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TECHNICAL NOTE

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Identification of Human Skeletal Remains by Comparison of Bony Details of the Cranium Using Computerized Tomographic (CT) Scans*

ABSTRACT: A case is described where a cranium from an unknown individual is identified by comparison of antemortem and postmortem computerized tomographic (CT) images of the bony structure of the skull. While on at least one occasion CT scans of individual cranial landmarks have been used to identify unknown remains, this study is remarkable because positive identification of a deceased individual was accomplished by performing a CT scan on an unidentified cranium and comparing multiple landmarks and images with corresponding features in an antemortem CT scan of a missing man. Bony details of the frontal and sphenoid sinuses, ethmoid and mastoid air cells, sagittal cranial suture, and the torcula (the internal occipital protuberance) were exactly the same on both CT scans, confirming them as the same person.

KEYWORDS: forensic science, computerized tomography, CT scan, frontal sinus, sphenoid sinus, ethmoid air cells, mastoid air cells, sagittal cranial suture, torcula, internal occipital protuberance

Historically, radiographic identification has been accomplished by comparison of antemortem and postmortem conventional X-ray images (1–4). However, the advent of new technology in the form of CT scans and magnetic resonance imaging (MRI) is making traditional antemortem data increasingly scarce. In the following case, dentition, antemortem skull X-rays, and dental records of a missing man were unavailable. The only antemortem skull data available, a CT scan of the head taken nine days prior to the man's disappearance, was compared with the CT scan performed on the cranium of an unknown individual.

Case History

Human skeletal remains comprising approximately half a skeleton were discovered on a Colorado mountainside. There were no obvious bone duplications and it was initially believed that the degree of weathering, robustness, and time since death were consistent with the remains being from a single individual.

The basic description of the deceased provided by a forensic anthropologist was a male, age 50 ± 10 years, 186.2 ± 8.1 centimeters tall, Euroamerican ancestry, medium build, and probably a denture-wearer. Time since death was estimated at a minimum of six months to as long as several years. The general description fit that of a 42-year-old Caucasian man who was last seen in the vicinity nearly two years before the remains were discovered. He had disappeared in the midst of a terrible blizzard, was exceedingly weak and in failing health, and had left a suicide note.

Despite being badly damaged by predators and exposure, the bones had three distinguishing features. These included a healed fracture of the left fibula, a left rib with a healed fracture callus, and an edentulous cranium. However, antemortem X-rays of this missing person did not match the remains in every respect. Carnivore damage to trabeculae made it impossible for a forensic radiologist to identify the individual through a comparison of postmortem X-rays and antemortem radiographs of the healed ankle fracture taken four years before the man's disappearance. Despite this, strong similarities between the recovered left fibula and the antemortem X-rays made it possible to estimate a 90% likelihood that the ankle was that of the missing man. However, a chest X-ray taken nine days before the man disappeared showed absolutely no signs of a left rib fracture. In addition, when aligned at possible attachment sites along the vertebral column of a 1:1 chest radiograph, the rib in question projected several centimeters beyond the ribcage of the missing man, indicating its source to be an individual of much larger build. Antemortem skull and dental X-rays could not be located for a comparison of the cranial bony structure.

There were only two possible interpretations of the data. Either the remains belonged to an individual who was not the person it was believed to be, or the remains represented more than one decedent. It appeared that antemortem skull data would be necessary to resolve this issue. Ideally, these should take the form of skull X-rays, although dental X-rays might also prove acceptable and be easier to obtain.

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Unfortunately, the dentist who had made dentures for the missing man 4 ½ years before his disappearance had not retained X-rays on his patient. In addition, although an upper plate of dentures was found embedded in the pumice-like soil, months of exposure to such conditions meant that the dentist could no longer validate it as his work. Likewise, a forensic odontologist stated that erosion of both the maxillary arch and the dentures made it impossible to confirm a fit between the dentures and the cranium.

Another possible source of antemortem data presented itself when it was discovered the missing man had undergone a head CT scan nine days prior to his disappearance. Identification of another unknown skull had previously been achieved through comparison of lateral view skull X-rays with an antemortem scout topogram (5). While this method requires only basic X-ray equipment and is therefore very cost effective, it was unsuitable for use in this case due to flaws in the antemortem scout topogram that encompassed the anterior 35% of the cranium. The brow ridges, floor of the anterior cranial fossa, and anterior clinoid process of the sella turcica, were indistinct, thus eliminating half of the unique features used in this technique. Thus, in the absence of any other antemortem skull data, a postmortem skull CT scan was performed and compared with corresponding images in the antemortem scan.

Using the scout topogram, the cranium was oriented in a similar position to emulate the slice position and thickness of the antemortem exam. Images 5 mm in thickness were made through the posterior fossa, and images 10 mm in thickness were made through the remainder of the skull. This was repeated with the skull tilted backwards an additional 5°.

A comparison of the antemortem and postmortem CT scans (Fig. 1) shows that frontal and sphenoid sinus details, as well as fine septal bony details of the ethmoid air cells are exactly the same. In addition, images through the mastoid air cells are also identical. The bony detail of the torcula also matches, as do multiple features of the sagittal cranial suture (not shown). The gross bony detail of the calvarium (not shown) is also similar, but this is felt to be less characteristic than the fine bony detail of the sinuses and mastoid air cells.

