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# Anatomical Variations of the Frontal Sinus by CT-Scan

**Dr. Saniullah Zalmai[1], Dr. Abdulhafiz Rahmati[2], Dr. Mohammad Aref Ibrahimi[3], Dr. Shogoofa Barakzai[4]**

[1]Assistant Professor, MD, Academic Member of Anatomy Department of Kabul University of Medical Sciences "Abu Ali Ibn Sina", Kabul, Afghanistan
[2]Assistant Professor, MD, MPH Academic Member of Behavioral Sciences and Health Education Department of Kabul University of Medical Sciences "Abu Ali Ibn Sina", Kabul, Afghanistan
[3]Assistant Professor, MD, Academic Member of Otorhinolaryngology department of Kabul University of Medical Sciences "Abu Ali Ibn Sina", Kabul, Afghanistan
[4]Assistant Professor, MD, Academic Member of Anatomy Department of Kabul University of Medical Sciences "Abu Ali Ibn Sina", Kabul, Afghanistan

**Abstract:** ***Introduction: The sinuses are a system of connected hollow cavities in the face that contain air and a thin layer of mucus. Paranasal sinuses are a group of four pair aerated cavities that surround the nasal cavity. They are connected to the nose by small openings. The maxillary sinuses are located under the eyes; the frontal sinuses are above the eyes; the ethmoidal sinuses are between the eyes and the sphenoidal sinuses are behind the eyes. Frontal sinuses are rarely symmetrical and the septum between them frequently deviates to one or other side of the middle line. Their average measurements are as follows: height 28 mm, breadth 24 mm, depth 20 mm, creating a space of 6-7 ml. The frontal sinuses are absent at birth, but are generally well developed, and functional between the sixth and eighth years, though they continue to grow slower until reaching their maximum size after puberty. Through its copious mucus production, the sinus is an essential part of the immune defense/air filtration carried out by the nose. Objectives: Finding the average volume of the frontal sinus. Finding the difference in frontal sinus volume according to age, gender and side (right and left). Method & Material: This is a descriptive cross-sectional study which performed from 24/July/2019 to 06/August/2019 on the patients who are needed CT-scan examinations for their skull related problems to the radiology department of French medical institute for mother and children (FMIC) hospital in Kabul city. During that period of time, radiological caliches of 60 patients were studied. Radiological caliches obtained with a thickness of 0.75 mm in axial and coronal planes. Anatomical changes of the frontal sinus were studied for both sexes; it means 30 men and 30 women. The anterior, posterior, horizontal and vertical diameters of the sinuses in both right and left sides were measured in collaboration with the radiologist and inserted into dataset then analyzed. The volume is determined by the following formula according radiologist in CT-Scan. Results: The referred patients were 60 which from them 30 are men and 30 women. The minimum age of patients were 16 years old and the maximum age of patients were 65 years old, and the average age was 37.2 years old. The average volumes of the frontal sinuses for both sexes were estimated to 4.42 $cm^3$. The average volume of the frontal sinuses near men were estimated to 4.13 $cm^3$ and in women 4.71$cm^3$, which indicates the larger size of the frontal sinus in women than men. The average volume of the left and right frontal sinus in women were estimated to 4.85 $cm^3$ and 4.57$cm^3$, which shows the larger size of the left frontal sinus in women, but it is not statistically significant. The average volume of the left and right frontal sinus in men were estimated 4.11 $cm^3$ and 4.14 $cm^3$, which shows the larger size of the right side sinus than left, but is not statistically significant. The minimum volume of the right frontal sinus is (0) zero, its maximum volume is 15.14 and their standard deviation is 3.25 $cm^3$. Also, the minimum volume of the left frontal sinus was zero (0) and its maximum was 32.4 and its standard deviation was 5.1 cubic centimeters and it showed the larger frontal sinus in women. In 6.6% cases of the frontal sinuses were absent near referred patients. Conclusion: In this study, the average ages of patients were estimated 37.2 years old and the average frontal sinus volume was estimated 4.4 cubic centimeters. The volume of the frontal sinuses discovered larger in women than men. Left frontal sinus volume was larger than right one and in 6.6% of cases the frontal sinus was absent near referred patients.***

**Keywords:** Frontal sinus, vertical, transvers and anterior posterior diameters

## 1. Introduction

The sinuses are a system of connected hollow cavities in the face that contain air and a thin layer of mucus. Paranasal sinuses are a group of four pair aerated cavities that surround the nasal cavity. They are connected to the nose by small openings. The maxillary sinuses are located under the eyes; the frontal sinuses are above the eyes; the ethmoidal sinuses are between the eyes and the sphenoidal sinuses are behind the eyes.

Frontal sinuses are rarely symmetrical and the septum between them frequently deviates to one or other side of the middle line. Their average measurements are as follows: height 28 mm, breadth 24 mm, depth 20 mm, creating a space of 6-7 ml. The frontal sinuses are absent at birth, but are generally well developed, and functional between the sixth and eighth years, though they continue to grow slower until reaching their maximum size after puberty. Through its copious mucus production, the sinus is an essential part of the immune defense/air filtration carried out by the nose. Approximately 5% of people have absent frontal sinuses.

