ORIGINAL RESEARCH

Radiomorphometric Analysis of Frontal Sinus for Gender Determination in Rayalaseema.

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Abstract

Background: In the process of identifying unidentified human remains, sex determination is an important stage. In order to identify remains and determine gender, frontal sinus radiography has been performed.

Aim: The present study was aimed to determine the frontal sinus measurement and assess its application in gender determination among the rayalaseema population.

Materials and Methods: A total of 40 individuals (20-male and 20-female) aged between 25-30 years were included in the study for which height, width and area of frontal sinus was determined using posteroanterior view radiographs and were transferred to the Radiant Dicom viewer for the measurements of frontal sinuses.

Statistical analysis used: The data thus obtained was analysed by Student's t-test for comparison of the means of the dimensions measured for the two genders. The stepwise method was used to select the variables and composition of the mathematical model, where the variables were added and removed until the model was defined.

Results: Significant differences were observed for frontal sinus height, width and area between males and females.

Conclusion: Determining the sex of unidentified human remains is a crucial step in the identification process. Frontal sinus radiography has been carried out to locate the remains and establish the gender.

Keywords: Gender, Imaging, frontal sinus, sex determination and Forensic Odontology

Introduction

When applied in the modern context, where incidents like plane crashes result in the fragmentation of individual bones, efforts are focused on the determination of sexual dimorphism via radiological techniques. This is one of the most ancient areas of interest for the forensic sciences: determining age, sex, race, and stature in order to create a biological profile[1]. Mass casualty or mass devastation situations are becoming more frequent in today's kaleidoscopic globe. In these circumstances, determining gender becomes crucial since it can immediately positively rule out a number of options. In addition, gender differentiation in the context of forensic science is essential for creating a biological profile of human remains. Because each person's frontal sinus has a different morphology, assessing it is one of the most distinctive and trustworthy ways to identify a person[2]. Anatomically, the frontal sinuses are two pneumatic cavities covered with mucosa that develops from an ethmoidal cell during embryonic development. They are located in the back of the superciliary arcs, between the internal and external faces of the frontal bone[3]. The septum that separates them generally deviates from the midline, and they are rarely symmetrical in general. At birth, they are not discernible, but they start to develop in the second year of life. When viewed on a radiograph, they first appear around the ages of 5 or 6, grow slowly through puberty, and are fully mature by the time an individual is 20 years old[4]. Frontal sinuses are important for forensic sex analysis because of their distinctive layout.

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Researchers generally agree that no two frontal sinuses have exactly the same pattern. Even in monozygotic twins, the frontal sinus is as distinctive to each person as a fingerprint[5]. Frontal sinus radiography may be employed since sinus series examinations frequently expose it[6]. Adult male and female subjects can be used to examine adult male and female sinuses using linear and area measurements because changes in adult sinuses are uncommon and they often remain stable throughout life[7]. Present study was aimed to determine the frontal sinus measurement and to ascertain the gender of individuals among the Rayalaseema population.

Methods and Methodology

The study was conducted in the Department of Oral Medicine and Radiology, G. Pulla Reddy Dental College and Hospital, Kurnool, Andhra Pradesh, India. Ethical clearance was obtained from Institutional Ethical Committee. 40 individuals comprising of 20 males and 20 females of age group 25 to 30 years were included in the study. (The subjects included in the study were healthy individuals without any pathology in the sinus and the duration of study is about 1 year and 2 months). The reason for age criteria was due to the fact that the growth of frontal sinus completes or attains its development by 20 years and as age progresses the walls become thinner and hence, appears larger.

Patients with history of orthodontic treatment, hereditary facial asymmetries, orthognathic surgery, history of maxillofacial trauma, any surgery of the skull, history or clinical characteristics of endocrine disturbances or hereditary were excluded. Poster anterior Radiographs were taken with frontonasal support were evaluated. The source to object distance was kept constant at 1.44 cm and using an exposure of 80 kvp and a time of 2.5 sec at 10 mA the exposures were made using a panoramic machine with cephalometric function. The radiographic images were saved as high resolution JPEG file. The digitized radiographs were analysed using Radiant dicom viewer.

