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Original Research Article

To Compare Maxillary and Frontal Sinus Dimensions and to Assess its Reliability and Accuracy for Gender Determination Using CT scan

Asma Begum[1], Ashok Kumar Kattimani[2], Sandeep Deshmukh[3]

[1]Assistant Professor, Department of Anatomy, Fathima Institute of Medical Sciences, Kadapa, Andhra Pradesh, India

[2]Associate Professor, Department of Radiology, Bidar Institute of Medical Sciences, Bidar, Karnataka, India

[3]Professor and HOD, Department of Anatomy, Bidar Institute of Medical Sciences, Bidar, Karnataka, India

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Corresponding Author: Dr. Asma Begum

Conflict of interest: Nil

Abstract:

Computed tomography (CT) scan are excellent imaging modality to evaluate paranasal sinuses, it provides detailed information that are not available from radiographs. Morphometric knowledge about the paranasal sinuses is essential for an otolaryngologist, orthodontist and neurosurgeon to choose the most suitable surgical procedure and prevent damage to craniomaxillofacial structures. Gender determination is an important step in identification in forensic medicine; CT measurements of paranasal sinuses are useful to support gender determination. Parameters like, Width, lenghth, height of maxillary sinus together can be used for gender determination when only skull is available. There is very less literature to evaluate and compare maxillary and frontal sinuses for gender dimorphism using computed tomography. So, this study design to evaluate the reliability and accuracy of maxillary and frontal sinus for gender determination using CT and its application as an aid in forensic investigation for gender determination.

Materials and Methods: CT images of patients age group 18-40 years, admitted for CT evaluation of head and neck region without any facial trauma, previous sinus surgeries, pathological lesions involving frontal and maxillary sinus, in brims hospital bidar, Karnataka. Sample size of 75 males and 75 females can achieve a power of 80% to detect a difference of 2mm in the maxillary sinus mediolateral dimension between the males and females with pooled standard deviation of 3.6 and with a significance level of 0.05 using a 2 sided 2 sample t-test. The sample size was calculated using status at or software.

Results: The mediolateral width of maxillary sinus on right side for males was 22.51±2.82 when compared with the females 24.48±4.83showed statistically significant. The anteroposterior length of maxillary sinus on right side for males was 32.66±4.65 when compared with females 36±5.03showed statistically significant. Maxillary sinus height on right side for males was 27.81±4.82 when compared with the females 21.45±3.72 showed statistically significant. Frontal sinus height for males was 10.89±2.61 when compared with females 8.91±1.71 showed statistically significant with a p value <0.01.

Interpretation and Conclusion: Computed tomography provides an excellent method for imaging maxillofacial region. It has been stated in literature that skull remains intact despite other bones are disfigured. Personal identification is the primary area of concern in forensic from the present study results we conclude that dimensions of frontal and maxillary sinus can be used for gender dimorphism and proves vital in identifying gender of a person in forensic anthropology.

Keywords: Computed Tomography, Paranasal Sinuses.

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Introduction

Radiography was used as forensic tool for human identification, especially in cases where the body is decomposed, fragmented, or burned (Kiruba et al., 2014).[2] Historically, the application of x-ray in forensic sciences was introduced in 1986, just one year following the x-ray discovery by Prof. Wilhelm Conrad Roentgen on November 8, 1985. It was Schuller from Vienna who proposed the possibility of utilizing radiological images of the frontal sinus for identification purposes in 1921. The first complete radiological identification by using pneumatic cells of the skull was described by Culbert & Law in 1927 (Culbert & Law, 1927;

Gruber & Kameyama, 2001; Carvalho et al.,2009).[1]

By the end of the 19th Century Radiography is applied in many medicolegal and forensic anthropological investigations such as i) Age estimation (Greulich and Pyle, 1959; Murphy and Gantner, 1982) ii) Sex estimation (Krogman and Iscan, 1986)

iii) Ancestry estimation(Stewart, 1979) iv) Stature estimation (Murphy and Gantner, 1982) v) Locating and recovering bullets and other foreign bodies and determining the direction, angle and location of wounds (Eckert and Garland, 1984) vi) Detecting air-embolisms (Camps, 1969) vii) Detecting fractures and other trauma (Camps, 1969; Eckert and Garland, 1984) viii) Examining hyoid or cartilage fractures in hanging or strangulation victims (Camps, 1969; Fatteh and Mann, 1969) ix) Illustrating dental morphologies and anomalies (Eckert and Garland, 1984; Krogman and Iscan, 1986) x) Separating skeletal remains from wood charcoal and other charred material (Krognan and Iscan, 1986), xii) Detecting metallic poisons such as arsenic, lead and mercury in suspected poisoning cases (Fatteh and Mann, 1969; Schmidt and kallieris, 1982) [1]

In the last year of 20th century and first decade of 21st century, the use of radiological techniques has improved and became widespread after introduction of computed tomography (CT) by Godfrey Hounsfield in 1972. Today, forensic scientists are regularly using radiographic images as part of the autopsy procedures and forensic identification [1]. The value of radiography has become well established in the criminal and medicolegal work of police offices and medical examiners (Cornwell, 1956). Anthropologically, CT has been applied in the study of fossil skull and bite mark analysis.

