Preclinical Models of Blast Injury

Morphological Characterization of the Frontal and Parietal Bones of the Human Skull

Bone specimens were collected from the frontal and parietal bones of four adult human skulls. Researchers at the Army Research Laboratory (ARL; Aberdeen Proving Ground, Maryland) characterized regional skull microstructure using micro-computed tomography (CT) at about 6-micrometer resolution to map the change of porosity as a function of the depth, P(d), from the inner surface nearest to the brain, to the outer surface nearest to the skin. A quantifiable method was developed using the measured P(d) to objectively distinguish between the three layers of the skull: the outer table, diploë, and inner table. The thickness and average porosity of each of the layers were then calculated from the measured porosity distributions. A Gaussian function was used to represent the P(d) curves. The Gaussian parameters were identified through least squares, and the values indicated the peak porosity and the relative thickness of the diploë. The results for total thickness, the thickness and average porosity of each of the layers, and the Gaussian parameters were compared between the two bone types (frontal and parietal), while accounting for skull-to-skull variability. The primary differences were that parietal bones generally had a larger diploë accompanied by a thinner inner table. The arrangement of the porous vesicular structure within the outer table was also obtained with micro-CT scans and longer scan times using enhanced parameters for higher resolution and lower noise in the images. From these scans, the porous structure of the bone appeared to be randomly arranged in the transverse plane, compared to the porous structure of the human femur, which is aligned in the loading direction. Experimental studies were initiated to understand the mechanical response of microstructurally complex and partially porous human skulls. Understanding the response of animal and human skulls will also help to understand how the observed injuries in animal blast experiments relate to injury in humans, thus helping to develop better Service member head protection systems for relevant mechanical loading.

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