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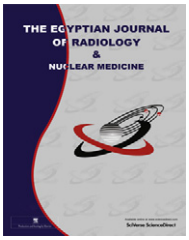

ORIGINAL ARTICLE

"Calvarial Butterfly" new multidetector computed tomography (MDCT) virtual osteoscopic (VO) fingerprint for identification

Abbas H.M.N. Moustafa [a,*], **Hayedi M. Megahed** [b]

[a] *Radiology Department, El-Minia University, Egypt*
[b] *Forensic Medicine & Toxicology Department, Alexandria University, Egypt*

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Abstract *Purpose:* The battle between criminal associations and law enforcement still rages to this day, providing ever more elusive ways to mask away the characteristics which will lead criminals, eventually, to justice. So we tried to find an easy way using one of the MDCT applications namely "virtual osteoscopy" to create a new internal "fingerprint" that could not be manipulated by any means.

Methods and material: Virtual osteoscopic evaluation (post-processing technique) of the calvarial bones of 1120 patients was carried out using the available software "Syngo" from Siemens Medical Technology – Erlangen – Germany; following routine MDCT evaluation of the brain due to different complaints. The generated images were reviewed, analyzed and the results were tabulated. Thorough evaluation of the axial cuts regarding any abnormalities including skull features, skull vault thickness, paranasal sinuses, brain lesions or normal variants which may be kept as a reference hand in hand with the virtual osteoscopic findings of the Calvarial Butterfly.

* Corresponding author. Address: 27, Abd El-Kader Ragab Street, Beside Al-Malaki Hospital, Roushdy, Alexandria, Egypt. Tel.: +20 112817541; fax: +20 35414107.
E-mail address: drabbas64@hotmail.com (A.H.M.N. Moustafa).

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Results: The generated data were tabulated regarding the patterns of the generated Butterfly-like structure representing the external features of the diploic space marrow cavity at the occipital protuberance level. From the examined patients it was shown that each individual had a unique Butterfly-like structure having distinct external features, patterns as well as calculated volumes.
Conclusion: The 3D virtual endoscopic models with the generated Butterfly-like appearance (i.e. virtual osteoscopy) at the occipital region will play a major role in the cases of identification and anthropology in both in vivo and in vitro cases and will solve a lot of forensic medicine mysteries.

1. Introduction

Despite the several methods for identification of human remains are now well established worldwide including facial features, scars, birthmarks, tattoos, fingerprints, palm and footprints all rest on preservation of the soft tissue components of the body in question, still some cases cannot be pinpointed. These methods are discarded when the remains are so decomposed, macerated, burned or fragmented that the surface topography is unrecognizable or lost its features. Bone is the final part of the body to be disintegrated; subsequently the Calvarial Butterfly which is an osseous part of the bony calvarium will remain for a long time. This assumption is fortified by the long lasting bony remnants seen since thousands of years without significant damage. At that time medical and dental radiological methods may be the sole clue for forensic mystery solving. The identification of human remains is of paramount importance in medicolegal investigations. The comparison of antemortem and postmortem radiographic records is one of the main techniques used to achieve a positive identification (1–3).

Virtual reality in the field of diagnostic radiology was first introduced by David Vining, who presented his initial experience of virtual bronchoscopy at the RSNA in the year 1993. Following that several researchers introduced many applications on the same theme, including virtual colonoscopy, virtual angioscopy and virtual autopsy. Recently virtual anthropology (VA) has been used to solve different problems that could not be properly addressed using conventional anthropological approach. Mainly when dealing with mummies (especially with the Pharaonic Egyptian mummies), the virtual approach is the only solution to carry out a detailed analysis of the skeleton without compromising the integrity of the physical remains. Three-dimensional (3D) digital models of the physical object allow for virtual manipulation, simulation, and bone sectioning, etc., in a virtual space, therefore preserving the original object from invasive procedures. Furthermore, the development of sophisticated software and hardware contributes not only to an increase in the amount of data available for scientific analysis, but also improves the quality and objectiveness of the research. However, up to our knowledge nobody employed the virtual endoscopy in the skeletal system, i.e. virtual osteoscopy (4–12).

The utilization of high-dimensional medical imaging in the investigation of major fatality incidents is valuable. It is a mean for non-invasive virtual autopsy or as a tool to conduct anthropological measurements and reconstruction of skeletal tissues in order to facilitate the identification process (13–21).

2. Aim of the work

The aim of this study is to introduce a new identification tool to the already present ones, in order to enrich this challenging field in a trial to solve the forensic mysteries.

3. Materials and methods

To our knowledge, it is the first time to employ the virtual endoscopy in the bony skeleton. The virtual endoscope was placed within the bony mass of the long axial bony skeleton including the femur and humerus.

The virtual osteoscopic view of the long bones of the axial bony skeleton revealed the "cave-like appearance" with its lower border represents the inner wall of the bone lining the marrow cavity of the shaft, while its superior aspect (roof) represents the outer wall of the cortex, i.e. we are navigating within the bony mass of the bone shaft. The threshold was chosen more or less identical to that of the factory pre-set used for the virtual angioscopy (ranging between 300 and 800 HU) (Fig. 1).

The resultant images are encouraging us to proceed and navigate within the bony calvarium. It was noticed that there is an internal constant "butterfly-like" structure within the diploic space at the level of the occipital protuberance, representing the outer surface of the intradiploic marrow space. This directed our curiosity toward proceeding into its investigation.

The current study was carried out over 1120 consecutive patients, their ages ranged between 12 and 79 years old with a male to female ratio 3:1; examined by MDCT of the brain for several pathological entities. The examination was carried out on Siemens AG Emotion 6 slices, Erlangen – Germany. The virtual endoscope with the same parameters for the virtual angioscopic evaluation was used to examine the bony calvarium using the available "Syngo" workstation using the preset parameters for the virtual angioscopic evaluation. The virtual endoscope is placed within the diploic space of the bony calvarium at the occipital region in a midline location with the virtual eye piece located toward the outer table while the virtual lens direction inclined upward toward the orbit facing the inner table of the occipital wall (Fig. 2). Virtual osteoscopy technique was carried out from different perspectives and the resultant images of the generated "butterfly" were thoroughly reviewed. Actually there is a technical difficulty in putting the virtual osteoscope at the inner table as there is not enough potential space for it from one hand, and from the other hand it is attached to inner table and subsequently it will not give a meaningful virtual endoscopic (virtual osteoscopic) image.