



# Frontal sinus parameters in computed tomography and sex determination



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## ABSTRACT

The frontal sinus is a sturdy part of the skull that is likely to be retrieved for forensic investigations. We evaluated frontal sinus parameters in paranasal sinus computed tomography (CT) images for sex determination. The study was conducted on 200 normal paranasal sinus CT images of 100 men and 100 women of Persian origin. We categorized the studied population into three age groups of 20–34, 35–49 and  $\geq 50$  years. The number of partial septa in the right frontal sinus and the maximum height and width were significantly different between the two sexes. The highest precision for sex determination was for the maximum height of the left frontal sinus (61.3%). In the 20–34 years age-group, height and width of the frontal sinus were significantly different between the two sexes and the height of the left sinus had the highest precision (60.8%). In the 35–49 years age-group, right anterior-posterior diameter had a sex determination precision of 52.3%. No frontal sinus parameter reached a statistically significant level for sex determination in the  $\geq 50$  years age-group. The number of septa and scallopings were not useful in sex determination. Frontal sinus parameters did not have a high precision in sex determination among Persian adults.

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## 1. Introduction

Identification is an essential part of forensic investigation. Since the skeletal remains are preserved over centuries, skeletal-based identification is an important section in any forensic reference. The precision of sex determination depends on several factors including age, fragmentation, bone fractures and biologic variables [1]. Therefore, sex determination is not based only on one criterion, rather the evaluation is based on as many evaluations as possible [2].

The frontal sinus is very resistant to trauma and is likely to be preserved in dismembered or burned corpses after mass disasters such as air crashes. The shape of the frontal sinus is affected by sex, race, diseases, environmental factors, growth and development [3]. Despite a number of studies evaluating frontal sinus characteristics in different populations and its role in identification [4–6], only a few studies are published focusing on sex determination using frontal sinus parameters [7]. Recently, Uthman et al. reported the predictive value of frontal sinus parameters for sex determination to be 76.95% [8], yet involvement of different factors merits evaluation of such parameters in different populations.

It is very likely that radiographs and CT scans are taken over the lifetime of a victim. In addition, the frontal sinus is usually preserved in traumas and retrieved after a catastrophe. This gives the specialists the opportunity to examine the radiograph images alongside the bones. Therefore, frontal sinus parameters should be identified in different populations and at different ages. Hence, we performed this study to evaluate the frontal sinus parameters in the Iranian population and measure their sex determination precision.

## 2. Materials and methods

This cross-sectional descriptive-analytic study was carried out in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans. Over the 2012–2013 period, 483 paranasal CT scan images from Iranian adults over the age of 20 years were captured in the imaging archives of Sina Hospital. Participant had already signed the informed consent for research utilization of their images and since no identifying information was available on the studied images, no further Institutional Review Board (IRB) was required. Based on Uthman et al. [8], the sample size formula and inclusion/exclusion criteria, we randomly selected 100 male and 100 female paranasal CT images. Therefore, the study population was

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**Table 1**  
Definition of frontal sinus parameters.

Definition	View	Parameter
Absence of any visible pneumatization	Axial	Absent sinus
Septa running from one sinus wall to the other wall and completely dividing the sinus into several compartments on the largest section	Axial	Complete septum
Septa incompletely extending from one sinus wall to other wall and dividing the sinus into several compartments on the largest section	Axial	Partial septum
Parts of the sinus wall lying between septa on the largest section	Axial	Scalloping
Maximum distance between the upper and lower sinus wall borders on the largest section	Axial	Max height
Maximum distance between the innermost and the outermost borders of the sinus wall on the largest section	Axial	Max width
Maximum distance between the outermost borders of the right and left sinus walls on the largest section	Axial	Max total width
Maximum distance between the anterior and posterior sinus walls on the largest section	Coronal	Max AP diameter

normal Iranian adults over 20 years of age who underwent paranasal CT scanning (Siemens 64 Slice) during the 2012–2013 period. Exclusion criteria were fracture in the frontal sinus walls, fracture of facial bones, frontal sinus diseases blurring the contours of the bony structures, images with more than 2 mm image thickness, anatomical abnormalities of the facial bones, and measurement failure due to inappropriate image conditions.

Images were retrieved and studied in the picture archiving and communication system (PACS). Measured parameters included presence or absence of the frontal sinus, number of complete and partial septa, number of scallopings, maximum height, maximum width and maximum anterior–posterior (AP) diameter (Table 1). Patients were divided into three age groups of 20–34 years, 35–49 years and  $\geq 50$  years [9].

