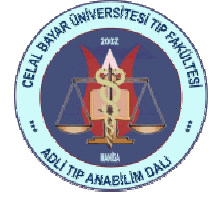




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Original Article / Orijinal Makale

CT study on morphometry of frontal sinus

[Frontal sinüsün morfometri üzerinde CT çalışması]

Tatlisumak Ertugrul*, Yilmaz Ovali Gulgun**, Asirdizer Mahmut***, Aslan Asim****,

Ozyurt Beyhan*, Bayindir Petek**, Tahran Serdar**.

(* Anatomy Department, Medical Faculty of Celal Bayar University, Manisa-Turkey.

(*) Radiology Department, Medical Faculty of Celal Bayar University, Manisa- Turkey.

(***) Forensic Medicine Department, Medical Faculty of Celal Bayar University, Manisa- Turkey.

(****) Otorhinolaryngology Department, Medical Faculty of Celal Bayar University, Manisa- Turkey.

(***** Public Health Department, Medical Faculty of Celal Bayar University, Manisa- Turkey.

Abstract

Frontal sinuses are paired lobulated cavities located posterior to the superciliary arches in the frontal bone and each frontal sinus opens in to the corresponding middle meatus via the infundibulum. They are radiographically visible after 5 years of age and reach their maximum size at the age of 20. The aim of this study was to evaluate the prevalence and morphological characteristics of the frontal sinus in an adult population. This study was conducted retrospectively on the paranasal CT scans of 2 mm thickness in the axial and coronal planes of 300 cases (123 male and 177 female) taken by a Siemens Emotion Tomography Machine. No apparent sinonasal pathology was present in the CT scans used for the study. The mean age of the cases was 40.74± 13.34 (range 20- 83). All evaluations and measurements were done together by two radiologists with a Dicom viewer program. Measurements of the width, height and antero-posterior length for each sinus and total width were obtained from CT scans. Measurements were compared statistically with relation to side and gender. In addition, cases were divided in to subgroups according to age for each gender and each measurement parameter was also compared among the subgroups. All measurements tended to be larger in the left side and were significantly larger in males than females. There was a significant difference in antero-posterior length for both sexes and height for males and width for females between the two sides. Regardless of sex, the highest values of measurements were observed at the subgroup of 31-40 age and there was a tendency to decrease with aging. The size of the frontal sinus is related to side, gender and age.

Keywords:

Frontal sinus, CT Scans, anatomy.

Özet

Frontal sinüsler, frontal kemikteki süpersiler arkaların arkasına yerleşmiş loblara ayrılmış boşluklardır ve her frontal sinus, infundibulum yoluyla ilgili orta kulağa açılır. Onlar radyolojik olarak 5 yaşından sonar görülebilir ve 20 yaşında maksimum genişliğe ulaşır. Bu çalışmanın amacı, yetişkin toplulukta frontal sinüsün prevalans ve morfolojik karakterlerini araştırmaktır. Bu çalışma, Siemens Emotion Tomografi Makinesi kullanılarak alınan 300 (123 Erkek, 177 Kadın) olgunun paranasal CT scanlarının 2 mm kalınlığındaki aksiyel ve koronal planları üzerinde retrospektif olarak uygulandı. Çalışma için kullanılan CT scanlarında sinonasal patoloji varlığı görülmedi. Olguların ortalama yaşı 40.74± 13.34 (range 20-83) idi. Tüm değerlendirme ve ölçümler iki radyolog tarafından Dicom viewer program kullanılarak uygulandı. CT Scanlarından yapılan ölçümlerde, her sinüsün genişliği, yüksekliği ve ön-arka uzunluğu ile toplam genişlik elde edildi. Ölçümler yer ve cinsiyete bağlı olarak istatistiksel olarak karşılaştırıldı. Ek olarak, her bir cinsiyet ve her bir ölçüm parametresi için yaşa göre subgruplara ayrılan olgular, subgruplar arasında da karşılaştırıldı. Tüm ölçümler sol tarafa daha büyük olma eğiliminde idi ve özellikle erkeklerde kadımlardan daha büyüktü. Her iki cinsiyette ön-arka uzunluk, erkeklerde yükseklik ve kadımlarda genişlik iki taraflı olarak anlamlı olarak farklı bulundu. Cinsiyet dikkate alınmadığında, en yüksek ölçüm değerleri 31-40 yaş alt grubunda elde edildi ve yaşlanma ile birlikte azalma eğilimi saptandı. Frontal sinüs ölçümleri tarafına, yaşa ve cinsiyete bağlıydı.

