Optimization of 3D-Printed Scaffolds for Dental Pulp Stem Cell Differentiation via Surface Coating of Proteins and Titanium Dioxide

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Abstract

Addition manufacturing has proven to be effective for tailoring prostheses and bone implants for individual needs. Titanium is also known as the preferred material for orthopedics, but printing of titanium metal has proved difficult and titanium implants are not biodegradable and have to be surgically removed. This study demonstrates an alternative method, where standard plastics and PDMS are used for the Functionalizing Melting printing of an implant, but the surface is coated with titanium dioxide via atomic layer deposition (ALD). Specifically, scaffolds were printed using PLA, and then titanium coating was deposited using ALD. Following treatment was applied to the scaffolds. Dental pulp cells were then plated and incubated in nutrient media without dose to investigate different biomarkers. Scaffolds coated with collagen were incubated at 37°C for 24 h in collagen solutions, where a collagen fiber mesh, with encapsulated cells, was only observed on the ALD-coated surface. After 24 h, biocompatibility was assessed using cell viability and colony formation. The ALD-coated surface is consistent with dental deposition. This study demonstrates a promising methodology to promote stem cell differentiation for periodontal treatment.

Introduction

Stem cell therapy can contribute over 50% of the regenerative medicine market, as it presents immense potential to cure diseases at a cellular level. Research in the field of regenerative medicine has advanced dramatically, and these advances can be applied to many areas. The stem cells can be cultured in the laboratory, and their differentiation can be controlled by controlling the growth of the engineered tissue. The three main components of tissue development are the stem cells, substrate, and growth factors. Various stem cell types have been discussed in the field of tissue engineering as embryonic stem cells, adult stem cells, mesenchymal stem cells, and induced pluripotent stem cells.

Conventional bone marrow and adipose tissue include common sources of stem cells but have limited expansion capacity. These cells require special culture conditions and are difficult to expand. Dental pulp stem cells (DPSCs) are a promising alternative as they have high proliferation rate, demonstrate multilineage differentiation, and can be cultured in non-invasive methods.

The main objective of this study is to investigate the behavior of stem cells on the printed scaffolds coated with various biomolecules. We also investigated the behavior of stem cells on the printed scaffolds with ALD coating.

Methodology

PLA Scaffold Surface Roughness Analysis

PLA scaffold surface roughness analysis was conducted to determine the effects of surface roughness on cell behavior. The results showed that the roughness of the scaffold surface significantly influenced the adhesion and differentiation of DPSCs.

Results

Cell Proliferation and Plating Efficiency

Analysis of cell proliferation and plating efficiency revealed that the DPSCs proliferated effectively on the coated scaffolds. The results suggested that the coating significantly improved cell adhesion and proliferation.

Confocal Imaging Reveals Protein and Orientation

Confocal imaging analysis revealed the expression of various proteins and their orientation on the coated scaffolds. The results demonstrated that the coating effectively influenced cellular orientation and protein expression.

Biomaterialization via Raman spectroscopy analysis

Raman spectroscopy analysis was performed to assess the biomaterialization of the scaffolds. The results showed that the coating successfully promoted biomaterialization, indicating the successful incorporation of the coating into the scaffolds.

Discussion

The use of 3D-printed scaffolds coated with ALD has been shown to be effective for promoting stem cell differentiation. The coating significantly improved cell adhesion and proliferation, allowing for successful integration into the dental and bone tissues.

Conclusion

The study demonstrated that 3D-printed scaffolds coated with ALD have potential for regenerative medicine applications. These scaffolds can be further developed and refined for clinical use.

Works Cited

