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Original Research Article

Morphometry of frontal sinus in correlation to age and gender by computed tomography

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ABSTRACT

Introduction: The frontal sinus is funnel-shaped cavity separated by septum. The frontal sinus is unique to individual and often thought as a more symptomatic sinus because of the difficulties encountered in treatment of frontal rhino sinusitis. It requires the clinician to have precise knowledge of nasal sinus anatomy in the surgical treatment of sinusitis in recent years, particularly in endonasal endoscopic surgery.
Materials and Methods: 100 patients (72 males and 28 females) undergoing coronal and axial sections of computed tomography scan of frontal sinus of head and neck aged between 1year to 90 years at the radiology department, Vydehi institute of medical science & research centre, Bangalore for reasons other than due to craniofacial abnormalities or sinus problem were taken for the study. Volume and dimensions of the frontal sinuses with its anatomical variations were obtained. Mean, SD, significant difference between age & gender was calculated.
Results: Mean value of all the parameters of frontal sinus of both right & left were more in males compared to females. Compared between sides, all the parameters of both sides in males were more in right sinus than left side, in females right depth & volume were more on right side & height & width were more on left side. There is a significant difference in height of right frontal sinus, width & volume of left frontal sinus between male & female. The maximum height was observed in the age group in males on right side was in 51-60 yrs & on left side was 71-80yrs, in females on right & left side was 61-70 yrs. The Maximum width, depth & volume of sinus in males & females on right & left side were in age group 51-60 yrs. There is a significant difference both side in males & females and in right & left sinus in depth was in age group 11-20 yrs & on right side in 21-30 yrs age group.
Conclusion: These results will be helpful in understanding normal and pathological conditions of the frontal sinuses & useful in clinical planning of medical or surgical interventions of the frontal sinuses.

1. Introduction

The frontal sinuses are paired lobulated cavities located posterior to the superciliary arches in the frontal bone and opens into the corresponding middle meatus via the infundibulum.[1] They are not apparent at birth and development begins during the second year of life and is completed by about 20 years of age and remains stable until further enlargement of the chambers can occur from bone resorption during the advanced ages.[2–4] The patterns of the rate of growth spurt of sinus around 7 to 9 years of age, rapidly increasing with age until 16 to 18 years of age coincides with puberty that the air sinus are related to hormonal changes.[5] The thorough knowledge of frontal sinus is required during the procedures involving frontal craniotomies such as Mayfield pin placement and emergency supra-orbital ventricular puncture to minimize morbidity.[6] Studies have been proved regarding limitations

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in the assessment of the anatomy of the paranasal sinuses by using cadaveric specimens, plain radiographs and magnetic resonance imaging and that CT imaging is the optimal technique in defining the paranasal sinuses anatomy ensuring accurate data capture of both the morphology and morphometry of the same.[7,8]The aim of this study was to determine sizes of the frontal sinus in both sexes & comparison with the opposite side can be useful to the surgeons in planning the diagnosis and management of sinus pathologies.

2. Materials and Methods

The retrospective study consisting of 100 patients (both males-72 and females -28) ages ranging from 1year to 90 years who had their computed tomography scan of head and neck (coronal and axial sections) at the radiology department, Vydehi institute of medical science & research centre, Bangalore for reasons other than due to craniofacial abnormalities or sinus problem. Age groups 1 year to 90 years of male & females were included for the study. Patients with history of trauma to the face, diseases of the nasal cavity and paranasal sinuses were excluded from the study. The various parameters like height, width, depth & volume of the maxillary sinus was measured using Computed tomography scans in the radianatdicom software. SPSS for Windows 11.0 was used for the statistical assessment. Descriptive statistics are provided as the mean with standard deviation (SD). Analytic assessment was done by the Student t-test and a P value less than 0.05 accepted as statistically significant difference.

