

Stem Cell Fate Decision Depending on TiO₂ Nanotubular Geometry

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Abstract : In clinical application of TiO₂ implants on tooth and hip replacement, migration, adhesion and differentiation of neighboring mesenchymal stem cells onto implant surfaces are critical steps for successful bone regeneration. In a recent decade, accumulated attention has been paid on nanoscale electrochemical surface modifications on TiO₂ layer for improving bone-TiO₂ surface integration. We generated, on titanium surfaces, self-assembled layers of vertically oriented TiO₂ nanotubes with defined diameters between 15 and 100 nm and here we show that mesenchymal stem cells finely sense TiO₂ nanotubular geometry and quickly decide their cell fate either to differentiation into osteoblasts or to programmed cell death (apoptosis) on TiO₂ nanotube layers. These cell fate decisions are critically dependent on nanotube size differences (15-100nm in diameters) of TiO₂ nanotubes sensing by integrin clustering. We further demonstrate that nanoscale topography-sensing is feasible not only in mesenchymal stem cells but rather seems as generalized nanoscale microenvironment-cell interaction mechanism in several cell types composing bone tissue network including osteoblasts, osteoclast, endothelial cells and hematopoietic stem cells. Additionally we discuss the synergistic effect of simultaneous stimulation by nanotube-bound growth factor and nanoscale topographic cues on enhanced bone regeneration.

Keywords : TiO₂ nanotube, stem cell fate decision, nano-scale microenvironment, bone regeneration

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