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Analysis of the Frontal Sinus Morphology and the Titanium Plates Shape in Skull Fracture for Human Identification

Análisis de la Morfología del Seno Frontal y la Forma de la Placa de Titanio en Fractura de Cráneo para la Identificación Humana

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ABSTRACT: Human identification can be performed by several methods, as anatomical structures of the facial skeletal and individuals signals. The aim of this study was to report a case of human identification from the morphological evaluation of the frontal sinus and the presence of titanium plates in skull after examination of Postero Anterior (PA) radiographs ante and postmortem. In 2008 a skull was found on a highway. Later, an alleged victim was found , who disappeared in late 2007. The skull showed postmortem teeth lost, presence of round hole in the right supra-orbital region, consistent with lesion caused by gunshot. It was also noted the presence of a miniplate of bone fixation in the form of inverted "T" in several locations of the nasal bones and bone remodeling signals in the face. PA radiograph of the skull was performed for the purpose of comparison with the X-rays provided by antemortem family. By overlapping radiographic images, there was similarity between the characteristics presented by the skull and found the alleged victim, as the frontal sinus, shape and height of the orbits, and miniplate fixation of bone with the same shape and size, not leaving no doubt that the radiographs belong to the same individual.

KEY WORDS: frontal sinus, forensic anthropology, radiography.

INTRODUCTION

For human identification, in situations in which the body is unrecognizable, the comparative analysis ante and postmortem of anatomical structures in skull may be required for individual identification (da Silva *et al*., 2009; Rossi *et al*., 2012).

The frontal sinus is an anatomical structure widely used for human identification because it presents sexual dimorphism, is absent in only 4 % of the population and possesses areas that are unique among individuals (Riepert *et al*., 2001). Besides, the frontal sinus becoming radiographically evident at the age of 5 or 6 years and developing fully by the age of 20 years (Verma *et al*., 2015). The frontal sinus shows no changes after the age of 20 and remains stable throughout the individual's life until age, when gradual pneumatization can occur from atrophic changes (Patil *et al*., 2012).

In forensic dentistry, X-rays can materially support the processes of human identification. For the visualization of anatomical structures of the facial skeleton, commonly the posterior-anterior (PA) Caldwell radiographic technique is used for analysis of the paranasal sinuses and also for detection of fractures of the face and the skull (da Silva *et al*.).

PA Caldwell radiographic technique is usually performed for diagnosis of frontal sinus fractures of the skull, allowing the view of morphological

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characteristics of each individual, that distinguish one individual from another, such as anatomical peculiarities and individual signals as reduction of fracture plates, traumas, so important in forensic practice (Pretty & Addy, 2002; Kanchan *et al*., 2009; Hartung *et al*., 2011).

Thus, the aim of this study was to report a case of human identification by morphological analysis of the frontal sinus and the presence of titanium plates in skull in after examination of PA radiographs ante and postmortem.

MATERIAL AND METHOD

In 2008 a skull was found on a highway in Brazil. Later, an alleged victim was found, who disappeared in late 2007. The material belonging to the alleged victim and the human skull were sent to the Piracicaba Dental School - UNICAMP, in order to be submitted to expert examination for human identification.

As the unique available material was a dry human skull. We analyzed the frontal sinus and specific morphological signals.

The first step was considering the frontal sinus morphology for description. The shape of the sinus was evaluated as follows: presence of lobus, location of the septum and its deviation, upper border, partial septum and symmetry.

Caldwell PA radiograph of the skull (Fig. 1) was performed for the purpose of comparison with the antemortem X-ray provided by family. The PA skull projection was chosen because it is designed to provide a clear view of the frontal sinus without loss of definition by superimposition of portions of the sphenoid bone. The frontal sinus alone has the clearest silhouette in this projection and presents the least chance for error in interpretation (Verma *et al*.).

The method used to prove that antemortem radiograph belonged to the alleged victim, we proceeded to overlap area of each frontal sinus radiograph in Adobe Photoshop CS5 software (Fig. 2).

RESULTS

The skull showed teeth lost postmortem, presence of round hole in the right supra-orbital region, consistent with lesion caused by gunshot, and fractu-

Fig. 1. A) PA radiograph provided by the family of the alleged victim (antemortem). B) PA radiograph obtained by X-ray of the skull found (postmortem). In both cases, note the presence of fractures with miniplate fixation bone in the region of the nasal bones and frontal sinus.

Fig. 2. Overlap of antemortem and postmortem radiographs.

re of the anterior wall of the maxilla. The skull showed the presence of a miniplate of bone fixation in the form of inverted "T" in several locations nasal bones and bone remodeling signals with the face (Figs. 3 and 4).

