Author response to: Brough et al. in response to the recently published article: Lottering, N., MacGregor, D.M., Barry, M.D., Reynolds, M.S., Gregory, L.S., 2014. Introducing standardized protocols for anthropological measurement of virtual sub-adult crania using computed tomography 2(1), 34-38

Lottering, Nicolene; MacGREGOR, Donna M.; Barry, Mark D.; Reynolds, Mikaela S.; Gregory, Laura S.

Published in:
Journal of Forensic Radiology and Imaging

DOI:
10.1016/j.jofri.2014.06.003

*Title Page (with Author Details)

Author Response to: Brough et al. In response to the recently published article: Lottering, N., MacGregor, D.M., Barry, M.D, Reynolds, M.S., Gregory, L.S (2014) Introducing standardized protocols for anthropological measurement of virtual sub-adult crania using Computed Tomography 2(1): 34-38

Nicolene Lottering[a], B.For.Sc, B.App.Sc (Hons)

Donna M. MacGREGOR[a], B.Sc (Hons), M.Sc (For.Sc)

Mark D. Barry[b], B.Sc, GDTeach, GDCompEd

Mikaela S. Reynolds[a], B.For.Sc, M.Sc (BMed.Sc)

Laura S. Gregory[a], B.Sc (Hons), PhD

[a]Skeletal Biology and Forensic Anthropology Research Laboratory, School of Biomedical Sciences, Faculty of Health, Queensland University of Technology, Brisbane, Queensland, Australia 4001.

[b]High Performance Computing and Research Services, Queensland University of Technology, Brisbane, Queensland, Australia 4001.

Number of Pages: Text (3 pages)

Short Title: Author Response to Brough et al. Letter to the Editor.

Corresponding Author:
Miss. Nicolene Lottering
PhD Candidate (Forensic Anthropology)
Skeletal Biology and Forensic Anthropology Research Laboratory,
School of Biomedical Sciences, Faculty of Health, Queensland University of Technology,
2 George Street, Brisbane, Queensland, 4001 Australia.
Tel: +61 7 3138 1281
Mobile: +61 4 00 544 588,
Email: n.lottering@qut.edu.au

*Manuscript (without Author Details)

QUT

School of Biomedical Sciences
Faculty of Health
Queensland University of Technology
2 George Street, Brisbane, Australia 4001
Phone: +61 400 544 588
n.lottering@qut.edu.au

2ND JUNE, 2014

Authors' Response

Response to: *Brough et al. (2014) In response to the recently published article: Lottering, N., MacGregor, M.D., Barry, M.D, Reynolds, M.S., Gregory, L.S (2014) Introducing standardized protocols for anthropological measurement of virtual sub-adult crania using Computed Tomography 2(1): 34-38*

Dear Editor,

Firstly, we would like to thank Ms. Alison Brough and her colleagues for their positive commentary on our published work (1) and their appraisal of our utility of the "off-set plane" protocol for anthropometric analysis. The standardized protocols described in our manuscript have wide applications, ranging from forensic anthropology and paleodemographic research to clinical settings such as paediatric practice and orthopaedic surgical design. We affirm that the use of geometrically based reference tools commonly found in computer aided design (CAD) programs such as Geomagic Design X® are imperative for more automated and precise measurement protocols for quantitative skeletal analysis. Therefore we stand by our recommendation of the use of software such as Amira and Geomagic Design X® in the contexts described in our manuscript.

In response to the authors' first major comment - it certainly was not our intent to misrepresent the research presented in Brough et al.'s (2) article with respect to our statement concerning their use of "2D lateral and axial views rather than 3D isosurface mesh models". We would like to thank the authors for clarifying their use of the 3D MPR feature in their letter, as this was not described in their publication. Osirix® currently has multiple multi-planar reformatting (MPR) functions (i.e. 3D MPR, 3D curved MPR or 2D orthogonal MPR) each with different capabilities with respect to plane generation and viewing. Based on the reference to "orthogonal boundaries" (2), readers with experience using OsiriX® may assume that the 2D Orthogonal MPR function was implemented, which lacks the ability to rotate the arbitrary planes and thus is dependent on the original coordinate system of the dataset. We would like to take this opportunity to provide more technical specifications in light of any ambiguity pertaining to the geometric protocol utilized in our publication, and how this compares to the Brough et al. (2) publication.

