Original Research Article

Morphometry of frontal sinus in correlation to age and gender by Computed Tomography

Pawan Kumar Mahato[1], P. Moula Akbar Basha[2*], Prasad Anjali Krishna[3]

[1]Associate Professor, Department of Anatomy, Index Medical College, Indore, Madhya Pradesh, India
[2]PhD Research Scholar, Department of Anatomy, Index Medical College, Indore, Madhya Pradesh, India
[3]Assistant Professor, Sri Krishna Medical College, Muzaffarpur, Bihar, India

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Abstract

Introduction: Frontal sinus has distinct characteristics that can contributed to human identification. The frontal sinus morphology is considered to be unique with its peculiar characteristics in regard to its shape, size, and position, allowing for the frontal sinus' configuration to demonstrate highly individualistic markers that allow for the sinus to assist in personal identification. **Materials and methods:** This is a prospective study conducted at Department of Anatomy and Radiology, Index Medical College, Indore and Department of Anatomy and Radiology, Ayaan Institute of Medical Sciences, Hyderabad from January 2020 December 2021. **Result:** In this study, the maximum number of patients were in the age group of 18-30 years which were 41.1% (n =37) of total followed by age group 31–50 years having 34.4% (n = 31) in this group and 23.3% were 51-70 years. In this study, the average frontal sinus area of right side in males was 4.53 cm^2 and in females it was 3.73 cm^2. The area of the frontal sinus was not found to be significant in relation to gender in our study. Moreover, frontal sinus area of left side in males was 4.98 cm^2 and in females it was 3.98 cm^2. The frontal sinuses of males were found to be larger than that of females; however, the statistical difference of means between them was not significant. **Conclusion:** The present study states that 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. Our results may helpful in understanding normal volumetric values of the frontal sinuses.

Keywords: Computed tomographic, Frontal sinus, Gender.

Introduction

The frontal sinus makes a valid contribution to glabellar contours and the forehead[1]. The individuality of each frontal sinus is shown through considerable asymmetrical variations in the shape and capacity of the sinus[2,3]. Structure and size of the sinus can be influenced by genetic and environmental factors, including but not limited to, pathology, craniofacial configuration, thickness of the frontal bone and hormonal levels. Individuals with high sports activity levels may also experience structural and developmental changes such as hyper pneumatisation[4].

Frontal sinus has distinct characteristics that can contributed to human identification. The frontal sinus morphology is considered to be unique with its peculiar characteristics in regard to its shape, size, and position, allowing for the frontal sinus' configuration to demonstrate highly individualistic markers that allow for the sinus to assist in personal identification[5]. The uniqueness of the frontal sinus has been scientifically demonstrated through several studies in literature, allowing for the sinus' variations to be used successfully as the bases for forensic identification. The unique quality of the frontal sinus has even been demonstrated on the level of individuality amongst monozygotic twins[6].

The frontal sinus configurations and individualist qualities have been established through two and three-dimensional visualizations on radiographs and computed tomographic scans. The frontal sinus has been reliable in forensic identification of human remains when both antemortem and postmortem radiographs have been available for comparison[7].

*Correspondence
Dr. P. Moula Akbar Basha
PhD Research Scholar, Department of Anatomy, Index Medical College, Indore, Madhya Pradesh, India
E-mail: moulaanatomy@gmail.com

Radiography is used in forensic pathology commonly with decomposed, fragmented, or burned remains because the images can assist in measuring accurate dimension which can then be applied to formulas in order to identify sex, regardless of whether antemortem radiographs are available[8]. Radiographs to be a good method for identification in their research as they believed it was "simple and not time consuming. It could be easily employed by a general dentist, as it did not require expertise"[9].

Contrarily, computed tomographic scans are considered an excellent imaging modality for use with the assessment of sino-nasal cavities by most, due to the fact that it provides accurate assessment of not only the paranasal sinuses, but also of craniofacial bones, as well as the extent of pneummatisation of the sinuses and have been applied anthropologically in the study of fossilized skulls[10]. Computed tomographic scans have been more advantageous than conventional radiographs for many reasons. CT scans can avoid the superimposition of structures beyond the plane of interest to allow visualization of density differences at small levels. Computed tomography also allows for easy manipulation of internal points that when evaluated can be show by segmented images[11].CT scans have the ability to precisely locate and measure craniometric points more accurately than what can be performed on a conventional radiograph. Computed tomography imaging allows for volumes and areas to be calculated and the film includes a description of the patient's details which can be helpful in the identification process[12]. The nature of the contiguous cross-sections provides 3D info that is not easily replicated through radiography and the accessibility by means of most hospitals also contributes to the advantageous nature of CT scans[13].