Radiographs taken were transferred to the Radiant Dicom viewer for the measurements of frontal sinuses. The separation of the left and right sides of the frontal sinus was based on the frontal sinus "septum" which denotes the margin between the two main sinus cavities, as it continues from the nasal septum up through the sinuses. The morphology remains practically unchanged during one's entire adult life. For measuring the

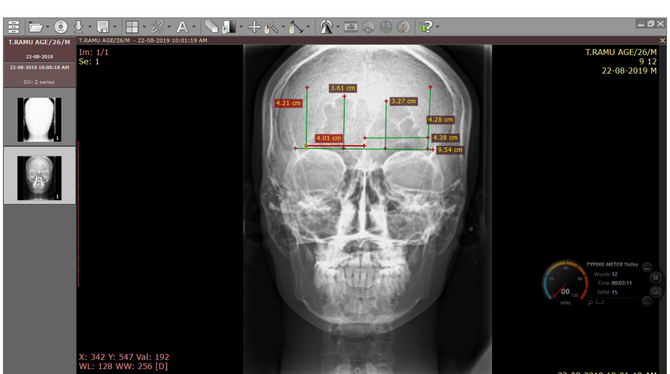


Fig. 1: Radiograph showing linear measurements

dimensions of frontal sinus, a baseline along the upper limit of both orbital cavities was drawn. All these measurements where obtained only for the portion projecting above the baseline (A). The separation of the left and right side of the frontal sinus was based on the frontal sinus "septum" which denotes the margin between the two main sinus cavities, as it continues from the nasal septum up through the sinuses[9]. This was done to permit quantifying one width only on each side[10]. Greatest height of each side was determined from the maximum distance between the base and upper lines of the frontal sinus. Width of the frontal sinus was determined from the maximum distance between the medial and lateral lines of the right and left side of the frontal sinus, Area was measured[8]. The linear measurements obtained from each radiograph were expressed in linear millimeters (mm) and the areas in square millimeters (mm2). The data thus obtained was analysed by Student's t-test for comparison of the means of the dimensions measured for the two genders. The stepwise method was used to select the variables and composition of the mathematical model, where the variables were added and removed until the model was defined.

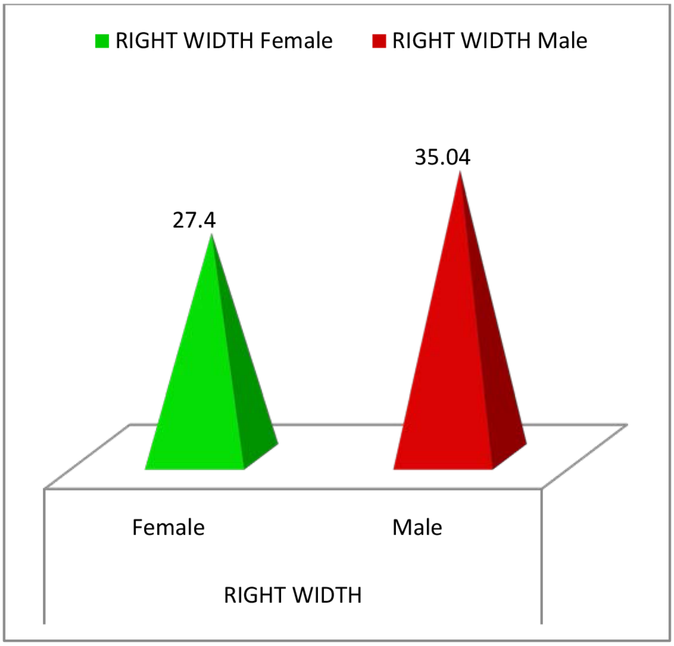
Parameters:

