CHARACTERIZING PORO-VISCOELASTIC MATERIAL PROPERTIES OF BRAIN TISSUE-MIMICKING HYDROGELS

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Introduction

The biomechanical characterization of brain tissue provides important insights into the underlying mechanisms of brain injuries, cerebral pathologies and neurological disorders. In particular, the poro-viscoelastic nature of brain tissue, the interaction between fluid-induced and viscous relaxation, and the interpretation of such effects from experiments remain only partially understood. In this work, we exploited the controllable microstructure and reproducibility of a brain tissue-mimicking hydrogel to gain better insights into the poro-viscoelasticity of soft hydrated tissue.

Methods

We synthesized a composite hydrogel and compared the mechanical response to that of native brain tissue in indentation tests [1]. A model recently proposed by our groups to describe the poro-viscoelastic behavior of brain tissue was adapted to predict the behavior of the hydrogel [2,3]. We derived the water content of the mimicking material by dehydration and verified the porous microstructure by cryo-SEM imaging. An inverse parameter identification scheme was used to determine the material parameters applied [4]. Finally, we validated the model by finite element (FE) simulation of an additional experiment not used for parameter calibration.

Results

The hydrogel mimics the mechanical response of native brain tissue in the proposed indentation tests (Figure 1a). From the measured water content (≈96%) we derived the solid volume fraction of the material. With this, we have fitted the first indentation cycle of the composite hydrogel (Figure 1b). In particular, the derived value for the permeability and the associated hydraulic conductivity k with $k = 2.5 \cdot 10^{-8}$ m/s in a similar range to that reported for brain tissue. We validated the model with a FE simulation of another experiment, which demonstrated excellent agreement with the viscoelastic relaxation behavior of the experimental data (see Figure 1c).

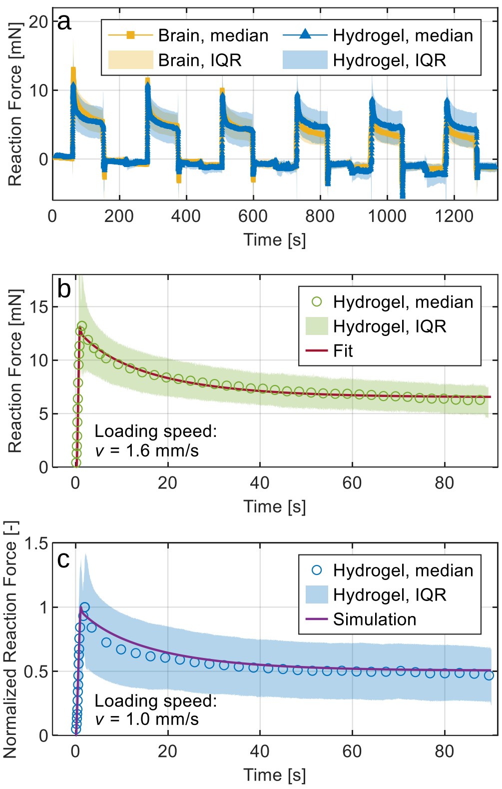

*Figure 1: **(a)** Reaction forces during indentation tests. **(b)** Fitted reaction force obtained from the parameter fit and **(c)** FE simulation with material parameters determined from the fit. Experimental dispersion is represented by the shaded interquartile ranges (IQR).*

Discussion

In the future, sensitivity analysis of the material parameters will be used together with Darcy-like hydraulic conductivity measurements to better discriminate between porous and viscous effects in brain tissue and related mimicking materials.

References

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