



Physical Anthropology Section - 2014

H77 Temporal Characterization of Ossification of the Crania in Australian Subadults: New Standards for Age Estimation Using Computed Tomography

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After attending this presentation, attendees will gain awareness of the ontogeny of cranial maturation, specifically the fusion timings of primary ossification centers in the basicranium and the temporal pattern of closure of the anterior fontanelle, to develop new population-specific age standards for medicolegal death investigation of Australian subadults.

This presentation will impact the forensic science community by demonstrating the potential of a contemporary forensic subadult Computed Tomography (CT) database of cranial scans and population data to recalibrate existing standards for age estimation and quantify growth and development of Australian children. This research welcomes a study design applicable to all countries faced with a paucity in skeletal repositories.

Accurate assessment of age-at-death of skeletal remains represents a key element in forensic anthropology methodology. In Australian casework, age standards derived from American reference samples are applied in light of scarcity in documented Australian skeletal collections. Currently, practitioners rely on antiquated standards, such as the Scheuer and Black compilation for age estimation, despite implications of secular trends and population variation.¹ Skeletal maturation standards are population specific and should not be extrapolated from one population to another, while secular changes in skeletal dimensions and accelerated maturation underscore the importance of establishing modern standards to estimate age in modern subadults. Despite CT imaging becoming the gold standard for skeletal analysis in Australia, practitioners caution the application of forensic age standards derived from macroscopic inspection to a CT medium, suggesting a need for revised methodologies.

Multi-slice CT scans of subadult crania and cervical vertebrae 1 and 2 were acquired from 350 Australian individuals (males: n=193, females: n=157) aged birth to 12 years. The CT database, projected at 920 individuals upon completion (January 2014), comprises thin-slice Digital Imaging and Communications in Medicine (DICOM) data (resolution: 0.5/0.3mm) of patients scanned since 2010 at major Brisbane Childrens Hospitals. DICOM datasets were subject to manual segmentation, followed by the construction of multi-planar and volume-rendering cranial models, for subsequent scoring. The union of primary ossification centers of the occipital bone were scored as open, partially closed, or completely closed; while the fontanelles and vertebrae were scored in accordance with two stages. Transition analysis was applied to elucidate age at transition between union states for each center and robust age parameters established using Bayesian statistics. In comparison to reported literature, closure of the fontanelles and contiguous sutures in Australian infants occur earlier than reported, with the anterior fontanelle transitioning from open to closed at 16.7±1.1 months. The metopic suture is closed prior to ten weeks post-partum and completely obliterated by six months of age, independent of sex. Utilizing reverse engineering capabilities, an alternate method for infant age estimation based on quantification of fontanelle area and non-linear regression with variance component modeling will be presented. Closure models indicate that the greatest rate of change in anterior fontanelle area occurs prior to five months of age.

This study complements the work of Scheuer and Black, providing more specific age intervals for union and temporal maturity of each primary ossification center of the occipital bone.¹ For example, dominant fusion of the sutura intra-occipitalis posterior occurs before nine months of age, followed by persistence of a hyaline cartilage tongue posterior to the foramen magnum until 2.5 years, with obliteration at 2.9±0.1 years. Recalibrated age parameters for the atlas and axis are presented, with the anterior arch of the atlas appearing at 2.9 months in females and 6.3 months in males, while dentoneural, dentocentral, and neurocentral junctions of the axis transitioned from non-union to union at 2.1±0.1 years in females and 3.7±0.1 years in males. These results are an exemplar of significant sexual dimorphism in maturation ($p < 0.05$), with girls exhibiting union earlier than boys, justifying the need for segregated sex standards for age estimation.

Studies such as this are imperative for providing updated standards for Australian forensic and pediatric practice and provide an insight into skeletal development of this population. During this



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presentation, the utility of novel regression models for age estimation of infants will be discussed, with emphasis on three-dimensional modeling capabilities of complex structures such as fontanelles for the development of new age estimation methods.

Reference:

1. Scheuer L, Black SM. Developmental juvenile osteology. San Diego CA: Academic Press, 2000.
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Subadult Age Estimation, Skeletal Maturation, Computed Tomography