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Investigation of the optimal collagen fibre orientation in human iliac arteries

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Abstract

The distribution of collagen fibres plays a significant role in the mechanical behaviour of artery walls. Experimental data show that in most artery wall layers there are two (or more) in-plane symmetrically disposed families of fibres. However, a recent investigation revealed that some artery wall layers have only one preferred fibre direction, notably in the medial layer of human common iliac arteries. This paper aims to provide a possible explanation for this intriguing phenomenon. An invariant-based constitutive model is utilized to characterize the mechanical behaviour of tissues. We then use three different hypotheses to determine the ‘optimal fibre angle’ in an iliac artery model. All three hypotheses lead to the same result that the optimal fibre angle in the medial layer of the iliac artery is close to the circumferential direction. The axial pre-stretch, in particular, is found to play an essential role in determining the optimal fibre angle.

Keywords: iliac bifurcation, constitutive law, collagen fibre, fibre orientation, remodelling, pre-stretch, residual stress, total energy

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