Infection of the frontal sinus causing sinusitis can give rise to serious complications, as it is in close proximity to the orbit and cranial cavity (orbital cellulitis, epidural and subdural abscess, meningitis).

### History of Study

Doppler ultrasound is used as a non-invasive device in the diagnosis of sinuses infections. Regarding Doppler ultrasound, two scientists named Sahlstrand-Johnson P in 2010 published an article entitled in vitro studies and safety assessment of doppler ultrasound as a diagnostic

tool in rhino sinusitis, in which doppler ultrasonography rolls were studied in diagnosis of sinus infections (6).

In this examination, the flow of non-suppurated secretions produces a kind of sound, and this production of sound helps the flow of non-suppurated secretions to be differentiated from suppurated secretions. In order to be able to continue the evolution and development of this examination, we need to determine the dimensions of paranasal sinuses, especially the thickness of the anterior wall and the anterior- posterior dimensions of the frontal sinus.

These sinuses have anatomical complex structures with major changes. The use of CT-scan compared to plain radiography in detecting and observing the pathological changes of the paranasal sinuses began in the early 1990s (1). From the beginning of the examination, a CT-scan is necessary to detect and observe changes in the sinuses before the sinus operation. CT-scan examinations were also used before endoscopic sinus surgery. Therefore, we can get different dimensions of the paranasal sinuses by CT -scan of these sinuses.

Following a report published in 1999 by Kawarai on the volume size of the paranasal sinuses by CT scan (2), some other studies were also performed. In addition, Sanchez Fernandez in 2000 in an article entitled morphological study of paranasal sinuses in normal and pathological conditions and Pirner S in 2009 in their article entitled CT-based manual segmentation and evaluation of paranasal sinus described this issue and caused this method to continuously develop and evolve (3-5).

Emirzeoglu M has also worked on finding the volume of the sinus in his article entitled volumetric evaluation of paranasal sinus in normal subjects by CT Scan (4). In another study conducted by Bolger WE in 1991 entitled paranasal sinus bony anatomic variations and mucosal abnormalities: CT analysis was found to be effective in the endoscopic surgery of the sinuses.

Many studies have been published on the anatomy of the paranasal sinuses, but in these sinuses and adjacent structures more research is needed to determine the dimensions and changes of the sinus. The purpose of this study is to determine the different dimensions of the right and left frontal sinus by CT-scan and also to find out whether age, relevant side or gender is related to these changes or not.

In this regard, Ariji Y and Kuroki T in 1994 in their article entitled changes in age on the volume of the sinus explained the relationship between age and the reduction of sinus volume (14).

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## 2. Objectives

Finding the average volume of the frontal sinus.

Finding the difference in frontal sinus volume according to age, gender and side (right and left).

**Research questions**:

1) Are there any changes in the average volume of the frontal sinus in men and women?
2) Are there any different in the frontal sinus variation according to the right and left sides?
3) Are there any different in the frontal sinus variations according to the age?

**Research hypothesis (if any):**

In this research, no hypothesis has been considered, but just only research questions.

## 3. Method & Material

This is a descriptive cross-sectional study which performed from 24/July/2019 to 06/August/2019 on the patients who are needed CT-scan examinations for their skull related problems to the radiology department of French medical institute for mother and children (FMIC) hospital in Kabul city. During that period of time, radiological caliches of 60 patients were studied. Radiological caliches obtained with a thickness of 0.75 mm in axial and coronal planes. Anatomical changes of the frontal sinus were studied for both sexes; it means 30 men and 30 women.

The anterior, posterior, horizontal and vertical diameters of the sinuses in both right and left sides were measured in collaboration with the radiologist and inserted into dataset then analyzed. The volume is determined by the following formula according to radiologist in CT-Scan.

$$\frac{\text{anterior posterior diameter} * \text{transvers diameter} * \text{vertical diameter}}{2}$$

**Inclusion Criteria:**

In this research study, only people were included for CT -scans of the skull related problems in terms of head traumas, headaches, strokes, epilepsy and some other conditions such as ear tinnitus and facial pain who have come for their CT-scan examinations for those problems.

**Exclusion criteria:**

In this study, people who had trauma in the orbital area or who had undergone surgery for orbital tumors were excluded from the study, and those who were less than 15 years old were also excluded from the study**.**

**Variables:**

In this research, variables such as age, gender and side are considered.

**Ethical considerations**: Ethical consideration of this study reviewed and approved by ethical committee of Kabul University of medical sciences “Abu Ali Ibn Sina” and ethical committee of French medical institute for mothers and children (FMIC) hospital in Kabul city.

