

## Material Response Characterisation of a PolyJet 3D Printed Human Infant Skull

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**Abstract :** To establish a causal relationship of infant head injury consequences, this present study addresses the necessary challenges of cranial geometry and the physical response complexities of the paediatric head tissues. Herein, we describe a new approach to characterising and understanding infant head impact mechanics by developing printed head models, using high resolution clinical postmortem imaging, to provide the most complete anatomical representation currently available, and biological material response data-matched polypropylene polymers, to replicate the relative mechanical response properties of immature cranial bone, sutures and fontanelles. Additive manufacturing technology was applied to creating a physical polymeric model of a newborn infant skull, using PolyJet printed materials. Infant skull materials responses, were matched by a response characterisation study, utilising uniaxial tensile testing (1 mm min<sup>-1</sup> loading rate), to determine: the stiffness, ultimate tensile strength and maximum strain of rigid and rubber additively manufactured acrylates. The results from the mechanical experiments confirm that the polymeric materials RGD835 Vero White Plus (White), representing the frontal and parietal bones; RGD8510- DM Rigid Light Grey25 (Grey), representing the occipital bone; and FLX9870-DM (Black) representing the suture and fontanelles, were found to show a close stiffness -correlation (E) at ambient temperatures. A 3D physical model of infant head was subsequently printed from the matched materials and subsequently validated against results obtained from a series of Post Mortem Human Surrogate (PMHS) tests. A close correlation was demonstrated between the model impact tests and the PMHS. This study, therefore, represents a key step towards applying printed physical models to understanding head injury biomechanics and is useful in the efforts to predict and mitigate head injury consequences in infants, whether accidental or by abuse.

**Keywords :** infant head trauma, infant skull, material response, post mortem human subjects, polyJet printing

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