The behaviour of brain tissue in compression

The Behaviour of Brain Tissue in Compression

M. Hrapko, J. A. W. van Dommelen, G. W. M. Peters, and J. S. H. M. Wismans
Eindhoven University of Technology, Department of Mechanical Engineering

Introduction

Traffic accidents in the European Union lead to 40 thousand fatalities, and cause over 3.3 million injuries each year [1]. To predict the mechanical response of the contents of the head during impact finite element (FE) models are being developed (see Figure 1). Although anatomically detailed, these models lack accurate descriptions of the mechanical behaviour of brain tissue.

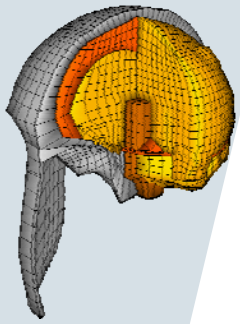

Figure 1: *FE model of the head [2].*

The purpose of this study is to determine the compressive behaviour of brain tissue and to validate a constitutive model previously developed based on shear experiments [3].

Methods

Two different compression protocols were used:

- without initial contact (protocol 1)
- with initial contact (protocol 2)

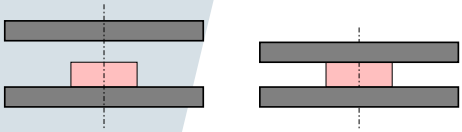

Figure 2: *left: protocol 1, right: protocol 2.*

The starting condition of the experiment was found to affect the response obtained (see Figure 3).

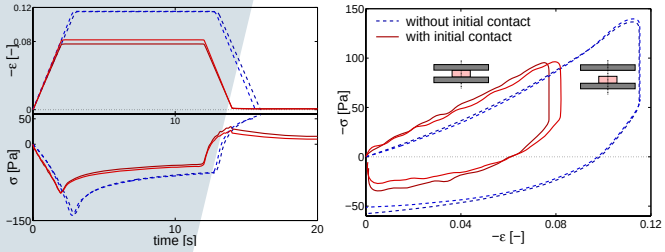

Figure 3: *Measurement results for two protocols.*

It was hypothesised that the difference is caused by the initial tensile loading in protocol 1 due to surface tension in the fluid on the surface of the sample. This hypothesis was confirmed by simulations with the constitutive model of [3], see figure 4. A non-equilibrated starting condition for the compression test was found for protocol 1.

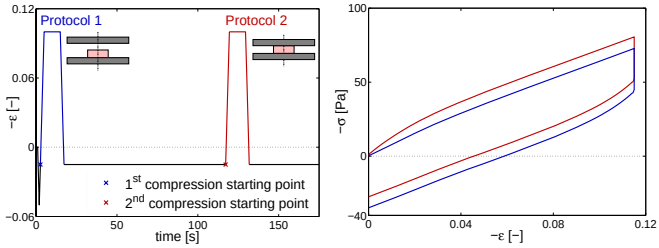

Figure 4: *Model prediction for two protocols.*

Model validation

The compression protocol with initial contact is selected to validate the constitutive model. For this purpose, shear and compression experiments are performed for the same samples, see figure 5. The model predictions for these deformation modes are given as well.

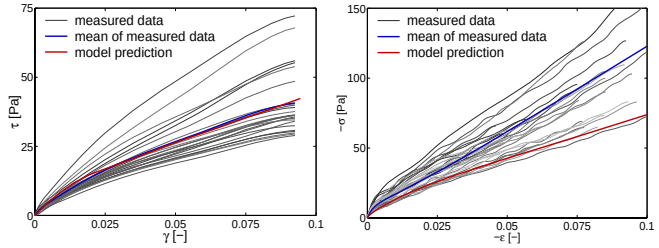

Figure 5: *Measurement results and the model prediction* ***left:*** *shear deformation* ($\dot{\gamma} = 1\ s^{-1}$)*,* ***right:*** *compression deformation* ($\dot{\lambda} = 0.04 - 0.06\ s^{-1}$)*.*

Although a reasonable prediction of the shear response was obtained, the mean of compression experiments were found to be 1.8 times stiffer (for $\varepsilon = 0.1$) than the model prediction.

Conclusions

The tissue response in compression measurements being stiffer than the model prediction suggests that a further model refinement is needed. However, first the possible effect of friction in the compression measurements is being investigated.

References:

[1] European Transport Safety Council, Exposure data for travel risk assessment, Brussels, 1999

[2] D.W.A. Brands et al., J. Biomech. 37, 2004, p. 127-134

[3] M. Hrapko et al., Biorheology, in press, 2006

PO Box 513, 5600 MB Eindhoven, the Netherlands