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Original Article

Determination of gender based on frontal sinus dimensions using multi-detector computed tomography

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Abstract

Background: Remains of skeleton are used for gender identification of individual. However, when the extreme post-mortem changes occur as in explosions and other mass disasters, identification and gender determination is often difficult. The skull is useful in gender assessment of skeletonized remains. Frontal sinus (FS) may be used in gender identification in recovered intact fragments. The present study is aimed to determine the gender based on frontal sinus dimensions using multi-detector computed tomography (MDCT). In our study two hundred and fifteen frontal sinuses were studied with age range from 20 to70 years with median age of 44 were selected for this study. FS dimensions for bilateral right and left sinuses (transverse, cranio-caudal & anteroposterior dimension) were measured from coronal and axial sections (4-mm slice thickness) using MDCT scanner. Transverse and craniocaudal (CC) dimensions of left frontal sinus was found statistically significant. Lower values for maximum transverse length of left FS and CC in female group were detected in comparison to the male group (p 0.002).
Methods: Hospital based retrospective study. CT images of patients were retrieved and dimension of bilateral frontal sinuses were analyzed and was recorded on a data sheet.
Results: In our study two hundred and fifteen frontal sinuses were studied with the age range from 20 to70 years with median age of 44 were selected for this study. FS dimensions for bilateral right and left sinuses (transverse, cranio-caudal dimension & anteroposterior lengths) were measured from axial and coronal sections(4-mm slice thickness) using MDCT scanner. Transverse and CC of left FS were found to be statistically significant. Lower values for the maximum transverse and CC dimensions of left FS in female group were detected in comparison to the male group (p 0.002).
It can be concluded that FS dimensions measurement especially the left transverse and CC length are valuable in studying sexual dimorphism using MDCT image.
Conclusion: From the current work, we concluded that CT scan helps in accurate measurements of FS (especially left anteroposterior length) and are valuable in differentiating gender.
Keywords: Frontal sinus, Gender differentiation , Paranasal sinus.

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Introduction

Gender determination of unknown people plays an prominent role in forensic investigations.[1] Skeletal remains are being used in gender determination. However, when extreme post-mortem changes have developed as in explosions and various other mass disasters, identification and gender determination are difficult.[2] Radiological identification of humans has a major role in forensic medicine.[3]

In gender assessment, the skull is often used; however, its fragmentation precludes the use of craniofacial markers. The sinuses therein frontal bone can also be recovered intact from the fragmented remains and can be useful in gender diferentiation.[4]

Paranasal sinuses are part of frontal sinuses and are located within the frontal bone above each eye. They consist of paired cavities communicating with the nasal fossa via infundibulum.[5]

Frontal sinuses have lot of variability because of its irregular shape which make the frontal bone unique for every individual.[6]

Also, the frontal sinuses have a strong walls and the structure of it will not change after crossing the age of 20 years except for rare occurrences as fractures, tumors or infections.[7]

Morphological or metric methodologies may be used for gender identification. Statistical methods using metric traits are more popular nowadays.[8] Computerized tomography (CT) is the imaging modality of choice in the determination of unknown human remains and could be used to evaluate the craniofacial bones and paranasal sinuses. It can provide valuable and precise measurement for frontal sinus dimensions.[9]

CT presents a lot of advantages as compared with conventional radiographs. First, it provides the opportunity of avoiding the superimposition of structures beyond the plane of interest and also it allows better differentiation of small differences in density.[10]

Figure 1: Coronal CT scan shows transverse dimension of right frontal sinus.

Figure 2: Axial CT scan shows anteroposterior dimension of right frontal sinus.

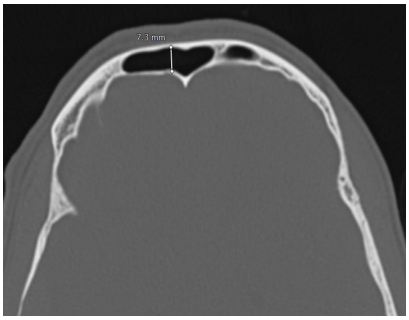
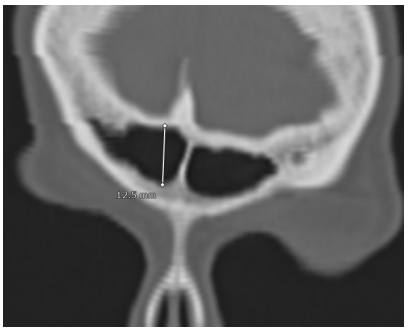


Figure 3: Coronal CT scan shows cranio-caudal dimension dimension of right frontal sinus.



