Original Article

Study of Multidetector Computed Tomography Images of the Frontal Sinuses for Human Identification: A Study in Regional Indian Population

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ABSTRACT

Background: Growth rate is diverse for different ethnic groups, and for this reason, studies are required to be population specific. To solve controversial identification issues in future, sexual dimorphism in cases of imaging of frontal sinus among the Eastern Indian population needs to be tested.

Objectives: The aim of the study was to determine sex by studying computed tomography (CT) scan images of the frontal sinus, using discriminant function analysis.

Methodology: We scanned 90 subjects, comprising 30 males and 60 females in the age bracket of 18 and 60 years using the CT scan in the Indian (Bengali) population.

Results: The Wilks' lambda for the model is 0.459 which signifies a good discriminating power of the model. The discriminant function equation is, *Df* = 0.04 Width + 0.221 Depth + 0.185 Height + 0.059 Frontal Distance −5.574 (constant). Overall, 86.7% of the samples were correctly classified into their group by this model.

Conclusion: This study shows that the accuracy rate of the prediction model for sex estimation using only frontal sinus is average. Further studies are required to conclude that this function can be used for forensic sex determination among the Eastern Indian (Bengali) population.

Key Words: *Computed tomography scan, forensic, frontal sinus, identification*

Introduction

Identification is one of the most important parts of forensic medicine. It is of utmost importance in case of controversial issues related to various legal problems. Identification becomes of great importance, especially in cases where the bodies have been mutilated. Various bones have been used for anthropological data generation for identification. Recently, the use of antemortem data to develop a database for various regional populations has been initiated. At first, knowledge about human paranasal sinus pneumatization was initially developed by taking anatomical measurements, injecting different materials into cadavers, or performing plain radiography. However, later on, computed tomography (CT) scanning was done in the Korean population to see the paranasal sinus pneumatization.[1]

Nowadays, the introduction of multidetector CT (MDCT) and magnetic resonance imaging, with thin axial sections and sagittal and coronal reformatted images as well as three-dimensional reconstructions, has allowed a more exact assessment of this structure. Furthermore, the application of morphometric procedures to these radiological images adds a new perspective to this analysis.

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The earlier studies done in Western populations have helped to generate data regarding the frontal sinus identification and its use for identification.[2] As the data base of one population cannot be used in another population belonging to a different race, it was the aim of this study to evaluate the significance of MDCT measurement of the frontal sinus in estimating sex in case of the Indian population. It has been reported that the frontal sinus remains intact although the skull and other bones may be badly disfigured in victims who are incinerated.[3] Therefore, the frontal sinus can be used for identification.

Earlier studies have shown that there is a significant sexual dimorphism in cases of imaging of frontal sinus in other populations.[4-9]

The objective of our study is to examine whether such dimorphism exists in the Indian population and whether a database can be built in future based on these findings. This database if feasible can help to solve controversial identification issues in future.

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Methodology

Study participants

The present work was conducted by the examiners of the Department of Forensic and State Medicine, Calcutta National Medical College, Kolkata. The study was conducted on 90 patients, in the age group of 18–60 years, comprising 30 males and 60 females, brought for CT scan examination of paranasal sinus for various reasons, at Calcutta National Medical College digital CT scan center. The duration of the study was 6 months. Proper informed consent was obtained from the patient/next of kin. Ethical clearance was obtained from the Ethics Committee of Calcutta National Medical College; no additional radiation exposure was given to the study participants.

Inclusion criteria

- Individuals who gave their consent for this study
- Normal cases without pathology of the peripheral nervous system (PNS).

Exclusion criteria

- Cases with pathological changes in the PNS
- Unclear CT scan images.

Methods

The CT scan was performed on 16 Slice Alexion Machine (Toshiba, Japan) at the CT scan center of Calcutta National Medical College campus. A routine thoracic CT protocol was followed. All scans were taken with the following parameters: tube voltage: 120 kV, effective 120 mA, and slice thickness: 1 mm. All the axial [Figure 1] and coronal [Figure 2] images were transferred to a commercially available workstation. On the workstation, multiplane reformatting of images in the sagittal and coronal planes was obtained using commercially available software (RadiAnt DICOM Viewer).

