6th European Conference on Computational Mechanics (ECCM 6)
7th European Conference on Computational Fluid Dynamics (ECFD 7)
11-15 June 2018, Glasgow, UK

A new microstructural strain energy function for the hyperelastic modelling of skin

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Keywords: *Hyperelastic, Microstructural, Skin, Collagen*

In the hyperelastic modelling of fibrous soft tissues, such as skin, we construct strain energy functions to model the anisotropic and nonlinear stress-strain behaviour that they exhibit. Phenomenological models can fit experimental data well. Parameters in microstructural models, however, are connected to the properties and arrangement of the tissue's constituents that influence the macroscopic behaviour of the tissue. Microstructural models thus enable us to understand how the tissue deforms and, potentially, to measure the values of the parameters directly in experiments [1].

We, therefore, introduce a new model that assumes that fibres of collagen, a strong fibrous protein, in the skin are crimped (i.e. wavy) according to a triangular distribution. Crimp is an important property because we assume that collagen fibres straighten as the skin is stretched, and only contribute mechanically once straightened. To test the new model, we compare its fit to four data sets of uniaxial loading on mammalian skin to those of a commonly used phenomenological model and a microstructural tendon model [1].

The new model achieves the closest relative fit to three data sets, and the phenomenological model to one. The new model achieves a closer fit than the tendon model for each data set. The tendon model also outperforms the phenomenological model for three data sets. The number of fit parameters in the new model is then reduced to that of the phenomenological model. The new model still produces a better fit than the phenomenological model for three of the four data sets.

REFERENCES

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