Computed tomography (CT) scans are excellent imaging modality used to evaluate the paranasal sinuses, craniofacial bones, as well as the extent of pneumatisation of the sinuses and provides detailed information that is not available from standard radiographs.

Hence, CT measurements of maxillary and frontal sinuses are useful to estimate gender.[3]

Establishing positive identification of an unknown individual is important in our society for both legal and humanitarian reasons. Legally, issues of inheritance and succession to property, collection of insurance policies and pensions, administration of wills, lawsuits involving negligent parties, prosecution of homicide, detection of fraudulent deaths, accident reconstruction, issuance of a death certificate and other matters concerning property and business interactions all depend on the ability to establish a positive identification (Phrabhakaran et al., 1999; Sopher, 1972; Wentworth and Wilder, 1932).

There was very less literature to evaluate and compare maxillary and frontal sinus dimensions for gender dimorphism using Computed Tomography (CT). So this study intends to evaluate the reliability and accuracy of maxillary and frontal sinus for gender determination using CT and its application as an aid in forensic investigation for gender determination.

Materials and Methods

Sources of Data: CT images of patients age group 18-50 years, admitted for CT evaluation of head and neck region without any facial trauma, previous sinus surgeries, pathological lesions involving frontal and maxillary sinus, in brims hospital bidar Karnataka.

Method of Collection of Data:

Sample Size: 150.

Sample size of 75 males and 75 females can achieve a power of 80% to detect a difference of 2mm in the maxillary sinus mediolateral dimension between the males and females with pooled standard deviation of 3.6 and with a significance level of 0.05 using a 2 sided 2 sample-test(1). The sample size was calculated using statulator software.

Reference for sample size calculation: Ulthman AT, Al-Rawi NH, Al-Naaimi AS, AI-Timmi JF. Evaluation of maxillary sinus dimensions in gender determination using helical CT scanning. Journal of forensic sciences. 2011 Mar;56(2):403-8.

Inclusion Criteria: Patients age group 18-50 years admitted for CT evaluation of head and neck region.

CT images without any artefacts.

Exclusion Criteria:

CT images of patients with facial trauma

CT images of patients with previous sinus surgeries

CT images of patients with pathological lesions involving frontal and maxillarysinus.

Statistical Analysis: The maxillary and frontal sinus datas were transferred on Microsoft Excel 2013 software (Microsoft office Professional Plus, Microsoft Corporation, Redmond, USA). The data were analysed using SPSS version 16. The Canonical discriminant functional analysis was performed to assess whether the maxillary and frontal sinus measurements could be used for gender determination. MANOVA test was carried out to find the difference between two groups.

Multiple logistic regression was performed to generate an equation and optimum cutting score (Zc) was derived that could be reliably used to classify

the observations according to gender. The paired t-test was done for comparison of the means of the dimensions measured for the two groups and p value < 0.05 was taken as statistically significant. ANOVA test is used to correlate the measurements of maxillary and frontal sinus with age subgroups. A two-way mixed intra-class correlation coefficient was carried out to test the degree of reliability.

Results

The total sample composed of 150 subjects with 75 males and 75 females, among the subjects highest value was seen in 31-40 age group

Table 1: Canonical discriminant functions for maxillary sinus right volume between males and females

Eigenvalues				
Function	**Eigenvalue**	**% of Variance**	**Cumulative %**	**Canonical Correlation**
1	0.001[a]	100.0	100.0	0.039
a. First 1 canonical discriminant functions were used in the analysis.				
Wilks' Lambda				
Test of Function(s)	**Wilks' Lambda**	**Chi-square**	**Df**	**Sig.**
1	0.999	0.219	1	0.640

Table 2: Canonical discriminant functions for maxillary sinus left volume between males and females

Eigenvalues				
Function	**Eigenvalue**	**% of Variance**	**Cumulative %**	**Canonical Correlation**
1	0.008[a]	100.0	100.0	0.090
a. First 1 canonical discriminant functions were used in the analysis.				
Wilks' Lambda				
Test of Function(s)	**Wilks' Lambda**	**Chi-square**	**Df**	**Sig.**
1	0.992	1.195	1	0.274

Table 3: Canonical discriminant functions for maxillary sinus total distance between males and females

Eigenvalues				
Function	**Eigenvalue**	**% of Variance**	**Cumulative %**	**Canonical Correlation**
1	0.020[a]	100.0	100.0	0.140
a. First 1 canonical discriminant functions were used in the analysis.				
Wilks' Lambda				
Test of Function(s)	**Wilks' Lambda**	**Chi-square**	**Df**	**Sig.**
1	0.980	2.932	1	0.087

The measurements of maxillary sinus were subjected to canonical discriminant functional analysis (table 15 to table 23) Wilk"s lambda (MANOVA test) was carried out to find the difference between two groups .

