Abstract

Brain injury is a significant source of mortality in the US and has been an important area of research over the past century. The need to understand injury thresholds and pathology coupled with the difficulty of measuring relevant injury mechanisms in a living subject logically gives rise to the idea that researchers need to create head models for use in simulation and experimentation. This study focuses on understanding the effects of material properties, size, and shape on the dynamic response of a head model so that head models used in simulations and experiments can more accurately represent the real human head.

Using a female skull from open-source MRI data, a head model with the full geometric complexity of the skull and a simplified model were created and modal analysis was conducted over a range of material properties and scales to understand the effects of size, shape, and material properties on skull dynamics. An impact experiment was conducted on a mass-scaled simplified head model based on the MRI geometry and mounted to a biofidelic 3D printed neck model which allowed the observation of intracranial pressure in viscoelastic gelatin. Additionally, modal analysis was conducted on three head models from literature used in blast and impact experiments where intracranial pressure was measured, and the natural frequencies and volume were compared to the skull and 3D printed material models for the head formed from the MRI scans. From this work, new models can mimic real heads or materials for improved human subject representation in lab experiments, while existing surrogates can be compared dynamically, enhancing result comparisons across models and paving the way for digital manufacturing of single layered models that represent multi-layered biological models.