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Gender identification from frontal sinus using multi-detector computed tomography

Sameera Sh. Hamed [a],*, Adel M. El-Badrawy [b], Sherif Abdel Fattah [b]

[a] Forensic Medicine and Clinical Toxicology, Faculty of Medicine, Mansoura University, Egypt
[b] Diagnostic Radiology, Faculty of Medicine, Mansoura University, Egypt

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ABSTRACT

The determination of gender of unknown persons is of vital importance in forensic investigations. The present study aimed to evaluate the accuracy and reliability of frontal sinus (FS) dimensions measurement in gender identification. One hundred people (50 males and 50 females) with age range from 20 to 70 years were selected in this study. FS dimensions for both right and left sinuses (transverse, height & anteroposterior lengths) were measured from axial and coronal sections (4-mm slice thickness) using multi-detector computed tomography (MDCT) scanner. Statistically significant lower values for the maximum transverse length of both right and left FS in female group were detected in comparison to the male group ($p=0.002$). In addition, the maximum height of right and left FS in females showed statistically highly significant lower values for in comparison to males ($p=0.001$). Also, the maximum anteroposterior length of the frontal sinus for right and left sides in female group had statistically significant lower values ($p=0.001$ and 0.01 respectively) in comparison to the male group. Multiple regression equations revealed that among all FS measurements, the right FS anteroposterior length was the best discriminate variable between genders with overall accuracy 67.0% (70.0% for women and 64.0% for men). It can be concluded that FS dimensions measurement especially the right anteroposterior length are valuable in studying sexual dimorphism using MDCT image.

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1. Introduction

Identification of human remains is one of the most essential aspects of forensic medicine. The determination of gender of unknown people is also of vital importance in forensic investigations [1].

Skeletal remains have been used for sexing the individual as bones of the body are last to perish after death, next to enamel of teeth. However, when extreme post-mortem changes have developed as in explosions, warfare and other mass disasters like aircraft crashes, identification and sex determination are not easy tasks [2].

Radiological identification of humans still has a very important place in forensic medicine especially in difficult cases of DNA analysis, or in cases where the body is putrefied, fragmented, carbonized or skeletonized [3].

The skull is useful in sex assessment of skeletonized remains; however, its fragmentation precludes the use of all conventional craniofacial markers. The frontal bone may be recovered intact in fragmented remains and the sinuses therein may be useful in sex differentiation [4].

The frontal sinuses are a part of paranasal sinuses and they are located in the frontal bone above each eye. They consist of paired, loculated cavities, which communicate with the nasal fossa via the infundibulum [5].

Frontal sinus has great variability due to its irregular shape and because of individual characteristics which make the frontal bone unique for every individual, just as with fingerprints even for monozygotic twins [6].

Also, the Frontal sinus has very strong walls and its structure does not change after the age of 20 years except for very rare occurrences as fractures, tumors or severe infections [7].

Gender estimation can be accomplished using either morphological or metric methodologies. Statistical methods utilizing metric traits are becoming more popular; with most of the bones have been subjected to linear discriminant classification [8].

Computerized tomography (CT) is an excellent imaging modality in the identification of unknown human remains and could be used to evaluate the paranasal sinuses and craniofacial bones. It can provide valuable and precise measurement for frontal sinus dimensions [10].

CT presents a lot of advantages as compared with conventional radiographs. First, it provides the opportunity of avoiding the superimposition of structures beyond the plane of interest and allowing the visualization of small differences of density [9].

* Corresponding author. Tel.: +20 1095040426.
E-mail address: drsameerashaaban@yahoo.com (S.Sh. Hamed).

Second, the images can be easily manipulated and internal points that should be evaluated can be shown by images segmentation. Third, Craniometric points can be precisely located and measurements can be more accurately performed than on conventional radiographs. Volumes and areas can be determined. Fourth, the film includes a description of the technical details and knowledge about the patient which can be very useful for the identification process [3].

CT measurements of frontal sinus may be a useful method in differentiating gender [11]. This study was designed to determine the reliability and accuracy of frontal sinus dimensions measurement using CT as a method for gender identification.

2. Subjects and methods

2.1. Study design

Total number of patients referred to radiology department, Mansoura University Hospital for performing CT scanning of paranasal sinuses from January to December 2012 was 280. 38 patients were excluded because they were too young for a complete maturation of frontal sinuses, 135 patients were excluded because of history of trauma, surgery or pathological lesions in the frontal region, further 7 patients were then excluded, because of the detection of frontal sinus aplasia. Thus, the final study population consisted of 100 patients (50 males and 50 females) with age range from 20 to 70 years.

All participants were supplied with written informed consent. Prior to imaging, the patient was informed about the investigation and instructed not to move or swallow during scanning. All examinations were performed on a multi-detector computed tomography (MDCT) scanner (SOMATOM Emotion 6, Siemens).

Frontal sinus dimensions for both right and left sinuses (transverse, height and anteroposterior lengths) were measured from axial and coronal section (4-mm slice thickness). The axial scan was parallel to orbitomeatal line and the coronal scan was perpendicular to this line. The protocol was 35 mAs, 110 kV, 4 mm slice thickness, 180 mm field of view (FOV), 512×512 matrix, 0.8 pitch and 0.8 sec rotation time. The greatest FS measurements were taken after going through different slices in axial and coronal sections.

To determine the reliability and reproducibility of FS measurements, inter- and intraexaminer calibrations were carried out by comparing the greatest measurements of randomly selected 10 multi-detector CT by the same radiologist after 2 weeks from the first reading for the intraexaminer calibration and by another senior general radiologist. Data post-processing was done with software Version syngo CT 2006A.

The FS transverse length (width) was measured from coronal or axial image as a distance from the outer most point of the lateral wall of frontal sinus to the medial wall (Fig. 1).

The FS anteroposterior length (depth) was measured from axial image as the longest length anteroposteriorly (Fig. 2).

The height of frontal sinus was represented by the distance measured from uppermost point of the superior wall of the sinus to the lowermost point of the inferior wall. The measurement was obtained from coronal section (Fig. 3).

2.2. Data processing and statistical analysis

All data were subjected to descriptive and discriminate analyses using the SPSS package (version 17.0) for Windows software. *P*-value was considered significant or highly significant at values ≤ 0.05 or ≤ 0.001, respectively.

Fig. 1. Coronal CT scan shows transverse diameter of left frontal sinus.

Fig. 2. Axial CT scan shows anteroposterior diameter of right frontal sinus.

3. Results

As shown in Table 1, the mean value for the maximum transverse length of the right frontal sinus in males was 23.72 ± 9.21 mm and 26.74 ± 10.15 mm for the left side. Female group had statistically significant lower values for both right and left sides (17.8 ± 9.85 and 20.17 ± 10.14 mm, respectively) in comparison to the male group ($p=0.002$).

The mean value for the maximum height of the right frontal sinus in males was 11.46 ± 4.49 mm and 12.46 ± 5.29 mm for the left side (Table 1). Females had highly significant lower values for both right and left sides (8.50 ± 3.94 and 9.42 ± 3.87 mm, respectively) in comparison to males ($p=0.001$).

The mean value for the maximum anteroposterior length (depth) of the right frontal sinus in males was 12.12 ± 4.72 mm while it was 12.32 ± 5.02 mm for the left side. Female group had