PRESSURE RESPONSE ANALYSIS IN HEAD INJURY

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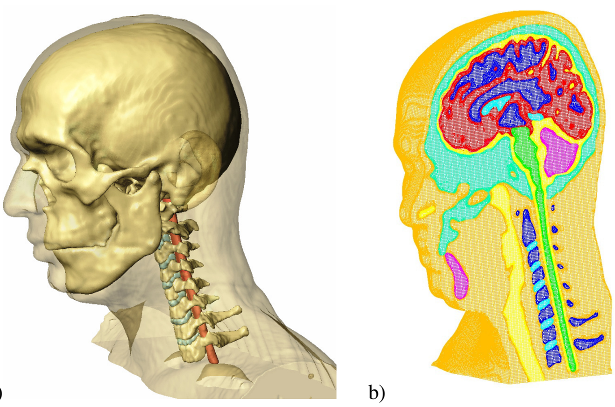
INTRODUCTION

Computational simulation technology has become an indispensable tool for researchers across the biomechanics discipline. Crucial to the effectiveness of such a tool is its ability to efficiently convert 3D images (provided typically by CT or MRI scanners) directly into highly accurate computational models [1].

In this study, analytical, numerical and experimental models were used in parallel to explore the pressure response of the human head as a result of low velocity impact. The aim of the study is to investigate whether it is possible to predict the response of the head for a particular impact scenario using these image-based modeling techniques.

DATA ACQUISITION, IMAGE SEGMENTATION AND MESH GENERATION

High resolution T1-weighted whole head MRI scans of a young male were obtained in vivo. Three-dimensional patient specific finite element models were generated from the 3D data sets using ScanIP and +ScanFE software (Simpleware Ltd., UK). 15 different structures were segmented and meshed simultaneously, i.e. brain (gray matter, white matter, brain stem, cerebellum); CSF, skull, mandible, cervical vertebrae, intervertebral discs eye (eyeball, optic nerve, fatty tissue), nasal passage, and skin (Figure 1a and b). A number of finite element models (between 2,000,000 – 10,000,000 elements) were generated based on the segmented image data. The resultant mesh was exported to LS-DYNA (LSTC - Livermore Software Technology, Corp., Livermore, CA, USA. In addition, the interface between the skin and exterior was used to define a contact surface.



a) b)

Figure 1: Head model generation: a) segmented head model in ScanIP (Simpleware); b) model loaded in LS-DYNA (LSTC).

RESULTS AND DISCUSSION

The resulting models are geometrically very accurate and were used to explore the intra-cranial response to impact. Previously developed approximate closed form analytical expressions were also used to provide additional comparison results [2]. The finite element models generated were solved using LS-DYNA. At early stages after contact a high pressure transient is observed under the site of impact which is followed by a negative pressure transient and then a high positive pressure transient as shown in Figure 2.

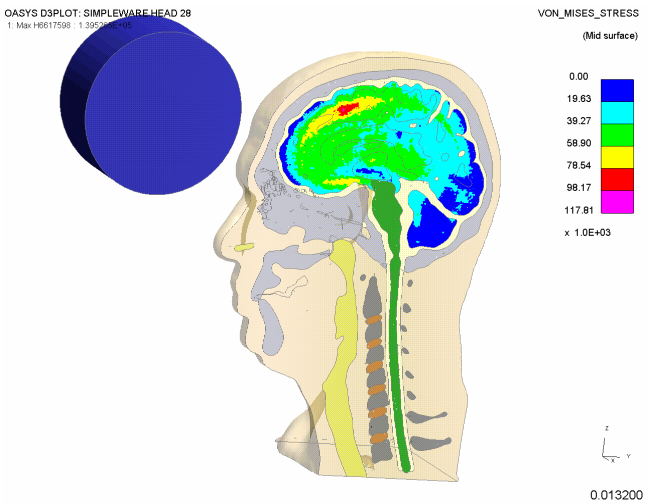


Figure 2: Impact analysis (Von Mises stress) in LS-DYNA.

CONCLUSIONS

The ability to automatically convert any 3D image dataset into high quality meshes is becoming the new *modus operandi* for anatomical analysis. The presented research demonstrates the potential of the approach for the generation of head impact models based on *in vivo* clinical scans. In spite of their complexity and sophistication, full FE simulations could be carried out on inexpensive and commonly available hardware platforms. The ease and accuracy with which models can be generated opens up a wide range of previously difficult or intractable problems to numerical analysis.

REFERENCES

1. Young, PG, et al., *Philosophical Transactions of the Royal Society A*, **366**:3155-3173, 2008.
2. Johnson, EAC, et al., *Journal of Biomechanics*, **38**:39-45, 2005.