Original Research
Journal of Forensic Dental Sciences, *Vol 13(3), DOI: 10.18311/jfds/13/3/2021.19, September-December 2021, p. 192-196*
ISSN (Print) : 0975-1475
ISSN (Online) : 0975-2137

Evaluation of Frontal Sinus Morphology in Gender Determination by Using PNS View in U.P. Population: A Radiomorphometric Study

Sumeet Shah

Private Practitioner, India; sumitshah51@gmail.com

Abstract

Background: The importance of frontal sinuses in Forensic Radiology has been well documented. Literature revealed few studies on the morphometric analysis of frontal sinuses on paranasal radiographs in sex determination. This initiated this radiographic study with the aim of analysing the dimensions of the frontal sinuses through digital PNS radiographs for gender determination. **Materials and Methods:** The study group comprised 150 healthy adults of either gender over the age of 20 years. One paranasal sinus radiograph was made for each patient using the standardized radiographic technique. Digital measurements of the height, width and area of the frontal sinuses were recorded using AutoCAD 2014 software. The data collected was subjected to statistical analysis. **Results:** This study found an accuracy rate of 68.6% for sex determination through paranasal sinus radiographs. It was noted that the right height of the frontal sinus was a better predictor than any other parameter assessed for identifying the gender. **Conclusion:** From the present study, we conclude that the dimensions of frontal sinuses on PNS views can be used as an essential tool for gender determination in forensic sciences.

Keywords: Forensics, Frontal Sinus, Gender Determination, PNS Views

Introduction

Forensic Radiology encompasses the performance, interpretation, and reporting of those radiological examinations and procedures that deal with the courts and/or the law[1]. Radiographic identification is beneficial, as radiographs are simple, easy and quick modes of procuring information. They are also economical when compared to DNA techniques[2].

The frontal sinus is one of the four paranasal sinuses that are present within the frontal bone. It is very useful in forensic identification as its structure is highly variable and unique to each individual[3,4]. Schuller in 1921 for the first time compared ante mortem and post mortem radiological images of the frontal sinuses for personal identification[5]. This paved the way for numerous radiographic studies on the frontal sinuses in forensic sciences.

The majority of the radiographic studies in the past have employed Caldwell views, PA views and CT scans to assess the morphology of the frontal sinuses[3,6-12]. These studies have concluded that there is a remarkable variation in the size and shape of the frontal sinuses based on gender. The frontal sinus has been found to be larger in males than in females, reasserting the inimitable characteristics and importance of these sinuses in the identification of an individual's gender[7,13,14].

Very few studies have been performed to determine the gender of an individual through morphometric analysis of the frontal sinuses on the frequently prescribed ***paranasal sinus view***. The lack of such noteworthy research prompted this radiographic study with the aim to analyse the dimensions of the frontal sinuses through digital paranasal sinus radiographs for gender determination.

Materials and Methods

The study group comprised 150 healthy adult patients of either gender above 20 years of age who were selected by simple random sampling. Patients with a history of trauma, orthodontic treatment, or cranio maxillofacial surgery, systemic diseases, endocrine disorders and

**Author for correspondence*

patients with known intrinsic or extrinsic paranasal sinus diseases were excluded from the study. The institution's ethical clearance was obtained prior to the conduct of the study. Following a brief clinical examination, one digital paranasal sinus view for each of the study subject was made with the PLANMECA Proline XC machine using standard technique. The exposure parameters were standardised at 68kvp, 5ma and 17sec. The height, width and area of frontal sinus were digitally assessed using AutoCAD 2014 software. In order to standardise the morphometric assessment of the sinuses on the images acquired, a radiographic base line at the supraorbital ridge was used to determine the height and the margins of the frontal sinus were used to define the maximum width (Figure 1). The observations pertaining to the frontal sinuses were entered in the subjects' proformas. The data collected was tabulated and subjected to statistical analysis namely Shapiro Wilk, Mann Whitney U, Wilcoxon Sign Rank test and a logistical regression study using with Statistical Package for Social Science (IBM SPSS version 22) for Windows to obtain the results.

