

Cellular Driven Surface Modifications of Titanium Implants to Advance Bone Integration and Spinal Fusion

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INTRODUCTION: With current advancements in 3D printing technology, implant surface modifications can aid in osseointegration. Surface characteristics in the macro, micro and nanoscale ranges allow for texturized surfaces designed to guide bone formation through the cellular response thereby optimizing osteoconductivity. Osteoblastic differentiation favors a micro-roughness while cellular adhesion is enhanced by nano-roughness. Investigation of surface roughness complexity in vitro can predict bony on-growth in vivo. The purpose of this study is to evaluate the response of mesenchymal stem cells to titanium implants with different surface morphology (roughness). We hypothesize that there is an ideal range of roughness that will best promote both cellular adhesion and proliferation towards bony ongrowth.

METHODS: Mesenchymal stem cells were cultured onto titanium coupons. 6 surfaces (A-F) of increasing roughness were selected for this study. After allowing time for growth, representative samples from each group were fixed and imaged via SEM. Cell lysate and media were collected at 7, 14, and 21 days and assayed for viability and via ELISA for cell signaling indicators of progression toward osteocyte differentiation such as osteocalcin, interleukins (IL) 1b, 6, 8, and 10, BMPs 4 and 7, and vascular endothelial growth factor (VEG-F).

RESULTS: Cell viability tests showed that cells were able to grow on all surfaces. Electron microscopy showed cellular attachment and communication on all samples except A, and at a greater amount in the C to E range. Cell protein assays showed that cells on all surfaces were expressing important targets towards bone formation, with some surfaces showing a stronger response.

DISCUSSION AND CONCLUSION: Cellular attachment and biological response are necessary for osteoblast differentiation and bone formation. Current 3D printing technology allows for the production of implants with surface morphology that optimizes an osteopromotive biological response. The results of our study can hopefully further our understanding of the specific characteristics that optimize bone formation for implants.