Materials & Methods

a. Design of study – Hospital based retrospective study
b. Total number of study subjects – 116.
c. Inclusion criteria- All patients who underwent non-contrast computed tomography (NCCT) brain and paranasal sinuses.
d. Exclusion criteria- Post-operative status and road traffic accident involving frontal bone / sinus.

Analysis & Statistical Methods

Confidence interval (2-sided) – 95%
Power - 80%

	Group 1	Group 2	Difference
Mean	9.92	12.3	-2.4
Standard deviation	4.0	5.0	
Variance	16.6	25.2	

Sample size of Group 1 – 58
Sample size of Group 2 – 58
Total sample size - 116
Minimal sample size was 116, in our study we included 215 frontal sinuses.Sample size was calculated from the study Hamed SS, El-Badrawy AM, Fattah SA.[11]

Results

Table 1: Characteristic of study subjects.

	Right Frontal sinus	Left Frontal sinus
Mean (SD) age	44.1 (17.5)	43.9 (17.5)
Gender		
Male	59 (55.7%)	59 (54.1%)
Female	47 (44.3%)	50 (45.9%)

Table 2: Statistical differences of FS measurements in the gender groups.

		Male	Female	p-value
Right Frontal sinus	Antero-posterior	1.15 (0.41)	1.10 (0.50)	0.532
	Transverse	2.67 (0.85)	2.40 (2.18)	0.091
	Cranio-caudal	1.73 (0.63)	1.42 (0.39)	0.003
Left Frontal sinus	Antero-posterior	1.27 (0.48)	1.09 (0.41)	0.036
	Transverse	2.95 (0.80)	2.28 (0.90)	<0.001
	Cranio-caudal	1.74 (0.57)	1.29 (0.46)	<0.001

Table 3: Receiver Operator Characteristic analysis (ROC) of FS measurements in gender groups.

		ROC	p-value
Right Frontal sinus	Antero-posterior	0.526 (0.416 – 0.637)	0.642
	Transverse	0.584 (0.475 – 0.693)	0.138
	Cranio-caudal	0.587 (0.478 – 0.696)	0.125
Left Frontal sinus	Antero-posterior	0.546 (0.437 – 0.656)	0.414
	Transverse	0.669 (0.565 – 0.773)	0.003
	Cranio-caudal	0.688 (0.585 – 0.790)	0.001

Table 4: Discriminant Analysis.

		Predicted		Correct percentage
		Male	**Female**	
Observed	**Male**	42 (71.2%)	17 (28.8%)	69.8 % correctly classified
	Female	15 (31.9%)	32 (68.1%)	

Both LFS & RFS

		Predicted		Correct percentage
		Male	**Female**	
Observed	**Male**	38 (64.4%)	21 (35.6%)	57.5% correctly classified
	Female	24 (51.1%)	23 (48.9%)	

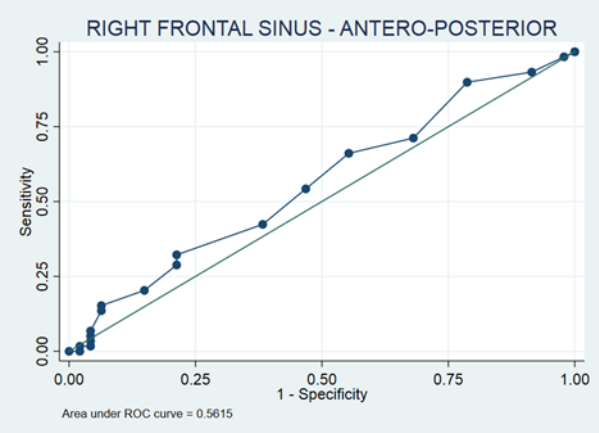
Only RFS

		Predicted		Correct percentage
		Male	**Female**	
Observed	**Male**	43 (72.9%)	16 (27.1%)	69.7 % correctly classified
	Female	17 (34.0%)	33 (66.0%)	