In PA Caldwell radiograph, it was found that the characteristics were coincidental with radiographic reports of the alleged victim, who had undergone radiographic examination in December 1992 with a diagnosis of fracture in the region of the frontal sinus and nasal bones (Fig. 1). Aspects related to the lobus, septum, upper border and symmetry are described in Table I.

By overlapping radiographic images (Figs. 2 and 3), there was great similarity between the characteristics presented by the skull and found the alleged victim, as the frontal sinus, shape and height of the orbits, and miniplate fixation of bone with the same shape and size, leaving no doubt that the radiographs belong to the same individual (Fig. 5).

When we analyzed the overlap formed by each frontal sinuses, noted the similarity in their particularities, without excluding factors, completing the case of frontal sinuses belonging to the same person (Fig. 2).

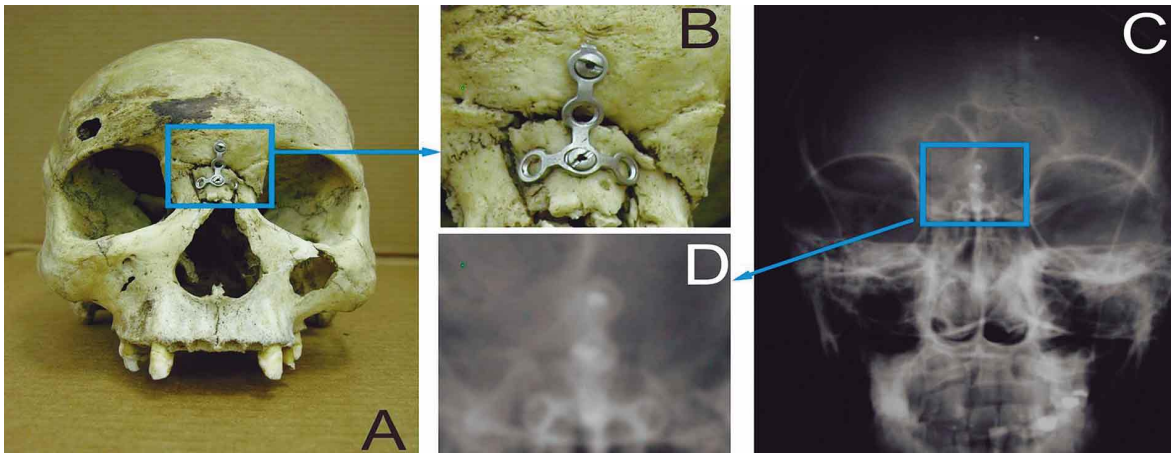

Fig. 3. A) Anterior view of the skull. B) Highlighting the miniplate on the skull. C) Antemortem radiographic image. Images and their approximation demonstrate the morphologic similarity between miniplate on skull (B) and miniplate on radiographic image (D).

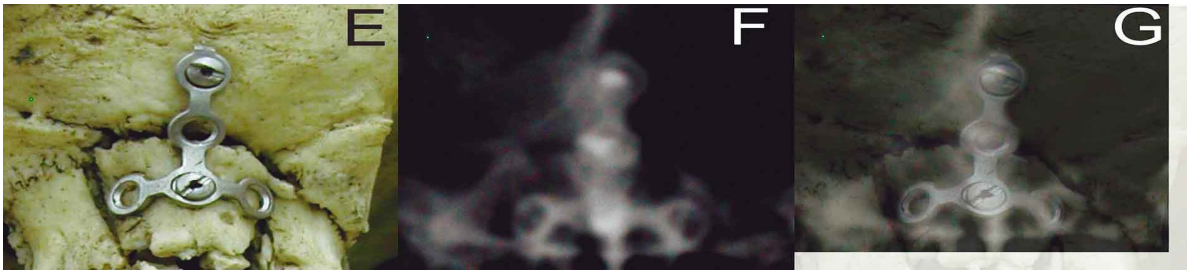

Fig. 4. E) Miniplate in form of inverted “T”, fixed in the skull. F) Postmortem radiographic image of the miniplate G) Images overlapped from skull and radiographic.

Table I. Morphology comparison between the radiographic findings.

