DETERMINING THE RELATIVE MECHANICAL PROPERTIES OF GREY AND WHITE MATTER IN THE RAT SPINAL CORD
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INTRODUCTION
Finite Element (FE) models have been used to determine the relationship between strain and tissue damage in traumatic spinal cord injury [1]. Previous FE studies have used mechanical properties determined from ex vivo loading of spinal cord tissue [1], despite the variation in results from such tests [2, 3]. Furthermore, it is known that the mechanical properties of spinal cord tissue degrade rapidly after death [4]. Thus far, there has been little success in determining the mechanical properties of in vivo spinal cord tissue.

The current study aims to develop a method with which to determine the relative mechanical properties of the two primary constituent tissues in the spinal cord; the grey and white matter.

METHODS
The current study used a quasi-static, 3D FE model to recreate mild contusion-type spinal cord injuries imposed on Sprague-Dawley rats (n=5) by Bhatnagar et al [5]. MR images of the undeformed spinal cords were used to generate the initial FE meshes. The gross shapes of the experimentally deformed spinal cords were used as pseudo-displacement boundary conditions, enforced using an Iterative Closest Point algorithm. The inner portions of the spinal cords were left unconstrained, and the morphology of the predicted grey matter was compared to that of the experimentally observed grey matter. A parametric study was conducted in which the ratio of the elastic moduli between the white and grey matter (W/G) was varied and the resulting morphologies of the spinal cords were observed. The predicted and observed grey matter shapes were compared for morphological similarity using the Dice Similarity Coefficient (DSC). The grey and white matter in each spinal cord were modeled as homogeneous, isotropic, Neo-Hookean solids. W/G values of 0.5, 1.0 and 2.0 were tested for each cord, while the Poisson’s ratio was maintained at ν = 0.45.

RESULTS AND DISCUSSION
Images of the undeformed and deformed spinal cords at the injury epicenter for two specimens are presented in Figure 1 (W/G = 1.0 for both test cases).

The DSC values for each specimen are presented for W/G values of 0.5, 1.0 and 2.0 in Table 1.

For the cases in which the contusion injuries were central on the spinal cord, good qualitative agreement was seen between the predicted and observed shape of the deformed grey matter at the injury epicenter for all values of W/G. For the asymmetric contusions, the model predicts greater grey matter deformations at the mediolateral center of the cord than seen in the experimental grey matter deformations for all values of W/G. However, the model adequately predicts the deformation at the lateral edges of the grey matter. These results suggest possible heterogeneity of the spinal cord white matter. Finally, small differences were observed with changing values of W/G, as evaluated both qualitatively and using the DSC.

CONCLUSIONS
There may exist heterogeneity within the white matter in the rat spinal cord.

REFERENCES

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