



G55 3D Analysis of Dental Crown Morphology in Laser-Scanned Dentitions: A Comparison of Three Software Packages

Ademir Franco, MSc*, Katholieke Universiteit Leuven, Kapucijnenvoer 7, block a, Leuven, BELGIUM; Guy Willems, PhD, Katholieke Universiteit Leuven, School of Dentistry, Kapucijnenvoer 7, Leuven B-3000, BELGIUM; Sérgio Ignácio, PhD, Pontifícia Universidade Católica do Paraná, R. Imac. Conceição, 1155, Curitiba PR80215-901, BRAZIL; Paulo Souza, PhD, PUCPR, R. Imac. Conceição, 1155, Curitiba PR, 80215-901, BRAZIL; and Patrick W. Thevissen, PhD, KULeuven, Dendermondsesteenweg 483, Sint-Amandsberg, Oost Vlaanderen B-9040, BELGIUM

After attending this presentation, attendees will: (1) be updated regarding the current investigations on the uniqueness of the human dentition; (2) understand the relevance of 3D morphological analysis of dental crowns in the context of forensic sciences; and, (3) be aware of an ideal software set-up to investigate the uniqueness of dental crowns.

This presentation will impact the forensic science community by exposing the current limitations on the investigation of the uniqueness of the human dentition. Moreover, the performances of three existing 3D software packages used to analyze metrics and superimpositions of the dental crowns will be evaluated and compared.

The existence or lack of uniqueness in human dentition became one of the most polemic topics in forensic sciences in recent years.¹ In 2009, the National Academy of Sciences highlighted the social impact of this controversy, exposing the harm involved in bitemark casework that led to several wrongful convictions worldwide.²⁻⁴ Specifically in bitemark cases, the uniqueness of human dentition consists of essential characteristics that are used for identification of perpetrators. These perpetrators are tracked by matching human dentition with patterned injuries. This procedure is not fully reliable or indisputable as long as the uniqueness of human dentition is still a matter of discussion. Currently, the legal integrity of convicted innocents is assured by special organizations such as The Innocence Project.⁵ From a scientific view, the uniqueness of human dentition remains uncertain, which necessitates major efforts to support bitemark evidence.¹ There is ongoing improvement of imaging tools in engineering and graphic design. This indicates potential approaches for analysis of dental morphology and optimal approaches for investigations of the uniqueness of human dentition.¹ The present research sought to compare three existing software packages for 3D analysis of laser-scanned dental models.

The present research was designed as a cross-sectional experiment approved by the National Committee of Ethics in Research. The sample consisted of 20 human dental models randomly selected. The dental models were laser-scanned using the xCAD 3D[®] automated motion device. The obtained 3D models had a resolution of <20 microns. The Geomagic[®] Studio[®], Cloud Compare[®], and Maestro 3D Ortho Studio[®] software programs were tested for their metric and superimposition performances. In superimpositions, landmarking and cropping procedures were assessed. A blind test was included, simulating a real forensic case in which identical dentitions were merged for identification into a pool of randomly selected models. Intra- and inter-examiner calibrations were performed before the experimental steps. Statistical tests consisted of Dahlberg's error, applied to correlate the total variance with the error variance; Pearson's correlation coefficient and reliability coefficient, applied to assess the correlation of two sets of paired data; and Student's *t*-test, applied to investigate the level of discrepancy between two sets of paired data within a confidence interval of 95%. A qualitative analysis was performed exposing individual advantages and limitations of the three software programs based on an established quality standard.

Intra- and inter-examiner calibration reached >96.56% agreement for metric analyses and 95.27% agreement for superimposition analyses, without statistically significant differences between the examiners ($p>0.05$). The superimposition of dental models determined the error variance only in the landmarking procedure ($p=0.01$), indicating that the cropping procedure did not influence the final outcomes. The blind test provided 42 possible combinations of dental models. Identical models were properly distinguished from the remaining dataset with no mean discrimination and standard deviation <0.07mm. Cloud Compare[®] and Geomagic[®] Studio[®] achieved optimal performances considering the research purposes. Due to the software performance, free acquisition of Cloud Compare[®] was considered the most advantageous for applying the established quality standard. The present research indicated that existing software packages may usefully be applied to perform 3D comparisons of dental crown morphologies. Specifically, Cloud Compare[®] and Geomagic[®] Studio[®] software have good potential for superimposition analyses and evident advantages for metric analyses and comparisons.

Reference(s):

1. Franco A., Willems G., Souza P.H.C., Bekkering G.E., Thevissen P. The uniqueness of the human dentition as forensic evidence: a systematic review on the technological methodology. *Int J Legal Med.* 2011; doi: 10.1007/s00414-014-1109-7.
2. Holtkötter H., Sheets H.D., Bush P.J., Bush M.A. Effects of systematic dental shape modification in bitemarks. *Forensic Sci Int.* 2013;228:61-9.
3. Bush M.A., Bush P.J., Sheets H.D. A study of multiple bitemarks inflicted in human skin by a single dentition using geometric morphometric analysis. *Forensic Sci Int.* 2011;211:1-8.
4. Clement J.G., Blackwell S.A. Is current bite mark analysis a misnomer? *Forensic Sci Int.* 2010;201:33-7.
5. The Innocence Project. Available from: www.theinnocenceproject.org. Accessed on July 27th 2015.

Uniqueness Human Dentition, 3D Scanning, 3D Superimposition

Copyright 2016 by the AAFS. Unless stated otherwise, noncommercial *photocopying* of editorial published in this periodical is permitted by AAFS. Permission to reprint, publish, or otherwise reproduce such material in any form other than photocopying must be obtained by AAFS.