# Correlating flow induced shear stress and chondrocytes activity in micro-porous scaffold using computational fluid dynamics and rapid prototyping

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Flow induced shear stress plays an important role in regulating cell growth and distribution in scaffolds. This study sought to correlate wall shear stress and chondrocytes activity for engineering design of micro-porous osteochondral grafts based on the hypothesis that it is possible to capture and discriminate between the transmitted force and cell response at the inner irregularities. Unlike common tissue engineering therapies with perfusion bioreactors in which flow-mediated stress is the controlling parameter, this work assigned the associated stress as a function of porosity to influence in vitro proliferation of chondrocytes. D-optimality criterion was used to accommodate three pore characteristics for appraisal in a mixed level fractional design of experiment (DOE); namely, pore size (4 levels), distribution pattern (2 levels) and density (3 levels). Micro-porous scaffolds (n=12) were fabricated according to the DOE using rapid prototyping of an acrylic-based bio-photopolymer. Computational fluid dynamics (CFD) models were created correspondingly and used on an idealized boundary condition with a Newtonian fluid domain to simulate the dynamic microenvironment inside the pores. In vitro condition was reproduced for the 3D printed constructs seeded by high pellet densities of human chondrocytes and cultured for 72 hours. The results showed that cell proliferation was significantly different in the constructs ($p<0.05$). Inlet fluid velocity of 3×10-2mms-1 and average shear stress of 5.65×10-2 Pa corresponded with increased cell proliferation for scaffolds with smaller pores in hexagonal pattern and lower densities. Although the analytical solution of a Poiseuille flow inside the pores was found insufficient for the description of the flow profile probably due to the outside flow induced turbulence, it showed that the shear stress would increase with cell growth and decrease with pore size. This correlation demonstrated the basis for determining the relation between the induced stress and chondrocyte activity to optimize microfabrication of engineered cartilaginous constructs.

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