


**Research Article**

## Conventional Frontal Air Sinus Imaging in Personal Identification among Adult Bangladeshi

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### Abstract

The frontal air sinuses are essential for anatomists, radiologists, anthropologists, dentists, and clinicians to diagnose diseases. Identifying unknown persons, sex differentiation, and age determination are vital in forensic investigations because individuals' frontal air sinus characteristics make the frontal bone unique for every individual. This study aimed to determine differences in frontal air sinus width by height ratio among Bangladeshi adults. In the Department of Anatomy of Dhaka Medical College, Bangladesh, a cross-sectional analytical study was done by applying conventional and purposive sampling techniques. This study was conducted from January 2016 to December 2016. The analysis was performed on 100 radiographs of the Caldwell view of the skull of adult Bangladeshis. Out of 100 radiographs, 50 were male, and 50 were female. The Caldwell radiograph of the frontal air sinus of the selected individual was collected and viewed on the x-ray view box, traced on a transparent graph paper sheet placed on each radiograph film, and the linear measurements of frontal air sinus height and width were obtained from each radiograph by counting the boxes of transparent graph paper sheet. Then the ratio of width by size was calculated by dividing the width of the frontal air sinus by the height of the frontal air sinus individually. Unpaired Student's t-test and paired Student's t-test were done for statistical analysis of the results. The adult male left frontal air sinus width by height ratio was significantly higher than the right frontal air sinus width by height ratio, but adult female shows that right frontal air sinus width by height ratio was higher than the left frontal air sinus width by height ratio, which was not significant. Both right frontal air sinus and left frontal air sinus width by height ratio were higher in males than females, which was highly significant. The result demonstrates that the cost-effective, non-invasive, and widely applicable Caldwell view radiological morphometric analysis of frontal air sinus can be used to identify an unknown person due to the unique morphological value of the frontal air sinus in every individual.

**Keywords:** Frontal air sinus width by height ratio; x-ray Caldwell view

### Introduction

The frontal air sinuses are paired, irregularly shaped, air-conditioning cavity lined by mucoperiosteum and are located posterior to the superciliary arches and at the roof of the nose between the outer and inner tables of the frontal bone [1]. The frontal air sinus divided into two chambers, right and left frontal air sinus. In between right and left frontal air sinus lies a septum which usually deviates from the midline. The right and left frontal air sinus chambers are rarely symmetrical [2]. Due to the independent development of each sinus, the right and left frontal air sinus chambers are typically

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asymmetrical. The sinuses are subdivided into several recesses and through incomplete bony septa the recesses are communicate with each other [3]. The frontal air sinus is a triangular, pyramid-shaped cavity extending between the two tables of the ascending portion of the frontal bone [4]. The frontal air sinus and the nasal fossa communicates through ethmoidal infundibulum. It begins to develop during the second year of life, reaches its maximum size at the age of twenty, and remains stable through the rest of life [5]. The frontal sinus development shows a growth rhythm similar to body height development with a well-defined pubertal peak. The frontal air sinus embryonically develops from an ethmoidal cell which is not visible at birth [6-7]. Even though during birth the frontal air sinus bud is present in the ethmoid region, it is actually radiologically evident after six years when it projects above the orbital rim [6]. Pneumatization of the skull is strictly connected with the morphology and degree of development of paranasal sinuses [8]. The frontal air sinus area, size, and shape vary from one person to another person and one race to another race [9-10]. The frontal air sinus usually shows unilateral or hypoplasia but Complete aplasia is very rare [11]. The hardness of the frontal air sinus may lead to a misbalance in the human cranium [12]. Frontal air sinus pneumatization depends on individuals growth differences and mucosal desorption processes, the frontal bone quality which is to be pneumatized, the pressure exerted by the growing brain on the internal lamina of the frontal air sinus, the various pressure and hydrodynamic conditions of the cranium that influences the blood supply of the frontal sinus area and hereditary factor, Genetic diseases, environmental condition, and past infection also affects the pneumatization process of the frontal air sinus within the frontal bone [8-9]. Pneumatization of the skull is strictly connected with the morphology and degree of development of paranasal sinuses [13]. The plain radiographic study provides knowledge of the anatomy, size, capacity, asymmetry, and variants of the frontal air sinus for specific populations. That knowledge is necessary for the clinician in pathologies of the acute and chronic sinuses and surgical procedures [14]. There is a correlation between frontal sinusitis and the possible complications from the orbit when the frontal air sinuses unusually extends above the orbital roof and these cases are considered high-risk cases [15]. The frontal air sinus study helps surgeons to avoid or minimize possible complications by providing clear knowledge about the variations that may predispose patients to increased risk of intraoperative complications [16]. The irregular shape and distinctive characteristics of the frontal air sinus vary from person to person and make the frontal bone unique for every individual Yoshino [10]. Even in monozygotic twins, the frontal air sinus plays a similar role in fingerprints and DNA tests as each frontal air sinus shows unique morphological value, and this distinctive characteristic of the frontal air sinus helps in the forensic identification of