Materials and methods

This is a prospective study conducted at Department of Anatomy and Radiology, Index Medical College, Indore and Department of Anatomy and Radiology, Ayaan Institute of Medical Sciences, Hyderabad from January 2020 to September 2021.

Inclusion criteria

- Either gender of Age group between 1 to 70 years were included.

Exclusion criteria

- History of sinus pathology issues could be excluded as possible outliers before measurements.
- History of maxillofacial trauma and history or clinical characteristics of any type of systemic disorders like bone diseases, nutritional and endocrinal diseases were excluded.

They were included in the study after recording demographic data, brief history of the present illness and past medical/surgical history. The various parameters like height, width, depth & volume of the frontal sinus were measured using Computed tomography scans in the Osirix software.

CT image files, with a slice thickness of 0.625, were then uploaded to the Osirix software database for examination. The CT slice thickness was 0.625. The study was designed to measure volume of the frontal sinus used for sex identification. This was done in an effort to identify a preferential sinus for sex identification.

Statistical Analysis

Descriptive statistics are provided as the mean with standard deviation (SD). Analytic assessment was done by the Student t-test and P value less than 0.05 accepted as statistically significant difference.

Result

A total of 90 patients who fulfilled the selection criteria during the study were enrolled. The data were analysed, and the final observations were tabulated as below.

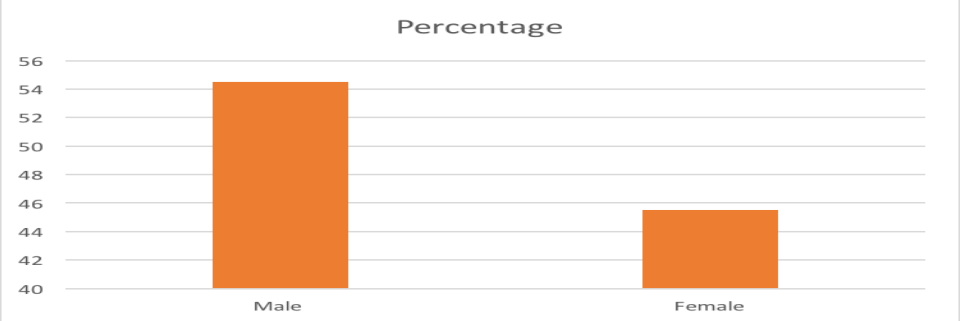

Fig 1: Distribution of Gender

In graph 1, of the 90 samples, 49 were males and 41 females, which correspond to 54.5% of male and the rest female in table 1.

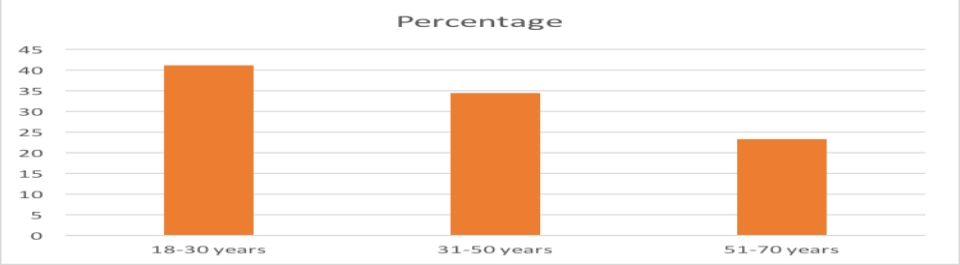

Fig 2: Distribution of the number of subjects according to age group

In this study, the maximum number of patients were in the age group of 18-30 years which were 41.1% (n =37) of total followed by age group 31–50 years having 34.4% (n = 31) in this group and 23.3% were 51-70 years in graph 2.

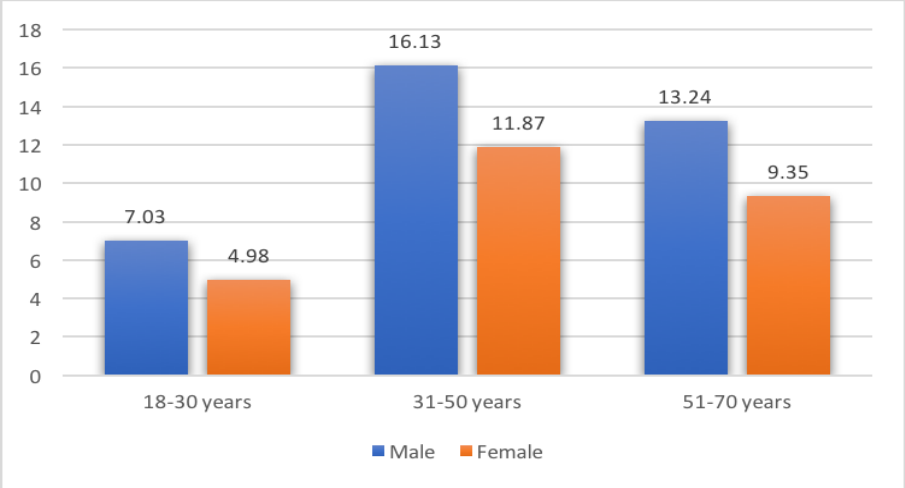

Fig 3: Descriptive Statistics of right volume (cm) of frontal sinus in males and females