The following measurements of Frontal sinus were done

1. Frontal sinus h eight was measured as the longest distance from the lowest point of the sinus floor to the highest point of the sinus roof in the coronal view (Figure 1).
2. Frontal sinus width was measured as the longest distance perpendicular from the medial wall of the sinus to the most lateral wall of the sinus in the axial view (Figure 2).
3. Frontal sinus depth was measured as the longest distance from the most anterior to the most posterior point of the sinus in the axial view (Figure 3).
4. Frontal sinus volume was measured using the following equation: (height x width $\times$ depth $\times$ 0.52).[9]

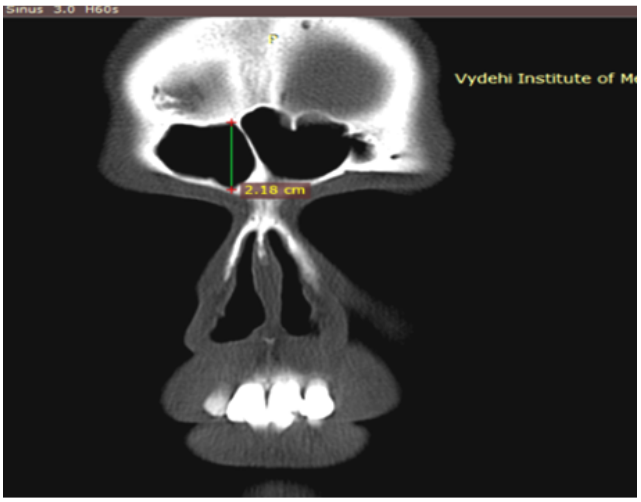

Fig. 1: Measurement of maximum height of frontal sinus by Computed Tomography scan in coronal view

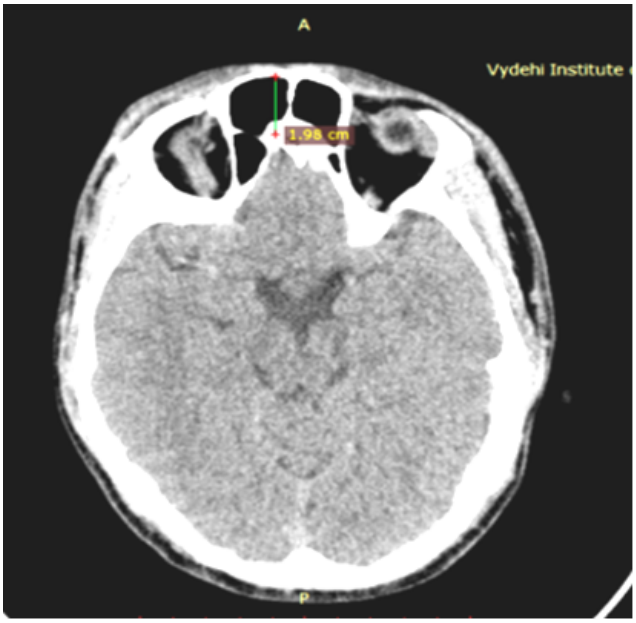

Fig. 2: Measurement of maximum depth of frontal sinus by Computed Tomography scan transverse (axial) view

3. Results

Mean value of all the parameters of frontal sinus are more in males compared to females. The maximum height was observed in the age group in males on right side was in 51-60 yrs & 31-40 yrs, on left side in the age group 71-80yrs & 31-40 yrs, in females on right & left side was observed in 61-70 yrs & 51-60 yrs. The maximum width of sinus in males on right & left side was in age group 51-60 yrs & 71-80 yrs, in females on right & left side the maximum value of width of maxillary sinus was in age group 51-60 yrs & 61-70 yrs. The maximum value of depth in males on right & left side of sinus was in the age group 51-60 yrs & 31-40 yrs, in females on right side maximum depth was in age group was in 51-60 yrs & 61-70 yrs, on left side 51-60 yrs & 21-30 yrs. The maximum volume of sinus was found in males on right & left side in the age group of 51-60 yrs & 31-40 yrs & in females was in age group 51-60 yrs & 61-70 yrs. When compared between sides there was a significant difference

Table 1: The various parameters of right & left frontal sinus in males & females

Measurements	Male Mean ± SD	Female Mean ± SD	P – Value
Right height(cm)	3.74 ±1.23	2.86 ±1.08	0.001
Right width(cm)	2.50 ±0.93	2.10±1.01	0.067
Right depth(cm)	2.16±1.07	1.81 ±1.04	0.059
Right volume(cm^3)	12.98 ±10.65	8.47 ±11.45	0.189
Left height(cm)	3.65 ±1.24	3.14±1.36	0.127
Left width(cm)	2.48±0.94	2.19±1.14	0.030
Left depth(cm)	2.27 ±1.05	1.78 ±0.94	0.059
Left volume(cm^3)	13.00 ±10.70	8.76 ±8.11	0.050