Table 4: Canonical discriminant functions for frontal sinus width between males and females

Eigenvalues				
Function	**Eigenvalue**	**% of Variance**	**Cumulative %**	**Canonical Correlation**
1	0.002[a]	100.0	100.0	0.042
a. First 1 canonical discriminant functions were used in the analysis.				
Wilks' Lambda				
Test of Function(s)	**Wilks' Lambda**	**Chi-square**	**Df**	**Sig.**
1	0.998	0.266	1	0.606

Table 5: Canonical discriminant functions for frontal sinus length between males and females

Eigenvalues				
Function	**Eigenvalue**	**% of Variance**	**Cumulative %**	**Canonical Correlation**
1	0.001[a]	100.0	100.0	0.036
a. First 1 canonical discriminant functions were used in the analysis.				
Wilks' Lambda				
Test of Function(s)	**Wilks' Lambda**	**Chi-square**	**Df**	**Sig.**
1	0.999	0.194	1	0.659

Table 6: Canonical discriminant functions for frontal sinus height between males and females

Eigenvalues				
Function	**Eigenvalue**	**% of Variance**	**Cumulative %**	**Canonical Correlation**
1	0.205[a]	100.0	100.0	0.413
a. First 1 canonical discriminant functions were used in the analysis.				
Wilks' Lambda				
Test of Function(s)	**Wilks' Lambda**	**Chi-square**	**Df**	**Sig.**
1	0.830	27.541	1	0.0001

Similarly the measurements of frontal sinus were subjected to canonical discriminant functional analysis (table 24 - table 26) Wilk"s lambda (MANOVA test) was carried out to find out the difference between two groups.

Table 7: Predicted group membership for maxillary sinus right width

Classification Results					
Group			**Predicted Group Membership**		**Total**
			Male	**Female**	
Original	Count	Male	47	28	75
		Female	32	43	75
	%	Male	62.7	37.3	100.0
		Female	42.7	57.3	100.0
a. 60.0% of original grouped cases correctly classified.					

Table 8: Predicted group membership for maxillary sinus left width

Group			**Predicted Group Membership**		**Total**
			Male	**Female**	
Original	Count	Male	49	26	75
		Female	38	37	75
	%	Male	65.3	34.7	100.0
		Female	50.7	49.3	100.0
a. 57.3% of original grouped cases correctly classified.					

Table 9: Predicted group membership for maxillary sinus right length

Classification Results					
Group			**Predicted Group Membership**		**Total**
			Male	**Female**	
Original	Count	Male	46	29	75
		Female	18	57	75
	%	Male	61.3	38.7	100.0
		Female	24.0	76.0	100.0
a. 68.7% of original grouped cases correctly classified.					

Table 10: Predicted group membership for maxillary sinus left length

Classification Results					
Group			**Predicted Group Membership**		**Total**
			Male	**Female**	
Original	Count	Male	53	22	75
		Female	40	35	75
	%	Male	70.7	29.3	100.0
		Female	53.3	46.7	100.0
a. 58.7% of original grouped cases correctly classified.					

Table 11: Predicted group membership for maxillary sinus right height

Classification Results					
Group			**Predicted Group Membership**		**Total**
			Male	**Female**	
Original	Count	Male	61	14	75
		Female	13	62	75
	%	Male	81.3	18.7	100.0
		Female	17.3	82.7	100.0
a. 82.0% of original grouped cases correctly classified.					

Table 12: Predicted group membership for maxillary sinus left height

Classification Results					
Group			**Predicted Group Membership**		**Total**
			Male	**Female**	
Original	Count	Male	49	26	75
		Female	34	41	75
	%	Male	65.3	34.7	100.0
		Female	45.3	54.7	100.0
a. 60.0% of original grouped cases correctly classified.					

Table 13: Predicted group membership for maxillary sinus right volume

Classification Results					
Group			**Predicted Group Membership**		**Total**
			Male	**Female**	
Original	Count	Male	32	43	75
		Female	30	45	75
	%	Male	42.7	57.3	100.0
		Female	40.0	60.0	100.0
a. 51.3% of original grouped cases correctly classified.					

Table 14: Predicted group membership for maxillary sinus left volume

Classification Results					
Group			**Predicted Group Membership**		**Total**
			Male	**Female**	
Original	Count	Male	40	35	75
		Female	38	37	75
	%	Male	53.3	46.7	100.0
		Female	50.7	49.3	100.0
a. 51.3% of original grouped cases correctly classified.					

Table 15: Predicted group membership for maxillary sinus total distance between males and females

Classification Results					
Group			**Predicted Group Membership**		**Total**
			Male	**Female**	
Original	Count	Male	48	27	75
		Female	31	44	75
	%	Male	64.0	36.0	100.0
		Female	41.3	58.7	100.0
a. 61.3% of original grouped cases correctly classified.					

