A128 The Influence of Three-Layered Cranial Architecture Development on Non-Accidental Pediatric Cranial Blunt Force Trauma (BFT) Outcomes

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The goal of this presentation is to document ontogenetic development of the three-layered (i.e., diploe, inner, and outer table) architecture of the juvenile cranium and investigate the effect of this development on pediatric BFT outcomes.

This presentation will impact the forensic science community by providing forensic anthropologists and pathologists with an enhanced understanding of the spatial and temporal variability in the emergence of a mature cranial architecture and its response to (and, thus, risk associated with) fracture across varying regions and age groups, with important scientific applications for non-accidental BFT trauma prevention.

Approximately 75%-80% of all non-accidental pediatric deaths involve cranial BFT, disproportionately affecting decedents less than the age of one year. These typically involve subdural and retinal hemorrhage and diffuse traumatic axonal injuries, often associated with cranial fracture.[1] A number of extrinsic and intrinsic factors influence pediatric cranial fracture vulnerability, although prior research has focused on biomechanical factors associated with injury, less attention has been paid to the influence of intrinsic features of bone structure on BFT outcomes.

The neonatal cranium is unilaminar — a three-layered cranial architecture does not develop until sometime during the first or second year and a mature structure may not be present until later in childhood; however, the exact timing and mechanism of this process have not been studied on dry bone.[2] Also unknown is the effect of three-layer development on non-accidental (including repetitive) episodes of pediatric BFT.

This study has two goals. First, temporal and spatial development of the three-layered architecture in the juvenile cranium is chronicled. Second, implications of this development for cranial fracture outcomes are explored through testing of the hypothesis that the absence or lesser development of a three-layered architecture in very young subadults leaves their cranial bones thin and vulnerable to the effects of BFT compared to older subadults. Thus, regions of the pediatric cranium manifesting delayed or inadequate development of the three-layer architecture will exhibit greater vulnerability to (and thus, higher risk associated with) the mal-effects of BFT than regions with a developed three-layer structure.

Development of the three-layered cranial architecture is chronicled through macroscopic and microscopic (5x-40x) analysis of a sample of 50 juvenile crania from the Scheuer collection, ranging in age from perinatal to 17 years; 37 of the crania were below the age of 5 years. Variables recorded across the sample included age, bone, bone location, bone maximum, mean and minimum thickness, inner and outer table differentiation, and diploe presence and morphology (including thickness and pattern of diploe distribution, measured with the aid of the digital microscope). These data, including more than 300 micrographs of internal bone structure, were used to illustrate the progression and character of diploe development and generate a topographic map of cranial and diploe thickness and development across age groups. Digital macroscopic and microscopic images of cranial fracture locations from seven Radford University Forensic Science Institute cases involving non-accidental pediatric BFT were compared to the topographic map data to test the above hypothesis.

Results indicate the absence of a three-layered cranial architecture until 4-6 months of age, when initial development of diploe combined with differentiation of inner and outer tables can be noted in the posterior parietal/superior occipital. By 9-12 months, this has expanded to include other buttressed areas of the frontal and occipital crest and pterion. Development of the three-layered structure lags behind at fontanelles and sutures as well as lateral vault walls. A more mature (adult) cranial architecture pattern is not seen until 8 years of age. Although based on a small sample, comparison of forensic case fracture locations with mapped cranial fracture high-risk BFT impact regions across the growing juvenile cranium shows a concordance, supporting the above hypothesis.

These findings illustrate the importance of the growing juvenile cranium's bony architecture on BFT risk and outcome, add to the understanding of intrinsic variables which influence fracture from pediatric BFT, and offer avenues for possible preventive-based education regarding pediatric mortality.

Reference(s):

1. Case, Mary. Inflicted Traumatic Brain Injury in Infants and Young Children. *Brain Pathology.* 18 (2008): 571-582.
2. Anzelmo, Marisol; Fernando Ventrice; Jimena Barbeito-Andres; Hector Pucciarelli; Marina Sardi. Ontogenetic Changes in Cranial Vault Thickness in a Modern Sample of *Homo*. *American Journal of Human Biology.* 27 (2015): 475-485.

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