Anahtar Kelimeler:

Frontal sinüs, CT imajları, anatomi.

1. Introduction

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 (1, 2). They are not apparent at birth and development of them begins during the second year of life but is not visible radiographically until the age of 5. It is widely accepted that the development of the frontal sinus is complete by about 20 years of age and remains stable until further enlargement of the chambers can occur from bone resorption during the advanced ages (3- 5).

Procedures involving frontal craniotomies, tasks such as Mayfield pin placement and emergency supraorbital ventricular puncture, all necessitate the knowledge of frontal sinus anatomy to minimize morbidity (6). Occasionally, it may be also necessary for the neurosurgeon who wishes to enter anterior cranial fossa by means of a supraorbital minicraniotomy (6- 10).

The aim of this study was to determine the sizes of frontal sinus in both genders for providing clues to the surgeons for planning the tasks mentioned above and to complete the anthropometric knowledge.

2. Materials and methods

This study was conducted retrospectively on the paranasal CT scans of 2 mm thickness in the axial and coronal planes of 300 cases (123 male and 177 female) taken by a Siemens Emotion Tomography Machine in the University Hospital. No apparent sinonasal pathology was present in the CT scans used for the study. The mean age of the cases was 40.74 ± 13.34 (range 20- 83). All evaluations and measurements were done together by two radiologists (Ovali GY and Bayindir P) with a Dicom viewer program.

Any visible pneumatization was accepted as presence of the sinus. The measurements of widths, heights and total width of the two sinuses were performed on coronal plane (Fig-1). Antero-posterior length was measured on axial plane (Fig-2). All measurements were done from the CT sections which had highest values. The measurements were presented in centimeter.

Measurements were determined for total population and each gender. Measurements of both sides were compared with each other for total population and each gender. Cases were divided into 5 subgroups according to age as 20- 30, 31- 40, 41- 50, 51- 60, 61 + for each gender and each measurement parameter was also compared among the subgroups.

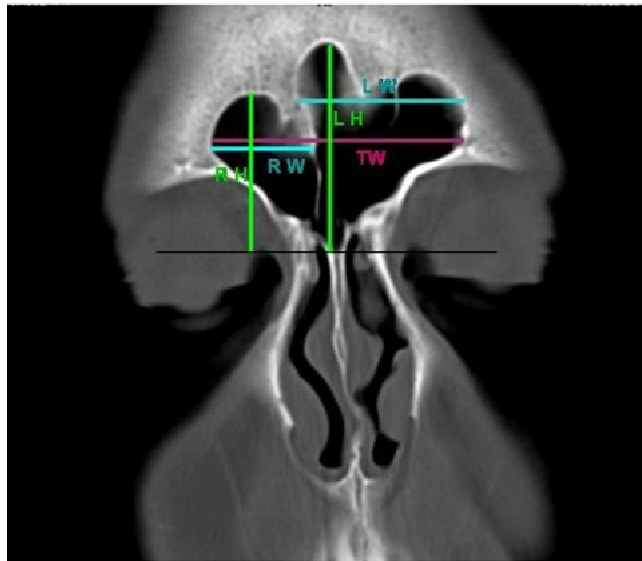


Fig-1: Measurements on coronal plane.

RW: width of the right sinus, LW: width of the left sinus, RH: height of the right sinus, LH: height of the left sinus, TW: total width.

3. Results

Bilateral absence of frontal sinus was not observed among our cases. There were four cases with unilateral absence of frontal sinus (one male and three female) and three of them at the right and one of them at the left side (Unilateral absence was 1.33 %).

The values of the measurements were higher at the left side in the total population (Table I).

All measurements had higher values in males and the differences were significant (Table II, $p < 0.05$ except total sinus width, it was $p < 0.001$).

