A8 Analysis of Interobserver and Intraobserver Error Associated With the Use of 3D Laser Scan Data of the Pubic Symphysis

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After attending this presentation, attendees will understand the intraobserver and interobserver error related to collecting and editing 3D laser scans of skeletal material, as well as the repeatability of three new age estimation methods that use bone shape data extracted from the laser scans.

This presentation will impact the forensic science community by providing best practice guidelines for using laser scanners, scanned images, and coordinating data in forensic casework that will contribute to the standardization of 3D image processing procedures between different forensic practitioners and labs. It will also provide validation for the age estimation methods discussed here.

In age-at-death estimation based on visual assessment, objective evaluation and correct diagnosis of age-related skeletal traits are crucial, as these factors determine whether the aging methods can achieve their full potential — producing the most accurate and reliable age estimates. Nevertheless, the traditional, phase-based age estimation methods have been reported to yield inconsistent age estimates both within and between observers.[1,2] The reasons for these discrepancies lie in the fact that accurate macromorphoscopic analysis heavily depends on the correct interpretation of qualitative trait descriptions, conformity of the bone, and experience of the observer.

Recently, Slice and Algee-Hewitt and Stoyanova et al. have introduced three novel, fully computational aging methods using 3D laser scans of the pubic symphysis that minimize subjectivity in age estimation by reducing the effects of observer experience in the age-indicator/trait assessment and methodological bias; however, the reproducibility of these methods has not been fully explored or quantified.[3-5] This is of concern because there is potential for introducing error in the first two steps of data processing — when the scans are taken and edited at different times by different observers. In response to this concern, the current study evaluates the repeatability of these novel methods by assessing intra-scan variation, within, and between, observer differences in scan editing and its impact on age estimation.

The test data used in this study represent replicate scans of the Suchey-Brooks' (SB) male casts, taken using a 3D desktop laser scanner. The upper and lower stages of each of the six phases were scanned three times by a single observer (n=36). Four different observers with various experience levels and training backgrounds independently edited the triplicate of the SB scans using the scanner's accompanying software, such that the symphyseal face is extracted from the surrounding bones. From these isolated faces, x, y, and z coordinates were retrieved and analyzed via the Subarachnoid Hemorrhage (SAH) Score method, the Thin Plate Splines/Bending Energy (TPS/BE) method, and the Ventral Curvature (VC) method to compute shape measures.[3-5] These measures were subjected to single-variable and multivariate regression models to obtain age estimates for each replicate scan per observer. Finally, using the shape measures and final age estimates, a series of the Intraclass Correlation Coefficient (ICC) were calculated to evaluate within- and between-observer reliability in scan editing. Additionally, extra editing conditions were tested to simulate the situation in which the practitioner misidentifies age-related traits due to unfamiliarity with the scan editing protocol. A set of the SB casts was edited with different widths of the margin (2mm vs. 4mm vs. 1cm) left around the symphyseal face and with/without the pubic tubercle, which may impact the VC values as it protrudes ventrally. Possible effects of these conditions on age estimates were evaluated using the paired t-test.

This study produced high ICC values (0.75-1.0), demonstrating that the raw scans were edited consistently within and between observers and that the derived shape measures and age estimates were in excellent agreement among observers. Moreover, despite the simulated improper editing of the scans with various margin widths remaining, the methods were robust enough to self-correct and produce consistent and accurate age estimates ($p > 0.05$), with the exception of the faces with 1cm margin. Interestingly, the inclusion of the pubic tubercle for the shape analysis did not necessarily yield inaccurate age estimates for the VC method, while it produced statistically significant mean differences between the documented chronological age and age estimates of the SAH score method, TPS/BE method, and the two multivariate regression models ($p < 0.01$). These results demonstrate high repeatability of the computational methods regardless of the observer's level of experience or training background and support using a 3D laser scanner and scanned images to aid in resolving the issue of subjectivity.

Reference(s):

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