, titanium

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