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A Novel Method of Establishing the Identity of an Individual by Analyzing the Pattern & Volume of the Frontal Sinus Using Computerized Tomogram – A Retrospective Cross Sectional Study

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Abstract

Background: The paranasal sinuses develop early in fetallife.Among the 4 major sinuses present in human skull, Frontal sinus helps in identification of an individual because of its uniqueness and so has the potential to be used as an aid for personal identification in disasters, accidents and natural calamities.

Aim and Objective: To determine the volume & shape of frontal sinus in individuals using CT scan and to establish the uniqueness of frontal sinus in the identification of individuals in forensic science.

Methodology: CT images showing the axial and coronal sections of frontal sinus of patients above the age of 20 years were considered as inclusion criteria and patients below the age of 20 years, previous injury, surgery or pathology in the frontal bone and frontal sinus were excluded. The length, breadth and height of right & left frontal sinus were measured and volume of the frontal sinus was calculated.The pattern of the frontal sinus was analysed in the axial & coronal sections of CT scan by taking screen shots of the slice. The pattern of the frontal sinus was drawn and copied to Microsoft Power Point Software for superimposing over other patterns.

Results: Among the 270 scans collected, the total length, breadth, height and volume of left and right side of male and females were compared by using Independent samples t-test and it showed that the frontal sinus was unique in nature.

Conclusion: The observations showed that no two individuals had the same sinus morphology based on division, volume, position and symmetry of frontal sinus.

Key words: *CT scan, Frontal sinus, Volume, Pattern, Unique.*

Introduction

The term "Forensic" is derived froma Latin word 'forum' where legal matters are discussed. Odontology refers to the study of teeth or dentistry[1]. Federation Dentaire Internationale[FDI] defined forensic dentistry as 'The branch of dentistry in the interest of justice that deals with proper handling and examination of dental evidence with the proper evaluation and presentation of dental findings' [2].

Forensic odontology plays a major role in the identification of an individual by using traditional methods such as bite marks, rugae pattern, dental profiling, assessment of DNA.When these traditional methods are unfeasible, the para nasal sinuses that develop early in fetal life might serve as a reliable guide for identification.

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Among the four major sinuses,frontal sinus plays a greater role in the identification of an individual. These sinuses are pneumatic cavities that become radiologically evident at the age of five or six years and develop fully by the age of 20 years [3]. Like fingerprints, frontal sinus patterns are unique for a person. Several authors have reported the uniqueness and it's importance in human identification[4,5].

Though there are many ways in visualizing the frontal sinus, a single CT image gives a three dimensional view of the sinus. The aim of the present study is to determine the volume & shape of frontal sinus in individuals using CT scan and to establish the uniqueness of frontal sinus in the identification of individuals in forensic science.

Material and Method

After obtaining the ethical clearance from the Institutional Ethical Committee, a retrospective study was performed using 270 Head and Neck CT images of patients that were previously taken for some therapeutic purpose. CT images of patients of age above 20 years were used and CT images of patients below the age of 20 years and the images with evidence of previous injury, surgery or pathology in the frontal bone and frontal sinus were excluded.Informed consent was also obtained

The slice containing the axial and coronal sections of CT's of individuals were selected in such a way that complete radiolucency is seen in the region of frontal sinus and the pattern and volume were analysed.

The following measurements were taken in the axial & coronal sections for measuring the volume of frontal sinus**:**

- Height of right & left frontal sinus
- Length & breadth of right & left frontal sinus
- Volume of the frontal sinus

For analysing the pattern of frontal sinus the outline of the pattern was drawn by taking screen shots (Fig 1,2).The pattern of sinus was compared to one another by using Microsoft PowerPoint software by:

1.Copping, pasting the cropped image on a PowerPoint presentation slide.

2.The background of the image removed by formatting the image.(This will make the image radiopaque in the sinus region.)

3.The pattern was compared by superimposing each image.

Results

A total of two hundred and seventy PNS Head and Neck CT images (axial and coronal slices) were selected following the selection criteria out of which 155 (57.41%) were males and 115 (45.59%) were females. Out of the 270 images examined the frontal sinuses were present in 266 (98.52%) people and absent bilaterally among 4 (1.48%)Among the 266 subjects, the frontal sinus was unilateral in 14 (5.27%) and bilateral in 252 (94.7%) (Tab 1).The unilateral frontal sinus was more common on the right side (4.81%) than the left side (0.37%). ((Tab 1).Division of the sinus was seen in 246 (92.48%) and absence of divisison was observed in 20 (7.52%). (Tab 1). The symmetry of the sinuses were compared in 232 subjects who had bilateral presence of frontal sinus, by analysing the pattern and simultaneously the volume and was found to be symmetrical in 18 and asymmetrical in 214. While comparing the pattern of the sinuses it was found to be unique in 98.89% (ie. among all the subjects with presence of sinus).The commonest shape of the front sinus seen in the coronal section was club shaped.

