H115 Elliptic Fourier Analysis of Vertebral Outlines for Victim Identification

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The presentation demonstrates a new quantitative method for obtaining a victim identification from radiographic comparison. It examines the vari- ability of the transverse process and its utility for this task. A discussion of the applicability of the method for other postcranial elements is also provided.

This presentation will impact the forensic science community by proposing methodology provides percent correct classifications and ID prob- abilities appropriate for current *Daubert* compliant standards. Results suggest that EFA of the transverse process can be particularly useful to reduce large lists of potential victims, such as in mass disasters or human rights cases. Furthermore, this methodology easily allows for the direct addition of other skeletal structures to obtain even higher associated probabilities, impacting both current practice and future research.

The comparison of antemortem radiographs with postmortem radi- ographs or photographs is one of the most common approaches to positive identification of skeletal remains. Traditionally, the method focuses mainly on cranial and mandibular elements, such as cranial sinuses and sutures, or dental elements, including the morphology and location of dental amalgams. This is related to the high variability of the outlines of these structures, which confers them a unique individual specificity allowing reliable ID assess- ments, even when performed just visually. Additionally, cranial and dental radiographs are among the most commonly registered antemortem records.

Postcranial elements present some disadvantages in this respect. Many different postcranial elements exhibit a structural complexity and variability similar to those of cranial and dental structures, but their morphology is assumed to be less stable through time due to mechanical loadings and Wolff's law. The predominance of dynamic articulations also increases error rates and variability related to radiographic perspective in postcranial elements.

Within this framework, the transverse processes of the lumbar vertebrae appear as an optimal postcranial alternative for positive identification: their morphology remains relatively unchanged throughout adulthood and, unlike the spinous process or vertebral body, they very rarely experience degener- ative osteoarthritic alterations over time. Additionally, antemortem radi- ographs of the lower back are reasonably common (primarily related to slipped vertebral discs), and pathologies and trauma observed in antemortem radiographs seldom affect the transverse processes.

Still, positive identification attempts based on this region are typically visual, lacking any assessment of the populational frequencies of the features considered and, therefore, any associated probabilities. This contradicts the *Daubert* criteria for admissibility of scientific evidence in a United States court.

The problem is common to most radiographic ID methods. Unlike fingerprints or DNA analyses, which rely on easily quantifiable discrete traits or base sequences, radiographic methods (with the exception of those relying on the presence or absence of dental elements or supernumerary bone struc- tures) are mainly based on the matching of continuous outlines. Apart from the problematic definition of quantifiable landmarks, these types of struc- tures are also affected by perspective variations between the ante- and post- mortem records. The development of geometric morphometric methods during the last two decades, has created a new source for the identification and analysis of new structures that can provide *Daubert*-compliant identity assessments.

The present study applies one of these techniques, Elliptic Fourier Analysis (EFA), to develop a new method and assess the utility of vertebral transverse processes for positive identification from antemortem radiographs. Parting from an approach similar to that of Angi Christensen (2003, 2004, 2005), antemortem and postmortem sets of records are simulated for a sample of 85 second lumbar vertebrae. Slight perspective differences between "antemortem" and "postmortem" radiographs were introduced to approximate the conditions expected in real forensic settings. Outlines of all left transverse processes were then produced, and transformed into Euclidean distances between all possible pairs of transverse processes after EFA and principal components analysis (PCA).

The modification of Christensen's methodology, through the intro- duction of PCA, serves to modify the variable space to produce orthogonal variables. The Euclidean distances are more appropriate in the new orthogonal space (becoming equivalent to weighted estimates, such as Maha- lanobis distances, in non-orthogonal spaces), providing a more accurate description of overall shape differences. The stepwise estimation based on the percent of common variance explained, inherent to the PCA method, also serves to weigh the relative contribution of each harmonic to the character- ization of the individual outlines. Finally, the examination of the principal components, representing meaningful shape differences, serves for a more revealing interpretation of the results, as well as to detect data input and recor- dation errors.

Confidence intervals for the distance between matching pairs were then produced, and this criterion used to assess the possibility of two records representing the same individual. The results show that this methodology provides percent correct classifications and ID probabilities appropriate for current forensic standards, even when large lists of potential victims are considered. Furthermore, this methodology easily allows for the direct addition of other skeletal structures to obtain even higher associated proba- bilities.

Geometric Morphometrics, Identification, Transverse Process

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