Drop-on Demand Printing of Cell and Materials for Designer Hybrid Cardiovascular Biomaterials

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Abstract

Contractile cardiac hybrids have been fabricated by arranging alternate layers of hydrogels and mammalian cardiovascular cells according to CAD models using inkjet printers. The hybrid materials have properties that can be tailored in 3D to achieve desired porosities, mechanical and chemical properties. Alginate hydrogels with controlled microshell structures were built by spraying cross-linkers onto ungelled alginic acid using inkjet printers. Endothelial cells were seen to attach to the inside of these microshells. The cells remained viable in constructs as thick as 1 cm due to the programmed porosity. Finite element modeling was used to predict the mechanical properties and to generate CAD models with properties matching cardiac tissue. When these were printed into hybrid cardiomyocyte sheets, microscopic and macroscopic contractile function was observed. These results suggest that the printing method could be used for hierarchical design of functional cardiac patches, balanced with porosity for mass transport and structural support.

Author Biography

Thomas Boland has a BS in Chemical Engineering from the Ecole Nationale Supérieure d'Ingénieurs de Genie Chimique in Toulouse (1990) and a PhD in Chemical Engineering from the University of Washington (1995). After post-doctoral training at the Pennsylvania State University, he worked for the Naval Research Laboratory and now as Assistant Professor of Bioengineering at Clemson University. He has pioneered the use of inkjet printers to assemble cells and biomaterials into viable and functioning structures.