Geometric Scaling Factors for the Pediatric Brainstem

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ABSTRACT

Injuries caused by motor vehicle crashes (MVCs) are the leading cause of death for children in the United States as well as the leading cause of head injury. Improved finite element models that integrated the correct shape of the pediatric brain with current injury prediction metrics would improve occupant response prediction for the pediatric occupant. The focus of this study is the improvement of geometric scaling factors for the brainstem to adapt current adult brain models to a pediatric model. The method used to assess shape change for this study was a geometric morphometric analysis technique. A sliding landmark form of a general Procrustes analysis was selected for its ability to compare curved structures with few true landmarks. The dataset consisted of fifty-nine individuals ranging in age from newborn to twenty-one years of age with groups specified at newborn, three months, six months, one year, three years, six years, ten years, fifteen years, and twenty-one years of age. Data was collected by outlining the structure on transverse and sagittal scans of magnetic resonance images and then creating a landmark dataset with a user defined number of points for each individual. Once all individuals had the same number of landmarks, bending energy calculations were completed to slide the points to positions that could be considered homologous across individuals. This analysis resulted in predicted landmark locations based on age for each age group. From this data set the dimensions of the brainstem were calculated for the predicted models. The final step was taking the dimensions of the predicted twenty-one year old model as the base and calculating a geometric scaling factor for shape, without including changes in size, for each age group. To assess the statistical significance of the process, permutation tests with 100,000 iterations were performed with resulting p-values of 0.17177 for a linear regression and 0.13467 for a quadratic regression of landmark location as a function of age.