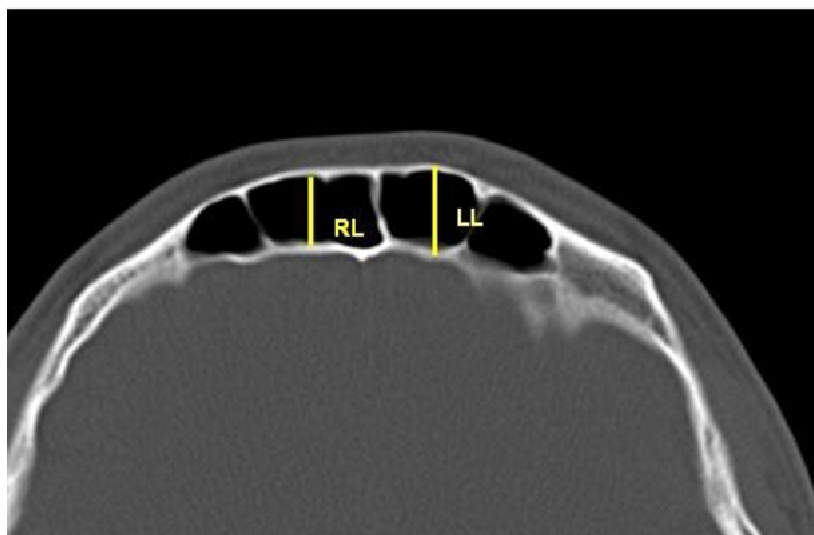


Fig-2: Measurements on axial plane.

RL: antero-posterior length of the right sinus, LL: antero-posterior length of the left sinus.

RW: width of the right sinus, LW: width of the left sinus, RH: height of the right sinus, LH: height of the left sinus, TW: total width.

Table-1: Mean of the measurements in the total population

Measurements	MALE		FEMALE		TOTAL	
	N	Mean \pm SD	N	Mean \pm SD	N	Mean \pm SD
The width of right frontal sinus	122	2,70 \pm 0,79	175	2,44 \pm 0,76	297	2,55 \pm 0,78
The width of left frontal sinus	123	2,85 \pm 0,81	176	2,60 \pm 0,74	299	2,70 \pm 0,78
The height of right frontal sinus	122	2,66 \pm 0,87	175	2,36 \pm 0,83	297	2,48 \pm 0,86
The height of left frontal sinus	123	2,82 \pm 0,91	176	2,47 \pm 0,82	299	2,62 \pm 0,87
The antero-posterior length of right frontal sinus	122	1,17 \pm 0,41	175	1,01 \pm 0,41	297	1,08 \pm 0,41
The antero-posterior length of left frontal sinus	123	1,31 \pm 0,52	176	1,08 \pm 0,41	299	1,18 \pm 0,47
Total length of sinuses	123	5,56 \pm 1,19	177	5,05 \pm 1,23	300	5,26 \pm 1,24

Table-2: The comparison of the measurements of frontal sinus in male and female

Measurements	N	Range	Mean \pm SD
The width of right frontal sinus	297	0,40 - 4,80	2,55 \pm 0,78
The width of left frontal sinus	299	0,80 - 4,50	2,70 \pm 0,77
The height of right frontal sinus	297	0,40 - 5,00	2,48 \pm 0,86
The height of left frontal sinus	299	0,70 - 5,50	2,61 \pm 0,87
The antero-posterior length of right frontal sinus	297	0,10 - 3,00	1,08 \pm 0,41
The antero-posterior length of left frontal sinus	299	0,40 - 3,20	1,18 \pm 0,47
Total length of sinuses	300	1,70 - 9,40	5,26 \pm 1,24

Measurements were evaluated for each gender at right and left sides and they were different in the favor of the left sides for both genders (Table III). In males, antero-posterior lengths ($p < 0.001$) and heights ($p < 0.05$) were significantly different. In females, the differences of antero-posterior lengths and widths of sinuses were

significant ($p < 0.05$).

Among the subgroups in the total population highest values were always observed in the 31-40 age group except the height of the left frontal sinus. 20-30 age group had the highest value in this measurement and 31-

40 age group had the second. Lowest values were always observed in the 61- < age group (Table IV).

Table-3: The comparison of the measurements of right and left frontal sinuses for both genders.

