A12 A Pilot Study Investigating 3D Variation in the Frontal Sinuses

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After attending this presentation, attendees will have an understanding of the issues plaguing current 2D methods to evaluate frontal sinus uniqueness and the potential of 3D approaches to visualize morphological variation.

This presentation will impact the forensic science community by providing a greater understanding of morphological variation which will enhance quantitative methods aimed at capturing individual uniqueness in these structures.

Identification of unknown individuals is an important aspect in forensic cases. The frontal sinuses are among several areas in the skeleton that have been proposed to aid in identification. These structures have long been considered unique to each individual because of the high degree of observed morphological variation. The most basic approach to compare the morphology of the frontal sinuses for personal identification purposes is either side-by-side comparison or superimposition of radiographic images taken of the frontal sinuses from similar angles and with similar magnification. This simple approach has given way to several methods that attempt to quantify observed morphological variation in the frontal sinuses.

A recent test of three methods on an independent sample revealed that these methods were not able to produce unique matches in all cases.[1-3] One explanation could be the predominant reliance on 2D data. To date, 3D variation in the frontal sinuses has only been explored in a single study which utilizes a coding system and reports two individuals in the sample produced the same ten-digit code.[4]

This study utilized an anonymized postmortem Computed Tomography (CT) sample of 130 individuals (males n=70, females n=57, unknown n=3) from the University of Copenhagen. The age range of the sample based on medical records is 19 to 88 years (mean males 49.9 years, mean females 54.9 years). The 3D rendering of the frontal sinuses was carried out using Materialise Mimics® for all individuals twice, permitting comparisons to be made between the same individual (different renderings). Ten trials were conducted using random groups of individuals. In nine trials, the second rendering of the primary individual was present and in one it was not. Stereolithography (STL) files were imported into Rapidform XOV3™ 64 and aligned with a sampling ratio of 100%. A whole deviation function was performed with a tolerance of zero. The tolerance value represents the amount of deviation from the target. By setting the tolerance to zero, any difference in size or shape between two frontal sinuses being matched was identified.

It was found that the mean overall out-of-tolerance percentage for same-skull comparisons was lower (16.24%, std dev 0.31) than that of the different skull comparisons (83.72%, std dev 1.29). Whenever the matching target render of the frontal sinus was present in the sample, it showed the lowest out-of-tolerance statistics and there was no overlap in the values between the same skull comparisons and the different skull comparisons. This is consistent with the assumption that two separate renderings of the same individual's frontal sinuses will be more similar to each other than renderings of frontal sinuses from two different individuals.

This preliminary study illustrates the potential for 3D quantification of variation and uniqueness seen in the anatomy of the frontal sinuses. Previously developed methods aimed at quantifying morphological variation have not been entirely successful because they attempt to reduce the variation seen in the frontal sinuses to a fixed number of variables or regions. Preliminary analysis shows that the variation is a function of both size and shape in all three dimensions and is not confined to specific regions of frontal sinus anatomy, viewable on 2D images. These findings highlight an important limitation to consider when developing and assessing methods and establish an explanation for why 2D methods are not fully capable of capturing the individual uniqueness present in these structures. Further methodological development needs to be carried out to improve the alignment procedure, including testing the use of specific landmarks and increased standardization in rendering. These 3D approaches to evaluating the uniqueness of frontal sinus morphology show promising results and represent future directions for research on personal identification.

References:

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Frontal Sinuses, 3D Comparison, Personal Identification