

## Frontal Sinus- A Useful Personal Identification Tool

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### Abstract

**Aim and objective:** The study aimed to assess the role of frontal sinus in personal identification by co-relating variations in dimensions of frontal sinus by gender, side and age.

**Methodology:** A total of 160 patients (60 males and 60 females) who visited the department O.P.D. were selected for the study. Postero-anterior cephalograms were taken with the help of Cephalometric X-ray machine. Measurements were done using Digora software (SORDEX, 2.8 version).

**Results:** 80 females showed two cases of bilateral absence of frontal sinuses whereas no such cases were noticed in males. 2.5% males showed unilateral absence of frontal sinus at left side, 6.25% males showed absence of the frontal sinus at right side and 5.00% females showed absence of frontal sinus at right side. 2.50% males and 1.25% females showed centrally located frontal sinus. Dimensions of frontal sinuses were greater in males than females. Significant difference was observed between different age-groups for left frontal sinus height.

**Conclusion:** PA cephalograms of the individuals proved to be an inexpensive, simple screening system through which assessment of dimensions and morphology of the frontal sinus in individuals became an easier way.

**Keywords:** Frontal sinus, Personal identification, PA cephalogram.

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### Introduction

Personal identification is defined as establishing the identity of an individual. The need for personal identification arises in natural mass disasters like earth quakes, tsunamis, landslides, floods etc., along with man-made disasters such as terrorist attacks, bomb blasts, mass murders, and in cases when the body is highly decomposed or dismembered to deliberately conceal the identity of the individual.<sup>1</sup>

The finger print is an accurate identifying method, widely applied; however, in some cases, the collection becomes difficult or even impossible, such as in decomposed, fragmented or charred corpses.<sup>2</sup>

The frontal sinuses are a part of paranasal sinuses and they are located in the frontal bone above each eye. They make an important contribution to normal forehead and glabellar contour.<sup>3</sup>

According to classical knowledge based on radiographs, frontal sinus is not apparent at birth and development begins during the second year of life.<sup>4</sup>

It has been found that the annual height (stature) increments in children reached a plateau at 16 years in

boys and 14 years in girls, and it was thought that these, too, were the ages at which frontal sinus enlargement ceased<sup>5</sup> and in 15-16 years old patients, sinusal area has same value as in adults.<sup>6</sup>

The frontal sinus is a triangular, pyramid-shaped (its apex is superior and its base is inferior) cavity extending between the anterior and posterior tables of the ascending portion of the frontal bone. It presents highly variable nature and shows variation even among the monozygotic twins. It has a relatively stable structure during adult life. These features make it very useful for identification.<sup>3</sup>

### Material and method

Present study was carried out on 160 individuals (60 males and 60 females) at Department of Oral Medicine and Radiology, Rishiraj College of Dental Science and Research Centre, Bhopal. Postero-anterior cephalograms were taken on Cephalometric X-ray machine (X-mind Pano D+ Digital Panoramic and Cephalometric X-ray Unit, Version 3, manufactured by SOREDEX, Tuusula, Finland) with their sagittal plane perpendicular and coronal plane parallel to the image receptor. The patients were positioned so that the canthomeatal line formed a 10-degree angle with the horizontal plane and the Frankfort plane was perpendicular to the image receptor. The central beam was perpendicular to the image receptor, directed from the posterior to the anterior, parallel to patient's midsagittal plane, and was centered at the level of the bridge of the nose. All the PA cephalograms were taken with the following exposure parameters 70-80kVp,

13mA and 1.5 seconds and data was stored in the computer system (Fig 1). Measurements were done using Digora software (SORDEX, 2.8 version) according to the following sequence:

1. A line was drawn directly between both orbital cavities, at the nasofrontal suture.
2. The width of the frontal sinuses at the widest points was measured- that is the distance between two projected lines that delineate the maximum lateral limits of the right and left sinus.
3. The height was measured by drawing a line parallel to the nasofrontal line at the highest superior point of the frontal sinuses; and then, the distance between both lines was measured.

## Results

Data analysis was done by using Statistical Package for Social Sciences (SPSS) version 21 for Windows. Kruskal Wallis test was applied and Spearman's rho was applied for co-relation between age and frontal sinus parameters. Mann Whitney U test was applied for comparison between different age groups.

Out of 160 individuals i.e. 80 males and 80 females, 78 (48.75%) individuals were in age group of 15-25 years, 36 (22.50%) in 26-35 years, 30 (18.75%) in 36-45 years, 16 (10.00%) in 46-55 years.

Among 80 females, two cases of bilateral absence of frontal sinus was observed and the percentage was found to be 2.5 whereas no such cases were noticed in males. Though unilateral absence of frontal sinuses was seen in both males and females as 2.5% males showed unilateral absence of frontal sinus at left side, 5 (6.25%) males showed absence of the frontal sinus at right side and 4 (5.00%) females showed absence of frontal sinus at right side. In females, unilateral absence of frontal sinuses at left side was not observed. Thus, cases of unilateral absence of frontal sinuses at right side were more in number as compared to left side (Graph 1). Three cases of the individuals showed centrally located frontal sinuses (2 males and 1 female) (Graph2). Left frontal sinus height, width and area among 76 males and 77 females were compared using Mann Whitney U test which showed that left frontal sinus height, width and area was significantly more in males than females (Graph 3a and 3b).

Among 73 males and 73 females parameters of right frontal sinuses were also compared using Mann Whitney U test which showed that frontal sinus height was significantly more in males than females, frontal sinus width was significantly more in males than females and area was significantly more in males at right side than females (Graph 4a and 4b)

Total (left + right) frontal sinus height, width and area were calculated and compared among males and females using Mann Whitney U test which showed that

total frontal sinus height, width and area was significantly more in males than females (Graph 5a and 5b).

Parameters of frontal sinus between left and right sides were compared by using Mann Whitney U test which showed that there was no significant difference for left and right frontal sinus height, width and area (Graph 6a) (Graph 6b).

Spearman's rank order Co-relation showed no significant relationship between age and left and right frontal sinus height, width, area and total (left and right side) height, width and area Co-relation coefficient showed no or negligible relationship to weak positive relationship. It means as age increases there is no prediction for change in these parameters (Graph 7a) (Graph 7b).

Kruskal Wallis Test showed significant difference between different age groups for left frontal sinus height. When Mann Whitney U test was applied for pair wise comparison it showed that there was no significant difference between 15-25 years and 26-35 years; 26-35 years and 36-45 years and; 36-45 years and 46-55 yrs for left frontal sinus height. But in 36-45 yrs and 46-55 yrs left frontal sinus height was significantly more than 15-25 yrs. Also, in 46-55 yrs left frontal sinus height was significantly more than 26-35 yrs. Kruskal Wallis Test showed no significant difference between different age groups for left frontal sinus width and area (Graph 8a) (Graph 8b).

