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Micro-mechanical model for the tension-stabilized enzymatic degradation of collagen tissues THAO NGUYEN, Mechanical Engineering, Johns Hopkins University, JEFFERY RUBERTI, Department of Bioengineering, Northeastern University — We present a study of how the collagen fiber structure influences the enzymatic degradation of collagen tissues. Experiments of collagen fibrils and tissues show that mechanical tension can slow and halt enzymatic degradation. Tissue-level experiments also show that degradation rate is minimum at a stretch level coincident with the onset of strain-stiffening in the stress response. To understand these phenomena, we developed a micro-mechanical model of a fibrous collagen tissue undergoing enzymatic degradation. Collagen fibers are described as sinusoidal elastica beams, and the tissue is described as a distribution of fibers. We assumed that the degradation reaction is inhibited by the axial strain energy of the crimped collagen fibers. The degradation rate law was calibrated to experiments on isolated single fibrils from bovine sclera. The fiber crimp and properties were fit to uniaxial tension tests of tissue strips. The fibril-level kinetic and tissue-level structural parameters were used to predict tissue-level degradation-induced creep rate under a constant applied force. We showed that we could accurately predict the degradation-induce creep rate of the pericardium and cornea once we accounted for differences in the fiber crimp structure and properties.

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