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Computational Approaches for Analyzing the Mechanics of Atherosclerotic Plaques: A Review

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Abstract. Vulnerable and stable atherosclerotic plaques are heterogeneous living materials with peculiar mechanical behaviors depending on geometry, composition, loading and boundary conditions. Computational approaches have the potential to characterize the three-dimensional stress/strain distributions in patient-specific diseased arteries of different types and sclerotic morphologies and to estimate the risk of plaque rupture which is the main trigger of acute cardiovascular events. This review article attempts to summarize a few finite element (FE) studies for different vessel types, and how these studies were performed focusing on the used stress measure, inclusion of residual stress, used imaging modality and material model. In addition to histology the most used imaging modalities are described, the most common nonlinear material models and the limited number of models for plaque rupture used for such studies are provided in more detail. A critical discussion on stress measures and threshold stress values for plaque rupture used within the FE studies emphasizes the need to develop a more location and tissue-specific threshold value, and a more appropriate failure criterion. With this addition future FE studies should also consider more advanced strain-energy functions which then fit better to location and tissue-specific experimental data.

Keywords: Atherosclerotic plaque, plaque geometry, plaque rupture, constitutive model, residual stress, image modality, finite element model

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