- Baseline
- Maximum Left Height
- Maximum Right Height
- Maximum Area on Right Side
- Maximum Area on Left Side
- Maximum Left Width
- Maximum Right Width

For measuring the dimensions of frontal sinus, a baseline along the upper limit of both orbital cavities was drawn. All these measurements where obtained only for the portion projecting above the baseline (A). The separation of the left and right side of the frontal sinus was based on the frontal sinus "septum" which denotes the margin between the two main sinus cavities, as it continues from the nasal septum up through the sinuses[9]. This was done to permit quantifying one width only on each side[10]. Greatest height of each side was determined from the maximum distance between the base and upper lines of the frontal sinus. Width of the frontal sinus was determined from the maximum distance between the medial and lateral lines of the right and left side of the frontal sinus, Area was measured[8]. The linear measurements obtained from each radiograph were expressed in linear millimeters (mm) and the areas in square millimeters (mm2) as shown in Figure 1.

Results

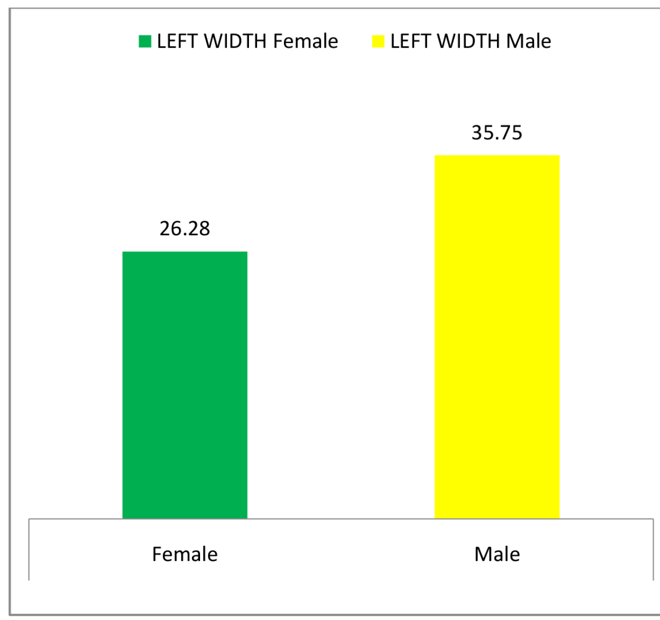
The raw data from the measurements were entered into SPSS for statistical analysis. Among a total of 40 samples taken. Student`s t test was employed to compare the means of the groups for all the response variables studied. The results obtained are presented in Table 1. There was no significant difference between the mean age group, left width, left height, right width, and right height. But the variables pertaining to the left area, right area, and the total area were found to be statistically significant. The means for the measurements for men were consistently greater than those for women. Based on the findings of the Student's t test the parameters most suited for the determination of an individual`s gender were, left area, right area and total area. A logistic regression model was then developed based on logit link function and the female sex. Parameters of the model were determined that allowed the prediction of probability of relevance of the cranium to the female gender. Right width of both male and female was 35.04 and 27.4 respectively as shown in Graph 1. Left width of both male and female was 35.75 and 26.28 respectively as shown in Graph 2. Left height of male and female was 24.60 and 11.53 respectively as shown in Graph 3. Right height of male and female was 24.71 and 12.575 respectively as shown in Graph 4. Right area of both male and female was 880.42 and 348.53 respectively as shown in Graph 5. Left area of both male and female was 892.93 and 304.98 respectively as shown in Graph 6. Total area of both male and female was 1771.71 and 637.19 respectively as shown in Graph 7. The study of selection of variables detected that the area (total, right and left) was more suited for determining gender. The results of the analysis with sex as dependent variable are illustrated likelihood for



