



Dynamic Modeling of Fluid Flow within Three-Dimensional Perfusion Bioreactor

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Dynamic Modeling of Fluid Flow within Three-Dimensional Perfusion Bioreactor

Abstract

Three-dimensional perfusion bioreactors have been shown to enhance cell viability and function through improved nutrient exchange. However, the ideal bioreactor scaffold geometry is still unknown. The focus of this study is to use computational fluid flow studies to inform bioreactor design. Specifically, we will model the effect of bioreactor design on fluid shear stress and then correlate these values with stem cell viability in the bioreactor. Previous studies have shown that the maximum shear stress level for the viability of human mesenchymal stem cells (hMSCs) is 0.3 dynes/cm^2 . Two distinct Computer Aided Design models were created consisting of parallel planes of pillars (0.5 mm diameter, 2 mm height) in a linear array with 1 mm center to center spacing. One design consists of seven horizontal layers inserted into a 3D printed housing while the other consists of five layers encapsulated by a cylinder matching the inner diameter of silicon tubing (0.5 in). For *in vitro* testing, both scaffold designs were created by 3D printing and were coated with collagen to facilitate hMSC adhesion. To quantify results, hMSCs were harvested from the scaffolds for analyses by picogreen DNA quantification for total DNA and cell viability, and immunohistochemical markers for stem cell population maintenance. In the effort to establish a predictive model, we will compare the flow simulation results to the degree of cell proliferation in the bioreactor experiment. The significance of cell proliferation will indicate further improvements on the bioreactor design.

Keywords

Computation Flow Modeling; Bioreactor; 3D Printing

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Three-dimensional perfusion bioreactors have been shown to enhance cell viability and function through improved nutrient exchange. However, the ideal bioreactor scaffold geometry is still unknown. The focus of this study is to use computational fluid flow studies to inform bioreactor design. Specifically, we will model the effect of bioreactor design on fluid shear stress and then correlate these values with stem cell viability in the bioreactor. Previous studies have shown that the maximum shear stress level for the viability of human mesenchymal stem cells (hMSCs) is 0.3 dynes/cm². Two distinct Computer Aided Design models were created consisting of parallel planes of pillars (0.5 mm diameter, 2 mm height) in a linear array with 1 mm center to center spacing. One design consists of seven horizontal layers inserted into a 3D printed housing while the other consists of five layers encapsulated by a cylinder matching the inner diameter of silicon tubing (0.5 in). For *in vitro* testing, both scaffold designs were created by 3D printing and were coated with collagen to facilitate hMSC adhesion. To quantify results, hMSCs were harvested from the scaffolds for analyses by picogreen DNA quantification for total DNA and cell viability, and immunohistochemical markers for stem cell population maintenance. In the effort to establish a predictive model, we will compare the flow simulation results to the degree of cell proliferation in the bioreactor experiment. The significance of cell proliferation will indicate further improvements on the bioreactor design.

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