Preliminary Cell Culture Study of Medical Grade Beta Titanium Alloys for Next Generation Orthopaedic Applications

The word “osseointegration” was originally termed by Professor Brånemark in the late 1950s. The integration of titanium and bone was observed after the interfacial remodelling between bone and implant(1). Ideal osseointegration can be achieved if the biomaterial surface offers(2) good and tight initial adhesion (2), supports cell attachment and viability and (3) elicits a positive influence upon differentiation(2). In this study samples were heat-treated between 400°C and 700°C, and the microstructure was characterised using optical microscopy and X-ray diffraction (XRD) techniques. Results showed that recrystallisation occurred at ~700°C. A preliminary cell viability study was also conducted on the control samples. Results indicated that the samples were biocompatible as evidenced by the elongated fibroblasts attached to the surface.

Methodology

Material Characterisation

β Ti (Ti-35Nb-7Zr-6Ta) samples were pre-processed using selective sanding method to obtain consistent surface roughness. Characterisation was performed using optical microscopy and XRD to examine the surface microstructure and phase composition.

Heat Treatment

β Ti samples (4 x 3 x 2mm³) underwent HT in a furnace at varying temperatures in accordance with literature. On heating, the HT process can result in the following stages: precipitation, recovery, recrystallization and grain growth. Recovery removes the dislocations within the material’s structure. Recrystallization allows new grains to grow and replace those deformed by internal stresses.

Metallurgical Preparation

Samples were ground to achieve a consistent finish using a sandpaper grit progression of 300 - 1500. The samples were then polished using 9µm and 3µm diamond paste. The samples were chemically etched using a strengthened Kroll’s reagent; 8% hydrofluoric acid, 15% nitric acid and 77% H₂O₂ for 90 seconds.

XRD

Analysis was performed in accordance with laboratory protocol to compare the resulting spectra’s of samples that underwent HT versus the control and to determine phase composition and possible changes.

Cell Culture

Human fibroblasts 153 at passage 6 were seeded onto two control β Ti samples at 1x10⁶ cells/cm². After 24 hours (37°C and 5% CO₂) cells were stained with DAPI nucleus stain. Imaging was performed using confocal scanning laser microscopy.

References: