H25 Sacral Epiphyseal Fusion at S1-S2: Classification, Comparability, and Error

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After attending this presentation, attendees will understand how sacral fusion can be used properly in age estimation, problems associated with current techniques, and proposals for best practices when using sacral fusion as an age estimation technique.

This presentation will impact the forensic science community by examining sacral fusion age estimation in response to critiques raised by the National Academy of Sciences Report (NAS) concerning the need to evaluate the reliability and accuracy of methods used in forensic science.

Epiphyseal fusion as an age estimation method is useful because fusion generally occurs at the same time for all individuals. The fusion of the anterior margins of the sacral vertebrae has further potential for age estimation in young adults because of the delayed union of the first two sacral segments (S1 and S2). McKern and Stewart's 1957 publication of *Skeletal Age Changes in Young American Males*, one of the first and most comprehensive analyses of age estimation, examined sacral fusion employing a five-stage system (e.g., Stage 0=nonunion; Stage 4=complete union). Several more recently published methods also examine sacral fusion, albeit with the use of different scoring systems (e.g., Coqueugniot and Weaver (2007) used a three-stage letter system [a=open, b=partial, c=complete], and Belcastro *et al.* (2008) used a four- stage numbering system [e.g., Degree 0=absence of fusion, Degree 1=less than 50% fusion]). These differences complicate comparisons of results from essentially the same technique.

The current study was designed to examine the performance of the sacral fusion age estimation method using the scoring system and age intervals given by McKern and Stewart (1957:148). The known age-at- death was compared to the predicted age-at-death based on the recorded stage of fusion for all individuals identified at the JPAC-CIL between 1972 and 15 June 2010 whose case documentation specifically referenced the McKern and Stewart (1957) method (n=40). Correct classification, or the percent of individuals whose known age-at-death fell within the assigned age interval, was used to test this method. Additionally, the sample was compared to the overall JPAC-CIL identified sample and the Korean War identified sample from McKern and Stewart (1957).

The JPAC-CIL sample for the McKern and Stewart (1957) sacral fusion method (n=40) has a mean age-at-death of 24.2 years, an age range of 12 years (youngest individual=18, oldest individual=30), and is entirely male. There is a statistically significant difference (p=0.002, Student's *t*-test) in mean age-at-death between this sample and the total known age-at-death sample of JPAC cases (*n*=979, =27.2); the sample aged using S1-S2 fusion is younger than the entire identified sample.

Of the 40 individuals whose case files referenced this method, 45% (n=18) were placed in Stage 0. The second largest group was comprised of individuals scored as Stage 2 (n=12). Stages 1, 3, and 4 each had three individuals, and one individual was scored as "Stage 1 or 2." Compared to the McKern and Stewart (1957) sample, there were considerably more individuals observed with nonunion of the S1-S2 joint in the JPAC-CIL sample.

The age distribution of the samples also differs. For example, in the McKern and Stewart (1957) sample, Stage 0 (nonunion) was observed only in individuals between the ages of 17 and 18, whereas nonunion was seen in the JPAC-CIL sample in individuals up to 30 years of age. Because of this, the sacral age estimation method based on McKern and Stewart's (1957:148) reported ages had a correct classification rate of 32.5% and an incorrect classification rate of 67.5% for the JPAC-CIL sample. However, when applying a simple "fused versus unfused" model, the percentage of correct classification increases to 95% for the

entire sample (n=40). This model classifies Stages 0, 1, and 2 as incomplete fusion and Stages 3 and 4 as complete fusion and categorizes individuals with incomplete fusion as less than 30 years of age and individuals with complete fusion as 17 years of age or older.

Analyses of the JPAC-CIL case files indicate that employing the age intervals provided by McKern and Stewart (1957:148) results in large- scale misclassification of age when presented with an S1-S2 joint in any stage of incomplete (i.e., partial or open) fusion. It is therefore recommended that incomplete sacral fusion be regarded simply as an accessory to other more precise methods of age estimation. Incomplete sacral fusion can be used to establish an upper bound for the age estimate; in this sample, age 30 was found to be a useful sectioning point. However, further research in a more varied sample could modify this sectioning point. Additionally, there is a great need for anthropologists to agree on methods of age estimation, to include the use of identical scoring systems. This will alleviate unnecessary complications in data comparison and the continual redevelopment of these scoring systems. **Sacral Fusion, Age Estimation, Error**