Table 16: Predicted group membership of frontal sinus width between males and females

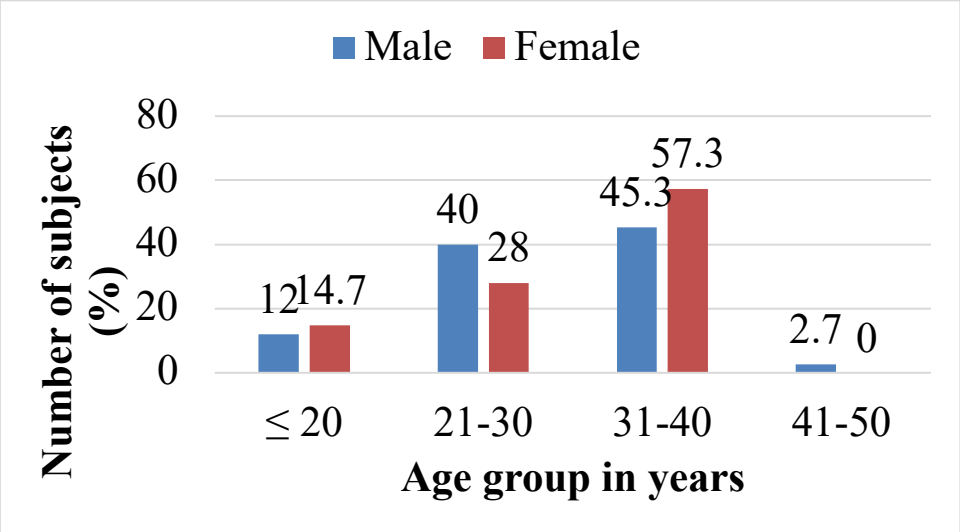
Classification Results					
Group			**Predicted Group Membership**		Total
			Male	**Female**	
Original	Count	Male	39	36	75
		Female	23	52	75
	%	Male	52.0	48.0	100.0
		Female	30.7	69.3	100.0
a. 60.7% of original grouped cases correctly classified.					

Table 17: Predicted group membership of frontal sinus length between males and females

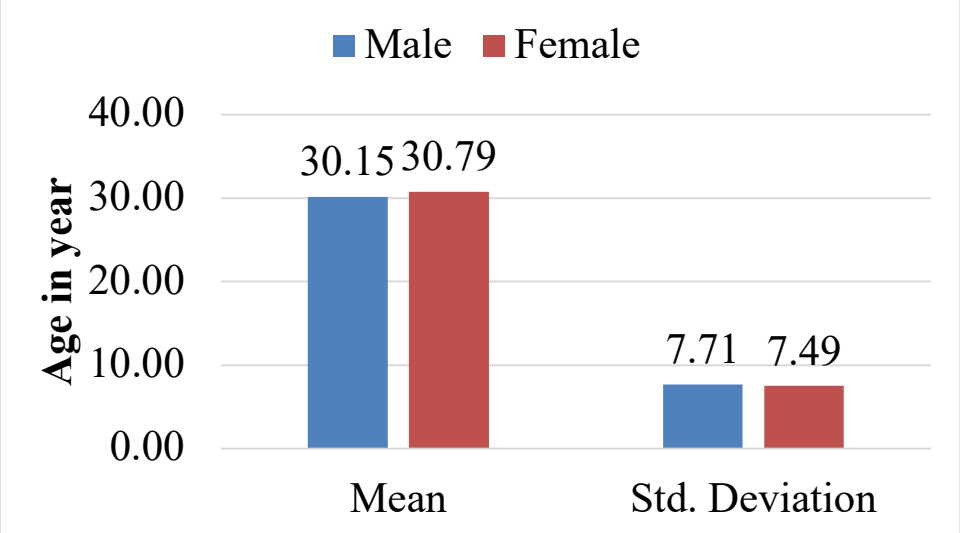
Classification Results					
Group			**Predicted Group Membership**		**Total**
			Male	**Female**	
Original	Count	Male	32	43	75
		Female	38	37	75
	%	Male	42.7	57.3	100.0
		Female	50.7	49.3	100.0
a. 46.0% of original grouped cases correctly classified.					

