A46 Introducing Standardized Anthropological Measurement Protocols for Postcranial Bones Using 3D Surface Reconstructions in Computed Assisted Design (CAD) Software

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After attending this presentation, attendees will appreciate the improved accuracy and reliability attributed to semi-automated anthropological measurement protocols on 3D reconstructions of postcranial bones using CAD software.

This presentation will impact the forensic science community by demonstrating the benefits of Multi-Slice Computed Tomography (MSCT) and the advances of a virtual approach as a non-invasive method for obtaining reproducible morphometric information in anthropological investigation. The visualization and measurement capabilities of reverse engineering software will be discussed. The protocol introduced in this study and the precision testing results presented are essential for advancing current medicolegal death investigations, accentuating the advantages of "virtual anthropology."

Consistent with the International Criminal Police Organization (INTERPOL) Disaster Victim Identification Guide, postmortem identification during mass disasters systematically involves the utilization of MSCT. Specifically in Australia, postmortem MSCT was regarded as a valuable tool in disaster victim identification during the 2009 Victorian Bushfires and constitutes standard protocol for external autopsy in a number of Australian mortuaries. The 3D surface-rendered models in CAD software has the potential to increase measurement accuracy in comparison to Multi-Planar Reformatted (MPR) assessment, which uses contiguous 2D orthoslices, where the outer boundary of macroscopic bony landmarks may be arduous to determine. Utility of MPR models also requires a considerable level of anatomical imaging knowledge, as the investigator is required to mentally construct a 3D representation from 2D images.

The goal of this present study was to introduce a contemporary osteometric protocol using CAD software and to conduct observer error testing to assess the reliability of this protocol. Six thin-slice Digital Imaging and Communications in Medicine (DICOM) datasets (thickness: 2mm, overlap: 1.6mm, voxel size: 0.78mm x 0.78mm x 2.0mm) of the femoral region of contemporary adult Australian individuals (aged neonate to 75 years old) were accessed from the Skeletal Biology and Forensic Anthropology Virtual Osteological Database. The femora were subject to manual segmentation to produce an isosurface model compatible with the engineering software program Geomagic Design X™ for osteometric examination. In Geomagic Design X™, the principal component axes were realigned for the construction of a series of anatomical reference planes required to depict a "virtual osteometric board." With reference to silhouette curves, extreme position planes corresponding to the outermost boundary of the isosurface are identified in order to obtain automated plane-to-plane measurements. Bicondylar length and epicondylar breadth were measured by four observers differing in CAD software experience over three separate days to evaluate intra- and inter-observer error. Technical Error of Measurement (TEM), relative Technical Error of Measurement (%TEM), and Intraclass Correlation Coefficient (ICC) were calculated to quantify the measurement error variance and observer agreement of the protocol.

Intra- and inter-observer error results demonstrate that the linear measurement protocol introduced is highly repeatable. Specifically, intra-observer error resulted in %TEM=0.10, ICC=1.000 (CI=0.999-1.000) for bicondylar length, %TEM=0.19, ICC=0.995 (CI=0.980-0.999) for epicondylar breadth. Inter-observer error resulted in %TEM=0.50, ICC=0.995 (CI=0.978-0.999) for bicondylar length, %TEM=0.20, and ICC=0.996 (CI=0.979-1.000) for epicondylar breadth. Since these results are within the acceptable levels of agreements for anthropometric measures, it is recommended that this protocol be implemented in anthropological casework and contemporary anthropological research.

The protocol introduced in this study utilizes high-quality 3D models, which allow "hidden features" such as the medullary cavities to be observed, with the software also providing the opportunity for novel geometric morphometric methods to be developed. A further benefit of CAD software is the use of automated plane-to-plane measurements, which eliminates the requirement of manual identification of landmarks, also reducing the subjectivity associated with the alignment of the bone in MPR protocols.

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As it is crucial that all contemporary scientific methods are validated and standardized, this study introduces a technologically new, standardized protocol for linear measurement of postcranial bones using 3D surface reconstructions, with observer error testing demonstrating strong observer agreement. It is therefore suggested that 3D isosurface models using CAD software can be utilized for osteometric assessment of human remains. In addition, this presentation will emphasize the wide application of this protocol, demonstrating standard anthropological measurement of other skeletal elements of the postcranial skeleton (e.g., humerus and scapula) inclusive of subadult long bones.

MSCT, Reverse Engineering, Observer-Agreement