

ANATOMICAL VARIATION OF FRONTAL SINUSES EVALUATED BY CT SCAN IN RELATION TO AGE AND SEX IN SULAIMANI CITY



Twana Muhammad Raouf*, Kamal Ahmad Saeed**
and Kawa A Mahmood**

Submitted: 15/4/2012; Accepted: 2/11/2012; Published: 1/6/2013

ABSTRACT

Background

There are considerable variations in the shape, capacity, and symmetry of the frontal sinuses. Hence, knowledge of frontal sinus anatomy and its variations is important for the diagnosis of sinus pathologies and prior to relevant surgical procedures.

Objectives

This study was undertaken to determine the presence of the anatomical variations and morphological characteristics of the frontal sinuses in a population aged between (20 – 85) years in Sulaimani city.

Methods

A review the CT scans of paranasal sinuses, which were taken in axial and coronal sections, of 100 individuals (58 males and 42 females), in the radiology department Sulaimani Teaching Hospital between April 1st 2009 to June 30th 2009.

Results

All measurements tended to be larger on the left side and were significantly larger in males than females. There was a significant difference in the anteroposterior dimensions of right and left sides in both sexes.

Conclusion

Morphometric features differed significantly in the two sexes at different ages and comparison with previous studies presented great regional variability.

Keywords: *Frontal sinus, CT scan.*

*Directorate of Health, Sulaimani city, Iraq. Corresponding email: drtwana@yahoo.com

**Department of Surgery, School of Medicine, Faculty of Medical sciences, University of Sulaimani.

INTRODUCTION

The frontal sinuses are paired lobulated cavities located posterior to the superciliary arches in the frontal bone and each frontal sinus opens into the corresponding middle meatus via the infundibulum; in 38% frontal sinus opens through the anterior ethmoidal cell in the ethmoidal infundibulum while the rest 62% opens into the frontonasal duct^(1, 2). The frontal sinuses are not visible on the skull radiograph until the age of 2 years and achieve adult proportions by the age of 14 years. Asymmetry is common, and one or both may fail to develop. Frontal sinuses appear as pyramidal in shape, vary in size, and they may extend into the orbital plate of frontal bone⁽³⁾.

Computerized tomographic (CT) scanning in either axial or coronal planes provides excellent visualization of the paranasal sinuses. Particular attention is paid to the region of the ostiomeatal complex. The earlier studies of the frontal sinus revealed important information about its shape, complexity and individuality, as well as its contribution to human identification, including post-mortem cases⁽⁴⁾. Since then, complementary studies have been conducted examining the anatomic characteristics and variations of the frontal sinus among the most distinct ethnic groups, for forensic purposes⁽⁵⁾.

PATIENTS AND METHODS

This study was conducted in the radiology department of Sulaimani Teaching Hospital. The reviews were on the CT scans of paranasal sinuses of 100 patients (58 males and 42 females), was carried out during the period April 1st 2009 to June 30th 2009 inclusive.

The CT scans were taken in coronal and axial planes of 2 mm thickness by neusoft (CT-C3000) CT scan machine. The same radiologist carried out all evaluations, and measurements, in addition measurements were expressed in millimeters.

Any visible pneumatization was accepted as presence of the sinus. The border between the right and left sinuses was determined by the intersinus septum.

The maximum measurements of widths, heights of each sinuses and total width of the two sinuses were taken in a coronal plane. The anteroposterior dimension was measured on an axial plane. All sections were examined in each individual, and

for each parameter, the maximum value was recorded. Measurements of both sides were compared with each other for the total population and for each sex.

The Cases were divided into five groups according to age as 20–30, 31–40, 41–50, 51–60, 61 and above for each sex, and for total population and each measurement parameter was also compared among the subgroups.

The pathological cases were excluded to avoid complex variation due to illness. The SPSS software package version 15 had been applied for the statistical analysis.

RESULTS

Among the 100 individuals studied 58 were males and 42 were females. Mean age was 40.45 (range 20-85 years). Their distribution according to age groups and gender is shown in table 1.

It was found that the frontal sinuses were absent bilaterally in 3 cases (3%); while it was unilaterally absent in another 3 cases, two on the right side and one on the left. Table 2, figures 1 and 2.