Visualisation programs like OsiriX® utilise the 3D volume data of the scan and predominately provide combinations of 2D slice views which are the most historically used images in medical domains. MPR is a technique that provides the viewer with planar cross-sectional images extracted from the volume data. Thus, this requires that either a voxel-based 3D image first be constructed, or that an algorithm be used that can extract arbitrary orientated planes from the original set of acquired 2D images (3). This extracted image is a conventional 2D slice that the operator can position and orient to the optimal image plane based on anatomical reference points. Based on the methodological workflow described by Brough et al. (2), it can be assumed that an orthogonal plane MPR technique has been utilized, which provides three perpendicular, arbitrary planes displayed simultaneously, with graphical cues indicating their relative orientations and intersections. Single or multiple planes can be moved within the 3D image volume to provide a cross-sectional view at any desired location along the adjusted principal axes. Identifying landmarks accurately from 2D slice views requires substantial visualisation experience. Our major caution with the current capabilities of OsiriX® relates to the fact that once the anatomical landmarks are located with reference points, there is currently no tool in OsiriX® to use this geometric information to automatically align the 3D MPR axis, which CAD applications such as Geomagic Design X® can achieve. Without a volume or surface reconstruction, users of OsiriX® are required to mentally transform multiple 2D images to form a 3D impression of the anatomy and pathology, which may introduce error as it is dependent on extensive anatomical and/or medical imaging knowledge. Currently, the task of aligning the axes in the 3D MPR tool requires manual manipulation, a process that is more standardized in our geometric protocol. The protocol proposed in our publication therefore utilizes a 3D surface reconstruction, otherwise known as an isosurface mesh model, which serves as a virtual replica of the geometry of the bone and streamlines the measurement process by providing a more automated protocol. Further, CAD programs exhibit multi-axis modalities, in which the automated plane-to-plane measurements can be derived using the local geometry of the surface as opposed to manual identification of landmarks. We would encourage the authors to review the article by Fenster et al. (3) who discuss the limitations of the MPR approach, including the success of the diagnostic or interventional procedure being largely dependent on the skill and experience of the operator in performing these tasks.

The second major concern raised by the authors relates to the software programs implemented in the publication, specifically the utility of Amira® and Geomagic Design X®. The standardized protocol presented in our manuscript refers to the mathematical technique, irrespective of the software programs utilized; and offers wide utility, not limited to forensic practice. In the previous paragraph we have outlined some of the relevant advantages of using CAD-based programs in virtual skeletal analysis. Amira® or Aviso® constitute gold standards for manual segmentation, while Geomagic Design X® features prominently in reverse engineering, 3D printing, orthopaedic surgical planning and design. In our publication we acknowledge that the "principals of the methodological process can be readily adapted for use in similar programs such as Mimics® (Leuven, Belgium) independent of the imaging modality"; expansions to readily available commercial programs such as OsiriX® or open source projects such as MeshLab®, could possibly be implemented to achieve our proposed methodology. We would welcome the addition of more CAD like geometrically based tools to visualisation platforms like OsiriX® by the software developers.

Further the authors consistently refer to "PMCT" data, however we would like to clarify that although our protocol may be applied to post-mortem CT data, our data were actually acquired from retrospective clinical multi-slice computed tomography (MSCT) scans obtained from major Queensland children's hospitals. We would like to thank the authors for their clarification concerning the official Interpol DVI protocol, however we would like to point out that CT scanning is currently included in the phase 2 component of the DVI process at the Victorian Institute of Medicine in Melbourne, Australia (4) and constitutes standard autopsy protocol in most Australian mortuaries, including Queensland, Australia (5). We also acknowledge that although documented skeletal collections exist, there are currently no documented osteological collections housed in Australia that allow anthropological assessment of an Australian population, as eluded to in the opening paragraph of our publication. Brough et al. agree with the universal paucity in juvenile material in their manuscript (2); and while The Scheuer Juvenile Collection is without doubt an incredible resource in the forensic anthropology community, it is not immune to shortcomings associated with antiquated data such as secular trends, possible nutritional deficiencies, low socioeconomic status and contains some material of unknown documented identity. With the exception of the subadult radiographic database recently developed by Ousley et al (6) for American subadults, the Skeletal Biology and Forensic Anthropology Research Osteological Database constitutes the only active computed tomography sample of 21st century children aged birth to 20 years (n=858), that we are currently aware of. Data acquisition using this approach is recommended for countries such as Australia with a lack of skeletal collections, or to overcome limitations associated with inactive osteological collections i.e. Lisbon Collection and Terry Collection.