Table 2: The age wise comparison of height of right & left frontal sinus between males and females

S. No.	Age groups(yrs)	Males		Females		P Value	
		Right(cm)	Left(cm)	Right(cm)	Left(cm)	Right	Left
1	1 – 10	-	-	-	-	-	-
2	11 – 20	3.55	2.95	1.79	1.31	0.001	0.001
3	21 – 30	3.47	3.11	2.23	2.52	0.071	0.298
4	31 – 40	4.31	4.55	-	-	-	-
5	41 – 50	4.04	4.11	-	-	-	-
6	51 – 60	4.63	4.46	3.25	3.75	0.040	0.186
7	61 – 70	3.40	3.90	3.72	4.28	0.422	0.508
8	71 – 80	4.30	4.60	-	-	-	-
9	81 – 90	3.21	3.40	-	-	-	-

Table 3: The age wise comparison of width of right & left frontal sinus between males and females

S. No.	Age groups(yrs)	Males		Females		P Value	
		Right(cm)	Left(cm)	Right(cm)	Left(cm)	Right	Left
1	1 – 10	-	-	-	-	-	-
2	11 – 20	2.86	1.86	1.48	0.58	0.004	0.005
3	21 – 30	2.28	2.21	1.25	1.73	0.033	0.314
4	31 – 40	2.54	2.94	-	-	-	-
5	41 – 50	2.70	2.62	-	-	-	-
6	51 – 60	3.18	3.40	2.71	2.97	0.464	0.281
7	61 – 70	2.21	2.62	2.28	2.59	0.804	0.934
8	71 – 80	3.10	3.40	-	-	-	-
9	81 – 90	1.80	2.30	-	-	-	-

Table 4: The age wise comparison of depth of right & left frontal sinus between males and females

S.No.	Age groups(yrs)	Males		Females		P Value	
		Right(cm)	Left(cm)	Right(cm)	Left(cm)	Right	Left
1	1 – 10	-	-	-	-	-	-
2	11 – 20	2.07	2.20	1.39	1.08	0.001	0.001
3	21 – 30	2.31	2.39	0.95	1.61	0.015	0.155
4	31 – 40	2.36	2.70	-	-	-	-
5	41 – 50	2.06	1.87	-	-	-	-
6	51 – 60	2.70	2.74	2.41	2.29	0.661	0.422
7	61 – 70	1.78	1.86	1.79	1.55	0.980	0.373
8	71 – 80	1.20	2.40	-	-	-	-
9	81 – 90	1.30	1.50	-	-	-	-

Table 5: The age wise comparison of volume of right & left frontal sinus between males and females

S.No.	Age groups(yrs)	Males		Females		P Value	
		Right(cm^3)	Left(cm^3)	Right(cm^3)	Left(cm^3)	Right	Left
1	1 – 10	-	-	-	-	-	-
2	11 – 20	11.48	7.26	1.92	0.43	0.002	0.003
3	21 – 30	13.18	10.78	1.72	6.56	0.023	0.329
4	31 – 40	15.05	22.54	-	-	-	-
5	41 – 50	13.34	12.11	-	-	-	-
6	51 – 60	24.35	22.06	14.87	13.55	0.295	0.103
7	61 – 70	7.85	11.41	7.92	8.90	0.972	0.469
8	71 – 80	8.32	19.52	-	-	-	-
9	81 – 90	3.91	6.10	-	-	-	-

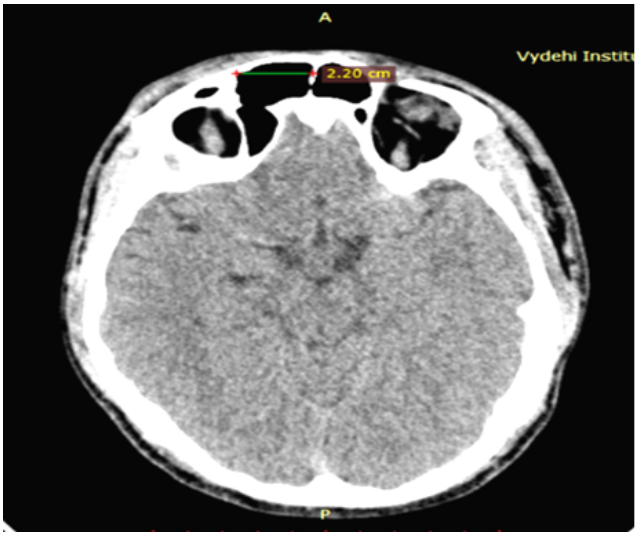

Fig. 3: Measurement of maximum width of frontal sinus by Computed Tomography scan transverse (axial) view

