

Cell-Fiber Complex as a Scaffold for the Heart Valves Tissue Engineering Produced via Electrostatic Processing

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Purpose

The goal of this work was to selectively position cells within a micro- or nanofibrous scaffold in order to produce a highly bio-mimetic scaffolding material. This cell-fiber construct was achieved through simultaneous and/or sequential electrospinning of polymer fibers and electro-spraying of cells, to entrap the cells within select areas of the matrix.

Methods

Initial studies were carried out with a single polymer/cell type construct. Poly(epsilon-caprolactone) (PCL) was electrospun from chloroform. Subsequently, human umbilical cord blood-derived endothelial progenitor cells (EPCs), recovered by culturing on fibronectin-coated tissue culture plates, were electrospayed from cell media. Later work focused on developing scaffolds with multiple cell types and polymers. To construct a biomimetic heart valve structure, outer layers of collagen electrospun from HFIP were combined with electrospayed EPCs. These collagen layers were sandwiched around an inner layer of electrospun PCL containing electrospayed mesenchymal stem cells. This allowed for the development of a scaffold consisting of two localized cell populations in a layered

multi-component polymeric scaffold. After production, mats were kept in culture conditions with DMEM media with 2% fetal bovine serum. Electrospun mats were characterized via scanning electron microscopy for fiber diameters and porosity. Cell distribution within the scaffold was identified through hematoxylin and eosin staining and visualized with light microscopy. Cells were visualized using casein-2-acetoxy methylester and cell viability was assessed using propidium iodide which labels non-viable cells.

Conclusions

Scaffolds consisting of integrated electrostatically processed polymer fibers and cells were created by a combined electrospinning/spraying approach. Cell viability was maintained through the electrospinning process and subsequent culturing. Cells were found to be well distributed through the cross section of the scaffolds. Multilayered collagen-PCL-collagen scaffolds containing endothelial cells and mesenchymal stem cells were also obtained, providing a highly organized construct similar in structure to the natural heart valve leaflet tissue.