We appreciate that discriminate functions for sex and ancestry determination are only used in the analysis of adult remains, but we also believe that this is a consequence of paucity in large, diverse child datasets. Furthermore, we would argue that in the current climate, subadult measurements are not routinely conducted as we do not have a basis for comparison such as FORDISC. The Skeletal Biology and Forensic Anthropology Research Osteological Database is a result of a protracted dissertation which aims to provide up-to-date, population-specific age standards for contemporary Australian children through assessing the application of current methods and developing novel morphometric analyses to quantify the presence of sexual dimorphism and ontogeny of various skeletal elements. Therefore, data acquisition using CT imaging serves as the vector to achieve this and consequently creating a large virtual repository which will provide the basis for assessing growth and development in modern Australian children for clinical examination, and offer improved sex and age standards with statistically determined prediction intervals in the forensic setting.

We can appreciate that from a traditional anthropological standpoint that the practical application of our method may be limited in the current climate of forensic practice, however the linear protocol presented in our study is widely applicable in paleodemographic research, for the development of reference standards of growth and development and benefits orthopaedic management, particularly in cases of craniosynostosis. Measurements of absolute dimensions are also required to account for intra-sample variation in cranial size in young children to eliminate the effect of size when conducting more complex geometric analyses i.e. volumetric and areal dimensions. Importantly, our published protocol is not limited to the crania, with the same methodological approach currently applied to the pelvis and lower limb in our laboratory and is applicable to adult skeletal elements. This point is emphasised in the final sentence of the conclusion in our manuscript stating that, "whilst this paper focuses on the assessment of the cranium, our research laboratory is currently undertaking metric anthropological analysis of MSCT 3D models of the post-cranial skeleton…"

We invite the authors to contact our research group if they require further clarification pertaining to our geometric protocols, and thank them for the opportunity to clarify a number of points pertaining to our work.

On behalf of all co-authors,

Nicolene Lottering.
B For Sc. B Appl Sc (Forensic Anthropology)
PhD Candidate (Forensic Anthropology)
Skeletal Biology and Forensic Anthropology Research Laboratory,
School of Biomedical Sciences, Faculty of Health, Queensland University of Technology,
2 George Street, Brisbane, Queensland, 4001 Australia.
Tel: +61 7 3138 1281
Email: n.lottering@qut.edu.au

References

1. Lottering N, MacGregor DM, Barry MD, Reynolds MS, Gregory LS. Introducing standardized protocols for anthropological measurement of virtual subadult crania using computed tomography. J Forensic Radiol Imag 2014;2(1):34-38.

2. Brough AL, Bennett J, Morgan B, Black S, Rutty GN. Anthropological measurement of the juvenile clavicle using multi-detector computed tomography – affirming reliability. J Forensic Sci 2013;58:946-51.

3. Fenster A, Downey DB, Cardinal HN. Three-dimensional ultrasound imaging. Phys Med Biol 2001;46(5):R67-99.

4. O'Donnell C, Iino M, Mansharan K, Leditscke J, Woodford N. Contribution of postmortem multidetector CT scanning to identification of the deceased in a mass disaster: Experience gained from the 2009 Victorian bushfires. Forensic Sci Int 2011;205(1):15-28.

5. Lottering N, MacGregor DM, Meredith M, Alston CL, Gregory LS. Evaluation of the Suchey-Brooks method of age estimation in an Australian subpopulation using computed tomography of the pubic symphyseal surface. Am J Phys Anthropol 2013;150:386–399.

6. Ousley SB. Final Technical Report: Radiographic database for Estimating Biological Parameters in Modern Subadults. National Institute of Justice: Award No: 2008-NIJ-1793-SL#000802, 2013.