Parameters studied from the images are[10,11]

- The frontal sinus transverse length (width) was measured from the axial image
- The frontal sinus anteroposterior length (depth) was measured from the axial image
- The height of the frontal sinus was obtained from the coronal section
- The distance between the highest points of the two sinuses was obtained from the coronal section (Frontal Distance).

Statistical analysis

All the data were collected, compiled, and subjected to suitable statistical analysis using appropriate methods (discriminant function). The results are presented using tables and diagrams. Finally, the findings will be critically studied on the background of present knowledge and the experience of the past work.

Results

This study consisted of data from 90 study participants from 18 to 60 years, comprising 30 males and 60 females [Table 1]. On comparing the measurements [showing mean, minimum, and maximum in Table 2], we found that all the dimensions were greater in male than female. Discriminant function was performed using the data from the measurements of the frontal sinus. The Wilks' lambda was 0.459 [Table 3], with significance value being 0.000. Receiver operating characteristic curve also showed good discrimination function between male and female.

The discrimination function equation is, Df = 0.04 Width + 0.221 Depth + 0.185 Height + 0.059 F. Distance − 5.574 (constant), as shown in Table 4.

The cutoff point is 1.517 − 0.758/2 = 0.3795, as shown in Table 5. Hence, above this value 0.3795, the cases are male. Below this value 0.3795, the cases are female. Overall, 86.7% of the samples were correctly classified as male or female by this model [Table 6]. Cross-validated results showed 85.6% of the cases correctly classified by this model. After the results were used to get a discriminant equation, the formula was used on a separate sample of 20 cases to validate the results.

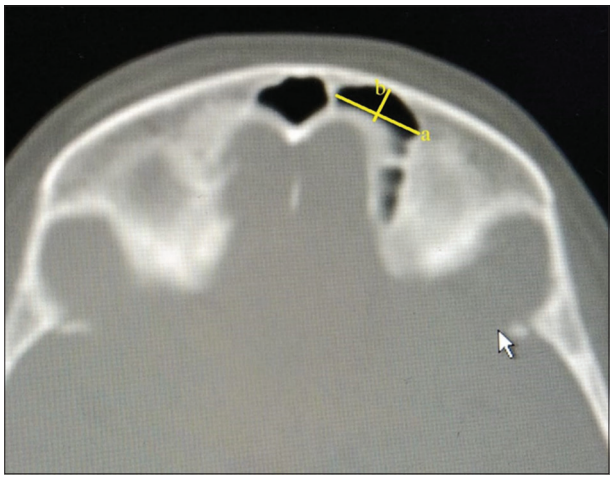

Figure 1: Axial computed tomography showing the frontal sinus width (a) and frontal sinus depth (b)

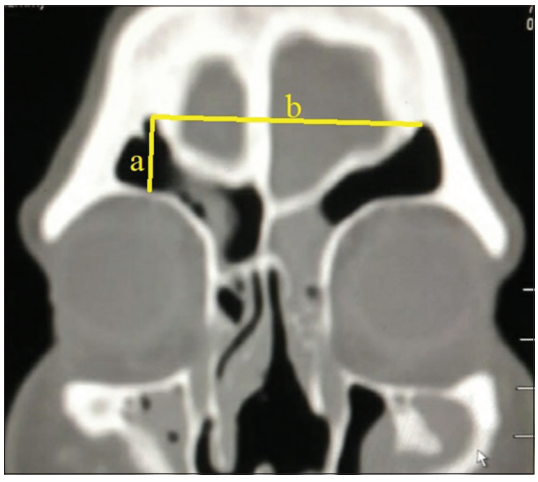

Figure 2: Coronal computed tomography scan showing the frontal sinus height (a) and the distance between the highest points of the two sinuses (b)