The total length, breadth, height and volume of left and right side of male and females were compared. Independent samples t-test was performed by calculating the mean, SD and SEM. While comparing the volume of right and left side of sinus, volume of the right frontal sinus was more in males whereas it was vice versa in females. The mean total volume of males was greater than that of females, which implies that the sinuses are larger in size in males (Tab 2).

The uniqueness of frontal sinus was analysed by comparing the pattern of the sinus among 266 subjects by superimposing the images in Microsoft paint software.

The following observations showed that no two individuals had the same sinus morphology.

1. The patterns were unique between each individual.

2. Divisions within the sinus varied.

3. Measurements such as length, breadth, height or volume were different between each individual.

4. Positions of the sinus (unilateral/ bilateral) varied.

5. Symmetry of the sinus varied.

Table 1: Statistics showing distribution of the presence/absence,pattern,division between the sides.

Table 2: Statistics showing Length, Breadth and Height of right and left side of frontal sinus in male and female

Table 1 Statistics showing distribution of the presence/absence, pattern, division between the sides.

		Position								
	Unilateral Right			Unilateral Left			Bilateral			
	N	%	Row %	N	%	Row %	N	%	Row %	
Pattern	Presence	13	100.00	4.89	1	100.00	.38	252	100.00	94.74
	Absence	0	.00	.00	0	.00	.00	0	.00	.00
Sinus/No Sinus	Sinus	13	100.00	4.89	1	100.00	.38	252	100.00	94.74
	No Sinus	0	.00	.00	0	.00	.00	0	.00	.00
Division	Division	13	100.00	5.28	1	100.00	.41	232	92.06	94.31
	No Division	0	.00	.00	0	.00	.00	20	7.94	100.00

Table 2: Statistics showing Length, Breadth and Height of right and left side of frontal sinus in male and female

	Gender						Independent Samples t-test	
	Male			Female				
	Mean	SD	SEM	Mean	SD	SEM	t-Value	P – Value
Length – Right	21.24	9.03	.75	17.21	7.76	.74	3.740	.000
Length – Left	22.00	8.34	.70	19.33	8.19	.79	2.520	.012
Breadth – Right	24.37	8.68	.72	19.19	8.52	.81	4.757	.000
Breadth – Left	23.90	7.90	.67	20.63	6.85	.66	3.432	.001
Height – Right	12.06	6.10	.51	9.66	3.84	.37	3.605	.000
Height – Left	11.96	4.22	.36	10.95	3.60	.35	1.966	.050
Volume – Right	7726.66	9630.82	802.57	3892.34	3763.91	358.87	4.361	.000
Volume – Left	6877.21	6318.19	512.47	4671.93	3693.02	345.88	3.567	.000
Volume – Total	14834.84	12449.13	1037.43	8704.18	5800.24	558.13	5.204	.000

Figure:1: Showing the cropped pattern of frontal sinus in Axial section

Figure 2: Showing the cropped pattern of frontal sinus in Coronal section.

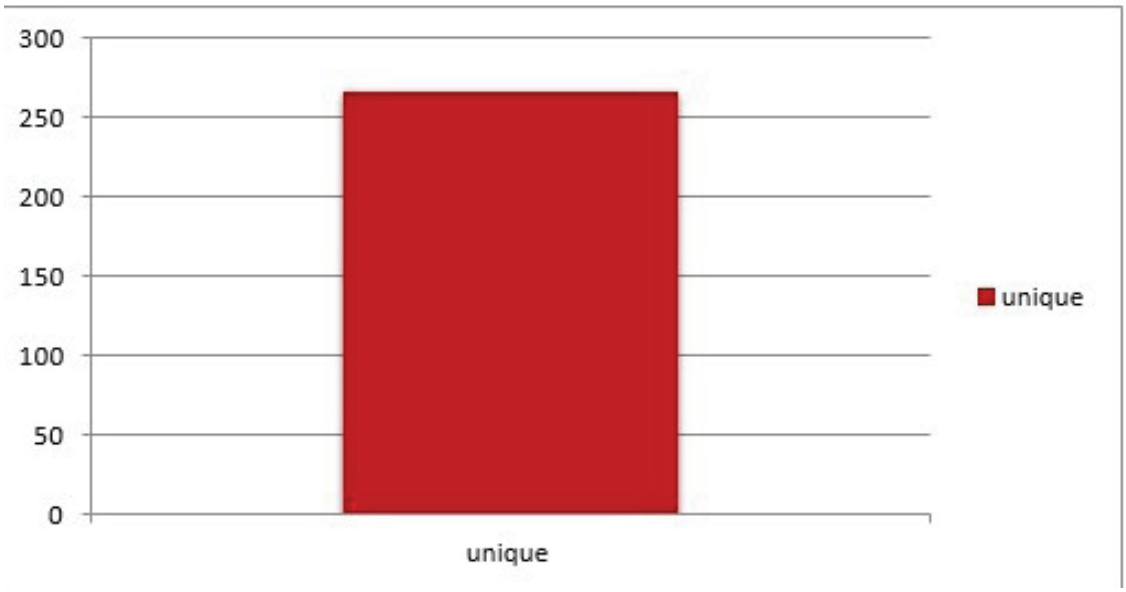

Figure 3: Bar chart showing the uniqueness of frontal sinus.

