Using Nanotechnology to Enhance Osteoblast Proliferation and Adhesion: Comparison of Different Implantable Biologically Inert Spinal Instrumentation Materials

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Interface and colloid science has produced nanoparticles with which researchers can manipulate materials at atomic, molecular or supramolecular levels. This new and extremely small investigation of materials is broadly defined as nanotechnology. This study explores manipulation of materials used regularly in spinal fusion surgeries such as PEEK (Polyether ether ketone), Cobalt Chrome (CoCr), Titanium and Titanium Alloy by coating these surfaces with Single-Walled Carbon Nanotubes (SWCNT) and Titanium Dioxide (TiO_2) nanotubes to study the effect on osteoblast proliferation and adhesion. Based on material properties and published data by others, the hypotheses were that SWCNT would adhere better to PEEK given that PEEK is a carbon based structure, and that TiO_2 nanotubes would probably adhere best to Ti substrates given their common Ti elements. Secondly, nanotube coating may enhance osteoblast proliferation and adhesion. The experiment was run in triplicate using an established mouse osteoblast (MC3T3-E1) cell line. The results showed that the osteoblast proliferation was impeded on the SWCNT-coated CoCr substrates ($p=0.008$), yet enhanced proliferation was seen on the SWCNT-coated Ti substrates ($p=0.02$). In comparison, TiO_2 nanotube-coated Ti Alloy substrates impeded osteoblast proliferation ($p=0.011$), whereas TiO_2 nanotube-coated CoCr substrates enhanced osteoblast proliferation ($p=0.005$). Additionally, the PEEK substrates could not be stably coated with TiO_2 nanotubes. Finally, it was noted that cell morphology differed depending on the substrate used. Given the high shear and tensile strength of CoCr and its prevalent use in spinal surgery, TiO_2 nanotube coating of this material could enhance osteoblast proliferation and ultimately, spinal fusion results.

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