A58 Quantification of Frontal Sinus Morphology From Radiographs for Positive Identification

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After attending this presentation, attendees will possess a general understanding of the key challenges facing forensic anthropologists in determining identity using frontal sinus radiographs. This study highlights an alternative and easily accessible method of metric analysis of the frontal sinus.

This presentation will impact the forensic science community by investigating a quantitative method for establishing positive identification of an unknown individual using frontal sinus form.

Human frontal sinuses are lobate cavities contained within the frontal bone; their morphology is evident on radiographs and they remain consistent over the adult lifespan. Prior research has attempted to use the frontal sinus for forensic identification, for which methodology is expected to adhere to the *Daubert* guidelines. The *Daubert* guidelines govern the admissibility of scientific evidence in the federal court system and require standardized methodology to have acknowledged limitations and a replicable technique. Earlier studies have successfully used the frontal sinus to identify individuals; however, the subjectivity of the methods does not meet the *Daubert* standards. The research presented here is an attempt to develop frontal sinus identification methodologies that meet the *Daubert* guidelines. Moreover, this study follows recent efforts to quantitatively assess the frontal sinus and the goal is to develop a simple analytical method that can be used on commonly accessible software (e.g., ImageJ®, R, and MS® Excel®).

For this study, 40 cranial radiographs with frontal sinuses meeting the selection criteria were randomly chosen from the C.A. Pound Human Identification Laboratory case archives. Using ImageJ®, the scale was independently calibrated for each radiograph and a lower boundary line was drawn to demarcate the sinus. Area, perimeter, width, height, and circularity measurements were obtained by tracing the superior margin of the sinus. Each of the cranial radiographs were then traced four times — twice each by two separate observers to test for both inter-observer and intra-observer error. To test the applicability of this method for antemortem vs. postmortem identification, a four-crania demonstration sample was generated by radiographing each crania twice; once with a bag of substrate under the cranium to produce noise in the "antemortem" radiograph, and then without the substrate to represent a postmortem image. Single blind tracings by were used to examine if an antemortem image could be correctly matched to its postmortem counterpart with the described measurements.

Intra- and inter-observer error were tested using paired *t*-tests and Pearson's correlations. The paired *t*-tests suggest that frontal sinus measurements are consistent and repeatable by observers who have practiced the tracing method. Pearson's correlations (r2-values>0.860) indicate good congruency of measures between observers. Measurements from the original 40 tracings were Z-score scaled, and Euclidean distances between three sets of measures were calculated: (1) distances between individuals measured twice by the same observer; (2) distances between individuals measured twice by two different observers; and, (3) distances between random pairings of individuals. *T*-tests on Euclidean distances demonstrate matched individuals to be significantly closer than randomly paired individuals. Furthermore, gamma distributions calculated from the Euclidean distance sets allowed for the generation of log-likelihood ratio values. Matched individuals' Euclidean distances consistently showed positive log-likelihood ratio values compared to randomly paired individuals, demonstrating quantitative reliability. Using Euclidean distance measures and the log-likelihood ratios, three of the four crania in the demonstration sample were positively identified. Measurement error associated with the height measure for one of the "antemortem" images precluded positive identification for this individual. Euclidean distances from all four random pairings of the demonstration sample indicated no-matches.

Although these preliminary results indicate that quantifying frontal sinus morphology can be accomplished with readily available software, there are some limitations to this method. For tracing simplicity, only individuals with connected sinuses were used. As such, features that could be used for individualization (e.g., separate sinus cavities, partial septa, etc.) are not captured in the presented method. Future studies should focus on expanding the sample size and enhancing the method by quantifying and incorporating more individualizing features. By excluding such diagnostic features, the individualizing power of frontal sinus morphology for identification purposes is constrained. Ultimately, while somewhat limited, the research presented here demonstrates a quantitative technique for using frontal sinus morphology in forensic identifications following the *Daubert* guidelines.

Forensic Anthropology, *Daubert* Guidelines, Log-Likelihood Ratio Values