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Technical note

Comparative radiologic identification with CT images of paranasal sinuses – Development of a standardized approach ☆

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ABSTRACT

The routine use of computed tomography (CT) to forensic medicine allows for new methods of radiologic identification. Here we present a method to reconstruct a standardized CT image of the head for comparative identification: CT images are reconstructed in MPR along skeletal anatomical landmarks of the inner ear and the orbit. The key advantage of working with standardized images for identification is that ante mortem and postmortem images can be reconstructed independently of one another.

1. Introduction

The use of computed tomography (CT) in forensic medicine allows for new methods of radiologic identification [1,2]. Comparing cross-sectional images of the paranasal sinus is a reliable and efficient method for comparative identification for both single identifications and disaster victim identifications (DVI) [3-10]. To establish the identity of a single individual, ante mortem CT images of the paranasal sinuses can be visually compared to corresponding post mortem CT (PMCT) images [1,8]. To achieve this, PMCT images are reformatted and manually adjusted using multiplanar reformation (MPR) to match the axial ante mortem CT reference images [1,8]. Although this method proved reliable with regard to identification [8], the quality of the reconstructed images and the degree of matching details between ante mortem and post mortem images depend on the skill and technical experience of the user. Currently, there is no standard operating procedure or standardized imaging plane used for comparison of the paranasal sinuses on CT.

Traditionally, axial CT images of the head in clinical radiology are oriented along the orbitomeatal line (or cantomeatal line) [11,12]. The orbitomeatal line is the line between the outer corner of the eye (canthus) and the center of the external auditory canal [12]. Scanning parallel to this line reduces artifacts in the posterior cranial fossa (because streak artifacts from metal fillings of the teeth are projected below rather than into the posterior cranial fossa) and reduces critical organ dose (because the eyes and especially the eye lens are not directly in the path of the x-ray beam) [12,13].

This internationally accepted standard in clinical head CT is still widely used today, therefore, the vast majority of all ante mortem head CTs used for radiologic identification are oriented parallel to the orbitomeatal line. In post mortem CT, however, the orientation of the axial images varies from case to case and depends of the position of the head of the decedent on the CT table. There are numerous factors which hamper or preclude repositioning of the head for dedicated scanning in the orbitomeatal plane after death (e.g., post mortem rigidity, advanced decomposition, or charring). In the personal experience of some of the authors, it usually takes about 15 min per case to manually adjust the PMCT images with MPR until the anatomy of the paranasal sinuses is aligned for best possible comparison to ante mortem images. While this approach

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may be adequate in single identifications, it is insufficient for mass fatality incidents.

In this article we present a method where comparative radiologic identification is achieved using a single reconstructed CT image of the skull. This standardized image is oriented along the orbitomeatal line relying on osseous anatomical landmarks, and can be reconstructed independently from both the ante mortem and the post mortem head CT data.

2. Methods

2.1. Reformation of the standardized reference image for identification

CT data of the skull were reconstructed with MPR using a dedicated, standard picture archiving and communication system (PACS) viewer (MM Reading, Syngo.Via VB10, Siemens Healthcare, Erlagen, Germany). It is important to note that the presented reformation technique is not limited to specific viewing software (it is vendor neutral) and can be performed on a wide range of commercially available or free DICOM reading software.

The standardized reference image uses the semilunar canal of the inner ear and the inferior rim of the frontal bone as anatomical references points. These specific reference points were selected for three reasons: (1) both anatomical reference points are osseous structures that remain in position relative to each other even after a long post mortem interval, (2) the reference points are easy to identify, and (3) both reference points are depicted on all ante mortem and post mortem CT scans of the head (meaning: these structures are always included in the scan volume of brain scans in living patients).