There was no significant difference between different age groups for right frontal sinus height, width and area (Graph 9a) (Graph 9b).

Kruskal Wallis Test showed No significant difference between different age groups for total frontal sinus height, width and area.



**Fig. 1: Position of patient in cephalostat of OPG machine**

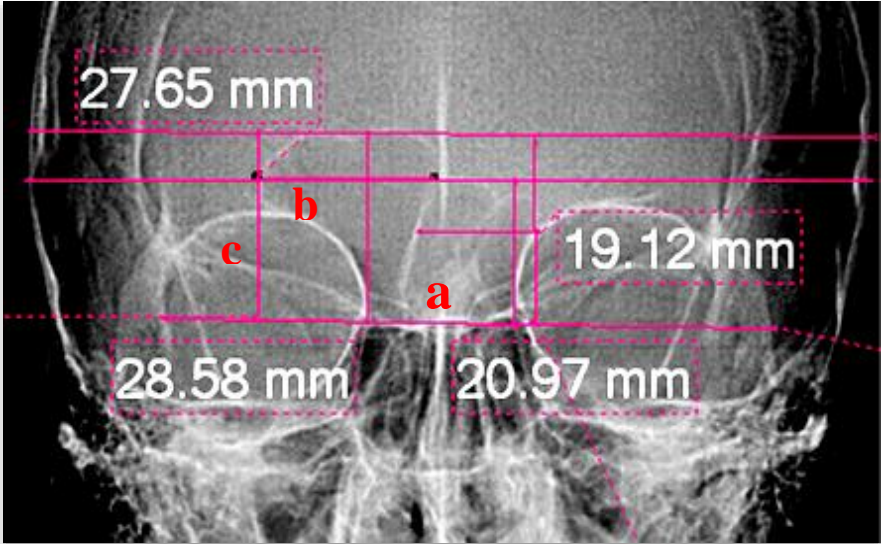
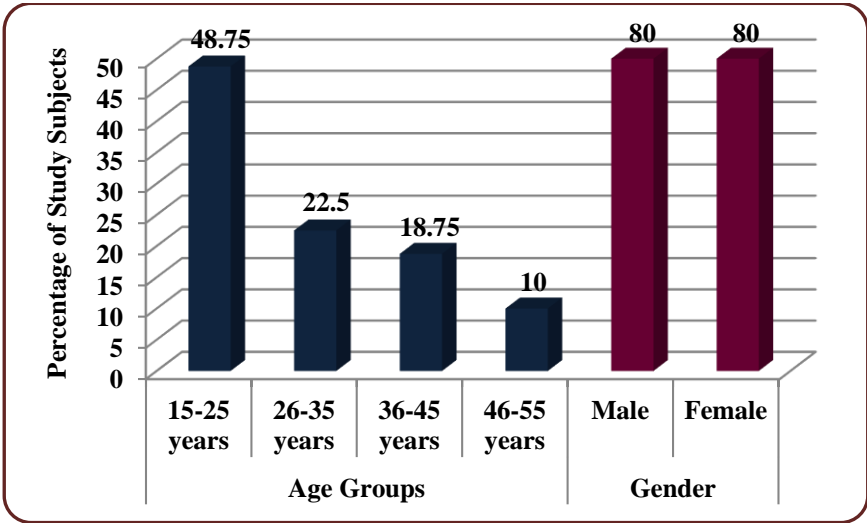
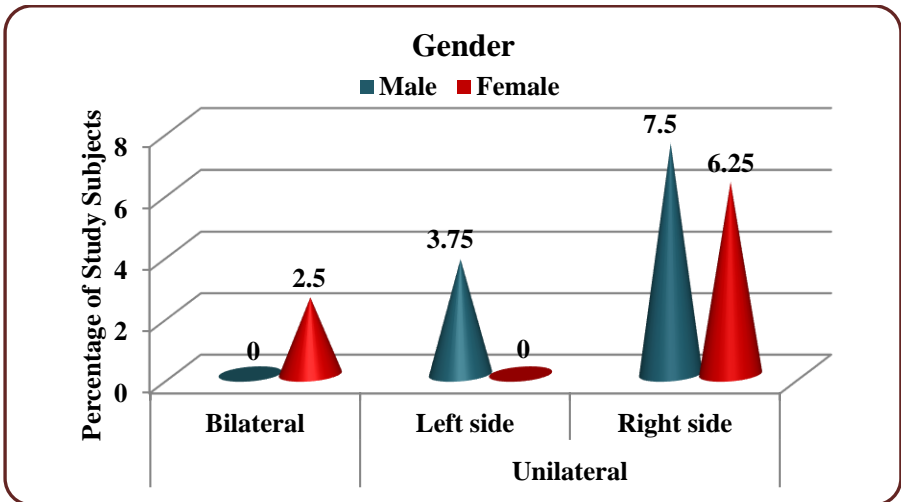


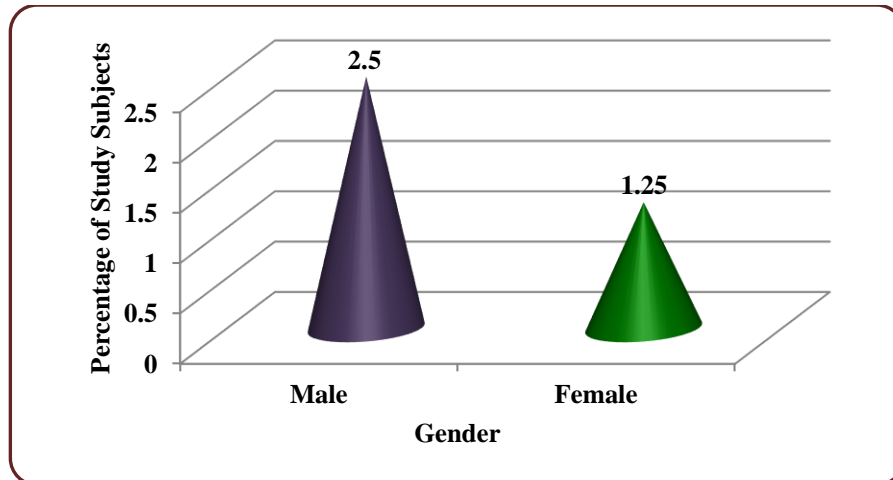
Fig. 2: Measurement of dimensions of frontal sinus



