Calculation of unloaded configurations for finite element simulations of patient-specific geometries with application to human common carotid artery

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Abstract

Finite element simulations of artery are significant for surgical applications. The geometry of an artery is reconstructed from medical imaging data under in vivo condition. It is loaded by the blood pressure which introduces a considerable prestress in the geometry. Calculating an unload configuration of a patient-specific geometry is one of the main challenges for biomechanical simulations since classical finite element approaches start from an unload reference configuration. Moreover, realistic material properties especially anisotropy of arterial tissue should be taken into account. Reorientations of collagen fibers in deformed configurations result in that specified material response in a patient-specific geometry differs from the realistic one fitted from stress-free specimens, but have not so far been considered in biomechanical simulations of the artery.

In the current contribution, we implement an iterative method to define the reference configuration of the patient-specific common carotid artery. In order to validate proposed method, an academic example is implemented. A polyconvex model and a new type mixed element are exploited to simulate large deformations of artery tissues. Finally, the accuracy of the proposed method is validated by comparing finite element simulations of an academic example to the result of a conventional method.

Keywords: Unloaded configuration; patient-specific geometry; anisotropy; artery.