in height of right frontal sinus p value of 0.001, width p value 0.030 & volume p value 0.050 of left frontal sinus between male & female. When compared between gender in males there was a significant difference between the in right & left sinus where p value of height was 0.671, width was 0.906, depth was 0.574 & volume was 0.989 and in females there was a significant difference between the right & left sinus, where p value of height was 0.368, width was 0.743, depth was 0.913 & volume was 0.910. There is a significant difference in right & left sinus in depth was in age group 11-20 yrs & on right side in 21-30 yrs age group.

4. Discussion

In the present study, the width of maxillary sinus was less in values when compared to Ertugrul et al,[11] Suzanne et al[13] but more in values when compared to Soman BA et al[10] and Pradynesh et al.[12] When compared between gender, sinus width size was more in values in males than females. When compare to other authors the width of frontal sinus on left side was being more than right side both in males & females in the present study which was similar to other study except in males where right sinus size was more than left sinus size. The Left side depth of sinus was being more than right sinus size in both males & females. In the males sinus size was more in values than females except in Pradynesh et al[12] studies & in the present study in females right side being more in value than left. The height of right sinus was more in males & left side sinus was more compared to other side & more in values compared to other authors. The volume of sinus being more on left side than right both in males & females, males size more in value than females sinus size except in Pradynesh et al[12] studies. In the present study, the height, depth & volume of maxillary sinus were more in value when compared to other authors. When compared between gender all the parameters were more in value in males compared to females. When compared between sides other studies showed that width & volume of sinus was more in value in left side compared to right side, height & depth were more in right side than left side sinus. The right sinus was more in values in width, height, volume in males & depth in females. On the left side sinus was more in values in width, height & volume in females & depth in males. On age wise comparison of growth of frontal sinus volume, according to Soman BA et al[10] studies the volume of frontal sinus was gradual increasing with age of maximum 11.80 cm^3 (male) & 7.62 cm^3 (female) by 31-45 age group, there after decreasing in growth by 45 yrs age minimum volume of 6.84 cm^3 (male) & 8.03 cm^3 (female). According to Carmen O et al[14] studies there was gradual increase in size of volume of sinus being maxi mum in 22-25 age group of 47.62 $\pm$ 40.16 cm^3 (right) 43.1 cm^3 (left) minimum of size of volume was noticed in 1-3 yrs age group of 4.85 $\pm$ 5.3 cm^3 (right) & 4.38 $\pm$ 7.7cm^3 (left side). Karakas S et al[16] also observed there was gradual increase in size of volume by 25 yrs & above age groups with maximum value of 8.41 $\pm$ 4.0 cm^3 (males) & 3.50 $\pm$ 2.4 cm^3 (females) with minimum size in age group of 5-10 yrs of 1.19+0.6 cm^3 (males) & 1.23 $\pm$ 0.2 cm^3 (females). In the present study maximum size of frontal sinus was observed in the age group of 51-60yrs on right side 24.3

Table 6: Showing comparison of height, width & depth of right & left frontal sinus of both males & females with other authors.