- Orange line - Base line for measurement of both right and left frontal sinus (supra orbital ridge)
- Yellow line - Maximum Height of Right Frontal sinus
- Green line - Maximum Width of Right Frontal sinus
- Red line - Area of the Right Frontal sinus

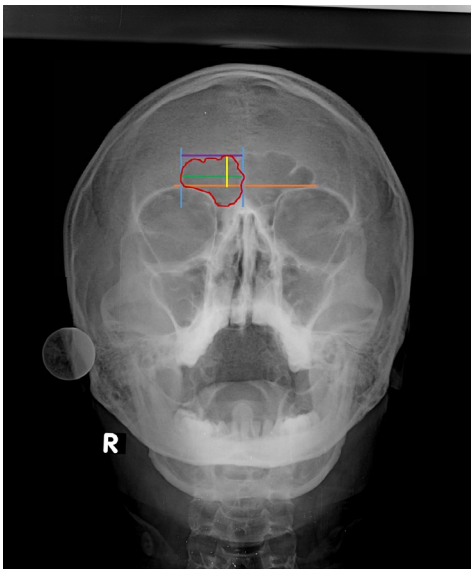
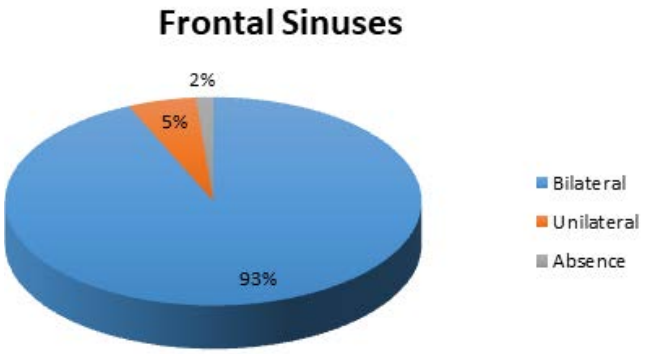


Figure 1. Measurements of frontal sinus.

Results

The total sample size of the study was 150, consisting of 75 males and 75 females. It was observed that out of 150 patients, 140 (93.3%) had bilateral frontal sinuses, 8 (5.3%) had unilateral frontal sinuses and 2 (1.3%) had a complete absence of frontal sinuses. Of the 150 radiographs procured, 10 were thus excluded from this study due to unilateral or bilateral absence of the frontal sinuses (Graph 1).



Graph 1. Percentage of presence of bilateral, unilateral or absence of frontal sinus.

Males had larger dimensions of frontal sinuses (right and left) than females. The mean values of the left frontal sinus in males were higher than the mean values of the left frontal sinus in females. The mean dimensions of the left frontal sinus in males for height, width and area were 30.75mm, 18.51mm and 620.11mm^2 respectively, and for the right sinus, the values were 20.82mm, 24.96mm and 508.67mm^2 respectively. The mean dimensions of the left frontal sinus in females for height, width and area were 27.79mm, 15.28mm and 533.39mm^2 respectively, and for the right sinus, the values were 16.93mm, 22.01mm and 432.83mm^2 respectively (Table 1).

Overall, the height of the left sinus is significantly greater as compared to the right sinus ($p < 0.05\%$). The left sinus had a mean height of 29.34mm (8.75) whereas the right sinus had a mean height of 18.96mm (6.45) Overall, the width of the right sinus is significantly greater than that of the the left sinus ($p < 0.05\%$). The left sinus had a mean width of 16.96mm (6.36) whereas the right sinus had a mean width of 23.55mm (10.62) Overall, the area of the left sinus is significantly larger as compared to the right sinus ($p < 0.05\%$). The left sinus had a mean area of 578.61mm^2 (238.50) whereas the right sinus has a mean area of 472.38mm^2 (198.03) (Table 2).