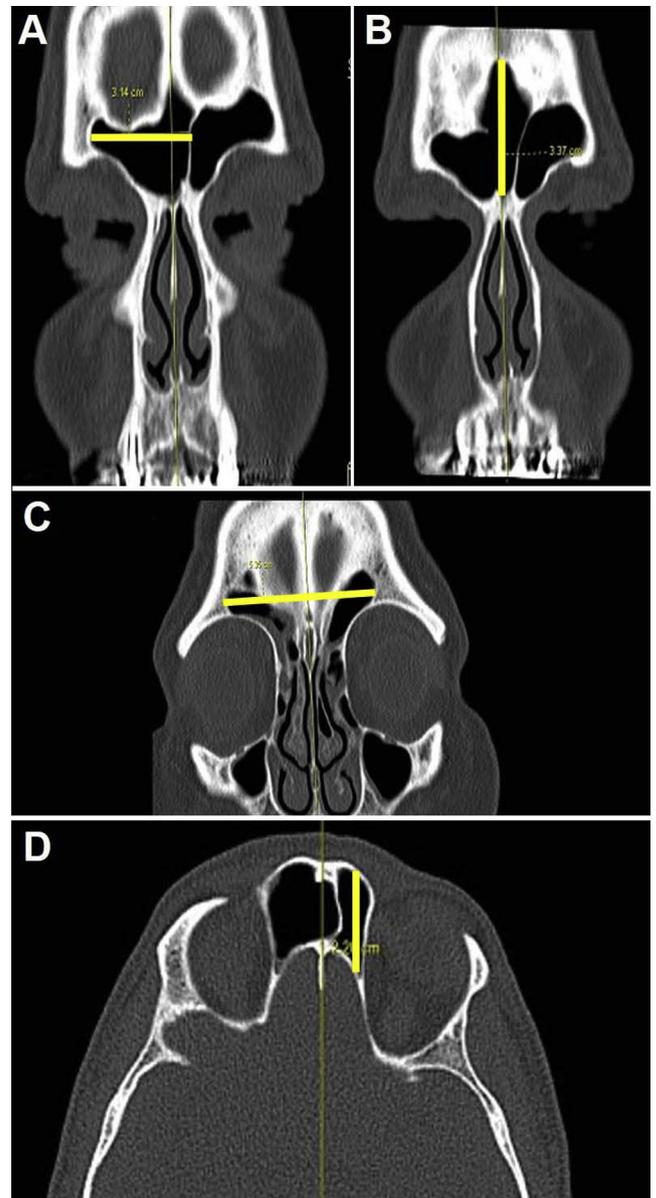
We used the highest measurement for each individual in our analysis. Fig. 1 shows an example of measured parameters. To minimize error, measurements were separately reported by two independent individuals (one radiologist and one forensic medicine specialist) blinded to the study and to each other. We used the mean of the two reported numbers for the final analysis. Statistical data analysis was done by Statistical Package for the Social Sciences (SPSS software version 16) using central and dispersion parameters. T-test was used to compare the parameters between the two sexes. The cutoff value in each ROC curve is determined by the point with the highest sensitivity and specificity for sex determination and  $p$  values below 0.05 were considered significant.

### 3. Results

Mean age of the participants was 39.4 years (interquartile range (IQR) 37.5–41.3 years). Mean age was 40.7 years in men (IQR 38–43.3 years) and 38.1 years in women (IQR 35.3–40.9 years). Table 2 summarizes the age–sex characteristics of the studied population and showing that they were not different in age.

Bilateral absence of frontal sinus was noted in seven cases (3.5%) including five women (5%) and two men (2%). Absence of the right frontal sinus was found in 15 cases (7.5%) including eight women (8%) and seven men (7%), and absence of the left frontal sinus was found in nine cases (4.5%) including five women (5%) and four men (4%). No statistically significant difference was found in the frequency of frontal sinus absence between the two sexes ( $p > 0.05$ ).

The comparison of frontal sinus parameters between the two sexes is shown in Table 3. Number of partial septa in the right sinus



**Fig. 1.** Measured parameters of the frontal sinus. The central perpendicular thin line delineates the central axis. The thick yellow line is the actual measurement. (A) Maximum width of the right frontal sinus. (B) Maximum height of the right frontal sinus. (C) Maximum total width. The small tilt is for correction of patient's head tilt in CT scanner. (D) Maximum anterior posterior diameter (left side).

**Table 2**  
Age of the studied population according to sex.

Sex	Mean	SD	Median	Mode	95% confidence interval	$p$ value
Female	38.1	14.2	35	23	35.5–40.9	0.19
Male	40.7	13.5	40	27	38–43.4	
Total	39.4	13.9	39	27	37.5–41.3	

and the maximum height and width in both sinuses were statistically significant between the two sexes ( $p < 0.05$ ). Since maximum height and width had a statistically significant difference between the two sexes, we calculated sensitivity, specificity, positive predictive value, negative predictive value and the precision of measured parameters on ROC graphs (Figs. 2–4) for sex determination, which is summarized in Table 4. The highest precision (61.3%)

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