

Title: Comparison of Different Titanium And Peek Surfaces For Implantable 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. Surface modifications are created by a number of different titanium manufacturing techniques that create a texture that promotes bone growth and integration with the surrounding bone tissue. The purpose of roughening the surface of the implant is to increase the surface area of the implant, which can improve the immediate stability and provide fixation through the implant to support arthrodesis. Immediate stabilization through an increase in primary roughness can help prevent the implant from moving or shifting, which can lead to complications aside from non-unions like implant failure, inflammation, and pain. The roughened surface of the titanium implant can be created using a variety of methods, such as sandblasting, acid etching, plasma spraying and newly developed additive manufacturing techniques. These methods create an engineered texture on the surface of the implant that can mimic the natural texture of bone tissue. This texture can encourage the growth of new bone tissue into the implant surface, which can further enhance the stability and fixation of the implant. 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 (Medyssey Spine, South Korea) were characterized through atomic force microscopy (AFM) as well as a stylus technique to measure primary roughness. In addition, to surface characterization, in vitro cell culture assays were performed on different titanium surfaces. The cellular response can vary depending on the type of surface modification used and the specific cell type being studied. However, in general, titanium surfaces that are modified to be roughened or porous have been found to enhance cell growth compared to smooth titanium surfaces. Roughened or porous titanium surfaces provide more surface area for cells to attach to and spread. This increased surface area also allows for greater diffusion of nutrients and signaling molecules that are necessary for cell growth and function. Furthermore, the roughness of the surface can promote the formation of focal adhesions, which are specialized structures that help anchor cells to the surface of the material.

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 PEEK, the primary roughness 0.67 micron.

When used as a substrate to measure cell adhesion and proliferation in a live dead test, the rougher surfaces generally resulted in more live cells indicated by the observed bioluminescence in the wells.

Discussion: The data on the roughened titanium surfaces include macro, micro and nano scale features have shown that different surface modification techniques can produce varying cell responses. Sandblasting, acid etching, and anodization have all been shown to decrease the roughness of titanium surfaces and consequently, illicit different cell responses. Additionally, the use of surface coatings, such as hydroxyapatite or collagen, can further enhance cell growth and differentiation on titanium surfaces. Therefore, engineered roughened titanium surfaces have been shown to promote cell growth and attachment depending on the primary roughness, making such surfaces potentially advantageous for clinical arthrodesis and surgical interventions that benefit patients with such endpoints

Significance/Clinical Relevance: Surface roughness plays an important role in both titanium and PEEK implantable orthopedic devices. Cell adhesion along with improved bone implant interfaces are dictated by material and surface characteristics. Long term clinical success should consider such implantable features on the fixation device.