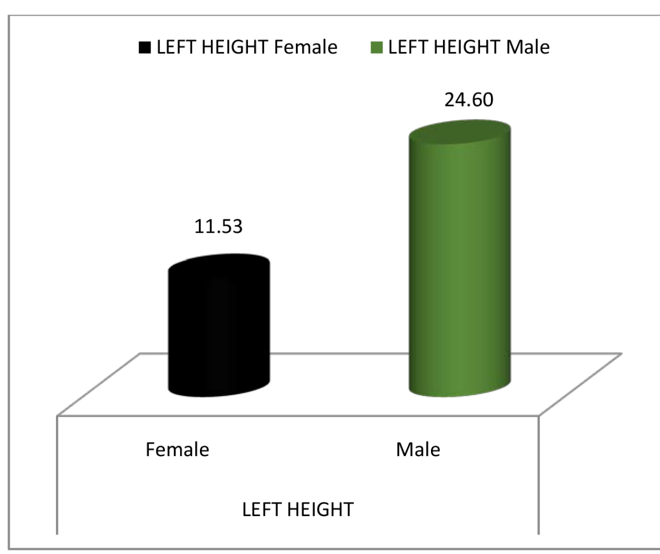
Graph 1: Right Width

Table 1: The means of the groups for all the response variables

		Mean	SD	t Value	P Value
Gender	Female	26.38889	1.500545	1.57487	0.124826 NS
	Male	27.23529	1.678147		
Left Width	Female	26.28333	6.314433	5.11287	0.0001 S
	Male	35.75882	4.423666		
Left Height	Female	11.53611	3.632543	7.5166	0.0001 S
	Male	24.60588	7.579617		
Left Area	Female	304.9883	140.6824	7.28595	0.0001 S
	Male	892.9318	333.4148		
Right Width	Female	27.4	5.965883	4.08683	0.000351 S
	Male	35.04118	3.915523		
Right Height	Female	12.575	3.756607	6.83821	0.0001 S
	Male	24.71882	9.398308		
Right Area	Female	348.5344	165.6037	6.55479	0.0001 S
	Male	880.4201	388.8078		
Total Area	Female	637.1917	308.7281	7.06691	0.0001 S
	Male	1771.716	704.2232		



