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Authors' response

Response to Dr. K. Miller (Re: Most recent results in the biomechanics of the brain)

We would like to thank Dr. Miller for his comments on our work. There was a typo in Fig. 7a. The unit of the vertical axis should be "Pa".

In our study, a six-term ($N = 6$) Ogden's form was used to fit the experimental data (Miller and Chinzei, 1997). When the material compressibility is neglected, the strain energy density function is expressed as

$$U = \sum_{i=1}^{N} \frac{2\mu_i}{\alpha_i^2}[\lambda_1^{\alpha_i} + \lambda_2^{\alpha_i} + \lambda_3^{\alpha_i} - 3], \quad (1)$$

where λ_i ($i = 1,2,3$) are the principal stretch ratios, α_i and $\mu_i (i = 1,\ldots,N)$ are the material parameters. In a uniaxial compression test ($\lambda_1 = \lambda_u$ and $\lambda_2 = \lambda_3 = 1/\sqrt{\lambda_u}$), the nominal stress in the stretch direction can be obtained by

$$\sigma_u = \frac{\partial U}{\partial \lambda_u} = \frac{2}{\lambda_u} \sum_{i=1}^{N} \frac{\mu_i}{\alpha_i}(\lambda_u^{\alpha_i} - \lambda_u^{-\alpha_i/2}). \quad (2)$$

The elastic material parameters were obtained by fitting the model to equilibrium stress/strain relationship, i.e. the tests performed at an extremely low loading rate. Assuming $t \to \infty$, the equilibrium elastic behavior can also be obtained from Miller and Chinzei's (2002) model by substituting $\mu = \mu_0(1-g_1-g_2)$ and $N = 1$ in Eq. (2).

The equilibrium stress/strain relationship obtained using the six-term Ogden-type model (Wu et al., 2004) agrees well with that obtained using the one-term model by Miller and Chinzei (2002) (Fig. 1). The magnitudes of the material parameters in these two models are not comparable, because one is expressed in a series form while the other has a single, integral form. It is seen from our analysis that the Ogden-type model fits well to the experimental data (Wu et al., 2004, Fig. 7a). The purpose of our study was, however, not to test if Ogden's form could fit to experimental data, but to demonstrate the effect of friction on the stress response in soft-tissue tests. The choice of the constitutive model in the analysis has no impact on the conclusion obtained in the study.

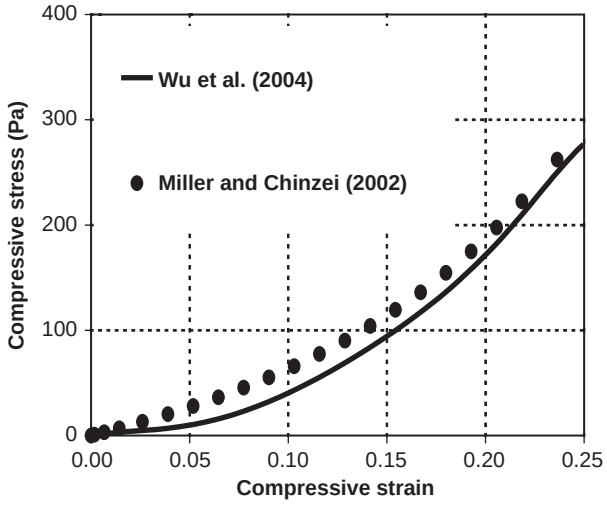

Fig. 1. Comparison of the equilibrium compressive stress/strain relationships of brain tissues predicted using two different constitutive models.

References

Miller, K., Chinzei, K., 1997. Constitutive modelling of brain tissue: experiment and theory. Journal of Biomechanics 30 (11–12), 1115–1121.

Miller, K., Chinzei, K., 2002. Mechanical properties of brain tissue in tension. Journal of Biomechanics 35 (4), 483–490.

Wu, J.Z., Dong, R.G., Schopper, A.W., 2004. Analysis of effects of friction on the deformation behavior of soft tissues in unconfined compression tests. Journal of Biomechanics 37 (1), 147–155.

John Z. Wu, Ren G. Dong, Aaron W. Schopper
National Institute for Occupational Safety and Health, 1095 Willowdale Road, Morgantown, WV 26505, USA
E-mail address: jwu@cdc.gov

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