100d Elastomeric Tissue Mimetics Fabricated by a Microintegration Approach

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Porous, biodegradable scaffolds that mimic the structure and function of the native extracellular matrix have been developed utilizing a microintegration approach by which cells are integrated within an elastomeric fiber network. In order to fabricate functional cardiovascular tissue, tissue scaffolds would be ideally mechanically compliant and possess the ability to direct cellular organization. Electrospinning represents a method by which sub-micron diameter fiber scaffolds can be fabricated that resemble the scale and architecture of the extracellular matrix. By modulating the appropriate process variables, aligned fiber morphologies can be generated to influence cellular behavior. One limitation of electrospun matrices is that their inherently small pore sizes can cause conventional cell seeding methods to be challenging and time consuming. To overcome this problem we have developed a microintegration approach by which cells are seeded in tandem with the scaffold fabrication process.

Vascular smooth muscle cells (SMCs) isolated from a rat aorta were electrosprayed concurrently with the electrospinning of a poly(ester urethane)urea (PEUU). Biodegradable and cytocompatible PEUU elastomers were based on a polycaprolactone diol soft segment, 1,4-diisocyanatobutane hard segment and a putrescine chain extender. No significant decrease in cellular viability due to the fabrication process was observed. SMC microintegrated PEUU was cultured statically or in a custom designed transmural perfusion bioreactor. Greater than two-fold significantly larger cell numbers resulted from perfusion conditions compared with static conditions at both days 4 and 7 after fabrication. Aligned cellular morphologies and high cellular densities incorporated within the elastomeric fiber matrices after perfusion culture were further observed with histological and fluorescient imaging. SMC microintegrated PEUU was mechanically robust and compliant with tensile properties that varied as a function of material fabrication axis. The preferred fiber axis possessed a tensile strength 6.5 MPa and a breaking strain of 850% and the cross-preferred material axis a tensile strength of 2.0 MPa and breaking strain of 1700%. Microintegration of smooth muscle cells into a biodegradable fiber scaffold to produce elastic tissue mimetics may be ideal for fabrication of cardiovascular or other compliant tissue with orientated cellular morphologies.