The detailed dimensions of the frontal sinuses according to the different age groups and gender are shown in tables 3,4,5,6 and 7. All measurements had higher values in the males and the differences were significant ($p < 0.05$), measurements were evaluated for each sex on right and left sides and they were different in favor of the left side for both sexes. In males, anteroposterior dimensions ($p < 0.001$) and heights ($p < 0.05$) were significantly different, also in females the differences of anteroposterior dimensions and widths were significant ($p < 0.05$).

The tables 8-A and 8-B show the mean measurements of the frontal sinuses in widths, heights and anteroposterior dimensions related to the age groups. The highest values were observed in the 41-50 age group, except the height, width of the left side and anteroposterior of the right frontal sinuses, which had highest value in the 20-30 age group. The anteroposterior dimensions of the left frontal sinuses the highest value observed in the 31-40 age group. In males, the highest values were observed in 41-50 age groups, except the width of the left frontal sinus, which had the

Anatomical Variation of Frontal Sinuses..

highest value in the 20-30 age group. In females, the highest values were in the 20-30 age group. The highest values on the anteroposterior dimension of the right sinus observed in the 20-30 age group, while the highest value on the

anteroposterior dimension of the left frontal sinus observed in the 31-40 age group.

Table 1. The number of patients in each sex and subgroup.

Age group	Male Number	Female Number	Total
20-30	14	13	27
31-40	14	7	21
41-50	13	3	16
51-60	8	7	15
More than 60	9	12	21
Total	58	42	100

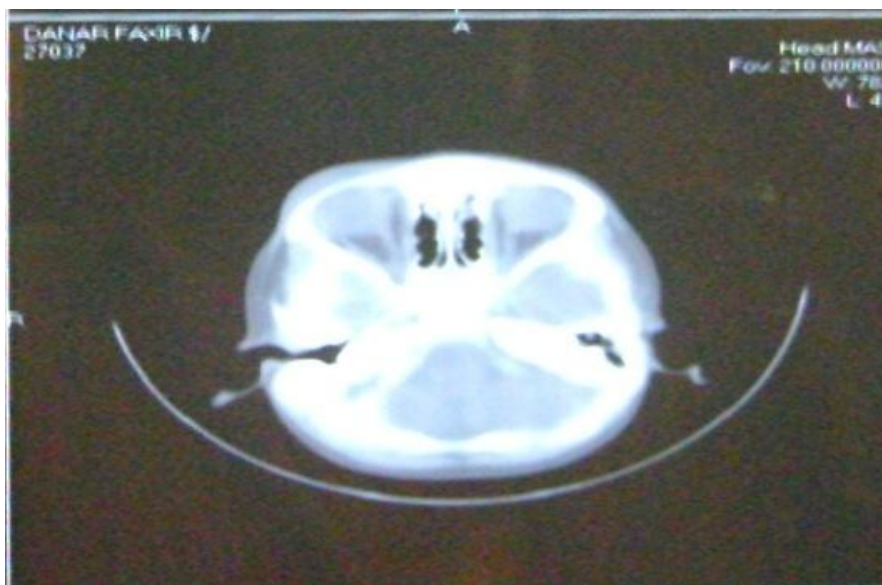


Figure 1. Absence frontal sinuses.

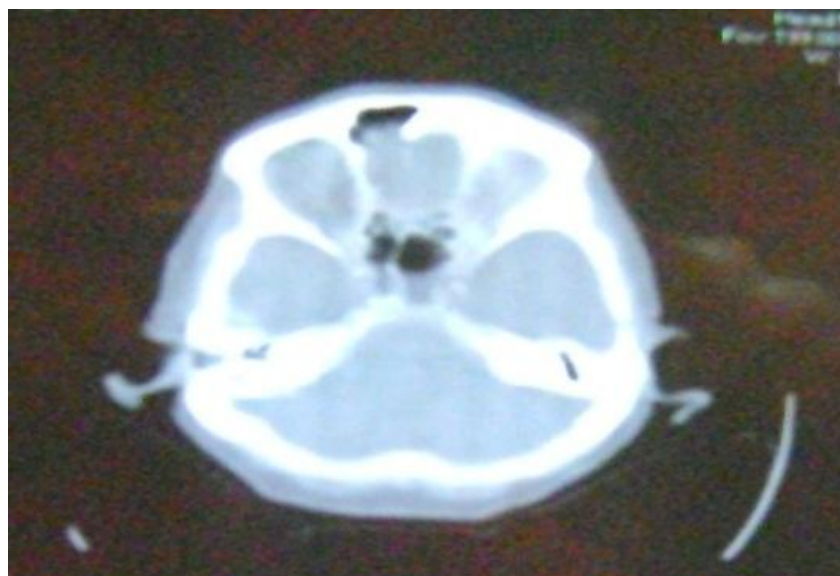


Figure 2. Unilateral absence of the frontal sinuses.