unknown deceased persons [17-18]. The frontal sinus is also smaller in females than in males because of morphological cranium differences between males and females [19]. The morphometric knowledge of sexual dimorphism also plays a vital role in the determination of the gender of an unknown person in forensic investigation, especially in cases where only fragments of the skull remain and there is no possibility of identification [20]. To confirm the identification of highly decomposed or burnt or disfigured human remains, radiographic comparison of osteologic structures like frontal air sinus has been commonly used [20]. Radiological identification of frontal air sinuses has a very important place in forensic medicine, particularly in the lack of comparative evidence like DNA samples and fingerprints [21]. The human skull has been massively studied and involves the comparison of antemortem radiographs, usually carried out for clinical reasons, with post-mortem radiographs taken solely for the identification of specific, individualizing structures. As the chance of two people having the same morphology of frontal air sinus is extremely rare, the radiographic comparison of frontal air sinus dimension is a scientifically secure method for the identification of unknown dead bodies [22-23]. The study was done to evaluate and compare the width by height ratio of the frontal air sinus on a Caldwell view radiograph and to use the data to determine and establish the identity of an individual.

## Materials & Methods

The cross-sectional analytical study was carried out by applying a convenient and purposive sampling technique in the Department of Anatomy, Dhaka Medical College, Bangladesh, from January 2016 to December 2016. The study was performed on 100 radiographs of Caldwell's view of the skull of adult Bangladeshis. Out of 100 radiographs, 50 were male and 50 were female, with ages ranging from 20 to 50 years. Individuals with a history or X-ray showing any feature of sinusitis, repeated common cold, chronic headache, trauma or surgery of the skull or face including eye, ear, and nose, and clinical features of endocrine disturbances or systemic disorder or any sort of cranial asymmetry or facial asymmetry were excluded from the study. The X-ray machine was used for doing skull radiographs in Caldwell view. The study subject was in an erect posture in the posterior - anterior position in front of a part of the x-ray machine facing stand greed. The cassette of the stand greed machine had an imaging plate that was kept towards the head position. The vertical axis was parallel to the film in Caldwell projection and no space between the frontal bone and the cassette. The center of the forehead and nose was adjusted in a position so that the midsagittal plane was perpendicular to the plane of the film, and the orbitomeatal line formed an angle of 15 degrees from the plane of the film. Then the head was immobilized in that position, and the shoulder was adjusted

in the same horizontal plane. The subject was advised to suspend respiration for the exposure. Using a well-collimated beam, the horizontal central ray is centered in the midline to the occipital region at the level of the lower orbital margin. Radiation was projected on the imaging plate, and it was transformed in the monitor for editing and zooming of the radiograph. It was zoomed at 100%. AGFA printer was used for printing the X-ray film. The radiographs were collected from every selected individual and viewed on the x-ray view box and transparent graph paper sheet was placed on the view box containing the radiograph, and the frontal air sinus was traced on a transparent graph paper sheet placed on each radiograph film, and then the different dimensions of the frontal air sinus was measured. All the measurement of the frontal sinus was taken by drawing a tangential line above the superior border of the two orbits because the inferior limit of the frontal air sinus is not so clear [10].

The measurement was done according to the sequence below by Camargo et al. [24].