Table 18: Predicted group membership of frontal sinus height between males and females

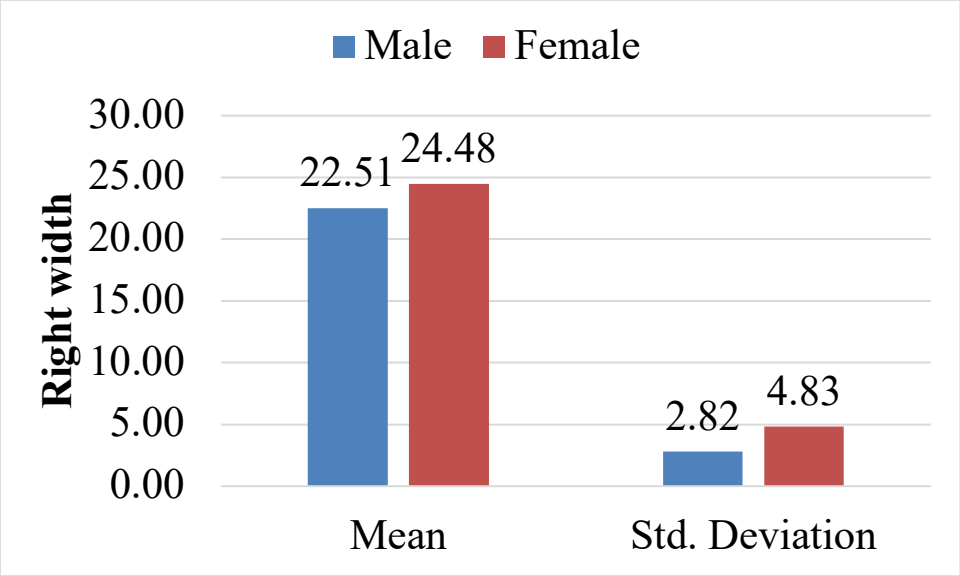
Classification Results					
Group			**Predicted Group Membership**		**Total**
			Male	**Female**	
Original	Count	Male	32	43	75
		Female	31	44	75
	%	Male	76.0	24.0	100.0
		Female	41.3	58.7	100.0
a. 67.3% of original grouped cases correctly classified.					



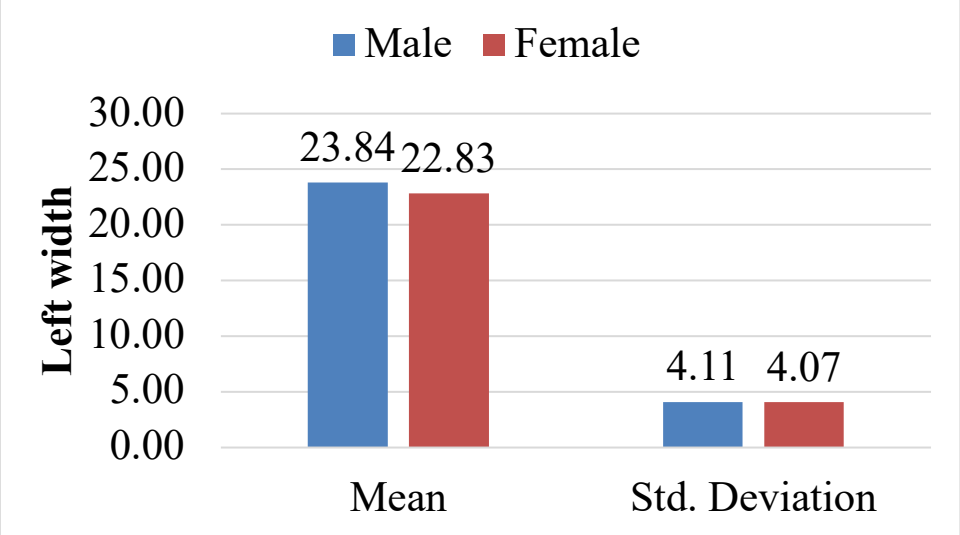
Graph 1: Distribution according to age group



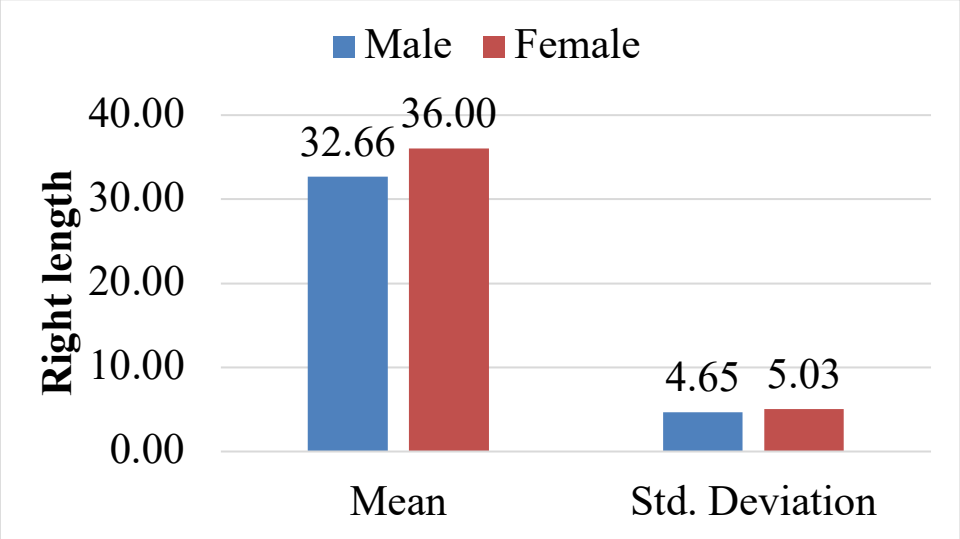
Graph 2: Comparison of age between males and females



