Design and Production of Customizable and Highly Aligned Fibrillar Collagen Scaffolds

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The ability to fabricate anisotropic collagenous materials rapidly and reproducibly has remained elusive despite decades of research. Balancing the natural propensity of monomeric collagen (COL) to spontaneously polymerize *in vitro* with the mild processing conditions needed to maintain its native substructure upon polymerization introduces challenges that are not easily amenable with off-the-shelf instrumentation. To overcome these challenges, we have designed a platform composed of concentric cylinders that aligns type I COL fibrils under mild shear flow and builds up the material through layer-by-layer assembly. Our material displayed fibril alignments that were comparable to fibril alignment in native tendon. We explored the mechanisms propagating fibril alignment, targeting experimental variables such as shear rate, viscosity, and time. In addition, we demonstrated that the dimensions of our device could be altered to increase the scale of the collagenous material, and that additional biomolecules could be incorporated into the material. Overall, the mechanistic insights gleaned from this study inspired the design, iteration, fabrication, and then customization of the fibrous collagenous materials, illustrating a platform material that can be readily adapted to future tissue engineering applications.