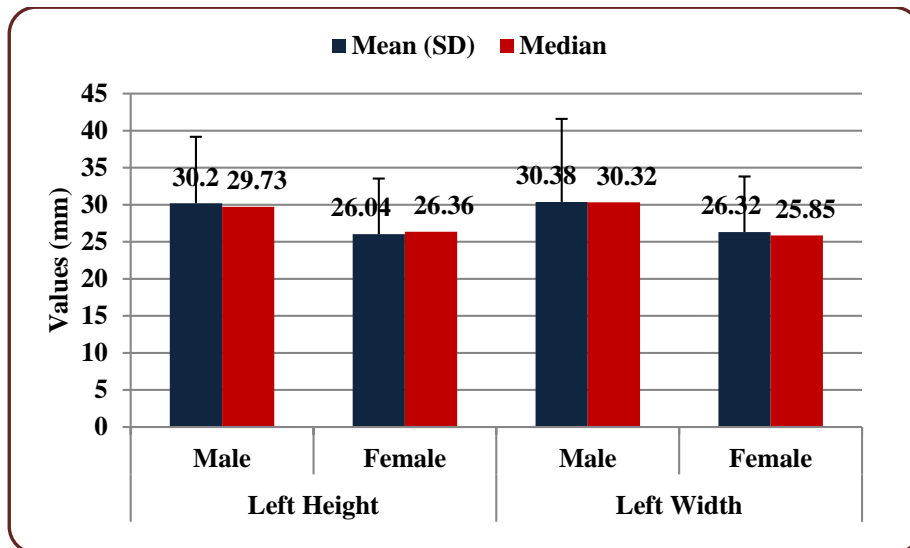
Graph 1: Characteristics of Study Population (n=160).



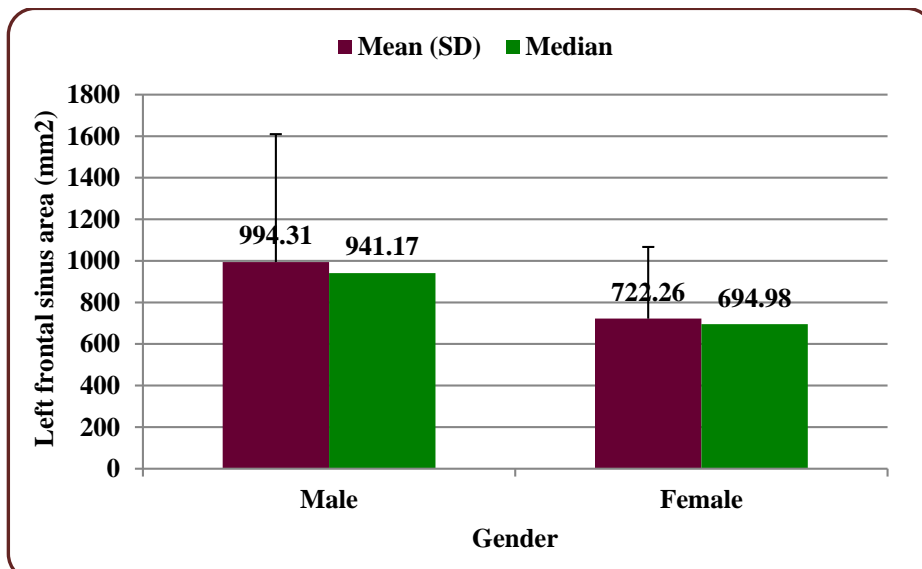
Graph 2: Bilateral and Unilateral absence of frontal sinus according to gender.



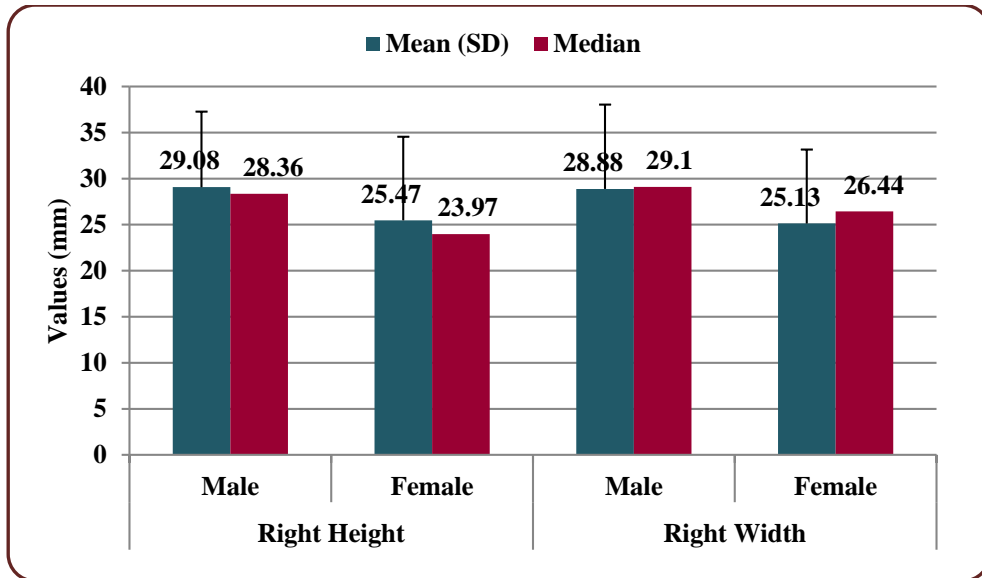
Graph 3: Distribution of centrally located frontal sinus according to gender



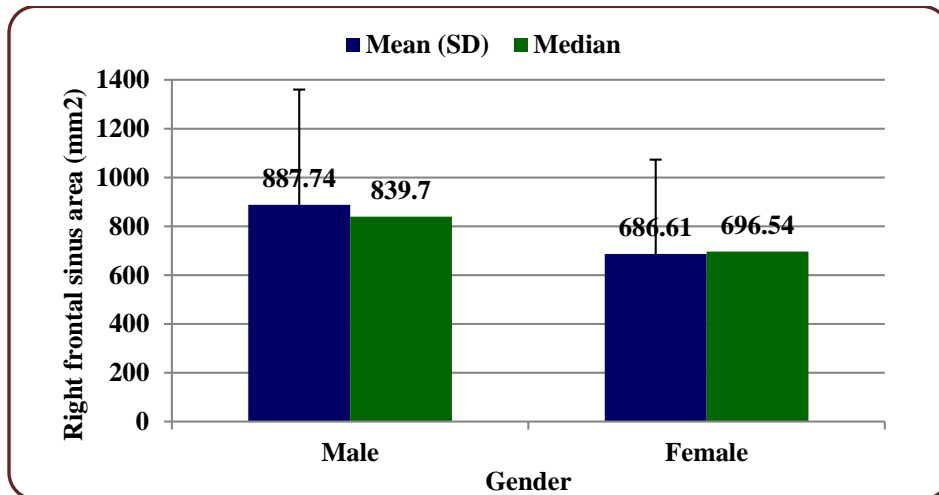
Graph 4a: Comparison of left frontal sinus height and width between males and females