- At first, the radiography was placed on a view box, and the transparent graph paper sheet was placed on the radiograph.
- The baseline (A) was drawn directly on the transparent graph paper at the level of the superior border or upper limit of two orbits (inferior border of the frontal sinus), as illustrated in the figure.
- The separation between the right and left frontal sinus was based on the frontal inter-sinus septum in order to permit quantifying one width on each side.
- The height of each side (B and C) was determined by marking and drawing a straight line between the baseline and upper limit of the frontal sinus.
- The largest width (D and E) of the frontal sinus was determined by marking and drawing straight lines from the maximum distance between the medial and lateral lines of the right and left side of the frontal sinus.
- Linear measurements of height and width of the frontal air sinus were obtained from each radiograph by counting the boxes of graph paper; height and width were expressed in centimeters (cm).
- Square box was counted within the sinus, and an area covering more than 50% of the square was considered.
- All these measurements were obtained by the portion projecting above the baseline. The separation of the right and left sides of the frontal sinus was based on the inter-sinus septum, which denotes the margin between the two main sinus cavities.
- The ratio of the width by height of the frontal air sinus

was calculated by dividing the width of the frontal air sinus by the height of the frontal air sinus individually [25].

Paired Student t-tests were done to compare the differences between the height of the right and left frontal air sinus and the width of the right and left frontal air sinus. Unpaired Student's t-tests were done to analyze the differences between the right and left frontal air sinus dimensions between males and females. Statistical significance was accepted at ( $p < 0.05$ ).

Procedure measurement from a radiograph of frontal air sinus height and width is shown in Figures 1, 2 (i), 2 (ii) `

### Ethical Clearance

The study was approved by the ethical review committee of Dhaka Medical College, Dhaka, Bangladesh.

### Result

In males, width by height ratio of the right frontal air sinus ranged from 1.48 to 4.5 cm, the mean width by height ratio was  $0.51 \pm 0.15$  cm and width by height ratio of the left frontal air sinus ranged from 0.89 to 5.3 cm, and the mean width by height ratio was  $0.53 \pm 0.16$  cm. No significant difference ( $P=0.114$ ) was observed in the width-by-height ratio of right and left frontal air sinuses in males. In females, width by height ratio of the right frontal air sinus ranged from 0.33 to 4.14 cm, the mean width by height ratio was  $0.42 \pm 0.17$  cm and width by height ratio of the left frontal air sinus ranged from 0.26 to 3.2 cm and the mean width by height



**Figure 1:** procedure of taking caldwell view radiograph of skull



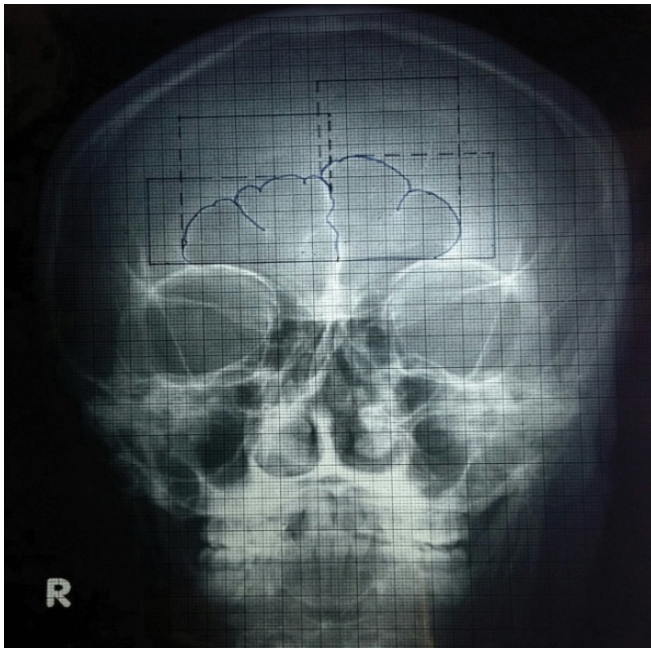


Figure 2 (i): procedure of tracing caldwell view radiograph.

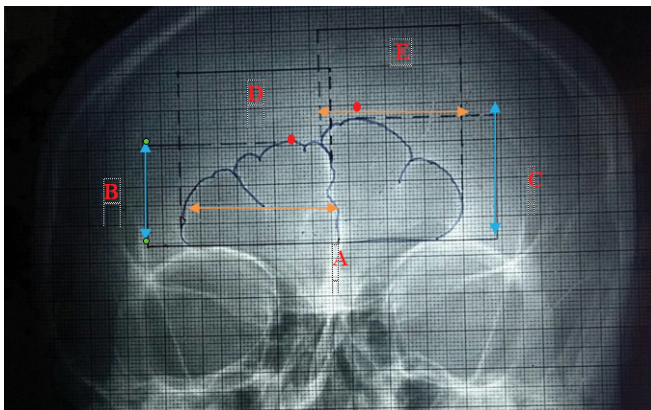


Figure 2 (ii): procedure of estimating of height, width of right and left frontal sinus.