Table 1. Gender wise comparison of the frontal sinus measurements (Mann Whitney U test)

	Sex	Mean (SD)	Mean difference	95% CI of difference		U statistic	p-value
				Lower	Upper		
Left height	Male	30.75(7.90)	2.96	0.06	5.85	1816.00	0.009*
	Female	27.79(9.41)					
Left width	Male	18.51(5.66)	3.23	1.17	5.30	1627.00	0.001*
	Female	15.28(6.69)					
Left area	Male	620.11(211.86)	86.72	7.98	165.45	1850.00	0.01*
	Female	533.39(258.56)					
Right height	Male	20.82(6.47)	3.89	1.83	5.96	1647.00	0.001*
	Female	16.93(5.83)					
Right width	Male	24.96(10.19)	2.95	-0.57	6.48	2026.00	0.08(NS)
	Female	22.01(10.94)					
Right area	Male	508.67(188.94)	75.84	10.59	141.09	1882.00	0.01*
	Female	432.83(201.50)					

*P < 0.05 statistically significant, P > 0.05 non-significant, NS

Table 2. Overall differences in measurements of frontal sinus (Wilcoxon Sign Rank test)

		N	Mean(SD)	Mean difference	95% CI of difference		Z	p-value
					Lower	Upper		
Overall	Left height	140	29.34(8.75)	10.37	8.75	11.99	-9.12	<0.001*
	Right height	140	18.96(6.45)					
	Left width	140	16.96(6.36)	-6.58	-8.15	-5.011	-6.62	<0.001*
	Right width	140	23.55(10.62)					
	Left area	140	578.61(238.50)	106.23	71.29	141.16	-5.46	<0.001*
	Right area	140	472.38(198.03)					

Wilcoxon Sign Rank test *P < 0.05 statistically significant, P > 0.05 non-significant, NS

Table 3. Logistic regression combining all the variables

	B	P-value	Odds Ratio	95% C.I. for Odds ratio		Percentage of correct classification
				Lower	Upper	
Left height	-.03(0.05)	0.55(NS)	0.97	0.87	1.07	68.6%
Left width	-.08(0.05)	0.12(NS)	0.92	0.83	1.02	
Left area	.002(0.002)	0.46(NS)	1.00	0.99	1.01	
Right height	-.13(0.04)	0.007*	0.88	0.80	0.97	
Right width	-.01(0.03)	0.75(NS)	0.99	0.92	1.06	
Right area	0.002(0.002)	0.39(NS)	1.00	0.99	1.01	
Constant	3.06(.94)	0.001*	21.27			

Variable(s): left height, left width, left area, right height, right width, and right area. Model chi- square value = 19.54, p = 0.003; -2 Log likelihood- 174.28; Cox and Snell R Square = 0.13; Nagelkerke R Square = 0.17; *P < 0.05 statistically significant p > 0.05 non-significant, NS

When logistical regressions for individual parameters were carried out, the accuracy rate for correct classification for left height, width area was 62.1%, 63.6% and 58.6% respectively, whereas for right height, and area was 64.3% and of 57.9% respectively. It was observed that the model including right width as a predictor does not provide a significant fit to the data ($p > 0.05$). For determining whether an individual is male or female, right height was a better predictor than any other parameter. After relating all the variables, an accuracy rate of 68.6% for the correct classification of an individual as male or female was achieved (Table 3).

Discussion

Numerous studies have highlighted the importance of the radiographic measurements of frontal sinus in gender determination. The radiographic techniques employed have ranged from conventional Caldwell views to the more advanced computed tomographic techniques. The majority of these studies have highlighted the uniqueness of the frontal sinuses in every individual.

In the present study, it was observed that out of 150 patients, 140 (93.3%) had bilateral frontal sinuses, 8 (5.3%) had unilateral frontal sinuses and only 2 (1.3%) had a complete absence of frontal sinuses and sex differences in size were also observed. On the contrary, a study conducted by Chrtstine. Hanson and Douglas w. Owsley on 143 Eskimo skulls showed variations in the results. There were no sex differences in the size of the sinuses, which were small and bilaterally absent, which could have resulted from variations in the population studied and the radiographic technique used[15].