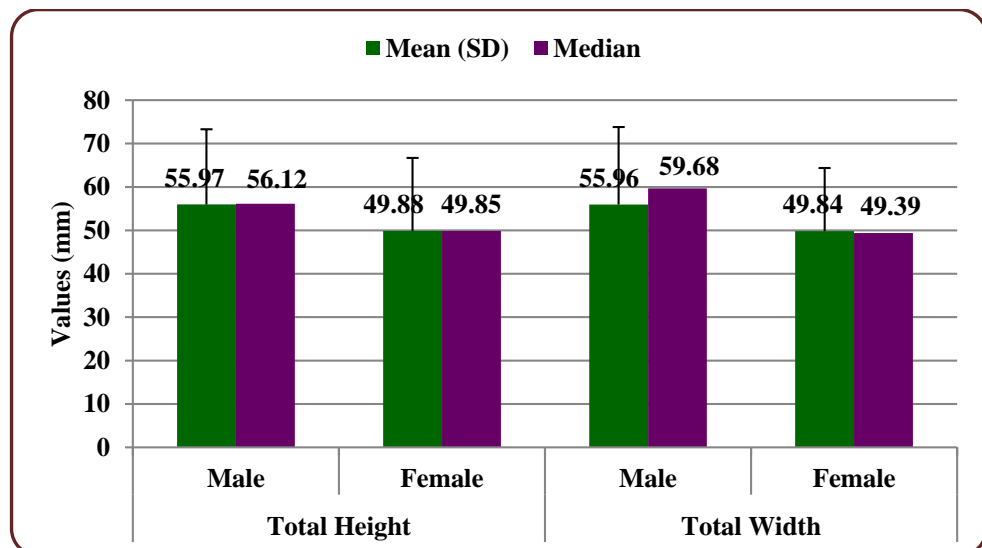
Graph 4b: Comparison of left frontal sinus area between males and females.



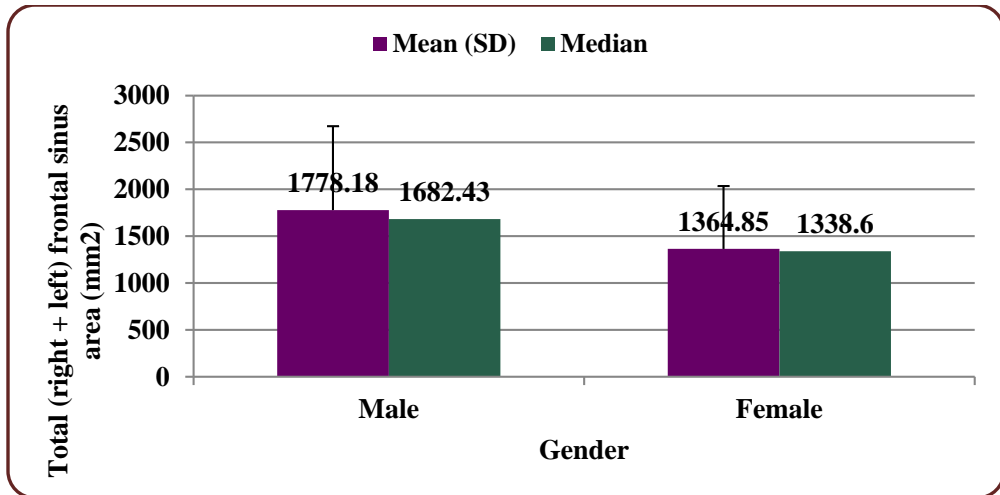
Graph 5a: Comparison of right frontal sinus height and width between males and females.



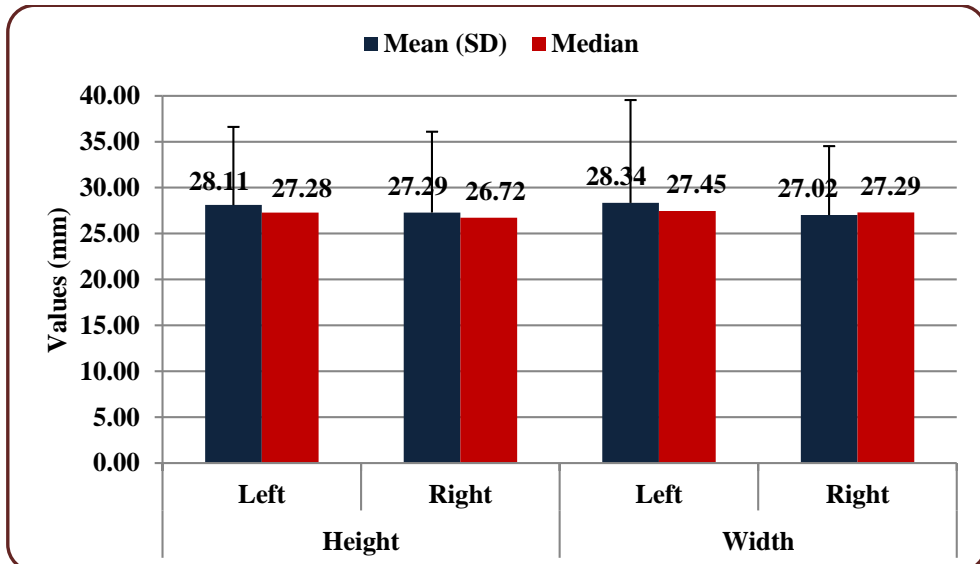
Graph 5b: Comparison of right frontal sinus parameters in males and females.



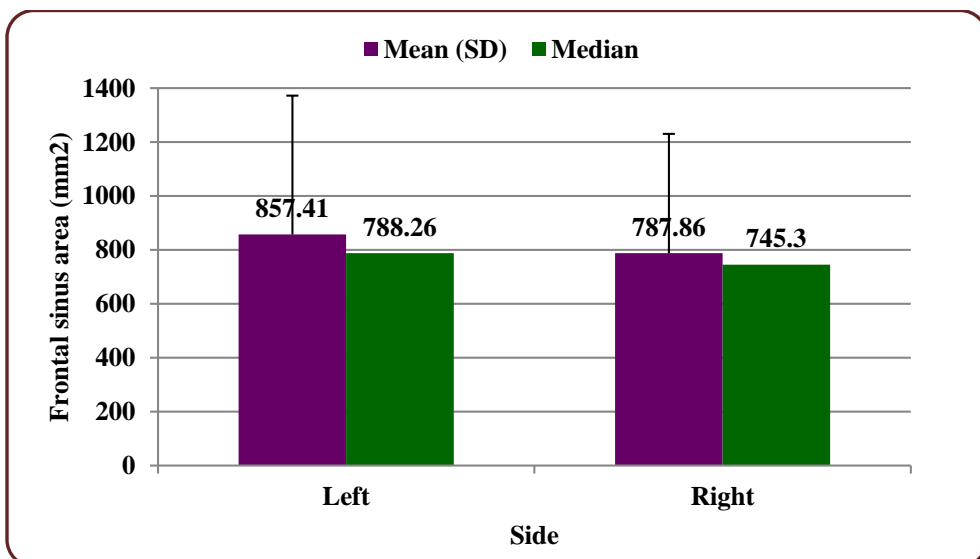
Graph 6a: Comparison of total height and width of frontal sinus between males and females.