Ages	20-30			31-40			41-50			51-60			61- 61<			TOTAL		
	N	Mean ± SD	Range	N	Mean ± SD	Range	N	Mean ± SD	Range	N	Mean ± SD	Range	N	Mean ± SD	Range	N	Mean ± SD	Range
The width of right frontal sinus	81	2,54 ± 0,69	0,40 - 4,40	66	2,65 ± 0,80	1,00 - 4,20	90	2,58 ± 0,79	0,50 - 4,50	41	2,42 ± 0,87	0,90 - 4,80	19	2,35 ± 0,81	0,60 - 3,90	297	2,55 ± 0,78	0,40 - 4,80
The width of left frontal sinus	81	2,69 ± 0,79	0,90 - 4,30	67	2,82 ± 0,85	0,80 - 4,50	91	2,81 ± 0,74	1,00 - 4,10	41	2,48 ± 0,69	0,90 - 3,60	19	2,32 ± 0,70	1,60 - 4,20	299	2,70 ± 0,78	0,80 - 4,50
The height of right frontal sinus	81	2,59 ± 0,77	0,50 - 4,30	66	2,60 ± 0,98	1,00 - 5,00	90	2,48 ± 0,80	0,60 - 4,90	41	2,25 ± 0,86	0,80 - 4,80	19	2,15 ± 0,92	0,40 - 4,70	297	2,48 ± 0,86	0,40 - 5,00
The height of left frontal sinus	81	2,82 ± 0,87	0,70 - 4,70	67	2,77 ± 0,99	1,20 - 5,50	91	2,64 ± 0,80	1,00 - 5,00	41	2,22 ± 0,71	0,80 - 4,40	19	2,94 ± 0,58	1,10 - 3,30	299	2,62 ± 0,87	0,70 - 5,50
The antero-posterior length of right frontal sinus	81	1,06 ± 0,40	0,30 - 2,50	66	1,17 ± 0,43	0,50 - 2,20	90	1,05 ± 0,38	0,40 - 3,00	41	1,09 ± 0,50	0,30 - 2,80	19	0,92 ± 0,34	0,10 - 1,50	297	1,07 ± 0,41	0,10 - 3,00
The antero-posterior length of left frontal sinus	81	1,10 ± 0,34	0,40 - 2,00	67	1,33 ± 0,58	0,50 - 3,20	91	1,19 ± 0,48	0,40 - 2,90	41	1,15 ± 0,47	0,50 - 3,00	19	0,93 ± 0,33	0,50 - 1,70	299	1,18 ± 0,47	0,40 - 3,20
Total length of sinuses	81	5,27 ± 1,13	2,30 - 7,90	67	5,46 ± 1,35	2,00 - 8,60	91	5,38 ± 1,19	2,40 - 9,40	41	4,99 ± 1,26	2,50 - 8,60	20	4,48 ± 1,15	1,70 - 6,50	300	5,26 ± 1,23	1,70 - 9,40

Table-4: The comparison of the measurements of frontal sinus according to age groups for total population.

Measurements	RIGHT SIDE		LEFT SIDE			
	N	Mean ± SD	N	Mean ± SD		
MALE	The width of each frontal sinus		122	2,70 ± 0,79	123	2,85 ± 0,81
	The height of each frontal sinus		122	2,66 ± 0,87	123	2,82 ± 0,91
	The antero-posterior length of each frontal sinus		122	1,17 ± 0,41	123	1,31 ± 0,52
FEMALE	The width of each frontal sinus		175	2,44 ± 0,76	176	2,60 ± 0,74
	The height of each frontal sinus		175	2,36 ± 0,83	176	2,47 ± 0,82
	The antero-posterior length of each frontal sinus		175	1,01 ± 0,41	176	1,08 ± 0,41

In males, highest values were observed in 31-40 age group except the width of the left sinus which had the highest value in 41-50 age group. Lowest values were observed in 61-< subgroup (Table V).

In females, highest values were in the 31-40 age group except the height of the left frontal sinus. Left frontal sinus had the highest values in 20-30 age group and the second highest value was observed in the 31-40 age group. Lowest values were in the 61-< group (Table VI).