Table 1: Descriptive statistics of age of the study population

	n	Minimum	Maximum	Mean	SD
Male age	30	18.00	60.00	39.0000	13.71
Female age	60	11.00	52.00	38.2667	12.92

SD: Standard deviation

Table 2: Comparing the measurements (mm) according to their sex

Sex	Width	Depth	Height	Frontal Distance
Male				
Mean	25.20	7.63	16.67	22.37
n	30	30	30	30
SD	3.47	1.87	4.40	2.85
Female				
Mean	19.25	5.85	9.62	16.57
n	60	60	60	60
SD	6.64	1.71	3.29	9.25
Total				
Mean	21.23	6.44	11.97	18.50
n	90	90	90	90
SD	6.41	1.94	4.97	8.18

SD: Standard deviation

Table 3: Power of the study determined by Wilks' lambda

Test of function (s)	Wilks' lambda	χ^2	df	Significant
1	0.459	66.893	4	0.000

Discussion

The frontal sinus is one of the most unique structures that can be found in the human body. In cases of various dismemberment of body in aviation accidents or mass graves where only the skull is available for sex estimation, forensic experts have used methods based on the measurement of various bone parameters. They have focused mostly on denser bones and the most inaccessible paranasal sinuses.[12-15] The paranasal sinuses usually complete their growth by 18 years of age. Hence, in our study, we have only included persons of more than 18 years of age, keeping this fact in mind. To determine the reliability and reproducibility of the frontal sinus measurements, intra- and interobserver variation was assessed. A comparison of the measurements showed no significant statistical difference.

After analyzing the data, it is seen that only in 8% of cases, bilateral aplasia is seen. This is in congruence to the study done by Soman *et al*.[16] The discriminant function conducted by Teke *et al*.[17] on the Turkish population to determine the usefulness of maxillary sinuses in sex estimation showed an accuracy of 69.3%. Similarly, the study by Uthman *et al*.[7] in the Iraqi population showed an accuracy of 71.6% and that by Attia *et al*.[18] on Egyptians showed an accuracy of 69.9%. In contrast to that, our study which has used discriminant function on the frontal sinus has shown accuracy of 85.6%, which shows that the frontal sinus has better discriminating power than the maxillary sinus. This is in congruence with the study on Brazilian population by Camargo *et al*.,[19] which showed an accuracy of 79.7% in case of sex estimation from the frontal sinus. Uthman *et al*.[17] also showed similar results in case of frontal sinus with an accuracy of 76.9%. The accuracy of sex estimation in the South Indian population by Belaldavar *et al*.,[20] though, varied in the range of 59.4%–64.6%.

Uthman *et al*.[11] in 2010 had shown that the accuracy rate was improved with the addition of cranial measurements. However, the cranial measurements were not included in our study. The cranial measurements could have improved the model further.

Table 4: Coefficients contributing to the differentiation of sex

	Function 1
Width	0.040
Depth	0.221
Height	0.185
Frontal Distance	0.059
Constant	−5.574

Unstandardized coefficients

Table 5: Cutoff values for determination of sex

Sex	Function 1
Male	1.517
Female	−0.758

Unstandardized canonical discriminant functions evaluated at group means

Table 6: Predictive classification of sex

	Sex	Predicted group membership		Total
		Male	Female	
Original				
Count	Male	24	6	30
	Female	6	54	60
Percentage[a]	Male	80.0	20.0	100.0
	Female	10.0	90.0	100.0
Cross-validated				
Count	Male	24	6	30
	Female	7	53	60
Percentage[b]	Male	80.0	20.0	100.0
	Female	11.7	88.3	100.0

[a]86.7% of original grouped cases correctly classified, [b]85.6% of cross-validated grouped cases correctly classified

Conclusion

This study shows that the accuracy rate of the prediction model using only frontal sinus is average. Thus, it can only be used as an adjunctive method for age estimation. Further studies are required in the Eastern Indian population to determine the actual accuracy rate in case of sex estimation from the frontal sinus.

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Conflicts of interest

There are no conflicts of interest.

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