EVALUATION OF BONE EXCISION ON OCCIPITAL AREA OF SIMULATED HUMAN SKULL

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Introduction

Surgical effects of bone and soft tissue tumours, whether for biopsy or full excision have been researched from as early as the 1970's [1]. These researches though have as main focus the biological (histological) rather the mechanical aspects of the effects [2]. With technological advances in biomedical and biomechanical modelling, a plethora of researchers have been exploring the possibilities of understanding [3] or even predicting musculoskeletal behaviour under different loading conditions [4]. This research is seeking to bridge these two different facets by looking into the mechanical effects bone tumour surgery might have to the structural rigidity of a simulated human skull.

Methods

Medical CT scans were used to create a 3D model of a patient's skull through *Simpleware ScanIP* software. These 3D models were printed in Acrylonitrile butadiene styrene (ABS) using a *Stratasys uPrint SE* printer. All brain cavities of all 6 skulls were filled with *PermaGell* to mimic the brains response and weight under loading. Prior to the mechanical testing; conducted with an *IMATEK IM10* drop tower, all skulls were coated with high contrast media and a speckle pattern to aid the high speed camera capture (*Phantom V12*) and Digital Correlation Imaging software (*Aramis*, *GOM*) capture and analyse the data.

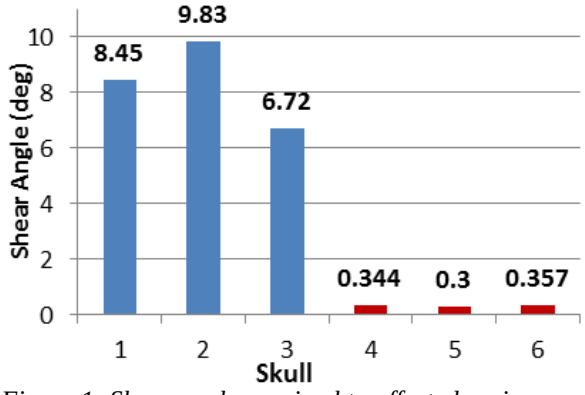

Figure 1: Shear angle proximal to affected region

Results

Two series of tests have been conducted T1 and T2 at striker velocities of 8 m/s and 9.5 m/s at 100 and 130 Joules respectively. During T1, all skulls with excision hole experienced increased shear angles (Figure 1) as well as strains when compared to the "healthy" skulls. During T2, both Skull 3 and Skull 4 failed, showing clearly 3 distinct crack paths. In both cases the cracks originated near the impact zone, where the sticker came in contact with the skull. This was true not only in the manner and sequence of the crack propagation but also in its magnitude. This is clearly shown in Figure 2.

Figure 2:Crack propagation on Skull 3 and Skull 4

Conclusions

This research highlights that the surgery performed on the patient has influenced the strain propagation and the mechanical response of the skull. Even though the hole acted as a stress raiser, the magnitude of the stresses was not enough to initiate a failure originating from the hole, but rather from the impact zone. In addition the excision hole experiences much greater strain concentration when compared to the rest of the occipital part of the skull. Although this research is patient specific, it forms the basis for further research in the effects of such surgeries, not only on the skull but also the rest of the musculoskeletal system.

References

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