

Radiological Analysis about Anatomical and Gender Variations of Frontal Sinus Parameters in Adults

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Abstract

Background: Morphological measurements of frontal sinus of human are known to exhibit sexual dimorphism. It was stated by previous workers that frontal sinus of no two individual is alike and as precise as finger print and could be used in personal identification. Radiograph of this sinus is more precise, easier, accurate, reproducible method of knowing the morphological variations in both sexes by linear measurements.

Objective: The present study was attempted to document and evaluate the radiological measurements of adult frontal air sinuses in both sexes and compare them to find out the differences in male and female and of both sides for frontal sinus.

Methods: This study was done in the department of anatomy of Rangpur medical college, Rangpur from January 2018 to December 2018. 100 plain X-ray films (50 male and 50 female) fulfilling the selection criteria were enrolled into this cross sectional, analytical study and these digital X-ray plates were collected from Hypertension and Research center, Rangpur. The X-ray films were collected from adult persons aged 18 to 55yrs. Plain X-ray of both antero-posterior (A/P) and lateral view (right) showing the skull with nasal cavity, orbit and paranasal sinuses were collected. With the help of measuring scale and digital slide calipers the height, width and depth of frontal sinuses were measured carefully and right area, left area and total area of frontal sinuses were calculated. On the basis of all measurements, different indices (frontal sinus index, asymmetry index of frontal sinus index) were calculated and the data were compared between two sex groups and both sides of frontal sinus. It is noteworthy, the height and width of frontal sinus was measured in A/P view and depth of frontal sinus was measured in lateral view of radiograph.

Results: In this study the mean \pm SD of height, width and area of right and left frontal sinus and total frontal sinus area in male was higher than that of female but difference reached on statistically significant level only in right side. Also, the depth of frontal sinus was significantly higher in male than that of female (p value- 0.007). Again the frontal sinus index of both side and asymmetry index of frontal sinus were higher in female than that of male. But the right and left frontal sinus index and asymmetry index did not reach significant level. It was observed that the frontal sinus septum was deviated to the mostly to left side in male (45.65%) but it was mostly in midline in female (56%). There was asymmetry between right and left side of frontal sinus. The height, width and individual frontal sinus area of subjects were found higher in right side than the left side in both sexes but reached significant level in males only. The left frontal sinus index in both sexes had higher value than that of right one but the result was non-significant. In this study, bilateral aplasia of frontal sinus was found only in case of male in 4% cases. Unilateral aplasia of frontal sinus was found only in case of female (1% in right side and 2% in left side).

Conclusion: The results of this present study indicate that it is possible to achieve accuracy and precision using a discrete number of morphological features of frontal sinus to determine sex of unknown skeletal remains. This study would help us to know the data of Bangladeshi people about frontal sinuses as well as would provide information for the clinicians (ENT specialists, neurosurgeons), anthropologist, radiologist and forensic experts in home and abroad.

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Introduction

Paranasal sinuses are the frontal, ethmoidal, sphenoidal and maxillary sinuses, housed within the bones of the same name. All sinuses open into the lateral wall of nasal cavity by small apertures which allow equilibration of air and movement of mucus; the detailed position of these apertures and indeed of the precise form and sizes of the sinuses, vary between individuals.¹ Their mucosa is continuous with that of the nasal cavity (a feature unfortunately favoring the spread of infections). Most sinuses are rudimentary or absent at birth; they enlarge appreciably during the eruption of the permanent teeth and after puberty, markedly altering the size and shape of the face at these times. Historically, shortly after the discovery of the X-ray in 1895, the paranasal sinuses were frequently studied by plain radiograph. Normal sinuses are radiolucent, whereas when they are diseased they show varying degree of opacity. In antero-posterior view most of the paranasal sinuses are visible. The frontal sinuses appear above the nasal cavity and the medial part of the orbits; their asymmetry, vertical extent and the position of their septa can be assessed by plain radiograph. The height, width and area on an average are larger in males than females, an aspect that points out its unique characteristic and importance in human identification.² Neha et al (2015, p. 9) on radiographic study of frontal sinus revealed that gender determination by frontal sinus based on logistic regression analysis is useful in 64.29%. Genetic background, climate, inflammation, mechanical stress was also postulated to be the reason for variation of size and shape and absence of frontal sinus. Hence the knowledge about frontal sinus anatomy and its variations is important for the diagnosis of acute and chronic sinus pathologies and for clinical and surgical procedures. For example, owing to the anatomical variability of the frontal sinuses, the neurosurgical approach to the orbit by the anterior cranial fossa in a patient with an

inflammatory nasal pathology may jeopardize the sterility of the surgical field.³