4. Discussion

Bilateral absence of frontal sinus couldn't be observed in the present study. Frequencies of bilateral absence of frontal sinus in several population were reported as follows: Japanese, 4.8 % in males (3); Alaskan Eskimo, 25 % in males and 36 % in females (11); Canadian Eskimo, 43% in males and 40 % in females (12); Buschman, 11 % in males and 11 % in females (13); Awarisch, 8 % in males and 13 % in females (13); Austrian, 10 % in males and 10 % in females (14); Germans, 3.4 % (15); Turkish, 2.6 % in males and 5.1 %

in females (16). Obviously, these frequencies were strictly related to the definition of the absence of a sinus. Most studies were based on the definition H. Leicher quoted from Szilvassy accepting the absence of the sinus when the area of pneumatization was below 0.8 cm². It could be one of the reasons explaining the difference between the results of our study and previous studies but there were apparent differences even among the previous reports. It is known that genetic and environmental factors control the configuration of the frontal sinus within each population (5, 12, 17) and differences among the frequencies could be explained with regional differences.

Frequencies of unilateral absence of frontal sinus in several reports were as Japanese, 14.3 % in males and 7.1 % in females (3); Germans, 3.6 % in males and 2.8 % in females (15); Turkish, 3.8 % in males and 5.9 % in females (16). 1.3 % frequency of unilateral aplasia observed in this study was low when compared with the previous reports probably related to the similar reasons mentioned for bilateral absence of the sinus.

Table-5: The comparison of the measurements of frontal sinus according to age groups for males.

Ages	20-30			31-40			41-50			51-60			61- 61<			TOTAL		
	N	Mean ± SD	Range	N	Mean ± SD	Range	N	Mean ± SD	Range	N	Mean ± SD	Range	N	Mean ± SD	Range	N	Mean ± SD	Range
The width of right frontal sinus	25	2,69 ± 0,65	1,80 - 4,40	33	2,88 ± 0,81	1,30 - 4,20	41	2,69 ± 0,79	1,00 - 4,30	16	2,66 ± 0,91	0,90 - 4,80	7	2,13 ± 0,74	0,60 - 2,70	122	2,70 ± 0,79	0,60 - 4,80
The width of left frontal sinus	25	2,98 ± 0,84	1,20 - 4,30	33	2,87 ± 0,91	0,80 - 4,50	42	3,02 ± 0,70	1,10 - 4,10	16	2,51 ± 0,62	1,40 - 3,60	7	2,03 ± 0,67	1,60 - 3,40	123	2,85 ± 0,81	0,80 - 4,50
The height of right frontal sinus	25	2,67 ± 0,60	1,50 - 3,90	33	2,95 ± 1,01	1,40 - 5,00	41	2,61 ± 0,81	1,10 - 4,90	16	2,42 ± 0,97	0,90 - 4,80	7	2,03 ± 0,88	0,40 - 3,00	122	2,66 ± 0,87	0,40 - 5,00
The height of left frontal sinus	25	2,96 ± 0,84	1,50 - 4,70	33	2,98 ± 1,03	1,30 - 5,40	42	2,93 ± 0,85	1,50 - 4,60	16	2,49 ± 0,77	1,50 - 4,40	7	1,76 ± 0,46	1,40 - 2,60	123	2,82 ± 0,91	1,30 - 5,40
The antero-posterior length of right frontal sinus	25	1,17 ± 0,38	0,60 - 2,20	33	1,36 ± 0,42	0,50 - 2,20	41	1,05 ± 0,25	0,60 - 1,80	16	1,20 ± 0,60	0,30 - 2,80	7	0,86 ± 0,40	0,10 - 1,20	122	1,17 ± 0,41	0,10 - 2,80
The antero-posterior length of left frontal sinus	25	1,22 ± 0,35	0,40 - 2,00	33	1,59 ± 0,62	0,70 - 3,20	42	1,25 ± 0,43	0,60 - 2,50	16	1,26 ± 0,60	0,80 - 3,00	7	0,90 ± 0,33	0,50 - 1,50	123	1,31 ± 0,52	0,40 - 3,20
Total length of sinuses	25	5,68 ± 1,04	3,10 - 7,90	33	5,84 ± 1,21	3,20 - 8,60	42	5,61 ± 1,17	2,40 - 7,90	16	5,26 ± 1,24	3,40 - 7,00	7	4,19 ± 0,72	3,20 - 5,20	123	5,56 ± 1,19	2,40 - 8,60

Table-6: The comparison of the measurements of frontal sinus according to age groups for females.

