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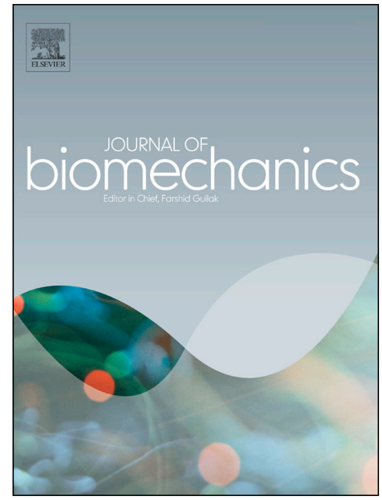

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Abstract

Aortic valve tissue exhibits highly nonlinear, anisotropic, and heterogeneous material behavior due to its complex microstructure. A thorough understanding of these characteristics permits us to develop numerical models that can shed insight on the function of the aortic valve in health and disease. Herein, we take a closer look at consistently capturing the observed physical response of aortic valve tissue in a continuum mechanics framework. Such a treatment is the first step in developing comprehensive multiscale and multiphysics models.

We highlight two important aspects of aortic valve tissue behavior: the role of the collagen fiber microstructure and the native prestressing. We propose a model that captures these two features as well as the heterogeneous layer-scale topology of the tissue. We find the model can reproduce the experimentally observed multiscale mechanical behavior in a manner that provides intuition on the underlying mechanics.

Keywords: Aortic Valve, Fiber Micromechanics, Anisotropy, Multiscale, Multiphysics

1. Introduction

Aortic valve (AV) disease is a public health concern with no effective treatment options available, due in part to our incomplete understanding of the complex biological system. Computational modeling is a promising approach for us to gain insight on AVs and to develop viable prevention and treatment modalities. However, such modeling must first accurately reproduce the known before we can use it to probe the unknown. Our focus here is to discuss critical aspects of developing a continuum biomechanical model of AV tissue that is consistent with available experimental data. This basic material specification is a fundamental building block for more complex and comprehensive AV studies, such as multiscale and multiphysics simulations.

1.1. Background

AV tissue is comprised of three layers: the fibrosa, the ventricularis, and the spongiosa. The fibrosa and the ventricularis are the main load-bearing layers and they consist of organized networks

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