Discussion

The bony details of cranial structures at multiple levels afforded by a CT scan provide a three-dimensional comparison of cranial anatomy that cannot be obtained from standard skull X-rays. This combination of structural details of the cranium is unique to the individual, and offers yet another tool for identification of unknown human remains when more traditional means are unavailable. In this case, positive identification of the cranium validated the tentative identification of the left fibula, thereby confirming that the remains were those of at least two different persons.

Previous efforts to identify human remains using CT scans have focused on particular aspects of cranial anatomy, using lateral view skull X-rays versus scout topograms as a means of comparison (5),

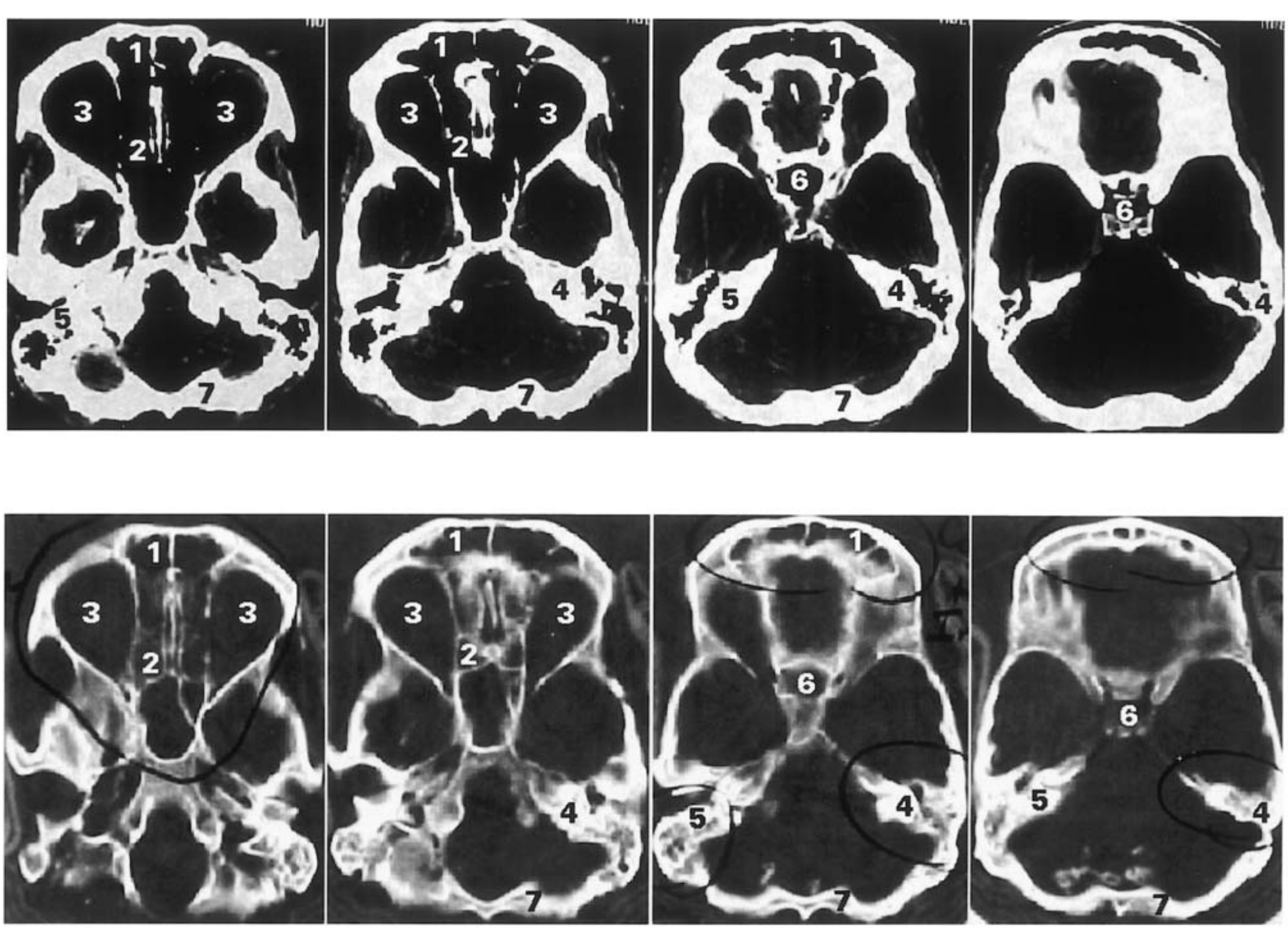

FIG. 1—*Top Row: Antemortem view. Bottom Row: Postmortem view.* 1 *Frontal sinuses,* 2 *Ethmoid air cells,* 3 *Orbits,* 4 *Right mastoid,* 5 *Left mastoid,* 6 *Sphenoid sinus, and* 7 *Torcula.*

frontal sinuses (6,7), or evaluation of antemortem and postmortem CT scans of vertebrae to establish identity (8). With the increased tendency to perform CT scans or MRIs to diagnose brain disorders, skull X-rays are becoming increasingly obsolete. CT scans, in addition to providing a better assessment of the living brain tissue than do skull X-rays, also provide significant details of cranial anatomy that can be used for identification of unknown remains. The primary difficulty with this method involves correct alignment of the skull so as to emulate the gantry angle and slice position of the antemortem CT scan. While the scout topogram provides a good overview of the skull to show the correct lateral alignment, minute variations in the frontal alignment may not be visible from this vantage point. This problem is probably best overcome by varying the orientation of the postmortem specimen by a few degrees in one or more directions until a high degree of correspondence is achieved in equivalent antemortem and postmortem images of the cranium.

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