

Orthopaedic Long Bone Model for Surface Apposition on Implantable Titanium Devices

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INTRODUCTION:

Roughened titanium surfaces on orthopedic implants have been an important known surface modification that is intended to improve the performance of the implant and thus mitigate acute and long-term hardware associated complications such as pseudoarthrosis. The implantation of implants made from the same material but with differing surface finishes could give insight into implants with similar finishes. We compare the results of these different surface roughened implants in a long bone orthopedic animal model. Clinically, the use of titanium roughened surfaces on spinal implants is hypothesized to improve the success rate of spinal fusion procedures and lead to better patient outcomes.

METHODS:

The primary roughness values reported for various titanium surfaces through advanced manufacturing techniques were characterized through atomic force microscopy. Eight New Zealand White rabbits underwent bilateral femoral defect surgery with titanium implants randomized between smooth and 3D-printed roughened titanium. All analyses were performed at 8 weeks post-operatively. Radiographic analysis using microcomputed tomography quantified bone volume fractions surrounding the implants was taken at three different circumferential zones around the implant.

RESULTS:

The roughest measured surface of all the different titanium surfaces was from the 3D printed titanium. The 3D printed titanium had a primary roughness value of 41.08 micron. In comparison, the de facto grit blasted titanium surface primary roughness was measured as 0.72 micron. When compared to machined titanium dowels, the roughness of the 3D printed surface remained significantly greater. When comparing bone ongrowth, mineralization was noticeable in the interconnected pores of the printed roughened titanium implant.

DISCUSSION AND CONCLUSION:

The data on the roughened titanium surfaces includes macro-, micro-, and nanoscale features which have shown that different surface modification techniques can produce varying cell responses resulting in different levels of mineralization. Additionally, surface finishes show greater bone density surrounding the implants compared to smooth titanium even in zones greater than 500 microns from the surface of the implant. Therefore, engineered roughened titanium surfaces have been shown to promote cell growth and mineralization for clinical arthrodesis and surgical interventions that benefit patients via better apposition at the bone implant interface.