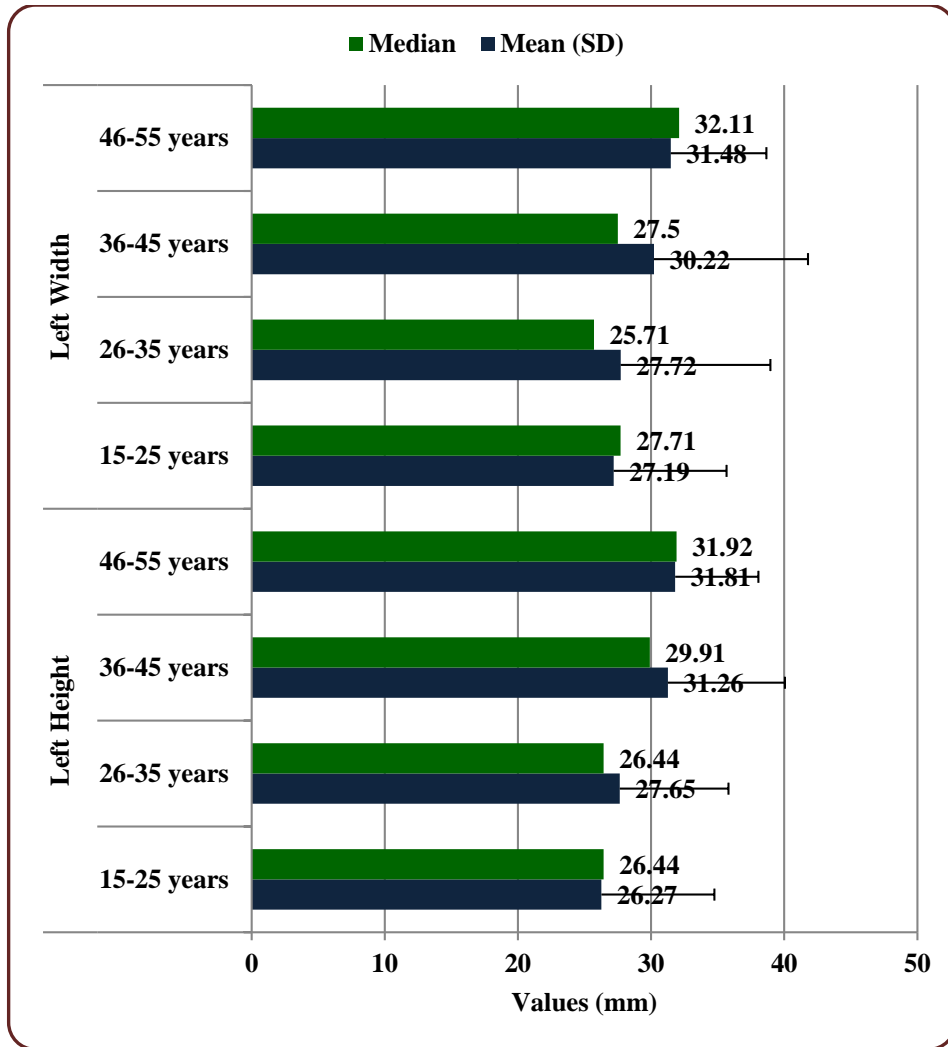
Graph 6b: Comparison of total area of frontal sinus between males and females.



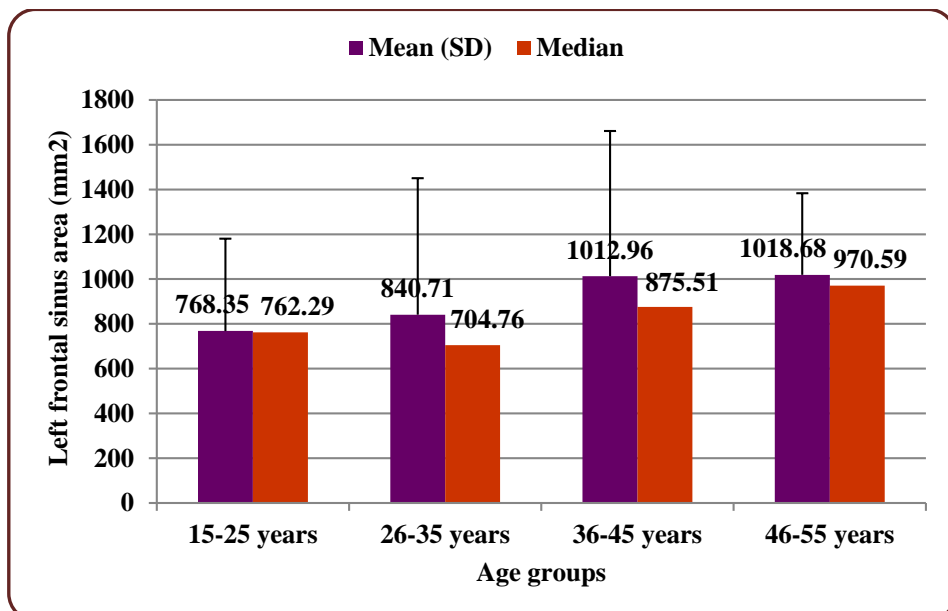
Graph 7a: Comparison of frontal sinus height and width between left and right sides.