Table 2. The presence and absence of frontal sinuses.

Total	Presence of sinuses	Absence of sinuses (total)	Unilateral absence on the right side	Unilateral absence on the left side
100	94	3	2	1

Table 3-A. The dimensions measurement in millimeter of 11 female patients from 20–30 years age subgroup, (In two patients frontal sinuses were absent).

Height right	Height left	Width right	Width left	Total width	Anterioposterior right	Anterioposterior left
23.43	29.15	33.32	21.87	58.32	20.92	25.64
21.92	32.09	28.35	42.26	78.05	27.8	26.24
20.19	16.75	27.59	20.19	50.23	25.61	26.1
24.52	17.44	21.23	22.16	48.54	18.43	16.49
27.55	16.41	15.25	27.56	44.55	32.83	28.14
48.83	47.47	44.42	47.94	91.81	53.44	48.82
24.64	35.84	17.09	32.26	42.28	20.72	19.83
17.23	20.76	13.21	26.34	41.05	16.84	16.31
22.11	27.4	12.98	19.71	34.61	20.67	32.21
11.9	16.67	7.67	19.04	29.51	16.18	24.75
20.68	20.19	24.62	34.69	60.56	20.19	20.19

Table 3-B. The dimensions measurement in millimeter of 14 male patients from 20 - 30 years age subgroup

Height right	Height left	Width right	Width left	Total width	Anterioposterior right	Anterioposterior left
21.63	23.76	29.87	33.51	62.74	40.58	40.26
21.54	31.8	25.09	34.93	61.81	18.83	24.2
22.5	32.22	23.02	31.69	56.75	19.43	25.56
18.1	21.82	27.68	31.94	61.76	15.44	18.64
22.89	14.18	28.16	22.89	55.7	24.65	12.32
24.04	24.02	19.87	20.33	42.97	20.41	20.32
20.52	13.49	21.1	19.38	41.62	18.17	7.64
16.9	21.87	12.92	24.38	39.27	15.57	19.81
21.33	25.51	15.49	19.54	37.82	18.04	15.93
23.08	22.08	20.1	24.08	47.68	13.06	16.06
21.57	27.5	25.89	33.44	62.02	24.27	25.91
23.52	16.17	29.89	25.97	59.78	18.62	19.11
27.61	33.79	32.37	32.84	68.06	22.85	20.47
19.04	17.87	20.34	19.67	42.56	18.29	19.32

Table 4-A The dimensions measurement in millimeter of the 7 female patients from 31-40 years age subgroup

Height right	Height left	Width right	Width left	Total width	Anteriopos. Right	Anteriopos. Left
10.44	absence	19.75	Absence	19.75	6.58	absence
13.76	16.92	11.41	25.21	40.49	21.01	20.48
23.24	21.48	28.94	26.31	57.88	19.73	28.95
17.91	18.38	12.25	13.2	32.05	26.39	22.15
20.36	16.29	25.34	23.54	53.4	21.33	22.1
21.54	20.09	20.29	28.48	50.35	13.08	15.71
11.62	21.36	7.03	26	41.78	25.11	21.86

Table 4-B. The dimensions in millimeter of 13 male patients from 31-40 years age subgroup, (in one patient the frontal sinuses were absent).

Height right	Height left	Width right	Width left	Total width	Anteriopos. Right	Anteriopos. Left
20.69	34.01	23.14	36.44	63.03	23.56	30.05
13.08	23.72	13.55	29.11	45.18	11.58	15.05
42.91	24.51	38.65	25.45	65.52	44.3	30.16
16.85	17.78	22.59	16.82	42.32	16.83	27.4
17.44	12.73	13.74	12.73	31.11	16.97	23.57
29.05	46.76	30.05	34.48	67.46	20.69	38.9
15.06	23.58	16.06	30.61	52.69	9.53	10.55
29.94	24.06	28.34	21.39	50.79	19.78	21.92
22.87	19.88	22.37	25.85	53.19	17.4	14.42
14.05	18.74	14.61	16.14	34.35	19.78	20.3
21.9	25.23	26.18	27.13	54.74	23.8	27.13
30.58	40.77	30.09	40.28	73.77	25.25	36.89
18.04	14.64	24.89	9.32	42.43	17.07	12.68

Table 5-A. The dimensions measurement in millimeter of the 3 female patients from 41-50 years age subgroup.

