

Mechanical Heterogeneity of Rat Brain Measured using a Micro-Indentation Technique

Soroush Assari, Ali Hemmasizadeh, Kurosh Darvish

Temple University, Philadelphia, PA

Abstract

Characterization of the heterogeneity of the mechanical properties of brain tissue is a fundamental step in improving our evaluations of brain deformation and tissue stresses and strains during high rate events that lead to traumatic brain injury (TBI). Recent advances in finite element models of brain tissue with sub-millimeter resolution have brought forth more attention to the heterogeneity of brain material properties. Although rat brain has been frequently used in in vivo neurotrauma studies and its heterogenous injury patterns are well characterized, little is known about its regional viscoelastic material properties. The goal of this study was to determine the local mechanical behavior of several anatomical regions of rat brain using a custom-designed micro-indentation device.

Four Sprague-Dawley rat brains were harvested after the animal was euthanized, and 2-mm coronal sections were made and kept in artificial cerebrospinal fluid at room temperature during the experiment period. A 200- μ m diameter spherical indenter was used to indent a few points in different anatomical regions including outer, middle and inner motor and sensory cortex, corpus callosum, hippocampus, alveus and thalamus. A quasilinear viscoelastic model was optimized for each region after performing stress-relaxation tests to 10% effective strain. The material parameters were calculated for four time constants of 10ms, 100ms, 1s, and 20s and compared between regions. The results showed that several anatomical regions have significantly different material properties. The results of this study can contribute to developing a heterogenous constitutive model for brain tissue and improving the predictability of TBI computational models.