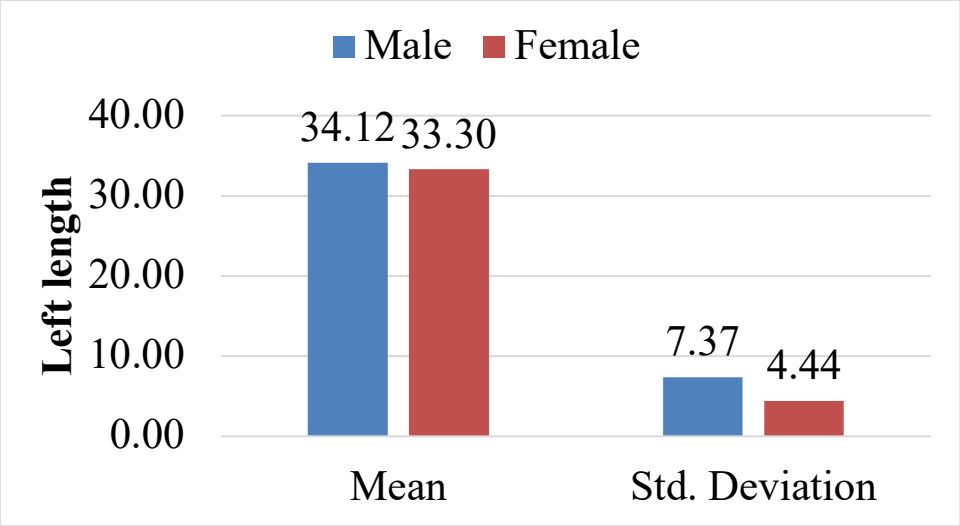
Graph 3: Comparison of Maxillary Sinus Right Width Between Males and Females



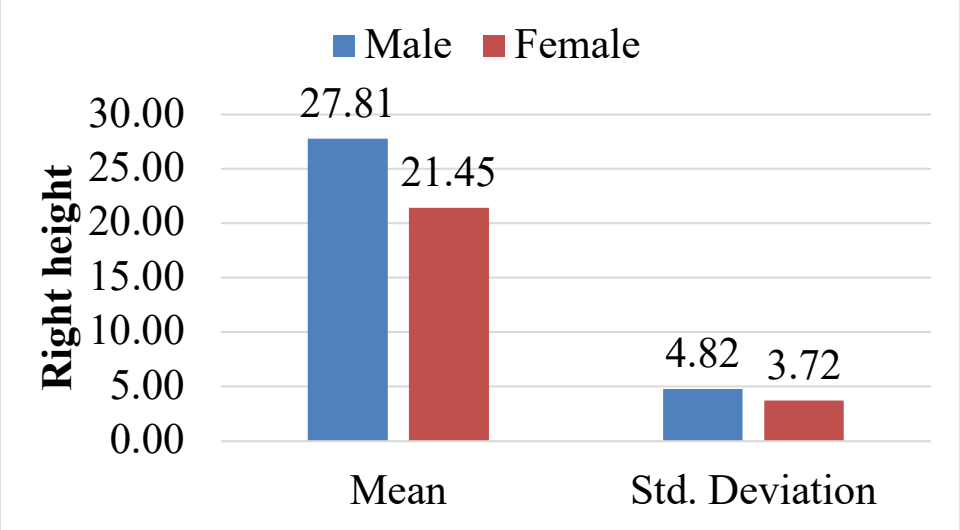
Graph 4: Comparison of maxillary sinus left width between males and females



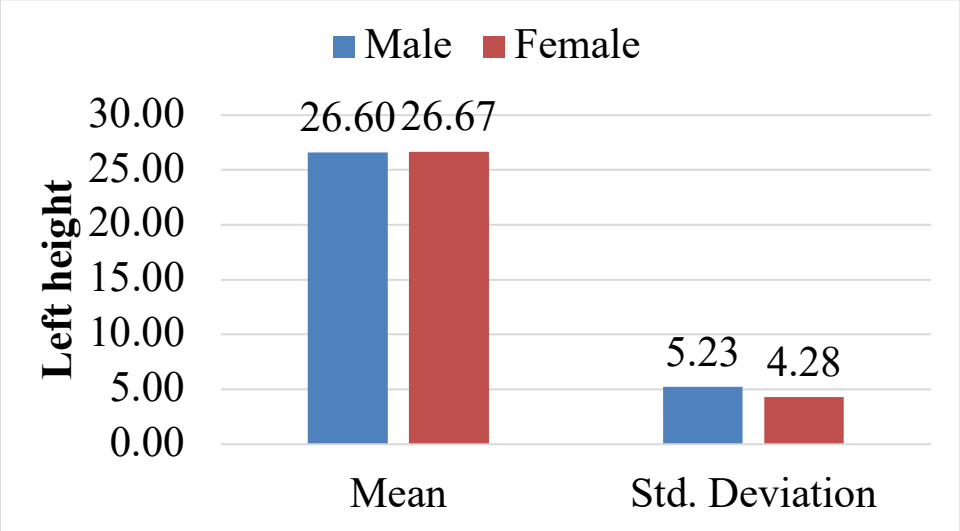
Graph 5: Comparison of Maxillary Sinus Right Length Between Males and Females