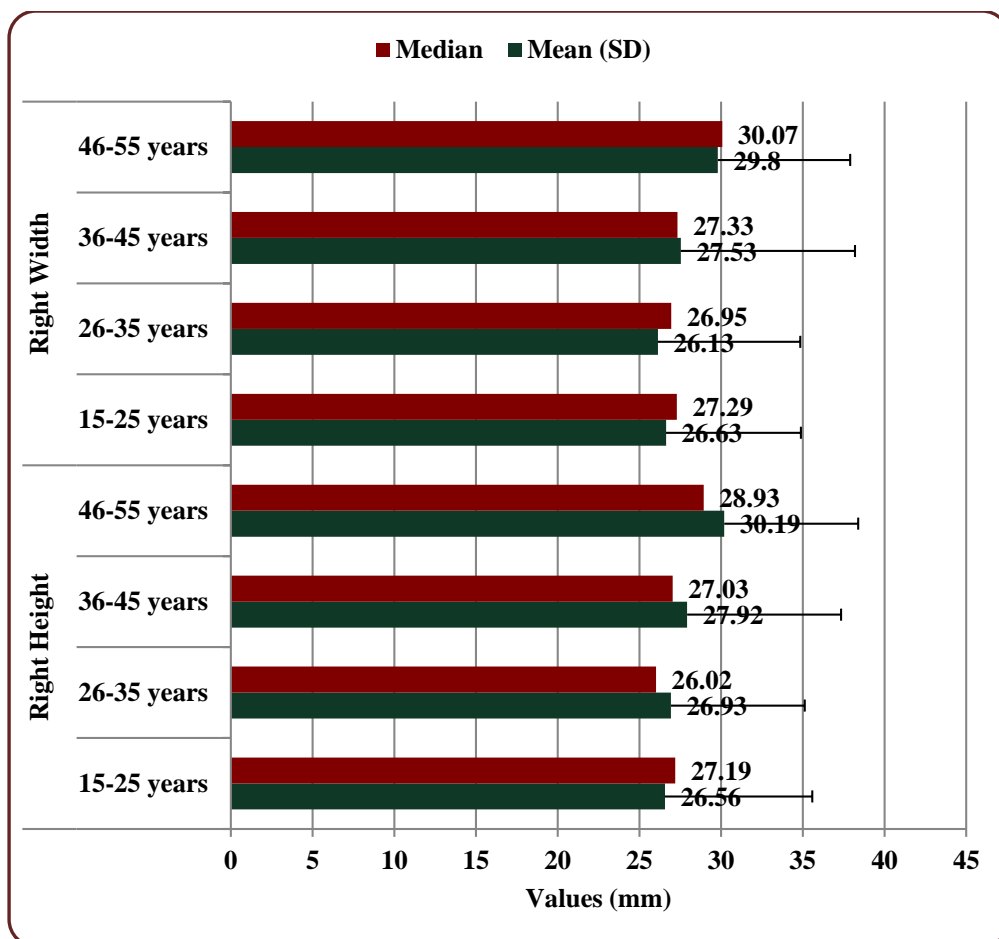
Graph 7b: Comparison of frontal sinus area between left and right sides



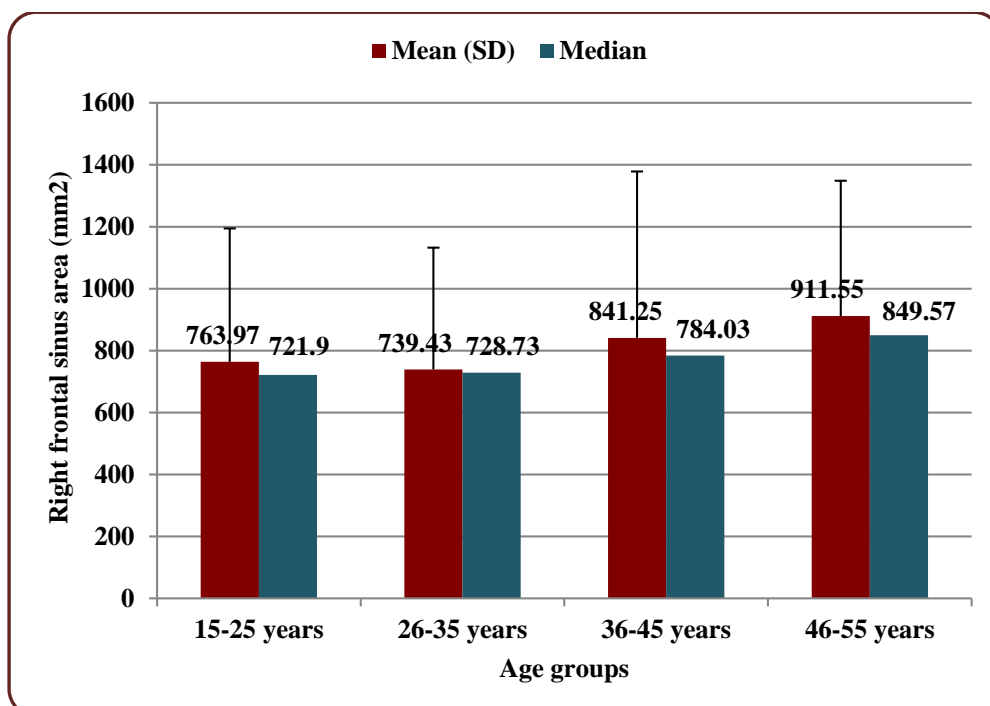
Graph 8a: Comparison of left frontal sinus height and width between different age groups.



Graph 8b: Comparison of left frontal sinus area between different age groups.

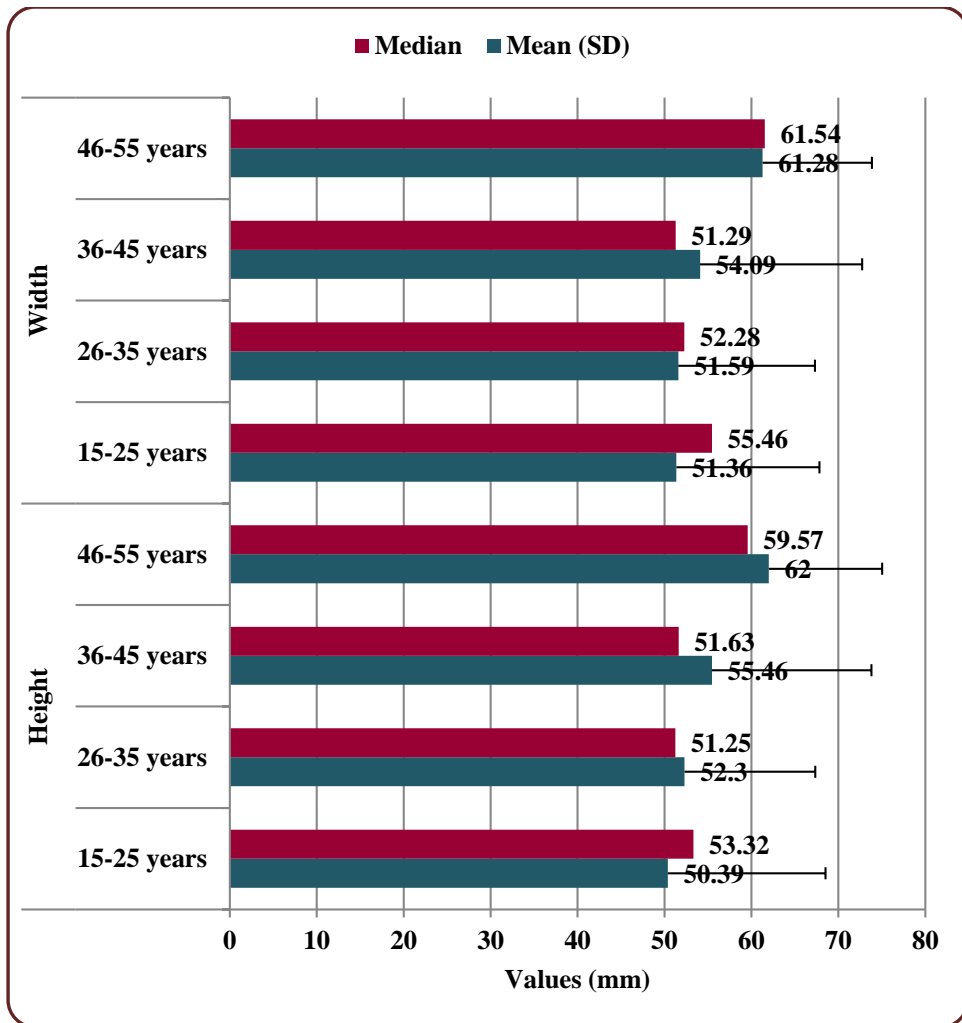


Graph 9a: Comparison of right frontal sinus height and width between different age groups

