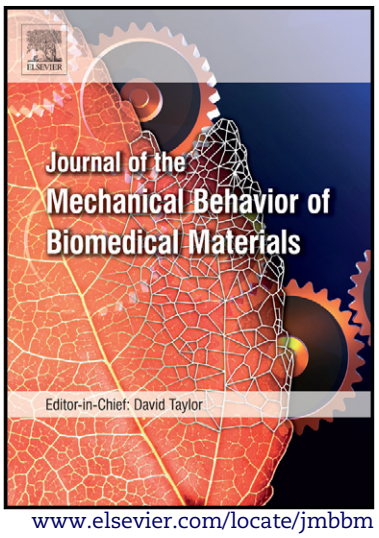

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Limiting extensibility constitutive model with distributed fibre orientations and ageing of abdominal aorta

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Abstract. The abdominal aorta is susceptible to age-related pathological changes (arteriosclerosis, atherosclerosis, aneurysm, and tortuosity). Computational biomechanics and mechanobiology provide models capable of predicting mutual interactions between a changing mechanical environment and patho-physiological processes in ageing. However, a key factor is a constitutive equation which should reflect the internal tissue architecture. Our study investigates three microstructurally-motivated invariant-based hyperelastic anisotropic models suitable for description of the passive mechanical behaviour of the human abdominal aorta at a multiaxial state of stress known from recent literature. The three adopted models have also been supplemented with a newly proposed constitutive model (limiting extensibility with fibre dispersion). All models additively decouple the mechanical response of the isotropic (elastin and smooth muscle cells represented by the neo-Hookean term) and the anisotropic (collagen) parts. Two models use exponential functions to capture large strain stiffening ascribed to the engagement of collagen fibres into the load-bearing process. The other two models are based on the concept of limiting extensibility. Perfect alignment of reinforcing fibres with two preferred directions as well as fibre dispersion are considered. Constitutive models are calibrated to the inflation-extension response adopted from the literature based on the computational model of the residually-stressed thick-walled tube. A correlation analysis of determined material parameters was performed to reveal dependence on the age. The results of the nonlinear regression suggest that limiting fibre extensibility is the concept which is suitable to be used for the constitutive description of the aorta at multiaxial stress states and is highly sensitive to ageing-induced changes in mechanical response.

Keywords: Abdominal aorta; ageing; anisotropy; constitutive modelling; limiting extensibility; strain energy density.