Graph 2: Left Width

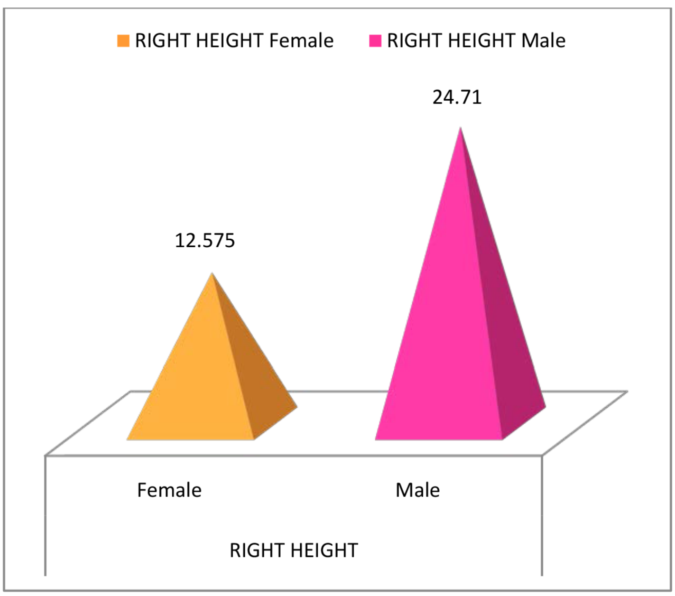


Graph 3: Left Height

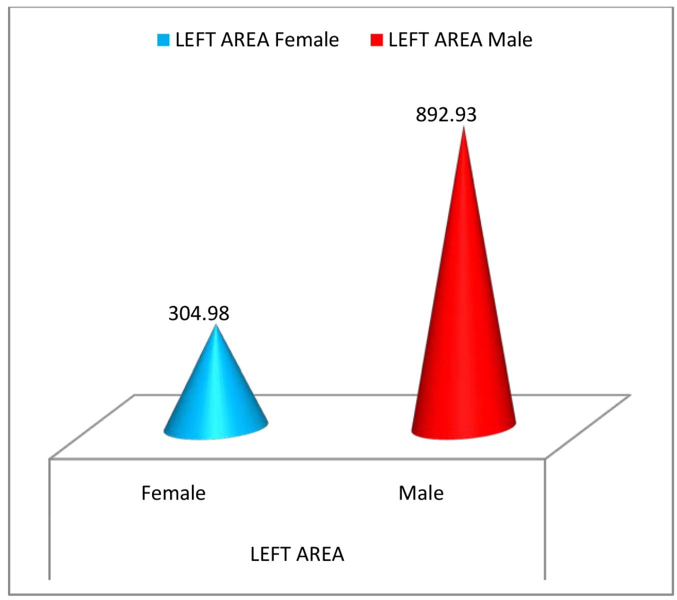
left area, right area and total area were 892.93, 880.42, 1771.71 respectively. For all of these the P value was found to be significant. Nonetheless, this success rate is more favourable than that for the prediction of gender based on chance with 50% probability of error.

Discussion

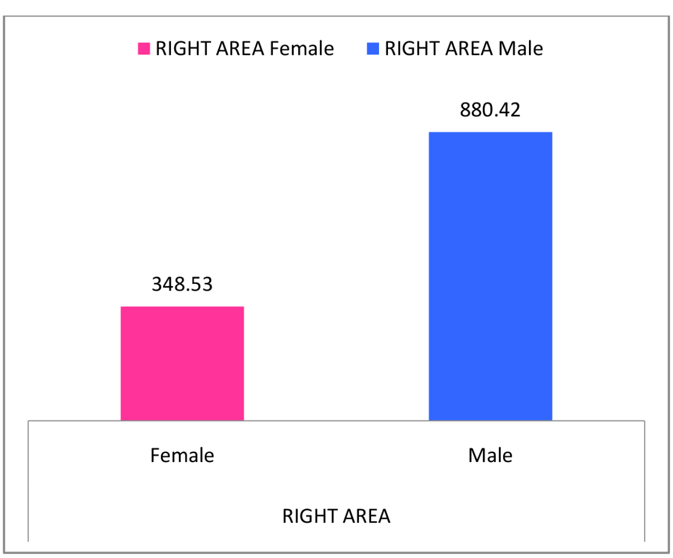
For individualised, social, and legal reasons, identification of human remains is necessary[20]. The first report on the use of radiography for identification was made in 1921 by Schuller[21]. The frontal sinus, which is one of the paranasal sinuses, is the one that is most significant and of importance in forensic identification because of its unique properties, which make the frontal bone distinctive for each individual, much like fingerprints[22, 23, 24]. The core of forensic odontology is dental identification using radiographs. Zukerkandl (1875), who drew attention to the frontal sinus' asymmetric anatomy, made the first observation of its uniqueness[11]. Culbert and Law described the first frontal sinus morphology-based identification of a human that was authorised in a legal proceeding in the United States in their article (1927)[12]. In earlier research, the sinuses were repeatedly measured, and the probabilities of each measurement were then combined[13,14]. The degree of metric differentiation of the frontal sinus is supported by probability analysis[15,16]. In accordance with all of previous investigations, we determined the gender of people within the Rayalaseema community using posteroanterior skull radiographs. The sample size employed was 40, 20 each of males and females between the ages of 25 and 30. The overall prevalence of bilateral frontal sinus absence in our investigation was 0%. Similarly, to how the Unilateral frontal sinus absence was 0%. Therefore, there is no discernible difference in the absence of



