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In forensic ballistics, the impact of a bullet to the human cranium is of high interest, as the fatality rate is significantly higher when compared to bullet wounds to other body parts. Of the various cranial ballistic impact results, the measurement of retrograde spattering of the biological target material, known as backspatter, provides high forensic interest. This is due to its value as evidence during crime scene reconstruction.

Unfortunately, due to the nature of how this data is created, live human samples are not available for use. Therefore, in order to aid crime solving, it is important to have accurate models representing the human cranium to better understand backspatter mechanisms. However, modelling is made difficult by the complex anatomy and physiology of the human cranium. The cranium is a highly irregular geometric shape, composed of inhomogeneous and anisotropic biological materials. As a result, the cranium possesses a unique set of ballistic responses. The accurate encapsulation of the desired ballistic response in the models is a difficult task. To resolve this problem, development of equivalent physical and virtual models is proposed. Creating these equivalent models concurrently allows for cross-validation, controlled experimentation, and more in-depth data collection.

For the physical model development, establishment of a comprehensive comparison criterion to validate the suitability of each simulant candidate is of prime importance. This is because the ballistic response of the physical model is largely determined by the properties of the simulant materials used. Once the criterion is established, the most suitable simulants will be selected and constructed into anatomically correct physical models, with a specific interest in the skin simulant. Extensive ballistic experimentation on the anatomical model will establish a final physical model that successfully mimics the cranial ballistic response, including the backspatter.

For the virtual models, ballistic impacts will be simulated using a Smoothed Particle Hydrodynamics (SPH) method to allow conservation of mass, leading to more realistic backspatter modelling. To improve on the accuracy of the ballistic simulation, dynamic material characterisation of the physical simulants will be used to inform the virtual model. The unique advantage of the SPH model is to provide quick modification and personalization, in conjunction with comprehensive energy exchange, stress and strain data.

Both the physical and virtual models will contribute hand in hand to increase the understanding on the backspatter mechanisms, increasing the evidential value of the backspatter. This will provide a valuable resource, relating actual events in crimes scenes with the bloodstain pattern observed, thus bolstering the credibility of this form of forensic evidence in courtrooms worldwide.

Keywords: backspatter, physical cranial model, virtual cranial model, SPH, dynamic material characterization, ballistic impact modelling, modelling validation, biomechanics, forensics