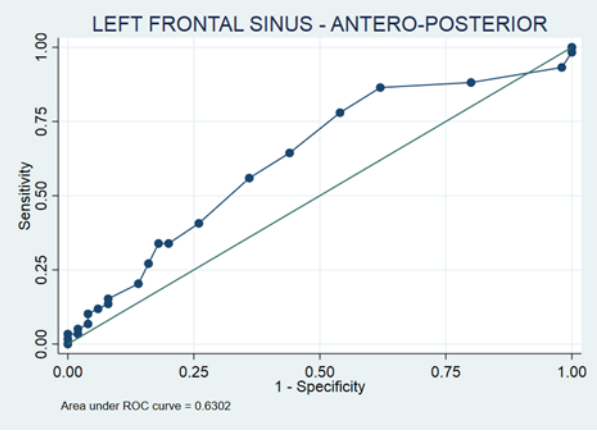
Only LFS

Graphs

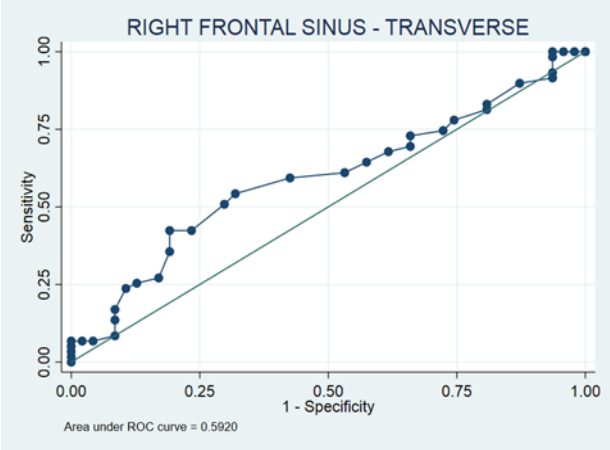
Graph 1: Antero-posterior dimension of right frontal sinus.



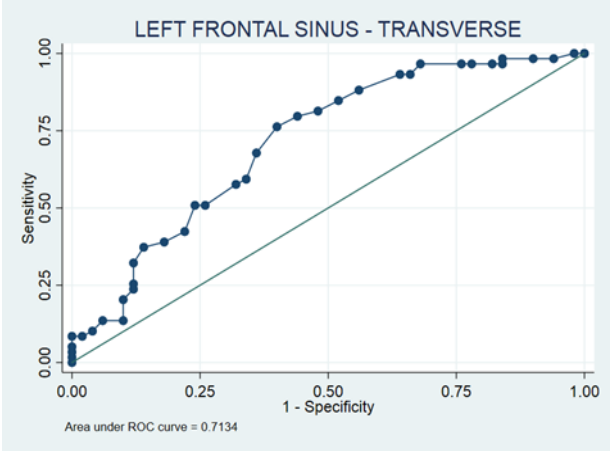
Graph 2: Antero-posterior dimension of left frontal sinus.



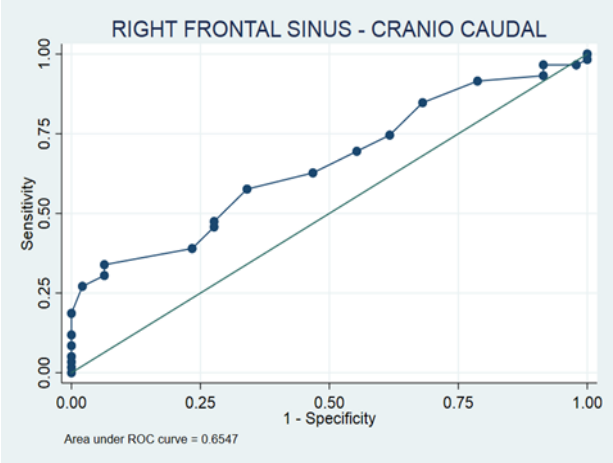
Graph 3: Transverse dimension of right frontal sinus.



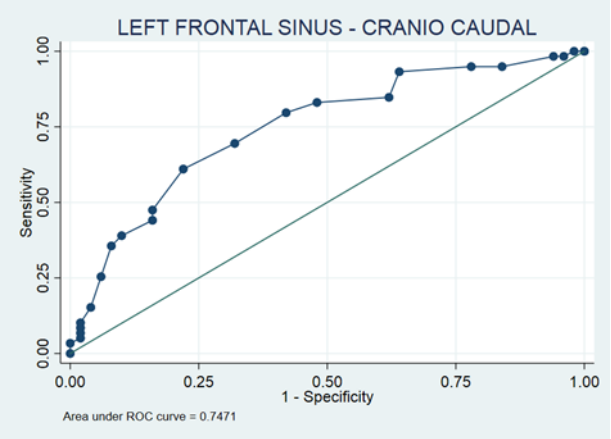
Graph 4: Transverse dimension of left frontal sinus.