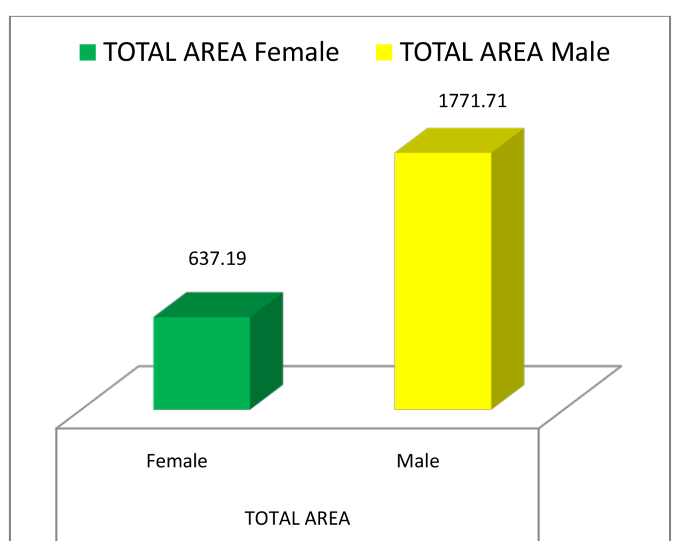
Graph 4: Right Height



Graph 5: Right Area



Graph 6: Left Area



Graph 7: Total Area

sinuses between the sexes. The increased size of the frontal sinuses in males compared to females has been confirmed by radiological studies by Schuller (1943)[17], same as in our study males have larger and prominent frontal sinuses than females. Our study was in accordance with their findings and the total area of males were significantly larger than females i.e. 1771.71. and 637.19 respectively. The mean values of left and right width of males and females was 35.75, 35.04 and 26.28, 27.4 respectively. The mean values of left and right height of frontal sinus in males is more than females i.e. 24.60, 24.71 and 11.53, 12.575 respectively. The student's P value is determined to be substantial, and these criteria primarily affected the assessment of gender. According to Brown, males have a noticeably bigger sagittal diameter[17], Similar findings were noted by Camarago et al.,[18] while in our study, even though the men' right and left sagittal diameters were bigger than those of the females, it was not statistically significant. Genetic factors predominate over dietary, hormonal, and muscular factors in determining the physical differences in the cranium between the sexes[18, 25]. The larger frontal sinus in males than in females may be attributed to these characteristics. The development of technical and approachable factors, such as assessment of the area, symmetry, and form of the frontal sinus, was inspired by the need to provide a trustworthy, affordable, and easily reproducible method for human identification[18]. Christenson (2005) employed an elliptical Fourier analysis to compare Euclidian distances, however it was a very labor-intensive and resource-intensive process[19]. Therefore, the construction of a low-cost system in the Indian context is a goal of our study as well. This is done so that the disaster management organisations in our nation may better meet the financial constraints that frequently affect them. A number of restrictions apply to the study. First off, because the sinuses in children fluctuate in size due to their development, this research is constrained by the age of the subjects because we are only looking at the age range of 25 to 30 years. Second, when exposing the radiographs for the bone remnants which in some circumstances may prove to be challenging the laws of radiology should be strictly followed. Thirdly, to estimate the area for research purposes, a mathematical technique utilising square grids was used. It should be used in the field with a measurement device that is more accurate, has the smallest margin of error, and is not prone to fluctuations between or within observers.

Conclusion

A crucial component of forensic odontology is gender identification, although there are no studies that provide conclusive frontal sinus values. The field of forensic sciences will greatly benefit from the digitalized storage of the morphological properties of each person's frontal sinus within a specified population. Since male frontal sinus measurements are larger than female ones in our investigation, they provided the highest degree of accuracy for radiographically identifying a person's gender. Therefore, the frontal sinus measures can be used in forensic studies to determine gender. However, we advise further research using new metrics and larger, more representative samples in order to more precisely determine the people.