- Red dot indicate highest point of right and left frontal air sinus.
- ↔ Blue arrow indicate height of right (line B) and left (line C) frontal air sinus m
- Green dot indicate widest point of right and left frontal air sinus.
- ↔ Orange arrow indicate width of the right (line D) and left (line E) frontal air sinus.

ratio was  $0.42 \pm 0.14$  cm. No significant difference ( $P=0.670$ ) was observed in the width by height ratio of right and left frontal air sinuses in females. The mean of right frontal air sinus width by height was observed to be significantly higher ( $p=0.004$ ) in males than females. The mean of left frontal air sinus width by height ratio was observed to be significantly higher ( $p=0.001$ ) in males than females.

Table1: Comparison of the Ratio between width by height of the frontal air sinus in male and female

Group	Ratio of width by height of the frontal air sinus		
	Right (Mean±SD)	Left(Mean±SD)	P value
Male (n=50)	$0.51 \pm 0.15$	$0.53 \pm 0.16$	0.114ns
Female (n=50)	$0.42 \pm 0.17$	$0.42 \pm 0.14$	0.670ns
P value	0.004*	0.001*	

Figures in parentheses indicate range. SD= Standard Deviation

Comparison between male and female was done by Unpaired Student's 't' test. Comparison between values of right and left frontal sinus of same group was done by Paired Student's 't' test ns= not significant, \*= significant

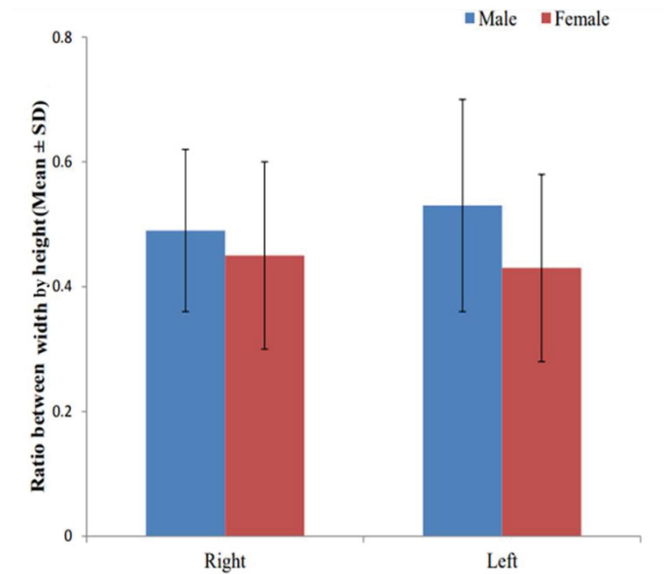


Figure 3: Comparison between ratio of width by height of right and left frontal air sinus in male and female

## Discussion

In the present study, the adult male left frontal air sinus width by height ratio was higher than the right frontal air sinus width by height ratio, but the adult female shows right frontal air sinus width/ height ratio was higher than the left frontal air sinus width by height ratio. Both right frontal air sinus and left frontal air sinus width by height ratio were higher in males than females. According to researcher Verma, P., et al. (2015), the adult male and female frontal air sinus width by height ratio had an average of  $1.67 \pm 0.04$  cm and  $1.62 \pm 0.04$  cm, respectively. The parameter shows that frontal air sinus width by height ratio was significantly higher ( $p<0.000$ ) in males than in females. So, the finding of the present study is similar to the finding reported by the researcher Verma, P., et al.(2015). It was observed that the value of the study conducted by Verma was significantly higher ( $p>0.000$ ) compared to the present study.

## Conclusion

The result of the present study demonstrates that the adult

male left frontal air sinus width by height ratio was higher than the right frontal air sinus width by height ratio, and the adult female shows right frontal air sinus width by height ratio was higher than the left frontal air sinus width by height ratio. Both right frontal air sinus and left frontal air sinus width by height ratio were higher in males than females. This study not only plays an important role in the medico-legal aspects of forensic science, like personal identification, age determination, and gender differentiation but also helps as a guideline for anatomists, clinicians, dentists, and surgeons.

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