50a Microaligned Collagen Matrices by Hydrodynamic Focusing: Controlling the Alignment and pH-Induced Self-Assembly of Collagen

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The hierarchical structure and organization of type I collagen fibrils primarily determine the mechanical properties of soft tissue extracellular matrices. Collagen fiber size and alignment also impact its biological function, profoundly influencing cell morphology, migration, proliferation and gene expression. To date, there are few methods available for precisely controlling collagen self-assembly and organization on size scales similar to cells (< 50 um). The objective of this work was to create highly aligned collagen substrata to systematically determine the effects of microscale collagen alignment on cellular behavior. We developed a novel microfluidic device that combines hydrodynamic focusing with diffusive mixing (see Fig); hydrodynamic micro-shear forces aligned soluble collagen monomers and concurrent diffusive mixing allowed collagen self-assembly by neutralization of the acidic soluble collagen solution. Simulations of the hydrodynamic and diffusive phenomena predicted operating conditions for tuning collagen self-assembly, which were verified experimentally by polarized light microscopy and x-ray scattering. Current work focuses on evaluating the importance of aligned collagen structure on vascular smooth muscle cell behavior. In particular, we aim to understand how matrix structure can be tuned to control cell response and ultimately increase our ability to engineer these interactions in the design of novel biomimetic vessel replacements.