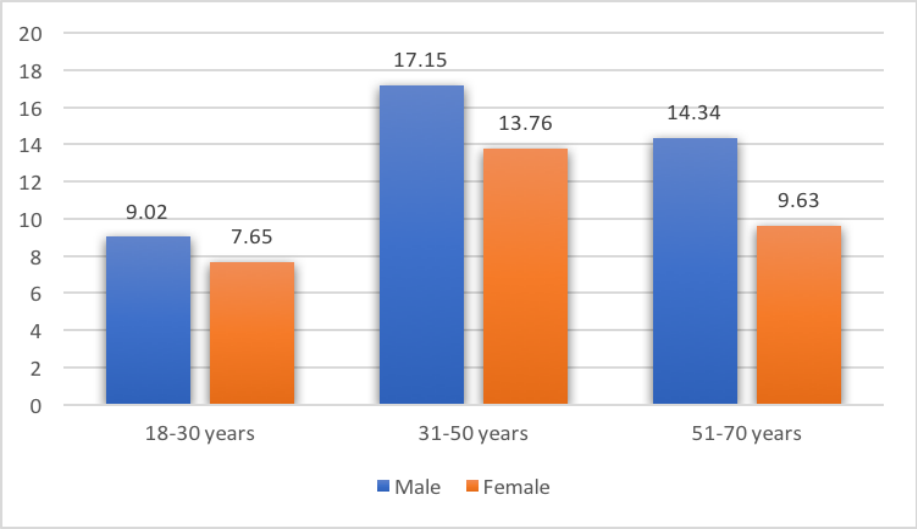

Fig 4: Descriptive Statistics of left volume (cm) of frontal sinus in males and females

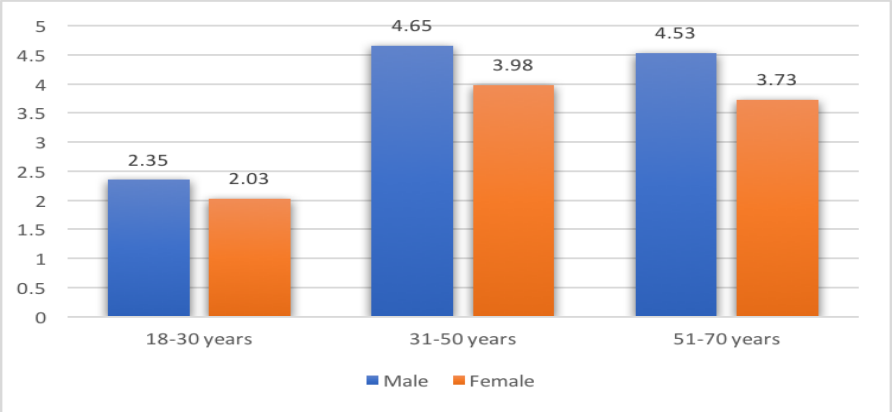

Fig 5: Descriptive Statistics of right area (cm) of frontal sinus in males and females

In this study, the average frontal sinus area of right side in males was 4.53 cm^2 and in females it was 3.73 cm^2. The area of the frontal sinus was not found to be significant in relation to gender in our study in graph 5.

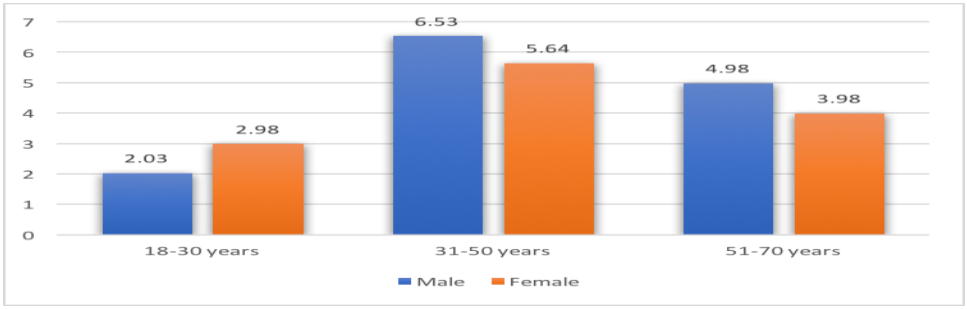

Fig 6: Descriptive Statistics of left area (cm) of frontal sinus in males and females

Moreover, frontal sinus area of left side in males was 4.98 cm^2 and in females it was 3.98 cm^2. The frontal sinuses of males were found to be larger than that of females; however, the statistical difference of means between them was not significant. The decrease of the frontal sinus area in males in the right side then left side as observed in graph 6.