Height right	Height left	Width right	Width left	Total width	Anteriopos right.	Antriopos. Left
14.77	23.63	15.76	24.62	43.33	20.68	23.63
17.15	13.23	21.08	10.79	33.81	20.12	12.25
22.11	15.38	21.15	18.75	41.34	15.38	23.55

Table 5-B. The dimensions measurement in millimeter of the 13 male patients from 41-50 years age subgroup.

Height right	Height left	Width right	Width left	Total width	Anteriospos. Right	Anteriospos. Left
17.1	26.32	25	22.37	49.55	21.49	29.38
23.36	22.57	19.98	30.71	52.54	22.67	21.25
absence	14.56		17.06	17.06		16.06
21.76	28.29	36.45	42.44	81.62	28.31	23.65
37.42	20.33	23.11	28.18	54.98	24.96	20.83
42.1	31.35	32.72	37.62	75.69	31.4	35.39
25.85	31.32	27.41	33.86	64.15	11.95	20.4
17.19	12.89	21.42	11.91	35.73	24.65	23.16
23.45	22.48	26.38	26.38	52.76	16	15.78
25.12	19.7	20.69	26.1	47.76	20.04	17.84
26.33	18.94	25.4	19.86	46.2	28.64	19.41
33.24	35.75	31.69	27.61	61.34	23	29.14
37.23	21.68	43.36	16.49	59.49	26.86	20.27

Table 6-A. The dimensions measurements in millimeter of 7 female patients from 51-60 years age subgroup.

Height Right	Height left	Width right	Width left	Total width	Anteriospos. Right	Anteriospos. Left
22.31	18.17	43.08	25.32	69.94	44.57	17.23
18.27	16.82	31.26	9.63	42.3	22.6	13.01
28.78	20.55	23.56	17.67	42.31	26.4	17.01
15.12	13.2	18.54	17.08	36.58	15.61	12.3
21.5	18.81	23.74	18.36	42.99	22.43	15.29
35.93	22.4	35.93	32.2	69.52	18.66	19.13
23.8	30.39	16.21	37.48	53.68	25.83	29.88

Table 6-B. The dimensions measurements in millimeter of 8 male patients from 51-60 years age subgroup.

Height Right	Height left	Width right	Width left	Total width	Anteropos. Right	Anteropos. Left
27.07	36.97	27.09	35.92	61.98	28.11	28.63
14.08	17.5	11.16	16.5	29.61	9.72	9.72
22.51	21.65	26.56	24.31	54.92	18.91	18.91
23.59	21.67	27.67	15.57	54.69	21.3	15.95
18.54	19.51	20	18.53	39.02	12.68	13.66
17.79	17.3	27.4	17.31	46.61	23.57	24.99
20.83	39.56	24.47	39.04	67.16	27.59	28.11
40.38	29.65	32.71	21.47	57.76	18.91	20.96

Table 7-A. The dimensions measurement in millimeter of the 12 female patients more than 60 years age.

Height right	Height left	Width right	Width left	Total width	Anteropos. Right	Anteropos. Left
27.32	23.74	32.26	18.41	51.52	33.14	34.48
20.15	25.98	28.22	35.83	66.28	26.42	29.11
21.73	15.51	22.23	9.76	42.16	14.21	15.96
12.72	19.85	7.14	22.39	33.58	8.2	23.41
10.58	20.1	8.54	21.08	37.64	18.57	25.09
12.54	17.56	7.02	29.6	43.18	11.54	18.06
15.86	absence	18.34	absence	18.34	17.73	absence
23.78	20.87	28.64	20.38	52.42	15.53	18.93
14.7	18.17	18.79	22.27	43.96	24.62	17.59
18.57	17.06	21.58	23.08	47.17	21.58	23.08
17.47	18.93	14.08	16.5	35.92	21.36	18.93
31.41	24.94	30.02	23.56	56.35	22.63	24.48

Table 7-B. The dimensions measurement in millimeters of the 9 male patients more than 60 years age.