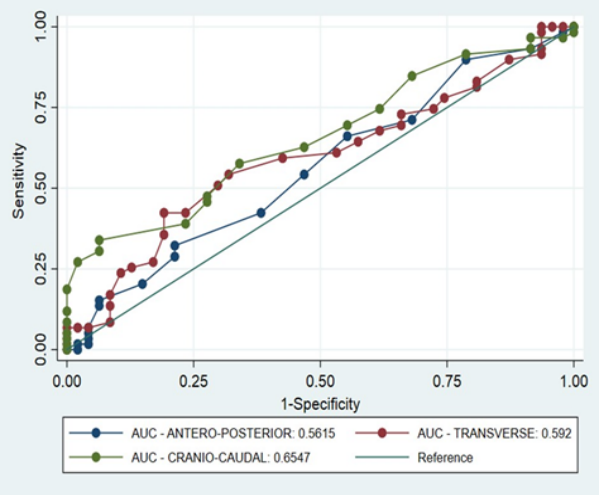
Graph 5: Cranio-caudal dimension of right frontal sinus.



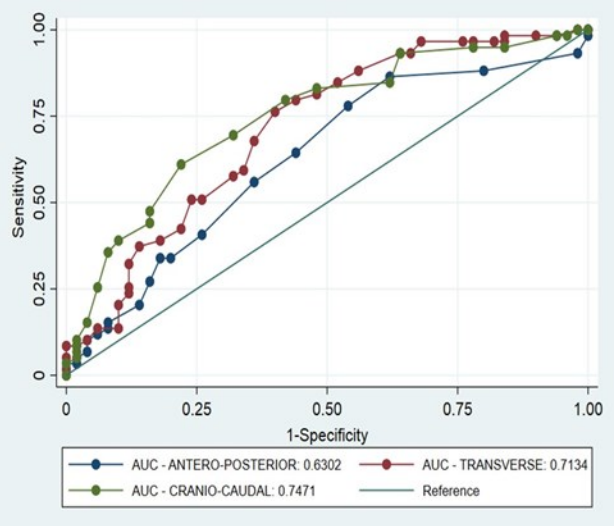
Graph 6: Cranio-caudal dimension of left frontal sinus.



Graph 7: Right frontal sinus dimensions.



Graph 8: Left frontal sinus dimensions.



Discussion

This study is being conducted to determine the accuracy and reliability of FS dimension measurements by using MDCT scanner as a method for gender identification. FS dimensions for bilateral right and left sinuses (transverse, cranio-caudal dimension & anteroposterior lengths) were measured from axial and coronal reformatted section (4-mm slice thickness) using MDCT scanner.

Subjects included in the study were above 20 years old to exclude the possibility of incomplete growth.[12]

Statistically high significant lower values of FS transverse and CC lengths on left side were detected in females in comparison to males. The present results were consistent with Lee et al.[13] who used CT imaging for comparing the gender and concluded that males had greater dimensions in most frontal sinus measurements. Similarly, Mathur et al.[13] found that demension of the frontal sinus had highly significant difference in males as compared to females.

Johnson et al.[9] and Ponde et al.[12] who also detected significantly higher anteroposterior and transverse measurements of the frontal sinus in males.

In our work, among all FS measurements the left FS transverse and craniocaudal length was the best discriminate variable between genders with overall accuracy of 69.7%. 69.7% of correct gender identification is good, however this percentage can be increased when combined with various other measurements for gender identification as seen by Uthman et al.[15] who reported higher accuracy rate of 76.9% for frontal sinus measurements to discriminate between males and females.

In the current study, the ROC curves is used for the assessment and the validity of tested variables.

In contrast, Uthman et al.[15] showed that among various cutoff points, the left frontal sinus cranio-caudal dimension was the best discriminating variable followed by the left frontal sinus transverse dimension.

For each measurement the cut-off value between sensitivity and specificity was determined and revealed that right FS anteroposterior dimension was the most sensitive and specific variable to discriminate between genders. [16]

The differences from present study may be related to nutritional, geographic and racial features.

Conclusion

From the current work, we concluded that CT scan helps in accurate measurements of FS (especially left anteroposterior length) and are valuable in differentiating gender.

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