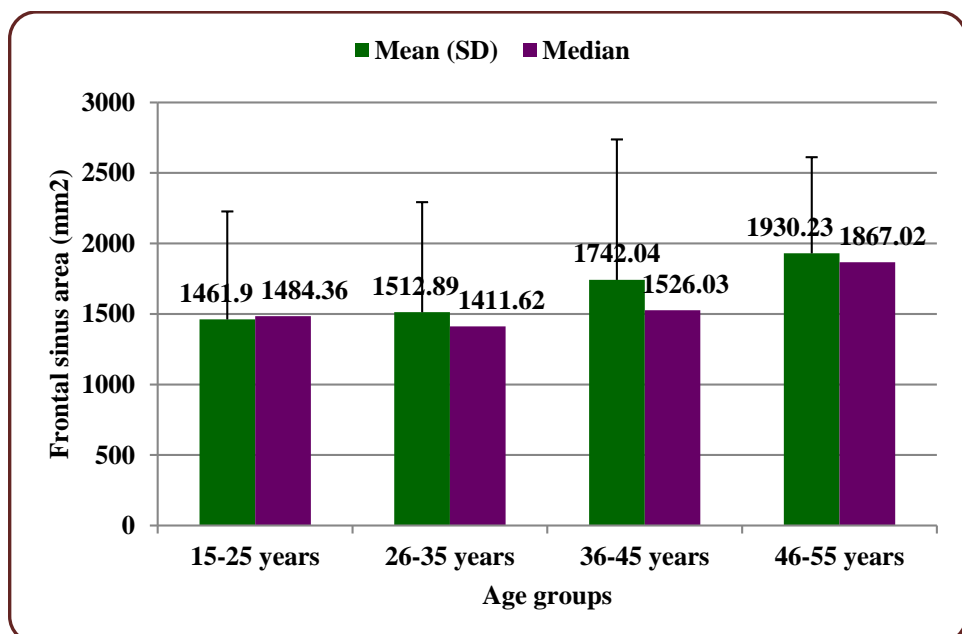


Graph 9b: Comparison of right frontal sinus area between different age groups





Graph 10a: Comparison of total height and width of frontal sinus between different age groups.



Graph 10b: Comparison of total area of frontal sinus between different age groups

## Discussion

In the last years of 20<sup>th</sup> century and first decade of 21<sup>st</sup> century, the use of radiological techniques improved and became widespread by the creation of newer techniques which help in forensic identification.<sup>3</sup>

The clinical radiographic examination of the skull is increasing due to various accidents. However, there are only sporadic reports of a systemic study or the practical use of skull radiographs for identification, such as vascular groove patterns, maxillary sinus, sella turcica and frontal sinus.<sup>7</sup>

The frontal bone may be recovered intact in fragmented remains and the sinuses therein may be useful in sex differentiation. 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.<sup>8</sup>

Several studies for assessing uniqueness of frontal sinus for personal identification were carried out by Silva FR et al (2015)<sup>9</sup>, Karjodkar FR et al (2012)<sup>10</sup>, Maria PD (2010)<sup>11</sup>, Ponde JM et al (2008)<sup>12</sup>, Taniguchi M. et al (2003)<sup>13</sup>, Cameriere R. et al (2008)<sup>14</sup>, Camargo RJ et al (2007)<sup>15</sup>, Brown et al (1984)<sup>16</sup> and Ferrante L et al (2005)<sup>17</sup>.

The sample size in the present study was 160, in comparison with the sample size of 100 in a study conducted by Karjodkar FR et al (2012)<sup>10</sup>, 158 by Rubira-Bullen IR et al (2010)<sup>6</sup>, 209 by Taniguchi M et al (2003)<sup>13</sup> whereas in contrast to these, the sample size was 410 in a study conducted by Cakur B et al (2011)<sup>18</sup>. The reason for a small sample size in contrast to this study is because they have done a retrospective study and our study was a prospective one (Graph 1).

In our study, males and females were equal in number i.e 80 males and 80 females (50% each), which is similar to the studies conducted by Mathur H et al (2013)<sup>19</sup>, Maria PD et al (2010)<sup>11</sup>, Camargo RJ et al (2007)<sup>15</sup> and Hamed SS et al (2014)<sup>20</sup>. In contrast to these, 190 males and 220 females were included in a study conducted by Cakur B et al (2011)<sup>18</sup>. Similarly, 116 males and 29 females were used in a study conducted by Rubira-Bullen IRF et al (2010)<sup>6</sup>.

In the present study as far as the age was concerned the patients were selected in the age range from 15 years to 55 years with a mean age of 29.60 years. This is almost similar to the studies done by Reddy S et al (2014)<sup>21</sup> who included individuals in the age range from 25 years to 40 years. Similarly in other studies done by Hamed SS (2014)<sup>20</sup>, Cakur B et al (2011)<sup>18</sup>, Maria PD et al (2010)<sup>11</sup> and Cameriere R et al (2008)<sup>14</sup> patients were included in the age range from 20 to 70 years, 15 years to 69 years, 25 to 50 years and 15 years to 74 years respectively (Graph1).

The methodology that was followed in our study was very much similar to the study conducted by Reddy S et al (2014)<sup>21</sup>, Mathur H et al (2013)<sup>19</sup>, Maria PD et al

(2010)<sup>11</sup>, Cameriere R et al (2008)<sup>14</sup> and Camargo RJ et al (2007)<sup>15</sup>.

In our present study, we have made use of digital PA cephalograms because of some of their advantages over the conventional radiographs. In similar studies which were conducted by Reddy S et al (2014)<sup>21</sup> and Mohan V et al (2015)<sup>22</sup>, digital PA cephalograms were used for analysis of frontal sinus. However in studies conducted by Rubira-Bullen IRF et al (2010)<sup>6</sup>, Camargo RJ et al (2007)<sup>21</sup> and Karjodkar FR et al (2012)<sup>10</sup> plain radiographs were taken by Caldwell view. We have used PA cephalograms in our study because it provides maximum detail of the frontal sinus.