Points	Ante mortem radiography	Post mortem radiography	Coincidence
a	Presence of miniplate bone fixation in inverted “T” shape.	Presence of miniplate bone fixation in inverted “T” shape.	Positive
b	One screw at the top of the miniplate. Visualization of others crews are impaired by imaging overlapping	Presence of two screws fixing the miniplate in inverted “T” shape to the bone.	Explained discrepancies
c	Left dominant asymmetry.	Left dominant asymmetry.	Positive
d	Three lobes, being the left the greatest.	Three lobes, being the left the greatest.	Positive
e	Creased groove that continues forming the main septum.	Creased groove that continues forming the main septum.	Positive
e	Groove on the left side just above the contour of the left orbit.	Groove on the left side just above the contour of the left orbit.	Positive
f	Two septa on the right side.	Two septa on the right side.	Positive

Fig. 5. H) Miniplate in form of inverted “T”, fixed in the skull. I) Antemortem radiographic image of the miniplate J) Images overlapped from skull and radiographic.

DISCUSSION

Associated with the clinical diagnosis, the radiographic documentation may constitute relevant source of evidence in forensic expert questions, but unless these documents are properly processed and archived. In the case reported, antemortem documentation was of utmost importance to identify the person, because it facilitated the identification process (Angyal & Dérczy, 1998; Campobasso *et al*., 2007).

The frontal sinuses can be defined as pneumatic cavities covered by mucosa, located between the internal and external cortical bones of the frontal bone. In our case, despite the frontal sinus used for comparison was left dominant asymmetry, forensic analysis of this structure requires some caution, because some environmental factors such as hyperpneumatization associated with sports activities, diseases, trauma and postmortem changes may alter the picture and make it impossible to positive identification (Cameriere *et al*., 2005).

Other evidence that has been reported was the presence of miniplate of bone fixation in inverted "T" shape present in the frontonasal suture. The miniplate presented the same size and number of bolts and holes in the radiographs antemortem and postmortem. Hartung *et al*. also made positive identification on an unknown body by plates bone in Western Europe. These authors confirmed that medical findings as plates

for fixation of bone fractures can be used as an individual signal, or individual characteristics, differential recognition of an individual. Matoso *et al*. (2013) presented a positive identification of a burned human body by tracking batch numbers engraved in an implanted orthopedic device found in the decedent's left ulna bone. The examiners also collected and analyzed other valuable hints related to the case. Forensic examination can provide reliable positive human identification, even if few, but precise information can be obtained from antemortem and postmortem records. These authors illustrated a set of valuable techniques and how identifying numbers in orthopedic devices are helpful to determine positive human identification in cases of carbonization. The use of the bone plates fixation allow low-cost identification procedures with accurate results, avoiding DNA profiling method that would be of higher cost and time consuming. In addition, considering social and legal aspects, it is quite important that physicians and dentists understand that correct and accurate records of surgeries they perform, such as fixation of orthopedic devices and dental implants, are utterly relevant and helpful in cases of human identification.

In our case report, the PA projection described by Caldwell is designed to provide a clear view of the cavities of the face as the orbits, the frontal and maxillary sinuses and piriform aperture without loss of definition by superimposition of portions of the sphenoid bone. The central X-ray was aligned to exit between the orbits at the base of the nose, eliminating the superposition with the petrous ridge of temporal bone (Nambiar *et al*., 1999; Rossi *et al*.).

In conclusion, in case reported, we verified the importance of the shape of the frontal sinus, unique to each individual as well as the analysis of individual signals as the presence of trauma to bone fixation plates.

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RESUMEN: La identificación humana puede realizarse por varios métodos, entre ellos a partir de estructuras anatómicas del esqueleto facial y del reconocimiento de señales individuales. El objetivo de este estudio fue reportar un caso de identificación humana mediante la evaluación morfológica del seno frontal y la presencia de placas de titanio en el cráneo después del examen con radiografías posteroanteriores (PA) ante y post mortem. En 2008, se encontró un cráneo en una carretera. Más tarde, se encontró una presunta víctima, que desapareció a finales de 2007. El cráneo mostró dientes perdidos post mortem, la presencia de un orificio redondeado en la región supraorbital derecha, en consonancia con lesiones causadas por arma de fuego. También se observó la presencia de una miniplaca de fijación ósea en forma de "T" invertida en varios lugares de los huesos nasales y señales de remodelación ósea en la cara. La radiografía posteroanterior del cráneo se realizó con el propósito de comparación con los rayos X antemortem proporcionados por la familia. Por superposición de imágenes radiográficas, hubo similitud entre las características que presentó el cráneo y las de la presunta víctima, ya que el seno frontal, la forma y la altura de las órbitas, y la fijación de la miniplaca de hueso presentaron la misma forma y tamaño, no dejando ninguna duda de que las radiografías pertenecían a la misma persona.

PALABRAS CLAVE: seno frontal, antropología forense, radiografía.

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