Height Right	Height left	Width right	Width left	Total width	Anteropos. Right	Anteropos. Left
22.79	19.76	30.9	23.81	54.7	15.2	7.6
21.58	24.08	28.1	17.07	49.68	26.64	25.61
28.36	27.88	23.07	24.04	49.52	23.56	12.51
26.7	27.22	28.17	17.48	46.13	19.42	36.9
17.62	19.51	16.21	16.66	38.55	14.29	26.65
29.41	16.3	25.34	9.96	36.21	27.16	25.34
16.66	10.78	24.52	12.75	39.72	22.55	14.7
19.04	16.66	15.23	18.09	38.55	19.51	16.66
20.37	25.24	28.64	36.89	66.01	18.44	16.99

Table 8-.The comparison of the measurements in millimeter of frontal sinuses according to age group

Measurement	Age Group	Sex											
		Male				Female				Total			
		N	Mean	SD	Range	N	Mean	SD	Range	N	Mean	SD	Range
Height_right	20 - 30	14	21.73	2.66	10.71	13	23.91	9.25	36.93	27	22.69	6.38	36.93
	31 - 40	14	22.50	8.55	29.83	7	16.98	5.07	12.80	21	20.57	7.85	32.47
	41 - 50	13	27.51	8.15	25.00	3	18.01	3.74	7.34	16	25.61	8.34	27.33
	51 - 60	8	23.10	8.02	26.30	7	23.67	6.90	20.81	15	23.37	7.26	26.3
	More than 60	9	22.50	4.68	12.75	12	18.90	6.31	20.83	21	20.45	5.83	20.83
	Total	58				42				100			
Height_left	20 - 30	14	23.29	6.51	20.30	13	25.47	10.01	31.06	27	24.25	8.12	33.98
	31 - 40	14	25.11	9.93	34.03	7	19.09	2.23	5.19	21	23.21	8.68	34.03
	41 - 50	13	23.55	6.75	22.86	3	17.41	5.49	10.40	16	22.4	6.83	22.86
	51 - 60	8	25.48	8.81	22.26	7	20.05	5.40	17.19	15	22.94	7.69	26.36
	More than 60	9	20.83	5.73	17.10	12	20.25	3.37	10.47	21	20.51	4.46	17.1
	Total	58				42				100			
Width_right	20 - 30	14	23.70	5.71	19.45	13	22.34	10.69	36.75	27	23.1	8.11	36.75
	31 - 40	14	23.40	7.52	25.10	7	17.86	7.94	21.91	21	21.46	7.94	31.62
	41 - 50	13	27.80	7.05	23.38	3	19.33	3.09	5.39	16	26.11	7.26	27.6
	51 - 60	8	24.63	6.49	21.55	7	27.47	9.71	26.87	15	25.96	7.97	31.92
	More than 60	9	24.46	5.50	15.67	12	19.74	9.07	25.24	21	21.76	7.94	25.24
	Total	58				42				100			

Table 8, continued

	Sex												
	Age Group	Male				Female				Total			
		N	Mean	SD	Range	N	Mean	SD	Range	N	Mean	SD	Range
Width_left	20 - 30	14	26.76	6.02	15.55	13				27	27.54	7.74	28.9
	31 - 40	14	25.06	9.41	30.96	7	23.79	5.43	15.28	21	24.66	8.22	30.96
	41 - 50	13	26.20	8.74	30.53	3	18.05	10.69	13.83	16	24.67	8.85	31.65
	51 - 60	8	23.58	9.07	23.47	7	22.53	6.97	27.85	15	23.09	9.03	29.41
	More than 60	9	19.64	7.89	26.93	12	22.08	2.91	26.07	21	20.98	7.17	27.13
	Total	58				42		9.36		100			
Anteriopos_Right	20 - 30	14	20.59	6.62	27.52	13	24.88		37.26	27	22.47	8.72	40.38
	31 - 40	14	20.50	8.45	34.77	7	19.03		19.81	21	19.99	7.81	37.72
	41 - 50	13	23.33	5.50	19.45	3	18.73		5.30	16	22.41	5.35	19.45
	51 - 60	8	20.10	6.54	18.39	7	25.16		28.96	15	22.46	8.11	34.85
	More than 60	9	20.75	4.58	12.87	12	19.63	6.85	24.94	21	20.11	5.88	24.94
	Total	58				42				100			
Anteriopos_Left	20 - 30	14	20.40	7.54	32.62	13	25.88	9.06	32.51	27	22.81	8.53	41.18
	31 - 40	14	23.77	9.05	28.35	7	21.88	4.25	13.24	21	23.17	7.77	28.35
	41 - 50	13	22.50	5.71	19.61	3	19.81	6.55	11.38	16	22	5.74	23.14
	51 - 60	8	20.12	6.86	18.91	7	17.69	5.89	17.58	15	18.99	6.32	20.16
	More than 60	9	20.33	8.99	29.30	12	22.65	5.58	18.52	21	21.6	7.2	29.3
	Total	58				42				100			