Ages	20-30			31-40			41-50			51-60			61- 61<			TOTAL		
	N	Mean ± SD	Range	N	Mean ± SD	Range	N	Mean ± SD	Range	N	Mean ± SD	Range	N	Mean ± SD	Range	N	Mean ± SD	Range
The width of right frontal sinus	56	2,47 ± 0,71	0,40 - 3,90	33	2,43 ± 0,75	1,00 - 3,90	49	2,49 ± 0,80	0,50 - 4,50	25	2,26 ± 0,83	0,90 - 4,00	12	2,48 ± 0,85	0,90 - 3,90	175	2,44 ± 0,76	0,40 - 4,50
The width of left frontal sinus	56	2,57 ± 0,73	0,90 - 4,20	34	2,77 ± 0,80	1,30 - 4,30	49	2,64 ± 0,72	1,00 - 4,10	25	2,46 ± 0,74	0,90 - 3,60	12	2,48 ± 0,69	1,70 - 4,20	176	2,60 ± 0,74	0,90 - 4,30
The height of right frontal sinus	56	2,55 ± 0,84	0,50 - 4,30	33	2,25 ± 0,84	1,00 - 4,20	49	2,37 ± 0,79	0,60 - 4,30	25	2,14 ± 0,79	0,80 - 4,70	12	2,22 ± 0,98	0,90 - 4,70	175	2,36 ± 0,83	0,50 - 4,70
The height of left frontal sinus	56	2,76 ± 0,88	0,70 - 4,60	34	2,57 ± 0,93	1,20 - 5,50	49	2,39 ± 0,66	1,00 - 5,00	25	2,05 ± 0,63	0,80 - 3,30	12	2,04 ± 0,63	1,10 - 3,30	176	2,47 ± 0,82	0,70 - 5,50
The antero-posterior length of right frontal sinus	56	1,01 ± 0,40	0,30 - 2,50	33	0,98 ± 0,37	0,50 - 1,90	49	1,06 ± 0,47	0,40 - 3,00	25	1,01 ± 0,42	0,40 - 2,10	12	0,96 ± 0,31	0,60 - 1,50	175	1,01 ± 0,41	0,30 - 3,00
The antero-posterior length of left frontal sinus	56	1,05 ± 0,32	0,40 - 1,80	34	1,09 ± 0,42	0,50 - 2,50	49	1,15 ± 0,52	0,40 - 2,90	25	1,08 ± 0,35	0,50 - 1,90	12	0,94 ± 0,34	0,60 - 1,70	176	1,08 ± 0,41	0,40 - 2,90
Total length of sinuses	56	5,08 ± 1,13	2,30 - 7,20	34	5,09 ± 1,39	2,00 - 8,20	49	5,19 ± 1,19	2,90 - 9,40	25	4,82 ± 1,27	2,50 - 8,60	12	4,64 ± 1,33	1,70 - 6,50	177	5,05 ± 1,23	1,70 - 9,40

When compared with literature, the study population had the lowest values of some or all diameters (1, 4, 7, 18, 19). All dimensions of the sinus were larger in males than females. Although not always statistically significant, frontal sinus was generally larger in males than females in previous studies (3, 7, 13, 14, 17) except for Canadian Eskimo population (12). Left sinus had bigger sizes in both genders as reported by several authors (7, 18). There may be a greater risk to violate the left sinus than the right one during a supraorbital craniotomy.

Authors usually accepts that the development of frontal sinus is complete by about 20 years of age even earlier (3- 5, 14, 18) but we couldn't confirm this suggestion. The highest measured values were in the 31- 40 age group except the width of the left sinus in males and the height of the left sinus in females. McLaughlin RB et al (20) had advocated that the frontal sinus continued to expand until age 40 years due to mechanical stresses of mastication and growth hormone levels and our results were fitting it. Contrary to the widely accepted ideas, frontal sinuses was not enlarged in the old ages but

lowest measured values were determined after age 60 (3- 5). We mentioned this point without an objective explanation.

5. Conclusion

The results of this study will provide useful clues for to plan the surgical intervention and complete a part of human anthropometry.

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