Development of a Göttingen Miniature Pig Finite Element Model for Investigation of Injury Scaling Techniques

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Traumatic brain injuries (TBI) are a major cost of both money and life in the USA with about 50,000 deaths per year. Many of these injuries are due to motor vehicle collisions and they can be prevented or lessened in severity by better design of the vehicle and safety systems. To do this requires the ability to predict TBI likelihood and severity at known loading conditions. Available data on the human brain is sparse and often real world injuries are the result of complex loading, so the development of injury metrics relies heavily on animal testing. Animal testing can bridge many of the gaps in knowledge, but the kinematics must be scaled to apply the data to the human brain. However, current scaling methods are very simple, mainly based on the mass of the brain. The objective of our study was to develop finite element model of Göttingen mini-pig, which allows the response of the brain at a tissue level to be studied and compared to human finite element models. This type of pig is often used for brain studies because it has similar properties to a human brain. *In vivo* tests were conducted using mini-pigs in a translation/rotation injury device subjecting the pig skull to a linear acceleration from 40-96 g's and an angular acceleration from 1000-3800 rad/s^2. The first set of the pigs' brains were embedded with neutral density radio-opaque markers to track the motion of the brain relative to the skull with a biplanar X-ray system. A second set of pigs were tested without markers to allow for injury data to be taken with MRI scans and immunohistochemistry. A finite element model of a miniature pig brain was created from MRI and CT scans of one of the pigs. The regions of the brain were divided into white matter, gray matter, and the ventricles each with viscoelastic material properties. The impact was then simulated in LS-DYNA, and the motion of nodes closest to the marker locations was recorded and used to optimize the model. The injuries to the model brain were quantified using measures such as the cumulative strain damage measure (CSDM), that rely on the tissue level response of the model. Finally, the test conditions were applied to the Global Human Body Models Consortium (GHBMC) 50th percentile male model and the Simulated Injury Monitor (SIMon) model. Kinematics were altered in these models so that similar injury measures were seen. This allows for an empirical scaling method to be determined, so pig impact tests can be better designed to help predict injuries in humans.