DISCUSSION

There are considerable variations in the shape, capacity, and symmetry of the frontal sinuses. Our finding that 3 individuals (3%) had bilateral absence of the frontal sinuses was in agreement with the studies done by Nowak *et al.* (Germany)⁽⁶⁾ and Aydinlioglu *et al.* (Turkey)⁽⁷⁾; while it was less than the finding of Yoshino *et al.* (Japan)⁽⁸⁾, Koertvelyessy *et al.* (Alaskan Eskimo)⁽⁹⁾, Hanson *et al.* (Canadian Eskimo)⁽¹⁰⁾, Szilvasssy *et al.* (Austria)⁽¹¹⁾. In addition, most of these studies indicate a greater frequency among females than males, which is similar to the findings in this study^(6, 7, 9 and 12).

The unilateral absence of frontal sinus was more frequent in females; this finding was in agreement with other studies: Japanese, 14.3% in males and 7.1% in females⁽⁸⁾; Germans, 3.6% in males and 2.8% in females⁽⁶⁾; Turkish, 3.8% in males and 5.9% in females⁽⁷⁾.

These differences in the prevalence of the bilateral and unilateral absence of the frontal sinuses could be attributed to genetic and environmental factors that control the presence and configuration of the frontal sinus within each population^(10, 13, 14, and 15). The environmental factor for example coldness, and genetic factors such as levels of growth hormone, craniofacial configuration, and the thickness of frontal bone can play a major role in these differences^(9, 10 and 15).

All measurements had higher values in the males and the differences were significant ($p < 0.05$), measurements were evaluated for each sex on right and left sides and they were different in favor of the left side for both sexes.

Although not always statistically significant, the frontal sinuses were generally larger in males than females in previous studies^(16, 17, 18, and 19) except the study of Hanson *et al.* on the Canadian Eskimo population who reported that the frontal sinuses were dimensions were larger in females⁽¹⁰⁾.

The left sinuses had bigger sizes in both sexes as reported by several authors^(18, 19, and 20).

The tables 3 to 7 show the mean value measurements in the total populations and the width is the largest diameter of the sinus and the mean values were 23.38 mm on the right side and 24.39 mm on the left side. The height was 22.31 mm on average on the right and 22.73 mm on the

left side and close to the width. The smallest diameter was the anteroposterior dimension with mean values of 21.42 mm on the right and 21.88 mm on the left sides and when compared with

Spaeth *et al.* Study⁽¹⁸⁾, they reported definitive sizes of frontal sinus width as 27.98 mm for males and 26.39 mm for females and anteroposterior dimension 17.38 mm for males and 16.11 mm for females.

Sa'nchez *et al.*⁽¹⁹⁾ determined the width of the frontal sinus as 18.0 mm and anteroposterior dimension as 13.0 mm in 79 healthy subjects older than 20 years from Basque in Spain. The width and height was slightly smaller in the Spanish population than in this study.

The tables 8-A and 8-B show the mean measurements of the frontal sinuses in widths, heights and anteroposterior dimensions related to the age groups. The highest values were observed in the 41-50 age group, except the height, width of the left side and anteroposterior of the right frontal sinuses, which had highest value in the 20-30 age group. While the anteroposterior dimensions of the left frontal sinuses the highest value observed in the 31-40 age group. In males, the highest values were observed in 41-50 age groups, except the width of the left frontal sinus, which had the highest value in the 20-30 age group. In females, the highest values were in the 20-30 age group.