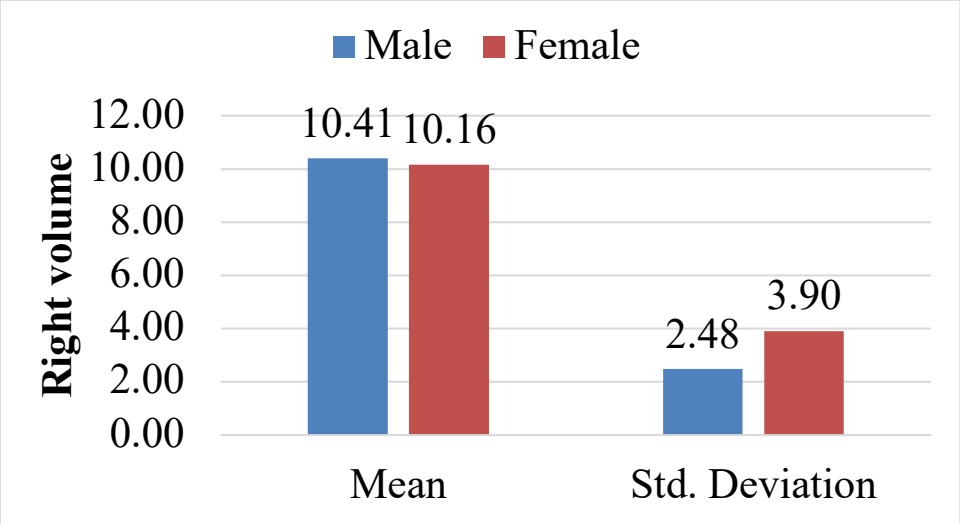
Graph 6: Comparison of maxillary sinus left length between males and females



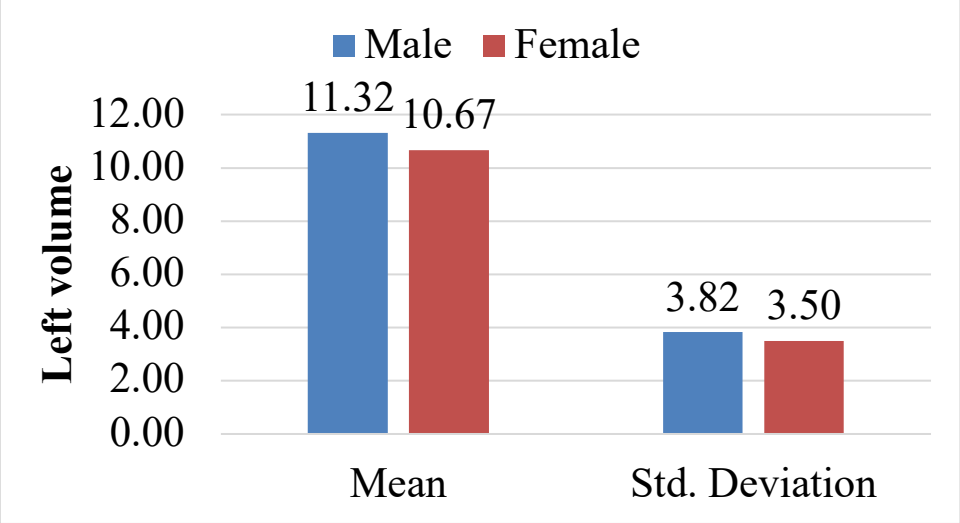
Graph 7: Comparison of maxillary sinus right height between males and females



