__Intracranial Displacements Due to Blunt Force Impact in a Post-mortem Human Surrogate Brain__

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Introduction

The prediction and prevention of mild traumatic brain injury (mTBI) is reliant on our understanding of the response of the human brain to blunt force trauma. The deformation of brain tissue is thought to be the primary mechanism of mTBI, caused by the motion and deformation of the brain in response to an impact. The use of finite element (FE) modelling is potentially an important and useful tool for the development of protective head equipment. These models require valid and accurate datasets to properly calibrate FE models however very few data sets are available to validate existing finite element models for the head and brain impacts. Anatomically specific data to describe the complex response of the brain to head impacts are needed to improve the accuracy and validity of existing models. In this study, a high-speed x-ray system and a series of optimized radiopaque markers were used to analyse the response of three post-mortem human surrogate (PMHS) brains subjected to blunt force impacts. The objective of the study was to determine (1) the relative displacement of the brain and skull, both the bulk motion as well as the response of the varying anatomical regions of the brain, (2) determine the strains that occurred in the varying anatomical regions of the brain, (3) compare the mechanical response of the brain when impacted by surfaces with different compliances.

Methodology

Radiopaque elastomeric markers were implanted into three PMHS brains, targeting 10 anatomical regions of the brain. These markers have been optimized in their stiffness, density, and spacing to reduce their interference in the deformation of brain tissue. The PMHS specimens, which were perfused and integrated with a mechanical neck were subjected to a series of blunt impacts. These impacts were conducted with a linear impactor having end caps of different compliances and at impact speeds varying from 1 m/s to 4.9 m/s. The resulting motion of the embedded markers were recorded along a parasagittal plane using a high-speed x-ray system. The anatomical locations of embedded markers were determined using MRIs, and the markers were tracked using the x-ray recordings to determine the internal relative displacements of the brain.

Results and Conclusions

The temporally resolved displacements and resulting strains of the embedded markers for three different PMHS subjects will be presented for varying impact speeds between 1 m/s to 4.9 m/s. We anticipate that the result of this work will be invaluable to the injury biomechanics community looking for additional validation data for their head injury models. In particular, additional datasets targeting specific anatomical regions of the brain will benefit the validation of the material models and boundary conditions used in modelling these regions. Improving our knowledge of the dynamic response of the brain to impact will translate into improvements in the design of protective equipment that may reduce the prevalence of mTBI.

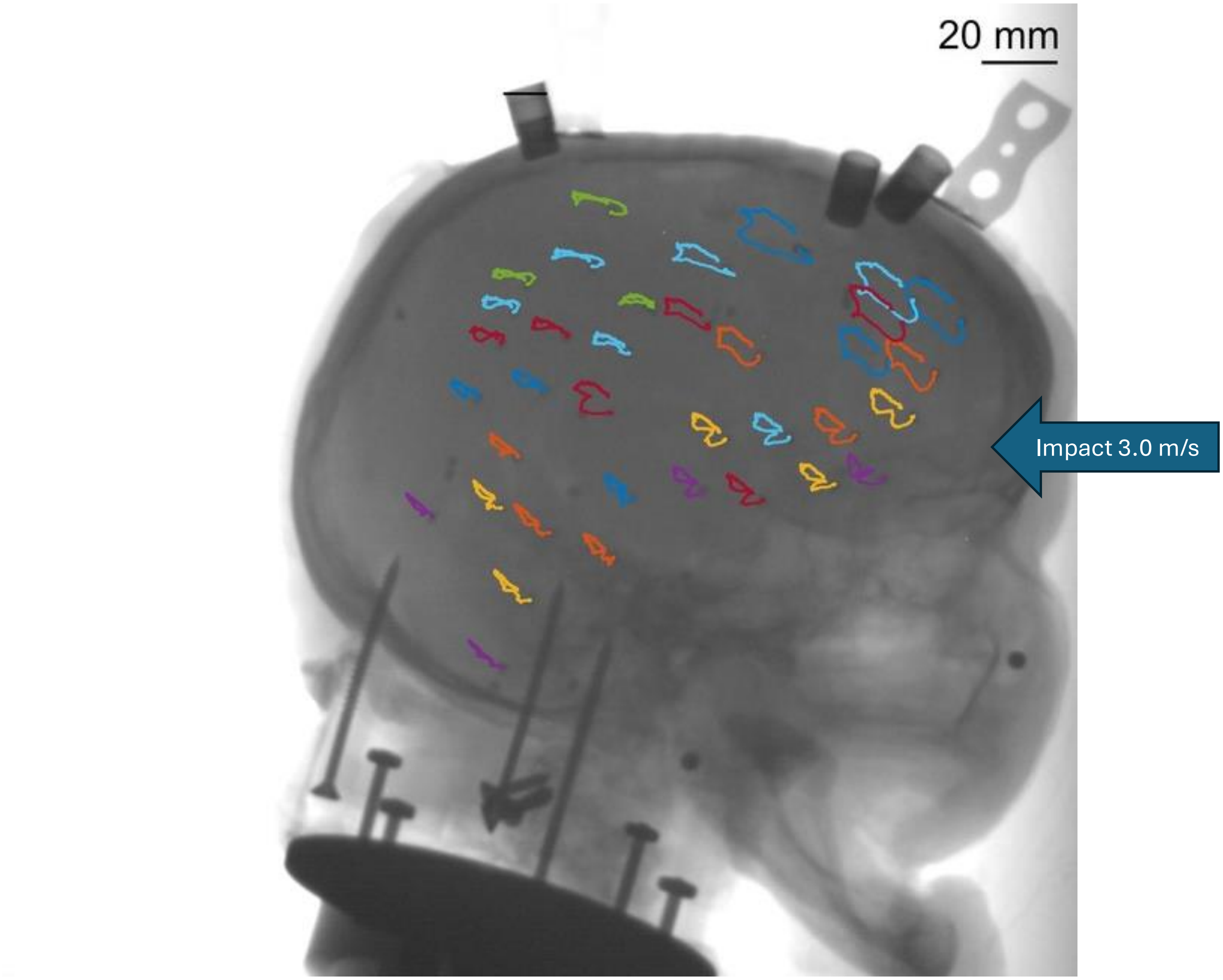

Figure 1 Displacement path of tracked markers for specimen CO-107 (3 m/s). Impactor type is low compliance MEP impactor. Marker displacement path is superimposed on X-ray image taken prior to impact using the High-speed X-Ray system. Direction and location of impact is shown.