The highest values on the anteroposterior dimension of the right sinus observed in the 20-30 age group, while the highest value on the anteroposterior dimension of the left frontal sinus observed in the 31-40 age group; in comparisons with the previous studies^(18, 19 and 20), the highest measured values were in the 31-40 age group except the width of the left sinus in males and height of the left sinus in females. McLaughlin *et al.*⁽²³⁾ advocated that the frontal sinuses continued to expand until the age of 40 years because of mechanical stresses of mastication and growth hormone levels and our results complied with it.

In conclusion the morphometric features of the frontal sinuses differed significantly in the two genders at different ages and comparison with previous studies presented great regional variability.

REFERENCES

- 1- Moore, K. L.(Ed). Clinically Oriented Anatomy. 3rd edition. Baltimore, Williams & Wilkins, 1992, p 760-762.
- 2- Standring, S. M. (Ed.). Gray's Anatomy. 39th edition, Edinburgh, Elsevier, Churchill Livingstone, 2005, p 575-576.
- 3- Stephanie R., Michelle M, Stephen E, Anatomy for diagnostic imaging. 2nd edition, Edinburgh, Elsevier, Churchill Livingstone, (2004).
- 4- Schuller A.Das.The roentgenogram of sinus: a tool for the determination. Monthly for ears ophthalmology and Laryngeal-Rhinology. 1921; 55: 1617-1620.
- 5- Libersa C. and Faber, anatomy-radiological frontal sinus in children. Lille Med. 1958; 3: 453-459.
- 6- Nowak R, Mehls G. Aplasia of the sinus maxillares and frontales under the special regard of pneumatization of cleft Patients. Anat Anz.1977; 142:441-450.
- 7- Aydinliog˘lu A, Kavakli A, Erdem S. Absence of frontal sinus in Turkish individuals. Yonsei Med J. 2003; 44:215-218.
- 8- Yoshino M., Miyasaka S., Sato H. Classification system of the frontal sinus patterns by radiography: Its applications to identification on the unknown skeletal remains (1987) Forensic Sci. Int. 1987; 34 (4):289-299.
- 9- Koertvelyessy T. Relationship between the frontal sinus and climatic conditions: a skeletal approach to cold adaptation. Am J Phys Anthropol. 1972;34:161-72.
- 10- Hanson CL. and Owsley, DW. Frontal sinus size in Eskimo populations. Am. J. Phys. Anthropol. 1980; 53 (2): 251-255.
- 11- Szilvassy von J. Zur variation, Entwicklung und vererbung der stirnho˘hlen. Ann Naturhist Mus Wien A. 1982; 84:97-125.
- 12- Szilvassy J. (Development of the frontal sinuses. Anthropol Anz. 1974; 39 (2): 138-149.
- 13- Harris A.M.P. R.E Wood, C.J. Nortje C.J. Thomas. The frontal sinus forensic fingerprint. A pilot study, J. Forensic Odonto- Stomatol. 1987; 5: 9-15.
- 14- Buckland Wright J.C. A radiographic examination of frontal sinuses in early British populations. Man. 1970; 5:512-7.
- 15-Quatrehomme G, Fronty P, Sapanet M, Grévin G, Bailet P, Ollier A. Identification by frontal sinus pattern in forensic anthropology. Forensic Science International. 1996;83(2):147-53.
- 16- Buckland Wright J.C. A radiographic examination of frontal sinuses in early British populations. Man. 1970; 5:512-7.
- 17- Yoshino M., Miyasaka S., Sato H. Classification system of the frontal sinus patterns by radiography: Its applications to identification on the unknown skeletal remains. Forensic Sci. Int. 1987; 34 (4): 289-299.
- 18- Spaeth J, Kru˘gelstein U, Schlo˘ndorff G. The paranasal sinuses in CT imaging: development from birth to age 25. Int J.Pediatric Otorhinolaryngol. 1997; 39:25-40.
- 19- Sa˘nchez Ferna˘ndez JM, Anta Escuredo JA, Sa˘nchez Del Rey A, Santaolalla Montoya F.Morphometric study of the paranasal sinuses in normal and pathological conditions. Acta Otolaryngol. 2000;120:273-278.
- 20- McLaughlin RB Jr, Rehl RM, Lanza DC.Clinically relevant frontal sinus anatomy and physiology. Otolaryngol Clin North Am. 2001; 34:1-22.