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Patient-Specific Artery Shrinkage and 3D Zero-Stress State in Multi-Component 3D FSI Models for Carotid Atherosclerotic Plaques Based on *Ex Vivo* / *In Vivo* MRI Data

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Summary

Image-based computational models for atherosclerotic plaques have been developed to perform mechanical analysis to quantify critical flow and stress/strain conditions related to plaque rupture which often leads directly to heart attack or stroke. An important modeling issue is how to determine zero stress state from *in vivo* plaque geometries. This paper presents a method to quantify human carotid artery axial and inner circumferential shrinkages by using patient-specific *ex vivo* and *in vivo* MRI images. A shrink-stretch process based on patient-specific *in vivo* plaque morphology and shrinkage data was introduced to shrink the *in vivo* geometry first to find the zero-stress state (opening angle was ignored to reduce the complexity), and then stretch and pressurize to recover the *in vivo* plaque geometry with computed initial stress, strain, flow pressure and velocity conditions. Effects of the shrink-stretch process on plaque stress/strain distributions were demonstrated based on patient-specific data using 3D models with fluid-structure interactions (FSI). The average artery axial and inner circumferential shrinkages were 25% and 7.9%, respectively, based on a data set obtained from 10 patients. Maximum values of maximum principal stress and strain increased 349.8% and 249% respectively with 33% axial stretch. Influence of inner circumferential shrinkage (7.9%) was not very noticeable under 33% axial stretch, but became more noticeable under smaller axial stretch. Our results indicated that accurate knowledge of artery shrinkages and the shrink-stretch process will considerably improve the accuracy of computational predictions made based on results from those *in vivo* MRI-based FSI models.

keywords: Atherosclerosis; vulnerable plaques; carotid artery; blood flow; artery shrinkage; fluid-structure interactions

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