A82 Virtual Forensic Anthropology: The Accuracy of Osteometry on 3D Virtual Models of the Os Coxa Derived From Clinical Computer Tomography (CT) Scans

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Learning Overview: This study seeks to address two important issues in “virtual” forensic anthropology: (1) the currently insufficient knowledge regarding the accuracy of 3D virtual reconstructions from clinical CT scans; and (2) the effect of 3D reconstructions on landmark recognition, which is pivotal for reliable measurements.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by providing insight into the accuracy of virtual models derived from clinical CT scans and how this might impact “virtual” forensic anthropology.

Background: Clinical radiological data (i.e., CT scans) are a promising source for contemporary population-specific data to test or develop forensic anthropological methods. However, the feasibility of this approach is unclear since: (1) the accuracy of 3D virtual reconstructions from clinical CT scans is insufficiently known; and (2) the effect of 3D reconstructions on landmark recognition (pivotal for reliable measurements) is largely unknown. This study seeks to address both these issues.

Materials and Methods: Twenty-seven (13 males, 14 females) fully intact cadavers from the body donation program of the Amsterdam UMC, University of Amsterdam, Department of Medical Biology, section Clinical Anatomy and Embryology were CT scanned using a patient scanning protocol (referred to as the “Fleshed CT”). Subsequently, the bodies were processed to obtain the dry os coxae and CT scanned again using the same scanning protocol (referred to as “Dry CT”). Both scan sets were used to render 3D virtual skeletal elements (“Fleshed CT virtual models” and “Dry CT virtual models”). Then, an Artec Spider 3D optical scanner was used to produce 3D models of a subset of ten dry os coxae from the sample. Given its minimal error (accuracy <0.05mm) and high resolution (~0.1mm) the optical scanner was used as the “gold standard.”

The accuracy of the Fleshed and Dry CT models was calculated by assessing the deviation (in mm) to the gold standard. This was done for the overall os coxae (left and right combined) and for Regions Of Interest (ROI) representing selected Landmarks (LMs). To compare the error associated with landmark recognition, the intra- and inter-observer error (Technical Error of Measurement (TEM) and %TEM) of nine traditional Inter-Landmark Distances (ILD) was measured on all dry os coxae and the 3D virtual models (Fleshed CT and Dry CT).

Results: Fleshed CT virtual models were found to be 0.64mm-0.88mm larger than the gold standard (deviations ranging from -4.99mm to 5.00mm). Dry CT virtual models were 0.36mm-0.45mm larger than the gold standard (deviations ranging from -0.27mm to 2.86mm). The accuracies at the various ROIs were variable and larger for Fleshed CT virtual models than for Dry CT virtual models.

For all three sets of virtual models, intra- and inter-observer error was in the generally acceptable range (TEM<2mm, %TEM <2%) for all ILDs, except for three ILDs all of which included the landmark located on the most inferior point on the ischial tuberosity.

Discussion and Conclusions: These results demonstrate that virtual models developed from clinical (i.e., “fleshed”) CT scans are larger than the scanned skeletal element. The same holds for virtual models developed from “dry bone” CT scans, although the difference is less pronounced. In both groups, this overestimation in size is on average <1mm for the overall os coxae; however, this difference in size between the modalities (Fleshed CT versus the gold standard and Dry CT versus the gold standard) has practical implications when constructing ILDs from the ROIs associated with the various LMs. Corresponding ILDs taken from ROIs with large (>1mm) variability on different modalities may result in ILDs greater than the generally accepted 2mm error in forensic anthropology. The majority of morphological LMs were consistently identified, and the use of 3D models thus apparently doesn’t affect the recognition of osteometric landmarks substantially.

Based on these results, it is argued that clinical CT data should only be used as a source for forensic anthropological reference data when the (sometimes considerable) shape and size differences between the virtual models and the dry skeletal elements are considered. Furthermore, osteometric methods for the estimation of sex, age, stature, and ancestry derived from dry skeletal elements cannot be readily applied to 3D reconstructions from clinical CT scans (and vice versa).

Virtual Forensic Anthropology, Metric Sex Estimation, Accuracy