A105 Semi-Automated Volumetric Quantification of the Frontal Sinuses: Sexual Dimorphism in a Contemporary Australian Subadult Population

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After attending this presentation, attendees will appreciate: (1) the benefits of a semi-automated protocol to conduct volumetric measurements of complex skeletal elements using tissue density-based voxel-processing of computed tomography scans; and, (2) the presence of sexual dimorphism in frontal sinus volume in subadults.

This presentation will impact the forensic science community by advancing understanding of subadult frontal sinus development through the use of 3D reconstructed Multi-Slice Computed Tomography (MSCT) scans. This research will also reinforce the invaluable nature and varied applicability a contemporary virtual skeletal repository offers to both forensic anthropology and osteoarchaeological fields of research.

Due to high probability in the recovery of the frontal bones within fragmented remains, comparison of frontal sinus morphology in antemortem versus postmortem radiographs are routinely conducted for personal identification in forensic casework. While sexual dimorphism in frontal sinus size has been widely reported in adults, there is currently no research signifying the age of onset of sexual dimorphism in morphometric analyses of the frontal sinuses in subadults. Accordingly, this study seeks to establish a temporal profile of frontal sinus development and determine the timing of sexual dimorphism of the frontal sinus volume in a contemporary population of Australian subadults, using a standardized 3D modeling protocol.

A total of 89 cranial Digital Imaging and Communications in Medicine (DICOM) datasets (males: n=45, females: n=44) aged 6 years to 19 years were accessed from the Skeletal Biology and Forensic Anthropology Virtual Osteological Database and imported into an advanced visualization software to generate an isosurface model and segmented masks of the right and left frontal sinuses.[1] A semi-automated method for volumetric calculation was developed to produce a standardized protocol for frontal sinus segmentation based on material discriminatory voxel intensity values. Voxels with intensity values ranging from -1,000 to 150 Hounsfield Units (HU) were selected, corresponding to the tissue density of air, fibrous connective tissue, cellular debris, and mucous that may be contained within the sinus cavity. Frontal chord (Bregma-Nasion) measurements were also conducted to standardize the crania, accounting for individual variability in cephalic size.

Intra- and inter-observer testing was conducted on three sample datasets obtained from randomly selected individuals of varying ages. Intra-observer error demonstrated high precision and consistency between repeated measurements with a mean percent Technical Error of Measurement (%TEM) of 3.15% and Intra-Class Correlation Coefficient (ICC) of 1.00 (Confidence Interval (CI)=0.992-1.00). Similarly, inter-observer reliability demonstrated a high degree of observer agreement despite varying anatomical and radiographic experience, with a mean %TEM of 1.26% and ICC of 0.99 (CI=0.991-1.00). Age and sex effects were analyzed using independent Student t-tests with relevant post-hoc tests.

The preliminary results of this study show a significant expansion of normalized total frontal sinus volume from 6 years to 16 years of age from 7.20±1.75 mm^2 to 99.84±13.16 mm^2 and 12.85±2.91 mm^2 to 65.64±10.49 mm^2 in Queensland males and females, respectively (P <0.01), with the greatest growth velocity occurring between 12 years and 16 years (P ≤0.01) represented by a 2- and 3.6-fold increase in males and females, respectively. Sexual dimorphism of frontal sinus volume was prominent from 12 years of age, with males exhibiting greater absolute and normalized volume than females in the 12 year-13 year, 15 year-16 year, and 18 year-19 year cohorts (P ≤0.05). This is markedly later than that reported in a recent *in silico* study investigating maxillary sinus volume in a Malay population which demonstrated the presence of significant sexual dimorphism after the 6th year.[2]

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Interestingly, the data also revealed a 9% bilateral and 3% unilateral absence of the frontal sinuses. Bilateral absence was highest in the 6 year-7 year age cohort, suggesting later pneumatization timings than previously recorded. This presentation highlights the use of voxelization-based *in silico* volumetric approaches to quantify irregular skeletal structures based on their tissue composition. This study provides the first insight into the complex morphological and volumetric changes of the frontal sinuses that occur with age in the cranium of Australian children. Classification accuracies using discriminant function analysis for subadult age estimation of individuals aged 6 years to 25 years of age as a new tool biological profile in contemporary subadults will also be discussed.

Reference(s):

1. Lottering N., MacGregor D.M., Barry M.D., Reynolds M.S., Gregory L.S. Introducing standardized protocols for anthropological measurement of virtual subadult crania using computed tomography. *J Forensic Radiol Imaging* 2014;2:34-38.
2. Masri A.A., Yusof A., Hassan R.A. Three dimensional computed tomography (3D-CT): a study of maxillary sinus in Malays. *Can J Basic Appl Sci* 2013;1:125-134.

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