References

1. Giles E. Sex determination by discriminant function analysis of the mandible. Am J Phys Anthropol1964;22:12936.
2. Walsh M, Reeves P, Scott S. When disaster strikes; the role of the forensic radiographer. Radiography 2004;10:3343.
3. Naikmasur VG, Shrivastava R, Mutalik S. Determination of sex in South Indians and immigrant Tibetans from cephalometric analysis and discriminant functions. Forensic Sci Int 2010;197:122.e16.
4. Schuller A. A note on the identification of skulls by xray pictures of the frontal sinuses. Med J Aust1943;1:5546.
5. Tang JP, Hu DY, Jiang FH, Yu XJ. Assessing forensic applications of the frontal sinus in a Chinese Han population. Forensic Sci Int 2009;183:104.e13.
6. Wood RE. Forensic aspects of maxillofacial radiology. Forensic Sci Int 2006;159:S4755.
7. Ribeiro Fde A. Standardized measurements of radiographic films of the frontal sinuses: An aid to identifying unknown persons. Ear Nose Throat J 2000;79:2633.
8. Available from: http://www.mathmate.com/chapter 28_1. shtml [Last accessed on 2011 Sep 22].
9. Besanna JL, Rogers TL. Personal identification using the frontal sinus. J Forensic Sci 2010;55:5849.
10. Camargo JR, Daruge E, Prado FB, Caria PH, Alves MC, Silva RF, et al. The frontal sinus morphology in radiographs of Brazilian subjects: Its forensic importance. Braz J Morphol Sci 2007;24:23943.
11. Zukerkandl E. Lichtwitz L, Garnault P. vol-1., Anatomy of the frontal sinus. In normal and pathological anatomy of the nasal cavity. Paris: G Masson; 1895. p. 34961.
12. Culbert Wl, Law FM. Identification by comparison of roentgenograms of nasal accessory sinuses and mastoid processes. JAMA 1927;88:16346.
13. Ribeiro Fde A. Standardized measurements of radiographic films of the frontal sinuses: An aid to identifying unknown persons. Ear Nose Throat J 2000;79:2633.
14. Harris AM, Wood RE, Nortjé CJ, Thomas CJ. The frontal sinus a forensic fingerprint? A pilot study. J Forensic Odontostomatol1987;5:915.
15. Chiba M, Terazawa K. Estimation of stature from somatometry of skull, Forensic Sci Int 1998;97:8792.
16. Kullman L, Eklund B, Grundin R. The value of the frontal sinus in identification of unknown persons. J Forensic Odontostomatol1990;8:310.
17. Pondé JM, Andrade RN, Via JM, Metzger P, Teles AC. Anatomical Variations of the frontal sinus. Int J Morphol2008;26:8038.
18. Quatrehomme G, Fronty P, Sapanet M, Grevin G, Bailet P, OllierA. Identification by frontal sinus pattern in forensic anthropology. Forensic Sci Int 1996;83:14753.
19. ChristensenAM. Testing the reliability of frontal sinuses in positive identification. J Forensic Sci 2005;50:1822.
20. Soman BA, Sujatha GP, Lingappa A. Morphometric evaluation of the frontal sinus in relation to age and gender in subjects residing in Davangere, Karnataka. J Forensic Dent Sci 2016;8:57
21. Doggalli N, Kumar A, Patil K. Frontal sinus as a tool in identification. Int J Forensic Odontol2018;3:55
22. Pandeshwar P, Kumar N, Shastry S, Ananthaswamy A, Markande A. Sexual dimorphism of radiomorphological features of frontal sinus. Int J Forensic Odontol2017;2:46.
23. Kullman L, Eklund B, Grundin R. Value of the frontal sinus in identification of unknown persons. J Forensic Odontostomatol1990;8:3-10.
24. Reichs KJ. Quantified comparison of frontal sinus patterns by means of computed tomography. Forensic Sci Int 1993;61:141-68
25. Nethan ST, Sinha S, Chandra S. Frontal sinus dimensions: An aid in gender determination. Acta Sci Dent Sci 2018;2:2-6.