Although this study used the paranasal sinus view which has been less employed for gender determination purposes, the mean values of the measurements assessed were significantly higher in males ($p < 0.05\%$) as compared to females which are in accordance with Comargo JR, *et al.*,[10] Jose Marcos Pond, *et al.*,[16] Mathew K Lee, *et al.*,[17] Twana Muhammad Raoof, *et al.*,[18] Hemant Mathur, *et al.*,[19] Chetan Belaldavar, *et al.*,[20] and Neha Garg, *et al*[21].

In the present study comparing left sinus dimensions between males and females, males had a significantly higher, wider and larger ($p < 0.05$) left sinus as compared to females. On comparing right sinus dimensions between males and females, males had a significantly higher and larger ($p < 0.05$) right sinus as compared to females, which is in accordance to Camargo JR, *et al.*,[10] Rubira-Bullen, *et al.*,[22] Twana Muhammad Raoof, *et al.*,[18]. Whereas another finding that was observed in the present study was that the difference in right sinus width in males as compared to females was not statistically significant ($p > 0.05$). This result is not in accordance with the inferences by, Chetan Belaldaver, *et al.*,[20] and Neha Garg, *et al*[21]. This variation of results could be due to geographic variation, different radiographic projection, the age limit followed in their study, and the sample size.

The logistic regression analysis in the present study showed that the accuracy rate in correct classification using all the variables was 68.6% and it ranged from 57.9% to 64.3% when individual variables were used. Of all the variables used, right height was found to be a better regressor and provided an accuracy rate of 64.3%. These results are in accordance with the studies conducted by Camargo, *et al.*,[10] Beladavar, *et al.*,[20] Neha Garg, *et al.*,[21] which reported accuracy rates of over 50%.

In the present study, no emphasis was given on the shape of the frontal sinus; only its height, width and area were focused on for sex determination. As the study was exclusively conducted on the western UP population, inter-racial differences cannot be concluded. The current study demonstrates that in a specific population, obtaining an average range of morphometric values of the frontal sinus can be a useful tool for determining an individual's sex.

In conclusion, the results of this study indicate that the radiographic dimensions of the frontal sinuses can be utilised as a dynamic tool in determining the gender of an individual. The present study is distinctive in that a paranasal sinus view has been employed to study the height, width and area of the frontal sinus. In our study, however, emphasis was not laid on the shape of the frontal sinuses. Further studies on paranasal sinus views with additional parameters such as shape of the sinus, inter-racial differences, and a larger sample size would aid in justifying our findings and providing a simple, economical and unique system for gender identification.

References

1. Pallagatti S, *et al.* Maxillofacial imaging: An emerging tool in forensic science. Journal of Forensic Research. 2011; 2(6):1-3.
2. Shahin KA, Chatra L and Shenai P. Dental and craniofacial imaging in forensics. Journal of Forensic Radiology and Imaging. 2013; 1:56-62. https://doi.org/10.1016/j.jofri.2012.12.001

