Simulate before you stimulate: predictive cell-based models for tissue engineering applications

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Purpose: In microfluidic tissue chips, angiogenesis processes are spatially guided by combinatorial signals such as interstitial flows and growth factor gradients. It is not always clear how endothelial cells respond to single signaling cues or a combination of signals during their organization into network patterns within hydrogels. We are developing hybrid cellular Potts models combined with a finite element approach to investigate the effect of growth factor gradients and fluid flows on microvascular network formation and organization.

Our findings: Evolution of different microvascular network types due to stimulation of VEGF growth factor gradients and interstitial flows

1. Types

2. Chemotaxis determines gradients sensitivity

3. Flow velocity and direction influences VEGF gradients

Our strategy: With this approach, our long-term aim is to include multifactorial cues such as matrix stiffness, fluid flows, multiple growth factors and cell types within a single model, to create virtual multiscale vascular networks. This provides us with valuable information that can be translated to in vitro setting, in order to create fully functional engineered tissues.