A58 Experimental Assessment of the Surface Quality of 3D Printed Bones for Evaluative Interpretation in Forensic Anthropology Reconstructions

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Learning Overview: After attending this presentation, attendees will appreciate the utility of 3D printed replica bones and the challenges around 3D printing fine surface features in forensic anthropology.

Impact on the Forensic Science Community: This presentation will impact the forensic science community by demonstrating challenges associated with the quality and validity of 3D printed bones to accurately portray forensic skeletal material.

The goal of this research was to investigate the surface quality of 3D printed bones, in order to determine if 3D prints can be a suitable proxy to human bones for demonstration of evidence in courts of law. It was expected that the overall shape of the prints would be accurate, but it was unknown whether the quality of the representation of fine surface details would be sufficient.

3D printed replicas of human remains have been shown to be useful tools in courtroom demonstrations of evidence and have been used in several court cases internationally.[1] 3D prints provide a medium that users (such as expert witnesses or jurors) can hold, touch, rotate, and even use to mimic mechanisms of injury.[1,2] Consequently, it is believed that using 3D prints as visual aids may assist laypeople in their understanding of expert/medical testimony.[3] While 3D printed bone replicas have been established as accurate and robust representations of skeletal elements, little research has investigated the representation of fine surface details, such as fracture lines, porosity or texture.[1] Such features are important in the forensic examination of remains, and especially so for exhibiting skeletal trauma in courtrooms.

In this study, nine human bones with differing morphology were digitized using Computed Tomography (CT) scanning on a Toshiba® Aquilion ONE™ Vision Edition scanner. The CT data were reconstructed using 3D Slicer and Blender software following Carew et al. to create 3D models.[1] The 3D models were 3D printed using Selective Laser Sintering (SLS) on an EOSINT® P100 with a white powder material. A three-phased approach was implemented to assess: (1) the metric accuracy of the 3D prints; (2) the viability of applying age and sex estimation methods (with multiple observers; *n*=8); and (3) the surface quality compared to the dry bones, using a customized scoring method (with multiple observers; *n*=8).

The results of phase 1 of this study indicated that the measurement data was reliable. The 3D prints were accurate to within ±2.0mm of the original dry bones, with no statistically significant difference observed between the dry bone and 3D print measurement data (p-value 0.75).

Phase 2 identified that multiple observers could successfully and confidently perform age and sex estimation methods on the four 3D prints tested when the method utilized gross features. Less success and confidence was seen when these methods utilized fine surface features. The customized ranked qualitative scoring method used in phase 3 found highest scores for surface quality were given for the general morphology of the 3D replicas, followed by detailed morphology, and texture received the lowest scores. Two of the prints (the cranium and mandible) were scored as accurate overall (average total scores >11).

This experimental study confirmed the accuracy of the gross morphology of the 3D printed bones, but importantly demonstrated that fine surface details were not always well represented compared to the dry bones. These findings confirm the utility of 3D printed replicas for courtroom exhibition where gross features are required, but suggests caution is necessary for the use of 3D prints when fine detailing is important for evaluative interpretation.

Reference(s):

1. Carew, Rachael M., Ruth M. Morgan, and Carolyn Rando. A Preliminary Investigation Into the Accuracy of 3D Modeling and 3D Printing in Forensic Anthropology Evidence Reconstruction. *Journal of Forensic Sciences* 64, no. 2 (2018): 342-352. doi:10.1111/1556-4029.13917.
2. Barrera, Christian A., Elizabeth Silvestro, Juan S. Calle-Toro, Philip V. Scribano, Joanne N. Wood, M. Katherine Henry, and Savvas Andronikou. Three-Dimensional Printed Models of the Rib Cage in Children With Non-Accidental Injury as an Effective Visual-Aid Tool. *Pediatric Radiology* 49, no. 7 (2019): 965-970. doi:10.1007/s00247-019-04368-7.
3. Blau, Soren, Erin Phillips, Chris O'Donnell, and Greg Markowsky. Evaluating the Impact of Different Formats in the Presentation of Trauma Evidence in Court: A Pilot Study. *Australian Journal of Forensic Sciences*, 2018, 1-10. doi:10.1080/00450618.2018.1457717.

3D Printing, Forensic Anthropology, Evidence Reconstruction

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