Paranasal sinuses are prone to great diversity of anomalies. It is important for surgeons to be aware of variations that may predispose patients to increased risk of intra operative complications and help to avoid possible complications and improve success of management.⁴ Thus, a better knowledge of normal pneumatization and development of frontal sinuses through radiographic study is important to evaluate sinus disease and to propose an adequate treatment. As the conventional plain radiographs are the first one to be analyzed by the clinicians, so still important to know the anatomy, size and variants of frontal sinus for specific population of both sexes.⁵

Objective

This study was attempted to document and evaluate the radiological measurements of adult frontal air sinuses in both sexes and compare them to find out the differences in male and female and of both sides for frontal sinus.

Methods

This study was performed in the department of Anatomy, Rangpur Medical College, Rangpur. This study was conducted from January 2018 to December 2018. This study was performed on plain digital X-ray films of adult frontal air sinuses (both anteroposterior and lateral view) in both sexes. The study was approved by the Ethical Review Committee of Rangpur Medical College, Rangpur. Sample was collected by convenient purposive sampling as per inclusion and exclusion criteria. Inclusion criteria includes apparently healthy adult male and female aged 18 - 55 years with no visible features of asymmetry in skull and patients who were willing to undergo PNS X-ray. Exclusion criteria includes-Pregnant female, adult persons with any congenital or acquired deformities of paranasal sinuses, adult persons with any

surgical interventions of paranasal sinuses, any disease condition of paranasal sinuses, history of any type of systemic disorders such as underlying bone diseases, nutritional and endocrinal diseases, Class III dental malocclusion patients, patients with posterior maxillary tooth extraction with no dental implant, Patients with having congenital syndrome involving craniofacial bones (cleft lip, cleft palate, hemifacialmicrosomy etc), history of orthodontic treatment or orthognathic surgery, trauma to nasomaxillary complex, mentally disabled patients, damaged or unclear X-ray films. 100 digital X-ray films were collected from the radiology department of a well-known diagnostic center of Rangpur (Hypertension and Research center, Rangpur). In case of female subjects help of a female attendance and in case of male subject help of a male attendance was taken for changing position. All X-ray were done by same radiology technician and in the same digital X-ray machine. The name of the machine was YZ-

200B 200mA Medical Diagnostic X-ray Machine (Appendix- V). DI-HT Fuji X-ray film was used to take images and the size of the X-ray film was 10 × 14 inch. Both views (anteroposterior and lateral) of the PNS X-ray were included in the same X-ray plate. The data collected from the radiological studies were processed according to their distributions, central tendencies, and dispersions. Then results were prepared from these data in terms of ranges, frequency distributions, mean values, standard deviations (SD), percentage value etc. as applicable. Mathematical relationships between measurements of male and female were analyzed by unpaired Students 't' test. Comparison had been done between the values of right and left frontal sinuses using paired "t" test. In all statistical analyses the level of significance was set as $p \leq 0.05$ at 95% confidence intervals (Appendix- IX). All the statistical analyses were done by using the SPSS software package for windows version 16.00.