Authors	Measurements	Male		Female	
		Right	Left	Right	Left
Soman BA [10]	Width (cm)	2.35 ± 1.29	2.92 ± 1.04	2.24 ± 1.04	2.61 ± 0.82
	Height(cm)	1.12 ± 0.93	1.50 ± 0.89	1.19 ± 0.77	1.32 ± 0.75
Ertugrul [11]	Width (cm)	2.70 ± 7.8	2.84 ± 0.81	2.43 ± 0.76	2.60 ± 0.74
	Height(cm)	2.65 ± 0.87	2.82 ± 0.91	2.36 ± 0.83	2.47 ± 0.82
	Depth (cm)	1.16 ± 0.40	1.31 ± 0.52	1.01 ± 0.40	1.08 ± 0.40
Pradynesh N [12]	Width (cm)	2.15 ± 0.87	2.32 ± 0.98	2.05 ± 0.91	2.13 ± 0.92
	Height(cm)	1.56 ± 0.69	1.58 ± 0.61	1.37 ± 0.61	1.33 ± 0.68
	Depth (cm)	1.43 ± 0.66	1.39 ± 0.65	1.28 ± 0.65	1.21 ± 0.50
Suzanne TN [13]	Width (cm)	2.58 ± 0.90	3.1 ± 0.97	2.48 ± 0.78	2.9 ± 0.88
	Height(cm)	1.6 ± 0.63	1.9 ± 0.95	1.4 ± 0.53	1.6 ± 0.62
Present study	Width (cm)	2.5 ± 0.93	2.48 ± 0.98	2.10 ± 1.01	2.19 ± 1.14
	Height(cm)	3.74 ± 1.2	3.65 ± 1.24	2.86 ± 1.25	3.14 ± 1.36
	Depth (cm)	2.16 ± 1.07	2.27 ± 1.05	1.81 ± 1.04	1.78 ± 0.94

Table 7: Showing comparison of volume of right & left frontal sinus of both males & females with other authors

Volume	Male		Female	
	Right (cm^3)	Left (cm^3)	Right (cm^3)	Left (cm^3)
Carmen O [14]	3.93 ± 3.8	4.31 ± 3.9	3.13 ± 2.8	3.63 ± 3.2
Sanchez fernandes JM [15]	1.9	1.9	1.6	2.1
Karakas S [16]	6.86 ± 4.31		2.87 ± 2.29	
Mehemet Emerzeoglu [17]	7.5 ± 4.3		4.1 ± 2.9	
Pradynesh N [12]	3.21 ± 1.6	3.06 ± 1.4	3.08 ± 1.2	2.83 ± 1.42
Present study	12.98 ± 10.6	13.0 ± 10.7	8.47 ± 11.4	8.76 ± 8.11

cm^3 (male) & 22.06 cm^3 (female), on left side 14.87 cm^3 (males) & 13.55 cm^3 (females) there after reduction in size with m inimum size of sinus was observed in 61-70 yrs age group on right side7.85 cm^3 (males) & 11.14 cm^3 (females) & on left side 7.92 cm^3 (males) 8.90 cm^3 (females) & in 81 -90 yrs both the sides in males & minimum size was observed also during initial growth period of 11-20 yrs age group on right side 11.4 cm^3(males) & 1.92cm^3(females) on left side 7.26cm^3 (males) & 0.43cm^3 (females). The present study coincides with the growth pattern of frontal sinus with other authors. Sanchez Fernandez et al [15] & Kawarai Y et al [18] reported that there were no statistically significant differences regarding asymmetry and gender. Studies done by Tatlisumak E, et al [19] & Mathew KL, et al [20] there was no significant difference in case of AP diameter, but in h eight & width where there is significant difference between male & female. Whereas Karakas KS et al [16] observed significant relation was more in males compared to females. These variations could be due to difference in the range of age group. In the present study there is a significant difference in height of right frontal sinus, width & volume of left frontal sinus between male & female.

It was found that the length and width of the frontal sinus area, increase with age. [21] and found to decrease in males in the age group of 45 years and above because of hormonal and mechanical stresses of mastication [11,22] but the size was increasing as studies done by Karakas S [16] and Fatu et al [21] due to bone resorption of sinus. This difference could have been due to morphological differences seen in various ethnic groups and various other radiographic techniques used for the morphological evaluation of the frontal sinuses. The morphological differences in the cranium between the two genders are determined mainly by the genetic factors, more so than nutritional, hormonal or muscular factors and also due to various ethnic groups and various other radiographic techniques used for the morphological evaluation of the frontal sinuses. [3,10]

Our results may helpful in understanding normal volumetric values of the frontal sinuses. The knowledge of the presented data may be useful in clinical planning of medical or surgical interventions of the frontal sinuses.

5. Conclusion

The sinonasal region is often imaged because infectious and allergic diseases of the nasal cavity and paranasal sinuses. Improved knowledge of normal pneumatization and development of frontal sinuses is important to allow sinus diseases to be evaluated such as functional endoscopic sinus surgery essential for a preoperative evaluation and an adequate treatment to be proposed.

6. Source of funding

None.

7. Conflict of interest

None.

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