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Research paper

Fiber angle and aspect ratio influence the shear mechanics of oriented electrospun nanofibrous scaffolds

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ABSTRACT

Fibrocartilages, including the knee meniscus and the annulus fibrosus (AF) of the intervertebral disc, play critical mechanical roles in load transmission across joints and their function is dependent upon well-defined structural hierarchies, organization, and composition. All, however, are compromised in the pathologic transformations associated with tissue degeneration. Tissue engineering strategies that address these key features, for example, aligned nanofibrous scaffolds seeded with mesenchymal stem cells (MSCs), represent a promising approach for the regeneration of these fibrous structures. While such engineered constructs can replicate native tissue structure and uniaxial tensile properties, the multidirectional loading encountered by these tissues *in vivo* necessitates that they function adequately in other loading modalities as well, including shear. As previous findings have shown that native tissue tensile and shear properties are dependent on fiber angle and sample aspect ratio, respectively, the objective of the present study was to evaluate the effects of a changing fiber angle and sample aspect ratio on the shear properties of aligned electrospun poly(ϵ -caprolactone) (PCL) scaffolds, and to determine how extracellular matrix deposition by resident MSCs modulates the measured shear response. Results show that fiber orientation and sample aspect ratio significantly influence the response of scaffolds in shear, and that measured shear strains can be predicted by finite element models. Furthermore, acellular PCL scaffolds possessed a relatively high shear modulus, 2–4 fold greater than native tissue, independent of fiber angle and aspect ratio. It was further noted that under testing conditions that engendered significant fiber stretch, the aggregate resistance to shear was higher, indicating a role for fiber stretch in the overall shear response. Finally, with time in culture, the shear modulus of MSC laden constructs increased, suggesting that deposited ECM contributes to the construct shear properties. Collectively, these findings show that aligned electrospun PCL scaffolds are a promising tool for engineering fibrocartilage tissues, and that the shear properties of both acellular and cell-seeded formulations can match or exceed native tissue benchmarks.

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