Discussion

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[14].

The mucous membrane in this sinus is innervated by the supraorbital nerve, which carries the postganglionic parasympathetic nerve fibers for mucous secretion from ophthalmic nerve and supplied by the supraorbital artery and anterior ethmoidal artery[15].

In addition, the volume of sinus being more on left side than right both in males & females, males size more in value than female sinus size except in Harris AM et al. Study[16]. In the present study, the volume of frontal sinus was more in value when compared to other authors. When compared between sides other studies showed that

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. On age wise comparison of growth of frontal sinus volume, according to Camargo JR et al. studies the volume of frontal sinus was gradual increasing with age of maximum 11.80 cm3 (male) & 7.62 cm3 (female) by 31-45 age group, there after decreasing in growth by 45 years age minimum volume of 6.84 cm3 (male) & 8.03 cm3 (female)[17].

In this study, the average frontal sinus area of right side in males was 4.53 cm^2 and in females it was 3.73 cm^2. The area of the frontal sinus was not found to be significant in relation to gender in our study, which was to the findings reported by Pondé JM et al[18]. Moreover, frontal sinus area of left side in males was 4.98 cm^2 and in females it was 3.98 cm^2. The frontal sinuses of males were found to be larger than that of females; however, the statistical difference of means between them was not significant, a finding noted in various studies[19]. Buckland et al. However, the decrease of the frontal sinus area in males in the right side then left side as observed in our study which was similar to Szilvassy[20].

Lynnerup N et al. (2014) attempted to identifying sex with the frontal sinus using the right height, left height, right width, left width, left area, and right area with predetermined baselines, and observed an overall accuracy rate of 64.6%[21]. Tatlisumak E, (2014) attempted sex identification of the frontal sinus using measurements for the height, transverse, and anteroposterior lengths, and resulted in an overall accuracy rate of 67.0%[22]. Fatu C, (2014) resulted in an overall accuracy rate of 67.59% of sex identification using measurements for the length, width, and sinus index of the frontal sinus[23]. McLaughlin RB et al. (2013) attempted sex identification using the maximum height and width of frontal sinuses with a previously standardized baseline and yielded an overall accuracy rate of 88.00%[24].The discrepancy of sexual dimorphism between the current study, and the before mentioned methods could be attributed to the vast difference in parameters used for sex determination. No linear measurements were utilized in the current study, whereas linear measurements were the focus in every other frontal sinus method previously mentioned. The current study overlooked this inconsistency in favor of the higher accuracy rates claimed by Karakas S et al. (2015) in hopes that the difference in linear versus volumetric parameters was the reason behind the higher accuracy rate of 72.50%[25].This suggests the possibility of sexual dimorphism in the frontal sinus amongst linear parameters despite the current study having determined no sexual dimorphism in the frontal sinus volume. Higher accuracy rates of other frontal sinus methods could also be attributed to formulae being developed based on parameters from a single sample, and then being applied to the same sample used to determine the formulae. Without applying an established method of sex determination formula to a new sample population, the formula's accuracy rate should be considered with caution.

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. Such aspects can explain why the frontal sinus of men is on an average larger than that of women. Bilateral aplasia was seen in 6.5% of cases in total; it was more frequent in females (9%) than males (4%), and was more in the age group of 14-20 years that was in accordance with the results of studies conducted by Danesh-Sani SA et al[26]. This difference can be attributed to geographic and racial features and the different methodologies used for each study[27].

Thus, the frontal sinus can be used in the personal identification of individuals by comparing the pre- and post-mortem radiographs. Like fingerprints, sinus patterns are unique for a person. Identification by comparison of radiographs of the pre- and post-mortem frontal sinuses is scientifically valid because the frontal sinus configurations of no two persons are alike. However, unlike fingerprints they are affected by pathology such as acute or chronic inflammations, some endocrine dysplasia, osteitis, and trauma. We had ruled out this possibilities in case history taking for subjects included in the study. Farias et al., reported that the frontal sinus is a reliable structure when related to maturation and prediction of mandibular growth but not a substitution for hand wrist radiographs by lateral cephalometric study that was not evaluated in our study[28].

Conclusion

The present study states that 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. 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.

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