The importance of considering the microstructure of soft biological tissues: A general fiber dispersion model with related analysis

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Abstract

Soft biological tissues such as artery walls are fibrous composites assembled by a matrix material and embedded families of collagen fibers. In several soft tissues the collagen fiber orientations are distributed spatially. Following the generalized structure tensor (GST) approach we briefly review a constitutive model that incorporates new structure tensors which capture non-symmetric fiber dispersion [1]. This approach is based on a bi-variate von Mises distribution of fibers involving an in-plane dispersion (tangential plane of the artery wall) and an out-of-plane dispersion, which turns out to be very much dependent on the state of disease [2]; related finite element examples are presented. It has become apparent that it is essential to consider the correct microstructure of the collagen fibers in order to describe the mechanical behavior of a variety of fibrous tissues.

Finally, based on the phase-field approach [3], we discuss an extension of this new model which is also able to describe fracture of aortic tissues; in particular, an energy-based anisotropic failure criterion is postulated. A fracture test performed on specimens obtained from a human thoracic aorta is simulated, while model parameters are obtained by fitting the experimental data to the predicted model response. Aortic dissections may occur in, e.g., the ascending or descending parts of aortas. These dissections are tears in the intima propagating to the middle layer and then in the axial direction, thus creating a false lumen. Aortic dissections are catastrophic clinical events, the underlying mechanism of which is tissue failure, one of the greatest challenges in modern medicine these days.

References

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