A1 Investigating the Accuracy of Additive Manufacturing Skeletal Samples for Evidence Reconstruction

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After attending this presentation, attendees will be aware of the problems inherent within 3D modeling and additive manufacturing (3D printing) in forensic anthropology and will recognize that these issues are pertinent to forensic science reconstruction approaches and, in particular, the presentation of 3D prints as evidence in court.

This presentation will impact the forensic science community by alerting attendees to the uses and limitations of additive manufacturing from Computed Tomography (CT) scans in a forensic context. Recommendations and thought-provoking findings could initiate discussions and collaborations toward further exploration into the use of models for reconstruction purposes in anthropology and wider forensic disciplines.

This research investigates the metrology of 3D modeling and 3D printing osteological samples from CT scans. It is expected that such models will be sufficiently accurate for anthropological comparisons, but the extent of the effect of modeling parameters is currently unknown.

There are two documented cases in which 3D prints of human remains have been used in United Kingdom courts of law.[1,2] In one of these cases, lawyers cast doubt on the reliability of a 3D-printed cranium, as the process has not been validated in a forensic context.[2] This type of evidence can be utilized after a virtual postmortem (avoiding disruption of remains), from antemortem clinical CT data, or in cases in which the subject survives. Studies have begun to validate these techniques, such as the reliability of obtaining accurate anthropological measurements from CT reconstructions of certain skeletal elements and the accuracy of 3D printing in medicine/anatomy, but further research is needed.[3-6]

Three dry osteological samples (a cranium, clavicle, and first metatarsal) were CT scanned using a multi-detector Toshiba Acquillon™ ONE. 3D models were segmented and converted into Stereolithic (STL) files for printing. First, the parameters applied in the virtual model generation were investigated for quality. Second, two additive manufacturing methods, Selective Laser Sintering (SLS) and Fused Deposition Modeling (FDM), were tested on three printers, and a statistical comparison of anthropometric measurements taken from the original samples, the virtual models, and the 3D prints was undertaken.

The results of this study indicate that: (1) the threshold values (labels) used in virtual model segmentation affect the quality of the model, as does the amount of smoothing employed; (2) there was no statistically significant difference between the clavicle and first metatarsal 3D prints and the original dry bone (p values >0.05), except for one of the clavicle FDM prints; (3) the cranium 3D print was not statistically distinguishable from the virtual model (p values >0.05) following removal of inconsistent cranial measurements, but the cranium 3D print was statistically significantly different when compared to the source bone (p <0.05); (4) the virtual models had mean Absolute Errors (AE) of 1.6mm±0.9mm for the cranium, 1.5mm±0.7mm for the clavicle, and 1.1mm±0.7mm for the first metatarsal; and, (5) the 3D prints produced using SLS technology had smaller respective AE, with 1.4mm±0.9mm for the cranium, 1.2mm±0.2mm for the clavicle, and 0.7mm±0.5mm for the first metatarsal.

This empirical research provides initial data to validate the process of additive manufacturing in forensic anthropology. The data demonstrated that accurate 3D prints can be produced from CT-scanned bones, but with limitations. Segmentation of the virtual model was found to be a crucial step for producing accurate models, and it is thought that applying additional smoothing could help. Further exploration of additive manufacturing and samples that exhibit trauma, pathology, and taphonomy will progress toward producing best practice guidelines and validation of the technique.

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