Discussion

Every individual is unique. The main aim of forensic science is identification of unknown human being in crime and disasters by using numerous technologies. Forensic odontology is a branch of forensic science which has established itself as an important and often indispensable science in medicolegal matters and identification of the dead. Methods like rugoscopy, bite marks, palatal rugae, photographs, lip prints, etc. are used for identifying the individuals.

Finger prints are more useful in identifying a person as they are unique. But there are situations where the other unique features of an individual must be used in identification. The one among the most interesting part

in the head and neck region of a human is Paranasal sinuses. The frontal sinus does not change in its shape after the age of 20 years[6] except during trauma or due to pathology.

The aim of the present study was to prove that frontal sinus is unique to each individual based on their pattern and volume, three dimensionally. Similar studies have been done previously using two dimensional radiographs where the length and breadth of the frontal sinus were measured. Schuller[7],Culbert and Law[8] were the first to propose the possibility of utilizing radiological images of frontal sinus in identification of an individual by studying its morphology. followed by Asherson[9] and Gerald Quatrehommea[10]who examined monozygotic and dizygotic twins and found that the pattern of frontal sinus was different in each of them.

In this study a total of 270 CT scans were analysed and it showed that 98.5 % participants had frontal sinus which was in accordance with Ertugrul Tatlisumak[11]and the bilateral absence of sinus was seen in 1.4% i.e. bilateral absence of frontal sinus.

The pattern of the sinus was compared with one another by superimposing the outline of the sinus, on Microsoft paint software. None of them matched each other which showed that the pattern of frontal sinus was unique. This was in accordance to other studies done by Schller[7],Culbert[8], Asherson[9], Gerald quatrehommea[10], Neha Patil[12] where they have compared the shape of frontal sinus and proved that frontal sinus is unique for each individual in a two dimensional radiographic view. Chetan Belaldavar[13]studied the frontal sinus in a three dimensional way and concluded saying that it has a unique pattern for each individual.

In this study bilateral presence of sinus was seen in 94.74%, unilateral presence on right side was seen in 4.89%, unilateral presence on left side in 0.38%, division of sinus was seen in 92.48% and no division in 7.52% which was in accordance to the study by Neha Patil[12] who showed 1% bilateral aplasia and 3% unilateral aplasia of frontal sinus. A study by Nateghian Z[14] showed that right and left frontal sinus was found in 67.7% of the individuals. Right frontal sinus was observed in 4.6% and left frontal sinus was seen in 9.2% of the individuals. Studies by Saraswathi Gopal[15], Vidya CS[16] showed bilateral absence of frontal sinus is 5%, unilateral aplasia in 2.5%. In Roberto Camerier[17]study out of 99 individuals he found that, there was bilateral aplasia in 10%, unilateral aplasia in 2%. A study by MP David[18] showed that there was 6% unilateral and 4% bilateral aplasia. The division of the sinus was not compared in other studies.

On comparing the bilateral symmetry of frontal sinus in our study, symmetry was seen in 7.76% and asymmetry in 92.2% which was in dispute to Vidya CS [16]who observed that 68% had symmetry and asymmetry was seen in 30% in her study.

This study showed that sinus was larger in males than females which were in accordance with Chetan Belaldavar[13]and Hemant Mathur[19]. In our study the volume of left and right sinus was compared and it was found that volume of the right sinus was greater in males and vice versa in females.

In the present study out of 270 scans viewed, only 4 showed bilateral aplasia which was present in males. The unilateral presence of frontal sinus was present in 5.18 %, out of which it was more common in right side for males like in other studies. The symmetry of sinus in each individual was compared, where 232 frontal sinuses out of 270 sinuses were compared because bilateral aplasia of sinus was seen in 4 subjects and 14 subjects had unilateral sinus (where the symmetry cannot be assessed). In the present study it is shown that only 7.76% of subjects had symmetrical sinus. But a study done by MP David[18]and Saxen[20] showed symmetry in 58 % of frontal sinus.

From the present study it is clear that frontal sinus is unique for each individual (Fig 3) and using the antimortem and post-mortem records of frontal sinus, individuals can be identified. Further gender can also be determined, as the frontal sinuses are larger in males.

Limitations of this study : The frontal sinus cannot be used in identification of an individual when they are completely absent or due to any pathologies affecting the sinus. The frontal sinuses are not present during the early stages of life and cannot be seen radiographically till the age of seven years.

Conclusion

To identify is to determine the individuality, or it is to prove by means of technical or scientific means that a person is that one & not the another. Human identification is not a difficult task, when it is about a live individual or a cadaver chronologically recent and

intact.

After the advent of Computerized Tomographic scan, it is possible to measure the linear and volumetric measurements accurately. In this study an attempt was made to establish the uniqueness of frontal sinus in the identification of an individual using CT scan and it was found that frontal sinus was unique in each individual and it can be used as fingerprint when they are not altered.

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