3. Kullman L, Eklund E and Grundin R. The value of the frontal sinuses in the identification of the unknown persons. J. Forensic Odonstostomatol. 1990; 8(1):3-10.
4. Reichs KJ. Quantified comparisons of the frontal sinus pattern by means of the computed tomography. Forensic Sci. Int. 1993; 61(1-2):141-168. https://doi.org/10.1016/0379-0738(93)90222-V
5. Wood R. Forensic aspects of maxillofacial radiology. Forensic Science International. 2006; 159S:S47-S55. https://doi.org/10.1016/j.forsciint.2006.02.015
6. Maurya M, Narvekar S, Naik S and Shet S. Computerized approach for dental identification using radiographs. International Journal of Scientific Research Publications. 2013; 3(5):1-5.
7. Fatu CO, Puisoru M, Rotaru M, *et al.* Morphometric evaluation of the frontal sinus in relation to age. Ann Anat. 2006; 188(3):275-280. https://doi.org/10.1016/j.aanat.2005.11.012
8. Kim GR. A morphological study on paranasal sinuses in Koreans. Yonsei Medical Journal. 1962; 3(1):11-17. https://doi.org/10.3349/ymj.1962.3.1.11
9. Tatlisumak E, Ovali GY, Aslan A, Asirdizer M, Zeyfeoglu Y and Tarhan S. Identification of unknown bodies by using CT images of frontal sinus. Forensic Science International. 2007; 166:42-48. https://doi.org/10.1016/j.forsciint.2006.03.023
10. Camargo JR, *et al.* The frontal sinus morphology in radiographs of Brazilian subjects: Its forensic importance. Brazilian Journal of Morphol. Science. 2007; 24(4):239-243.
11. Ferreira da Silva R, Pinto RN, Ferreira GM and Daruge EJ. Importance of frontal sinus radiographs for human identification. Brazilian Journal of Otorhinolaryngology. 2008; 74(5):798. https://doi.org/10.1016/S1808-8694(15)31396-3
12. Neha, Mohan V, Kumar JS and Kumar SC. Morphometric evaluation of Frontal sinus in relation to Gender - A forensic study. University Journal of Dental Science. 2015; 1(2):7-11.
13. Hanson Cl and Owsley DW. Frontal sinus size in Eskimo populations. Am. J. Phys. Anthropol. 1980; 53(2):251-255. https://doi.org/10.1002/ajpa.1330530209
14. Szilvassy J. Development of the frontal sinuses. Anthropol Anz. 1981; 39(2):138-149.
15. Chrtstine L Hanson and Douglas Owsley W. Frontal Sinus in Eskimo Populations. American Journal of Physical Anthropology. 1980; 53:251-255 https://doi.org/10.1002/ajpa.1330530209
16. Ponde JM, Andrade RN, Via JM, Metzger P and Teles AC. Anatomical Variations of the Frontal Sinus. International Journal of Morphol. 2008; 26(4):803-808. https://doi.org/10.4067/S0717-95022008000400003
17. Lee MK, Sakai O and Spiegel Jeffrey H. CT measurement of the frontal sinus. Gender differences and implications for frontal cranioplasty. Journal of Cranio-maxillo-facial Surgery. 2010; 38:494e-500. https://doi.org/10.1016/j.jcms.2010.02.001
18. Raoof TM, Saeed KA, Mahmood KA. Anatomical variation of frontal sinuses evaluated by CT scan in relation to age and sex in Sulaimani city. JSMC. 2013; 3(1):33-45. https://doi.org/10.17656/jsmc.10029
19. Mathur H, Mathur A, Ahmed J, Khorate M and Tripathi P. Conventional Frontal Sinus Imaging in Identification of Sex: Original Study in Population of Udaipur City, India. Journal of Medical Science and Clinical Research. 2013; 1(1):33-37.
20. Belaldavar C, Kotrashetti VS and Hallikerimath SR. Assessment of frontal sinus dimensions to determine sexual dimorphism among Indian adults. Journal of Forensic Dental Sciences. 2014; 6(1):25-30. https://doi.org/10.4103/0975-1475.127766
21. Garg N, Mohan V, Kumar JS and Kumar SC. Morphometric evaluation of Frontal sinus in relation to Gender - A forensic study. University Journal of Dental Science. 2015; 1(2):7-11.
22. Rubira-Bullen IRF, Rubira, Sarmento VA and Azevedo RA. Frontal sinus size on facial plain radiographs. J. Morphol. Sci. 2010; 27(2):77-81.

How to cite this article: Shah S. Evaluation of Frontal Sinus Morphology in Gender Determination by Using PNS View in U.P. Population: A Radiomorphometric Study. J Forensic Dent Sci. 2021; 13(3):192-196.

Access this article online	
Website: www.jfds.org	**Quick Response Code**