Results

Table I: Comparison of measurements of height and width of frontal sinus of both side between male and female subjects (male=46, female: RFSH and RFSW=49, LFSH and LFSW= 48)

Variables	Frontal sinus	Male	Female	p value
Height (mm)	Right	2.97 – 51.69 19.36 ± 12.01	2.4 – 42.86 14.28 ± 8.61	0.017(S)
	Left	1.44 – 45.76 16.21 ± 11.26	1.1 – 37.42 13.45 ± 8.71	0.136(NS)
Width (mm)	Right	10.99 – 71.14 38.36 ± 16.74	13.67 – 69.35 32.07 ± 13.95	0.044(S)
	Left	7.36 – 66.34 30.16 ± 15.66	9.37 – 49.78 28.84 ± 11.49	0.632(NS)

Table I shows the mean ± SD of maximum height and width of frontal sinus of both side in male and female. The mean ± SD of height of right frontal sinus in male and female were 19.36 ± 12.01mm and 14.28 ± 8.61mm respectively. In male the mean height of right frontal sinus was higher than that of female and

the difference was statistically significant ($p=0.01$).The mean ± SD of height of left frontal sinus in male and female were 16.21 ± 11.26mm and 13.45 ± 8.71mm respectively. In male the mean height of left frontal sinus was higher than that of female but the difference was statistically non-significant ($p=0.13$).

Table II: Comparison of height and width of frontal sinus between right and left side in both sexes (male=46, female: RFSH and RFSW=49, LFSH and LFSW=48)

Variables		Right	Left	p value
Height of frontal sinus (mm)	Male	19.36±12.01	16.21±11.26	0.001(S)
	Female	14.28±8.61	13.45±8.71	0.505(NS)
Width of frontal sinus (mm)	Male	38.36±16.74	30.16±15.66	0.000(S)
	Female	32.07±13.95	28.84±11.49	0.146(NS)

Table II shows the mean ± SD of height of frontal sinus of right and left side in both male and female. The mean ± SD of height of frontal sinus in right and left side in male were 19.36 ± 12.01mm and 16.21 ± 11.26mm respectively. In male the mean height of right frontal sinus was higher than left frontal sinus and the difference was statistically significant (p=0.001).

The mean ± SD of height of frontal sinus in right and left side in female were 14.28 ± 8.61mm and 13.45 ± 8.71mm respectively. In female the mean height of right frontal sinus was higher than left frontal sinus but the difference was statistically non-significant (p=0.50).

Table III: Comparison of measurements of depth of frontal sinus between male and female (n=100, male=50, female=50)

Variable	Male	Female	p value
Depth of frontal sinus (mm)	11.14 – 46.44 18.51 ± 7.74	9.08 – 23.64 15.19 ± 3.29	0.007(S)

Table III shows the mean ± SD of depth of frontal sinus in male and female. The mean ± SD of depth frontal sinus area in male and female were 18.51 ± 7.74 mm and 15.19 ± 3.29

mm respectively. In male the mean ± SD of depth of frontal sinus was higher than that of female and the difference was statistically significant (p=0.007).

Table IV: Comparison of measurements of individual area of right and left frontal sinus and total area of frontal sinus between male and female (n=100, male=46, female: RFSA=49, LFSA=48, TFSA=50)

Variables	Male	Female	p value
Right frontal sinus area (mm ²)	37.69 – 3677.22	40.72 – 2845.9	0.009(S)
	909.71 ± 782.71	549.52 ± 535.52	
Left frontal sinus area (mm ²)	19.26 – 2948.14	23.56 – 1655.46	0.100(NS)
	638.36 ± 659.15	458.14 ± 390.90	
Total frontal sinus area (mm ²)	64.99 – 6502.44	45.52 – 4501.36	0.015(S)
	1548 ± 1327.15	1007.6 ± 792.55	

Table IV shows the mean ± SD of individual area of right and left frontal sinus and total area of frontal sinus in male and female. The mean ± SD of right frontal sinus area in male and female were 909.71 ± 782.71mm² and 549.52 ± 535.52mm² respectively. In male the mean ± SD of right frontal sinus area was greater than

that of female and the difference was statistically significant (p=0.009). The mean ± SD of left frontal sinus area in male and female were 638.36 ± 659.15mm² and 458.14 ± 390.90mm² respectively. In male the mean ± SD of left frontal sinus area was greater than that of female but difference was statistically

non-significant ($p=0.1$). The mean \pm SD of total frontal sinus area in male and female were $1548 \pm 1327.15\text{mm}^2$ and $1007.6 \pm 792.55\text{mm}^2$ respectively. In male the mean \pm SD of total

frontal sinus area was greater than that of female and the difference was statistically significant ($p=0.01$).