2.2. Step-by-step guide to reformation of standardized reference image

1. Open head-CT data set (bone kernel) with MPR and set window manually to: center 1000 Hounsfield Units (HU), and width 4000 HU (marked with yellow circle in Fig. 1).
2. Scroll up (or down) through the stack of axial images (Fig. 2a) until the right external auricular canal is visible on the axial

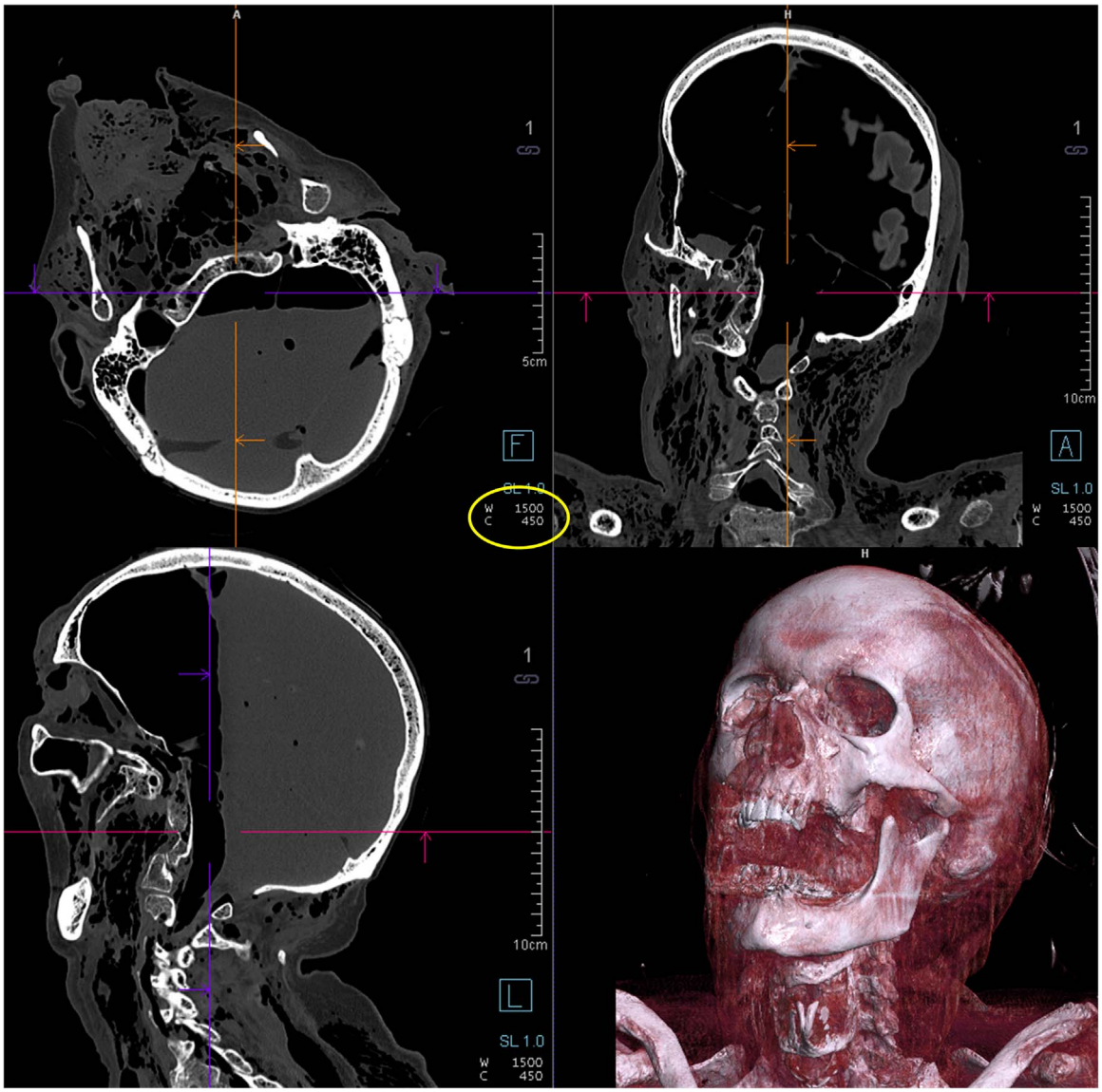

Fig. 1. Step 1 of the reformation: Open head-CT data set (bone kernel) with MPR and set window to: center 1000 Hounsfield Units (HU), and width 4000 HU (marked with yellow circle in Fig. 1a). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)