Name(s)

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Project Number

S2102

Project Title

Analyzing Dental Pulp Stem Cell Response to TiO2 ALD and Fused Deposition Modeling on PLA Bioscaffolds

Abstract

Objectives

With the increase in demand for tissue and organ replacement, bioscaffolds are being used to regenerate cells, serving as a foundation for them to regrow. As the biocompatibility of scaffolds is essential to cellular growth, factors that optimize their viability are being studied. Research has shown surface topography of a scaffold is a major factor in determining cellular proliferation and differentiation. In this study, surface topography of the scaffolds was altered by 1) the method of producing the scaffolds and 2) by adding materials onto the scaffold in order to analyze effects in dental pulp stem cell (DPSC) proliferation and differentiation.

Methods

The scaffolds were created with polylactic acid (PLA) using two methods: traditional molding and fused deposition modeling (FDM) with a 3D printer to change the surface topography of the scaffolds. In order to maximize plating efficiency, a thin layer of titanium dioxide (TiO2) was coated onto the scaffolds using atomic layer deposition (ALD) to create a rougher surface environment for the cells, measured by the attachment, proliferation, and differentiation of the DPSCs. Cells were cultured on 3D printed and molded scaffolds as well as with and without the titanium dioxide coating.

Results

The rougher scaffolds were predicted to have greater cell attachment and proliferation, due to greater surface area and physical resistance on the scaffolds. The results showed that the DPSCs were healthy on all of the scaffolds, with greatest biomineralization on the uncoated scaffolds. Initial testing showed TiO2 coating significantly increased cell attachment ($p<0.05$) on the printed scaffolds. However, biomineralization declined between day 28 and 35 for the TiO2-coated scaffolds, suggesting the TiO2 could've had detrimental effects. The ALP, OCN, and DSPP genes were highly expressed in the 3D printed TiO2 scaffold, showing high levels of cellular differentiation.

Conclusions

Novel bioscaffolds have been created using 3D printing and atomic layer deposition that significantly increases the surface roughness of the scaffold. The 3D printed scaffolds were shown to improve cellular attachment and differentiation, highlighting the viability of this promising technology. The TiO2 nanoparticles had positive effects initially, but ultimately had a detrimental impact on the cells, which needs further research to confirm.

Summary Statement

I created new bioscaffolds using FDM 3D printing and titanium dioxide deposition, and found that 3D printing has a significantly positive impact on cellular growth but titanium dioxide has a negative, potentially toxic, impact on cells.

Help Received

I conducted my research at Stony Brook University with supervision from Dr. Miriam Rafailovich, who helped refine my project proposal. The atomic layer deposition was done at a national laboratory, and the scanning electron microscopy of the cells was done by a university technician.