In the present study, out of 80 females, 2 cases (2.5%) of bilateral absence of frontal sinus was observed. Among 80 males no such cases were noticed (Graph 2). These findings were similar to the studies done by Rubira-Bullen IRF. et al (2010)<sup>6</sup>, Maria PD et al (2010)<sup>11</sup>, Bassiouny et al (1982)<sup>6</sup> and Karjodkar FR et al (2012)<sup>10</sup> who showed bilateral absence of frontal sinus with 1.3%, 2%, 1.3% and 1% respectively. Whereas in contrast to these, in studies conducted by Taniguchi et al (2003)<sup>13</sup>, Krogman et al (1962)<sup>23</sup> and Ponde MJ et al (2008)<sup>12</sup> it was found that bilateral absence of the frontal sinus was reported with 4%, 5% and 24.7% respectively.

In the present study, unilateral absence of frontal sinus was seen in 13.75 % of 160 individuals. 2 cases (2.5%) of males showed left side absence and 5 cases (6.25%) of males showed right side absence. Whereas females showed 4 cases (5%) of right side absence without any absence on left side(Graph 2).

These findings are in contrast to the studies done by Maria PD et al (2010)<sup>11</sup>, Rubira-Bullen IRF et al (2010)<sup>6</sup>, Fatu C et al (2006)<sup>24</sup>, Yoshino M et al (1987)<sup>25</sup> and Bassiouny et al (1982)<sup>6</sup> who observed 4%, 3.8%, 1.6%, 21.4% and 7.2% unilateral absence of the frontal sinus respectively. In addition, Yoshino M et al (1987)<sup>25</sup> found unilateral absence in 14.3% of males and 7.1% of females. They found that among these males, 4.8% showed the absence at left side and 9.5% at right side whereas 7.1% females showed the absence at right side without any absence at left side.

From these studies it was clear that the bilateral absence of frontal sinus was observed more frequently in females than males and the findings ranged from 1-2% to 18.2-24.7% and unilateral absence was observed more in males as compared to females. This wide range of findings may be because of the study samples taken from different population from different regions.

In the present study, out of 80 males and 80 females, 2 (2.50%) males and 1 (1.25%) female showed centrally located frontal sinus (Graph 3). This finding is similar to the study done by Rubira-Bullen IRF et al (2010)<sup>6</sup> who showed 2.5% cases of centrally placed frontal sinus out of 158 samples.

In the present study, left, right, total frontal sinus height, width, and area between males and females

were compared. It was observed that the frontal sinus height, width and area was significantly more in males than females (Graphs 4a, 4b, 5a, 5b, 6a, 6b). In males, mean left height, width, and area was  $30.20 \pm 8.98$ mm,  $30.38 \pm 11.21$ mm and  $994.31 \pm 615.10$ mm<sup>2</sup> respectively and in females mean left height, width and area was  $26.04 \pm 7.50$ mm,  $26.32 \pm 7.50$ mm and  $722.26 \pm 344.74$ mm<sup>2</sup> respectively (Graph 4a, 4b) ( $p < 0.01$ ). Mean right height, width and area in males was  $29.08 \pm 8.20$ mm,  $28.88 \pm 9.15$ mm and  $887.74 \pm 472.69$ mm<sup>2</sup> respectively and in females mean right height, width and area was  $25.47 \pm 9.07$ mm,  $25.13 \pm 8.03$ mm and  $86.61 \pm 386.75$ mm<sup>2</sup> (Graph 5a, 5b) ( $p < 0.01$ ). Mean height, width and area of total (left and right) frontal sinus in males was found to be  $55.97 \pm 17.31$ mm,  $55.96 \pm 17.83$ mm and  $778.18 \pm 895.91$  mm<sup>2</sup> and in females mean height, width and area of total (left and right) frontal sinus to be  $49.88 \pm 16.80$ mm,  $49.84 \pm 14.52$ mm and  $1364.85 \pm 670.86$  mm<sup>2</sup> (Graph 6a, 6b) ( $p < 0.01$ ). All these findings showed significantly more dimensions in males than females.

These findings are similar to the studies conducted by Hamed SS et al (2014)<sup>20</sup> and Camargo RJ et al (2007)<sup>15</sup> who also observed dimensions of the frontal sinus was greater in males when compared to females.

Further, the study was done to compare left and right sides of the frontal sinus. It was observed that there was no significant difference in left and right frontal sinus height, width and area (Graph 7a, 7b) ( $p > 0.05$ ).

Similarly, Rubira-Bullen IRF et al (2010)<sup>6</sup> found that there was no significant relationship between the dimensions of left and right sides as the cavities showed equal mean height and width in 57 (39.3%) among 158 individuals. Whereas in the studies conducted by Wolf et al (1993)<sup>6</sup> and Gulisano et al (1978)<sup>21</sup> it was found that there was a tendency for the left side of the frontal side to be larger than the right side. Wolf et al (1993)<sup>6</sup> showed 57 (39.3%) cases in which left side of the frontal sinuses was more when compared to right side.

In the present study, comparison of left frontal sinus parameters between different age groups was done which showed significant difference between different age-groups for left frontal sinus height (Graph 8a, 8b) ( $p > 0.05$ ). A pair wise comparison showed that there was no significant difference between 15-25 years and 26-35 years, 26-35 years and 36-45 years and 36-45 years and 46-55 years for left frontal sinus height. Left frontal height was smallest in age-group 15-25 years as 36-45 years and 46-55 years left frontal sinus height was significantly more than 15-25 years. Also, in 46-55 years left frontal sinus height was significantly more than 26-35 years (Graph 8a, 8b) ( $p < 0.05$ ).

There was no significant difference between different age groups for left frontal sinus width and area (Graph 8a, 8b) ( $p > 0.05$ ) and there was no significant difference between age groups for height, width and area of right frontal sinus (Graph 9a, 9b). Also, there

was no significant difference between age groups for total left and right frontal sinus. (Graph 10a, 10b) ( $p > 0.05$ ). These findings were in accordance with the study done by Rubira-Bullen IR et al (2010)<sup>8</sup> who also found that there was no significant difference in size of the frontal sinus with the age-groups.

There are certain limitations for the use of frontal sinus in personal identification as the size may be related to the environmental and genetic factors.

They may be affected by pathology, craniofacial configuration or thickness of the frontal bone. Also, growth hormone levels influence frontal sinus morphology.

With the help of this study, it was found that no two frontal sinuses have same morphology. Its irregular shape make a unique characteristic in personal identification.

### Conclusion

The frontal sinus is a constant structure in the human being but its shape and dimensions may vary among individuals.

This is a comparative study which explored and witnessed a possible useful tool of frontal sinus which aids in personal identification. PA cephalograms of the individuals proved to be an inexpensive, simple screening system through which assessment of dimensions and morphology of the sinuses in individuals became an easier way.

Our results proved that the technique was quite helpful in detecting the morphology of the sinuses as each sinus had considerable individual variation.

### Conflict of Interest: None

### Source of Support: Nil

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