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DETERMINING MATERIAL PROPERTIES OF ARTERIAL TISSUE IN ACCORDANCE TO CONSTRAINED MIXTURE MODELING

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Summary: Arterial tissue is constantly remodeling in order to maintain homeostasis or after disease or injury. In that process, the different constituents in the tissue each renew at their own pace. For example, collagen is constantly degraded and deposited, while elastin is present from birth throughout adulthood. This results in a particular mechanical interaction, causing residual stresses in the tissue. It is often assumed that excising an arterial segment and making a radial cut, brings it to its stress-free configuration, considered as reference. However, as a transition to patient-specific modeling is occurring, this configuration is most often unknown. The use of such a stress-free reference configuration is avoided with the constrained mixture modeling approach where constituent-specific deformations are considered, as well as a physiological reference state of the artery [1].
We present a method to determine material properties of arteries in accordance to the constrained mixture theory to reliably integrate residual stresses in the modeling of arterial behavior. The material model is defined by integrating so-called deposition stretches in the Gasser-Ogden-Holzapfel hyperelastic constitutive model [2] and shifting the reference state to the arterial configuration at diastole. Material parameters are obtained in an iterative way by subsequently fitting this material definition to experimental data and determining deposition stretches. The parameter fitting is performed in Matlab by minimizing the difference between model and experimental data from biaxial or extension-inflation mechanical tests. The resulting material parameters are used in a finite element simulation in Abaqus that determines the deposition stretches, assuming that they balance out the physiological pressure and geometry.
This new parameter fitting approach is validated against constructed sets of biaxial and extension-inflation test data and tested with experimentally obtained data. The results show a clear discrepancy between material parameters compatible with the constrained mixture approach and material parameters obtained by considering a stress-free reference state.

References

[1] C. Bellini, et al. A microstructurally motivated model of arterial wall mechanics with mechanobiological implications. Ann Biomed Eng, 42:488-502, 2014.
[2] T.C. Gasser, et al. Hyperelastic modeling of arterial layers with distributed collagen fiber orientations. J Royal Soc Interface, 3:15–35, 2006.