Research Areas

Biological Engineering

Research Interests

We are developing biologically-engineered "off-the-shelf" vascular grafts, heart valves, and vein valves. What is particularly exciting is that we have shown our material, produced by skin cells (fibroblasts), has the capacity to grow (Nature Comms, 2016) and may thus transform the treatment of pediatric congenital heart defects. The material is fabricated from entrapping fibroblasts in a biopolymer (fibrin) gel and constraining the cell-mediated gel compaction to create fibrin alignment. Bioreactors are used to create circumferentially-aligned tubes by stimulating the cells to replace the aligned fibrin with an aligned collagenous matrix, and these tubes can then be used as vascular grafts and tubular heart valves for surgical implantation. Upon decellularization, they become "off-the-shelf" non-immunogenic vessel and valve replacements that are conducive to recellularization by the host, leading to their growth capacity. Engineered human cardiac tissue that beats via entrapped iPSC-cardiomyocytes and contains a co-aligned self-assembled microvessel network has also been created in our lab using the same approach.

Our current research focuses creating transcatheter heart valves and vein valves, combining our unique tubes of cell-produced matrix with stent technology by growing the matrix tube directly on the stent, and conferring immediate or rapid hemocompatibility of the matrix using autologous stem cell and small molecule strategies.

Contact guidance -- the ability of cells to sense and aligned with aligned fibers -- is crucial to our ability to create tissues with prescribed alignment, such as the circumferentially-aligned tubes. The signal presented by aligned fibrils that cells actually sense is a longstanding open question being investigated using unique methods, including magnetic alignment and photo-crosslinking of fibrin, to systematically vary the chemical/physical signals that cells might be sensing.

Awards

- Distinguished McKnight University Professor
- Fellow of the Biomedical Engineering Society
- Fellow of the American Institute for Medical and Biological Engineering
- College Student Board Outstanding Professor in Biomedical Engineering
- Shell Land Grant Chair in Chemical Engineering & Materials Science
Selected Publications


