Research paper

Coupled experiment/finite element analysis on the mechanical response of porcine brain under high strain rates

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ABSTRACT

This paper presents a coupled experimental/modeling study of the mechanical response of porcine brain under high strain rate loading conditions. Essentially, the stress wave propagation through the brain tissue is quantified. A Split-Hopkinson Pressure Bar (SPHB) apparatus, using a polycarbonate (viscoelastic) striker bar was employed for inducing compression waves for strain rates ranging from 50 to 750 s^{-1}. The experimental responses along with high speed video showed that the brain tissue's response was nonlinear and inelastic. Also, Finite Element Analysis (FEA) of the SHPB tests revealed that the tissue underwent a non-uniform stress state during testing when glue is used to secure the specimen with the test fixture. This result renders erroneous the assumption of uniaxial loading. In this study, the uniaxial volume averaged stress–strain behavior was extracted from the FEA to help calibrate inelastic constitutive equations.

1. Introduction

Traumatic brain injury (TBI), due to mechanical insult of the head, is a leading cause of death and life-long disability in the United States. The Center for Disease Control (CDC) has estimated that, on average, 1.4 million Americans sustain TBI every year, 20% of which are the result of motor vehicle-traffic accidents. Nearly 50,000 people die of TBI each year. Around 5.3 million Americans currently have long-term disabilities after sustaining a TBI. Some of these long-term disabilities are linked to functional changes affecting thinking, sensation, language and emotions (Langlois et al., 2006). In the United States for the year 2000 alone, direct and indirect medical costs related to TBI amounted to an estimated $60 billion (Finkelstein et al., 2006). Similar statistics of TBI resonates among most European nations as well. On an average, for every 100,000 patients hospitalized, 235 were directly a result of TBI (Tagliaferri et al., 2006). Epidemiology reports from