Table V: Comparison of area of frontal sinus between right and left side in both sexes (male=46, female: RFSA=49, LFSA=48)

Area of frontal sinus (mm^2)	Right	Left	p value
Male	909.71 \pm 782.71	638.36 \pm 659.15	0.002(S)
Female	549.52 \pm 535.52	458.14 \pm 390.90	0.203(NS)

Table V shows the mean \pm SD of area of frontal sinus of right and left side in both male and female. The mean \pm SD of area of frontal sinus in right and left side in male were $909.71\pm 782.71\text{mm}^2$ and $638.36\pm 659.15\text{mm}^2$ respectively. In male the mean area of right frontal sinus was higher than left frontal sinus

and the difference was statistically significant ($p=0.002$).

The mean \pm SD of area of frontal sinus in right and left side in female were $549.52\pm 535.52\text{mm}^2$ and $458.14\pm 390.90\text{mm}^2$ respectively. In female the mean area of right frontal sinus was higher than left frontal sinus but the difference was statistically non-significant ($p=0.203$)

Table VI: Distribution of area of frontal sinus according to age in both sexes (Male=46, Female=50)

Age group (in years)	Male			Female		
	No.	%	Average frontal sinus area (in mm^2)	No.	%	Average frontal sinus area (in mm^2)
18-25	15	30	1302.92	9	18	665.85
26-35	28	56	1388.5	24	48	1018.87
36-45	3	6	2283.41	7	14	1260.09
>45	4	8	1810.38	10	20	1009.84

Table VI shows that the frontal sinus area increases with age and was found to decrease in the age group above 45 years in both male and

female. The highest frontal sinus area was found in the age group of 36-45 years in both male and female.

Table VII: Comparison of frontal sinus index and asymmetry index of frontal sinus between male and female ($n=100$, male=50, female=50)

Variables	Male	Female	p value
Frontal sinus Index	Right	1.02 – 6.43 2.17 \pm 1.15	1.008 – 7.94 2.63 \pm 1.32 0.062(NS)
	Left	0.74 – 9.29 2.18 \pm 1.49	1.03 – 19.47 2.77 \pm 2.66 0.177(NS)
Asymmetry index of frontal sinus (%)	6.08 – 90.93 48.97 \pm 27.47	4.94 – 98.81 49.88 \pm 29.82	0.873(NS)

Table VII shows the mean \pm SD of index of frontal sinus of both side and asymmetry index of frontal sinus in male and female. The mean \pm SD of right frontal sinus index in male and female were 2.17 ± 1.15 and 2.63 ± 1.32 respectively. In female the mean \pm SD of right frontal sinus index was higher in female than that of male but the difference was statistically non-significant ($p=0.06$).

The mean \pm SD of left frontal sinus index in male and female were 2.18 ± 1.49 and 2.77 ± 2.66

respectively. In female the mean \pm SD of left frontal sinus index was higher in female than that of male but the difference was statistically non-significant ($p=0.17$). The mean \pm SD of asymmetry index of frontal sinus in male and female were $48.97\pm 27.47\%$ and $49.88 \pm 29.82\%$ respectively. In female the mean \pm SD of asymmetry index of frontal sinus was higher than that of male but the difference was statistically non-significant ($p=0.87$).

Table VIII: Comparison of index of frontal sinus between right and left side in both sexes (n=100, male=46, female: RFSI=49, LFSI=48)

Variable		Right	Left	p value
Index of frontal sinus	Male	2.17 ± 1.15	2.18 ± 1.49	0.937(NS)
	Female	2.63 ± 1.32	2.77 ± 2.66	0.670(NS)

Table VIII shows the mean \pm SD of index of frontal sinus of right and left side in both male and female. The mean \pm SD of index of frontal sinus in right and left side in male were mm 2.17 ± 1.15 and 2.18 ± 1.49 respectively. In male the mean index of left frontal sinus was higher than right frontal sinus but the difference was statistically non-significant ($p=0.937$).

The mean \pm SD of index of frontal sinus in right and left side in female were 2.63 ± 1.32 and 2.77 ± 2.66 respectively. In female the mean index of left frontal sinus was higher than right frontal sinus but the difference was statistically non-significant ($p=0.67$).

