H48 Improving Sex Estimation From the Cranium Using 3-Dimensional Modeling From CT Scans

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After attending this presentation, attendees will learn about the utility of alternative approaches in exploring and quantifying sexual dimorphism in the human skeleton, particularly the cranium. This presentation will offer the forensic community simple and effective measurement techniques for improving sex estimation from the cranium providing measurements with the highest discriminatory power for sex estimation, as well as precise descriptions of how to take the measurements accurately using radiographs and/or calipers.

This presentation will impact the forensic science community by facilitating more accurate sex estimation techniques for the cranium than those used most frequently in forensic practice today. In addition, this study uses a large sample of modern Americans, thereby increasing statistical power of the discriminant functions. Finally, reducing the number of measurements needed to accurately discriminate sex from the cranium will lend these functions useful for fragmentary crania, as well.

Among the skeletal elements used for sex estimation, postcranial elements are generally superior to cranial elements. Therefore, when cranial and postcranial elements are present forensic anthropologists typically give more weight to postcrania, especially os coxae; however, skeletal forensic cases often consist of a skull only, or a skull and fragmentary/incomplete postcranial remains. A query of cases submitted to the Forensic Data Bank showed that 45% of cases consist of a skull with no sexable postcranial elements.

Metric sexing of crania using statistical procedures came to forensic anthropology via Giles and Elliott's classic paper on the American population.[1] Their success rate was in the high 80%, a rate typical of subsequent cranial sexing analyses. In general, accuracy rates exceeding 90% are rare in sexing crania, whether using morphological traits or measurements. Several studies have shown lateral radiographic cephalometry to be more accurate than traditional techniques for cranial sex estimation.[2-4] Hsiao *et al*. reported 100% accuracy in sexing Taiwanese adults with 18 variables, as well as rates ranging from 94% to 98% using between one and three variables only. A subsequent validation study on a European population achieved 96% accuracy.[4] A unique aspect of lateral cephalometry is that it allows the practitioner to take endocranial measurements and calculate angles that are informative of skull shape. In view of these promising reports, the present study conducts a similar analysis on the William M. Bass Donated skeletal population using computed tomography (CT) scans and an innovative 3D bone-modeling algorithm (the bone atlas). CT scanning technology enables the crania to be examined more thoroughly than has heretofore been possible and to examine structures that are not easily accessible in traditional evaluation.

The study sample consists of CT scans of adult skeletons from the William M. Bass Donated Collection. Each scanned cranium was rendered as a 3D model and then added to the cranial atlas. A statistical bone atlas is an average mold that captures the primary shape variation in the bone and facilitates rapid and accurate generation of automated measurements. An atlas consists of a sample of bones that all contain the same number of points and share the same spatial relationship. At the writing of this abstract, the cranial atlas contains 40 individuals; the projected atlas size upon completion will be 600-700 individuals (January 2011). A combination of linear and angular measurements was calculated from the atlas and t-tests and discriminant function analysis with cross-validation and stepwise variable selection were performed on these measurements. T-test results showed basion-nasion, metopion- glabella to glabella-basion angle, and the linear distance between the tips of the mastoid processes to be the most significant measurements ($p<.05$). Despite the small preliminary sample size, 90% accuracy was reached with just 7 measurements. Angular measurements capturing the inclination of the forehead and the cranial base angle, as well as measurements pertaining to mastoid size were selected as the best discriminators.

The analytical approach used in this study has been shown to improve sexing accuracy over traditional methods in postcranial bones, such as the patella, femur, and clavicle. Consequently, significant increases in discriminatory power is expected as the atlas sample size increases. Because CT scanning technology is not available to all forensic practitioners, measurements easily taken from lateral radiographs were used. Hence, the deeper understanding of sexual dimorphism can be introduced into forensic practice without the need for expensive equipment or programs. Results from an ongoing validation study on lateral radiographs will be included as part of the presentation, including observer error rates for the radiographic measurements.

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References:

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Sex Estimation, Cranium, Discriminant Analysis

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