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THE INFLUENCE OF HYPER-ELASTIC MATERIAL PROPERTIES ON MECHANICAL STRESS IN CAROTID ARTERY PLAQUES: A 3D STRUCTURAL SIMULATION ROBUSTNESS STUDY

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Summary: Mechanical stress within carotid atherosclerotic plaques have been shown to complement traditional methods such as luminal stenosis in assessing plaque vulnerability and predicting clinical presentation. However, the sensitivity of stress predictions to the modelling strategy has not been widely assessed. The vessel structural stress (VSS) calculation may be impacted by uncertainties from a number of sources, namely: i. Image acquisition quality and parameters, ii. Image segmentation accuracy, iii. Model boundary and loading conditions, and iv. Material properties. The choice of material properties for the arterial wall and plaque components is a major uncertainty, and these cannot be directly determined using *in-vivo* methods. The aim of this study is therefore to relate the impact of the uncertainty associated with the material properties to what extent the structural stress may be considered a useful clinical biomarker based. Model reconstruction has been carried out from multi-slice, high resolution magnetic resonance *in-vivo* carotid artery images, and 1-way-FSI simulation has been performed, culminating in a solid-only simulation with pressure loading from the CFD simulation applied to the lumen wall of the solid model which includes the vessel wall and plaque components. This process was repeated using an inverse pressurisation algorithm to obtain a more accurate estimation of the 3D *in-vivo* pressurised state (see attachment). The usefulness of the stress environment to characterise plaque is assessed by computing components of the VSS at locations of interest, such as within diseased regions susceptible to rupture. The models and plaque were modelled by a modified Mooney-Rivlin Strain Energy Density Function (SEDF), with three unknown variables (see attachment).The likelihood of critically high stress within a baseline model is assessed by measuring VSS at different locations on plaque and computing the result of running a number of simulations using randomised sampling of the SEDF coefficients. In the 3D simulations, it has been shown that stress can be an important determining factor of symptomatic plaque when comparing patients with both single-sided as well as bilateral stenosis. Additionally, the uncertainty associated with material properties used to model the vessel wall can have a significant impact on the derived stress environment.