A micromechanical viscoelastic model for soft biological tissue

BAPTISTE COUDRILLIER, THAO D. NGUYEN, Johns Hopkins University, PROF. NGUYEN LAB TEAM — Understanding the viscoelastic behavior of soft collagenous tissue from micromechanical considerations is critical to the characterization of their physiological and pathological response. In this study, we propose to model biological tissue as an aggregate of unit cells (UC). Each UC represents two wavy parallel collagen fibrils cross-linked by intrafibrillar bridges. A fibril consists of two linear springs deforming axially, and interconnected by a linear torsional spring modeling the fibril bending rigidity. When an axial displacement is applied to the unit cell, the uncrimping and stretching of the fibrils cause the ground substance to shear and the intrafibrillar bridges to rotate. This model assumes that the time-dependent behavior of the UC is due to the viscous rotation of the bridges, which are modeled as Maxwell solids. The constitutive equation of the tissue is calculated from the orientation average of the constitutive equation of the unit cell weighted by the probability density function for unit cell distribution. The performance of the model to predict the creep response will be illustrated using the results of an inflation test performed on the human sclera.

Baptiste Coudrillier
Johns Hopkins University

Date submitted: 27 Nov 2012