Table IX: Distribution of samples based on symmetry of right and left frontal sinus

Degree of bilateral asymmetry	Range of Asymmetry index (%)	Male(46)		Female(47)	
		count	%	count	%
Symmetry and almost symmetry	100-80	7	15.21	8	17.02
Slight asymmetry	79-60	14	30.43	12	25.53
Moderate asymmetry	59-40	9	19.56	12	25.53
Strong asymmetry	39-20	12	26.08	6	12.76
Extreme asymmetry	<20	4	8.69	9	19.15

Table IX shows distribution of frontal sinus according to asymmetric index. Slight asymmetry was observed most cases of male subjects (30.43%), slight and moderate asymmetry was observed in most cases of

female subjects (25.53%). Strong asymmetry was observed more in male subjects (26.08%), whereas extreme asymmetry was more observed in case of female subjects (19.15%).

Discussion

Frontal sinus is known as one of the anatomical structures that found only in humans and some apes in Africa. Other than age, sex and dimensions of the skull, genetic factors and weather condition influence sinus dimensions in each population. Interindividual and intraindividual variations in the size and shape of the frontal sinuses have been reported. The earlier study of frontal sinus by Schuller revealed important information about its shape, complexity and individuality; since then, complimentary studies have been conducted among most distinct ethnic groups for identification purposes.⁶ The need to establish a reliable, low-cost and easily reproducible method for human identification prompted the elaboration of technical, precise and accessible parameters, such as height, width, depth, area, asymmetry and shape of frontal sinus. The frontal sinus is one that is of most interest and significance in forensic identification due to its irregular shape and because of the individual characteristics which makes the frontal bone unique for every individual, just as fingerprint, even in monozygotic twins. The frontal sinuses may be a prime catalyst in the process of developing intracranial complications on the basis of its anatomical characteristics.⁷⁻⁹ Extension of the frontal sinus in the AP dimensions could happen either laterally (thus prominence of superciliary arch) or medially in association with dura. Extension of sinus towards dura causes thinning of the bone wall and increases the probability of intracranial involvement of sinus infections. In a series of pediatric patients with acute sinusitis the prevalence of intracranial complications was significantly higher (30.4%) in patients with frontal sinusitis compared with those without frontal sinus involvement (2.12%). Apart from its location, the venous supply comes from the dura matter for the inner table, the periorbita for the orbital plate and cranial periosteum for the outer table. Additionally, venous mucosal drainage is through the small diploic veins

extending through the bony sinus wall. These in turn communicate with the venous plexuses of the three structures.¹⁰⁻¹² This exceptional watershed between intra- and extra-cranial venous systems accounts logically for transmission of infection. The preoperative recognition of individual anatomic variations is a prerequisite for any successful surgical procedure performed on the frontal sinus. The analysis of radiographs of the frontal sinuses is therefore a useful tool to identify its size and configuration and to minimize the risk factors for any sinus or orbital operation.¹³ In elderly patients, asymmetrical bone resorption might determine the enlargement of the sinusal cavity. The osseous laminae separating the ethmoidal labyrinth from the inferior and posterior walls of frontal sinus becomes thinner and may cause intracranial dissemination of sinusal inflammation. Therefore, the knowledge of the extent of pneumatization and development of different parts of the paranasal sinus system is an important condition for adequate treatment of its disease and traumas. It is of special interest to determine development and size of the frontal sinus.¹⁴

Conclusion

In the present study, basic differences of measurements of radiological variables of frontal sinus was present in male and female. All the variables of frontal sinus had higher values in male than that of female but the differences were only statistically significant in case of right side. There was a considerable variation in the shape, capacity and asymmetry of frontal sinus. Knowledge of frontal sinus and their variations is important for the diagnosis of acute and chronic sinus pathologies and for clinical and surgical procedures. In the forensic medicine, the frontal sinuses are important for establishing a reliable identification of unknown human remains based on comparison of antemortem and postmortem radiographies. So the findings of the present study would be reliable enough and might help the surgeons

and anthropologists of our country enable to improve their performances in this field.

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