Application of the time-strain superposition - Part I: Prediction of the nonlinear constant shear rate response of brain tissue

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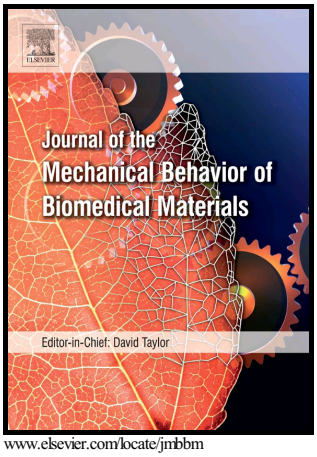

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Application of the time-strain superposition - Part I: Prediction of the nonlinear constant shear rate response of brain tissue

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KEYWORDS: brain tissue, stress relaxation, time-strain superposition, nonlinear viscoelasticity, internal-clock model, strain rate response

ABSTRACT

Modern surgical training, better understanding of the biomechanics of traumatic brain injury, and precise quantification of the difference between mechanical response of healthy and disease-modified brain tissue, require reliable experimental data and efficient mathematical/computational models.
In this paper, a new methodology is proposed for prediction of the nonlinear viscoelastic behaviour of porcine brain. Time-strain superposition is applied to the brain stress relaxation data for construction of the overall master curve. The nonlinear internal-clock viscoelastic model, which is based on the free volume concept, is utilized to predict the constant shear rate (CSR) response, based on the known stress relaxation master curve. Demonstrated theoretical procedure is evaluated on the porcine brain experimental data available from the literature.

Results show good agreement between the predicted CSR response and the previously published CSR measurements. We may justifiably speculate that the proposed approach serves well for prediction of the nonlinear CSR behaviour of the porcine brain tissue. Since the methodology is strongly supported by the physical background, it exhibits the potential to be utilized for prediction of nonlinear behaviour in other loading modes, as well as of other tissues or viscoelastic materials.

Graphical abstract

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