The verbal consent was obtained by cooperation of radiologist from patients who were referred for CT-scan of their skull related problems included in inclusion criteria of this study. For the patient who was minor or has no conscious the verbal consent was taking from his /her parents or their guardians. This study preformed just near patients who are needed for the CT-scan of their skull related problems.

There is no intended or obligatory exposure of patients or individuals to radiation, by the performers of this study.

**Facilities:** radiology department of FMIC, computer, radiologist, patients and their radiographies.

## 4. Results

The referred patients were 60 which from them 30 are men and 30 women. The minimum age of patients were 16 years old and the maximum age of patients were 65 years old, and the average age was 37.2 years old.

The average volumes of the frontal sinuses for both sexes were estimated to 4.42 $cm^3$. The average volume of the frontal sinuses near men were estimated to 4.13 $cm^3$ and in women 4.71$cm^3$, which indicates the larger size of the frontal sinus in women than men.

The average volume of the left and right frontal sinus in women were estimated to 4.85 $cm^3$ and 4.57$cm^3$, which shows the larger size of the left frontal sinus in women, but it is not statistically significant.

The average volume of the left and right frontal sinus in men were estimated 4.11 $cm^3$ and 4.14 $cm^3$, which shows the larger size of the right side sinus than left, but is not statistically significant.

The minimum volume of the right frontal sinus is (0) zero, its maximum volume is 15.14 and their standard deviation is 3.25 $cm^3$.

Also, the minimum volume of the left frontal sinus was zero (0) and its maximum was 32.4 and its standard deviation was 5.1 cubic centimeters and it showed the larger frontal sinus in women. In 6.6% cases of the frontal sinuses were absent near referred patients.

**Table 1:** General findings

| | |
|---|---|
| 37.29 years | Average of age |
| 4.42 $cm^3$ | Average of sinuses volume |
| 6.6 % | Absent of sinuses |
| 4.215 $cm^3$ | Standard deviation |
| 0.00 $cm^3$ | Minimum of sinuses |
| 32.4 $cm^3$ | Maximum of sinuses |

**Table 1:** In general findings the average age of participants were 37.29 years and the average sinuses volume were 4.42$cm^3$, near 6.6% of participants' paranasal sinuses were absent and the standard deviation was 4.215 $cm^3$.

**Table 2:** Comparison of paranasal sinuses volume according to the sex:

| Average of sinuses volume | Left sinus volume | Right sinus volume | Gender |
|---|---|---|---|
| 4.13 $cm^3$ | 4.11 $cm^3$ | 4.14 $cm^3$ | Man |
| 4.71 $cm^3$ | 4.85 $cm^3$ | 4.57 $cm^3$ | Woman |

In table 2: indicates that right and left sinuses volume are larger in women than men.

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**Table 3:** Comparison of paranasal sinuses volume according to side in both sexes:

| Sinus volume | Side |
|---|---|
| 4.36 $cm^3$ | Right |
| 4.48 $cm^3$ | Left |

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**In table** (3): indicates that left sinus volume is greater than right one.

## 5. Discussions

Research conducted by PONDE, JM: ANDRADE, TELES, A, S and others on the anatomical changes of the frontal sinus over one hundred (100) bony skulls in 2008 and found that the frontal sinus volume in men is larger than women which is in contradiction with present study (1).

Research conducted by O Eboh, Osesogie uOgbeide, Thiophius Ivwighren and others on the anatomical changes of the frontal sinus in 2017 over one hundred bony skulls in the city of Benin in South Nigeria has found that the volume of the frontal sinus in men were greater than women, which is in contradiction with this present research (4).

In addition, Dennis Ethisenebe and others conducted a study in 2017 on the anatomical changes of the frontal sinus in southern Nigeria over one hundred bony skulls found that the frontal sinus volume in men were greater than women, which is contrary to the present research study (6).

A study conducted in December 2008 by Patick Metzger on the anatomical changes of the front sinus over a hundred bony skulls found that the volume of the frontal sinus in men were larger than women, which is in contradiction to the present study (8).

Radiological and anthropometric studies of the frontal sinus to determine the sex conducted in 2017 by Dennis Ethisenebe O Eboh in South Nigeria found that the entire diameter of the frontal sinus in men were larger than women, indicating that the frontal sinus in men were larger than women, which is in contradiction to the present study (9).

Research conducted in 1981 by Szilvassy .J. about development of the frontal sinus. They found that in 4% to 6% of cases, there were absent of both side of the frontal sinus, which is completely consistent with the present study (10).

A retrospective study of agenesis and aplasia in Turkish individuals' conducted in 2011 by Binali Cakur et al.: found that frontal sinus were not present in 3-10% of cases, which is consistent with the present study which in 6.6% of cases frontal sinus were absent (21).

## 6. Conclusion

In this study, the average ages of patients were estimated 37.2 years old and the average frontal sinus volume was estimated 4.4 cubic centimeters. The volume of the frontal sinuses discovered larger in women than men. Left frontal sinus volume was larger than right one and in 6.6% of cases the frontal sinus was absent near referred patients**.**

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