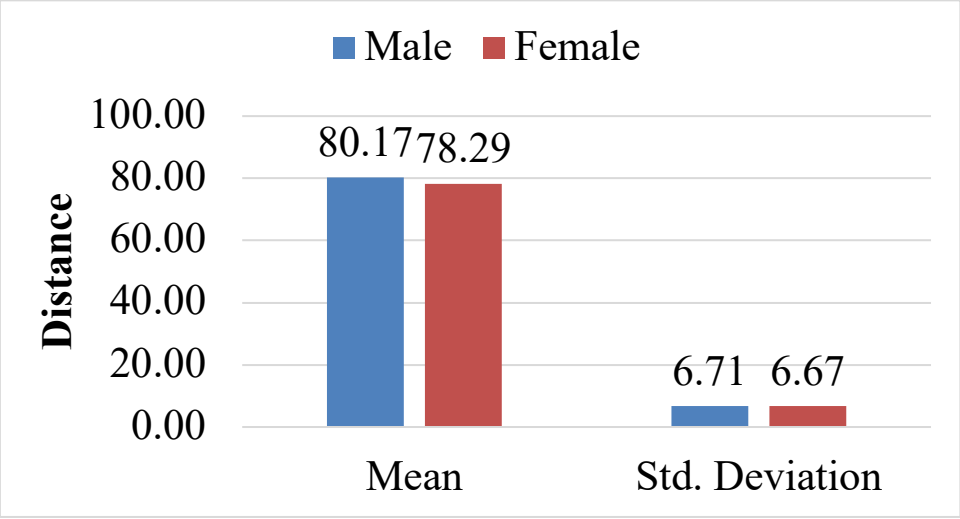
Graph 8: Comparison of Maxillary Sinus Left Height Between Males and Females



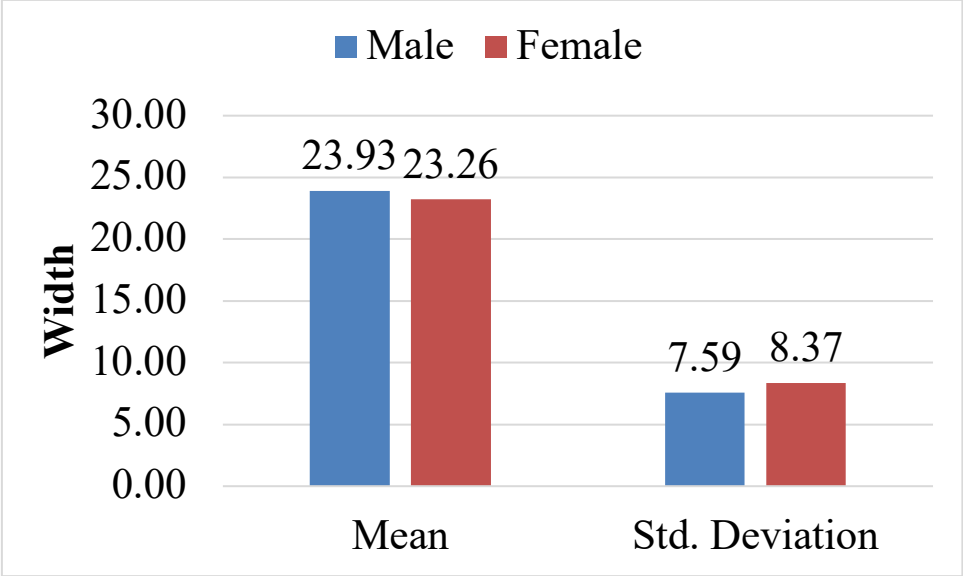
Graph 9: Comparison of maxillary sinus right volume between males and females



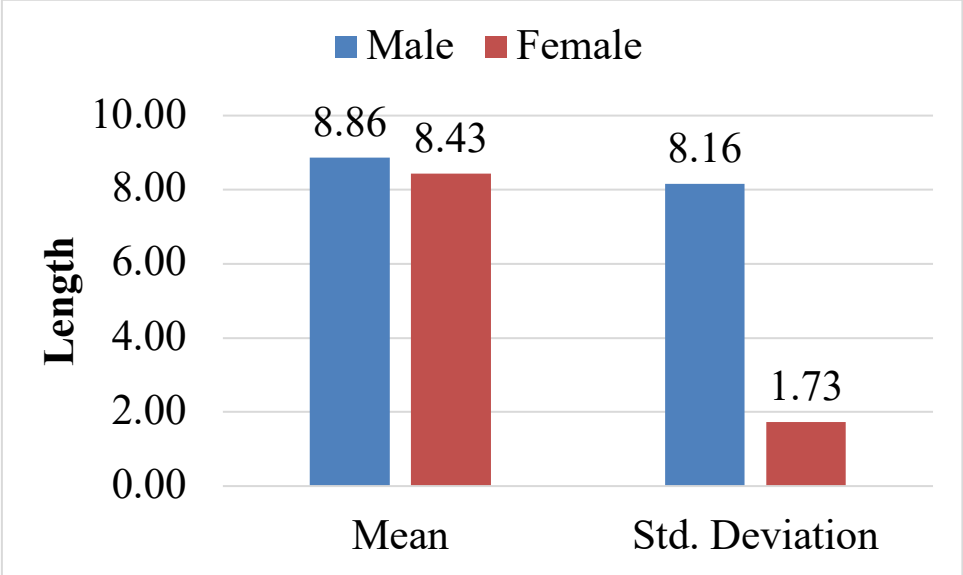
Graph 10: Comparison of maxillary sinus left volume between males and females



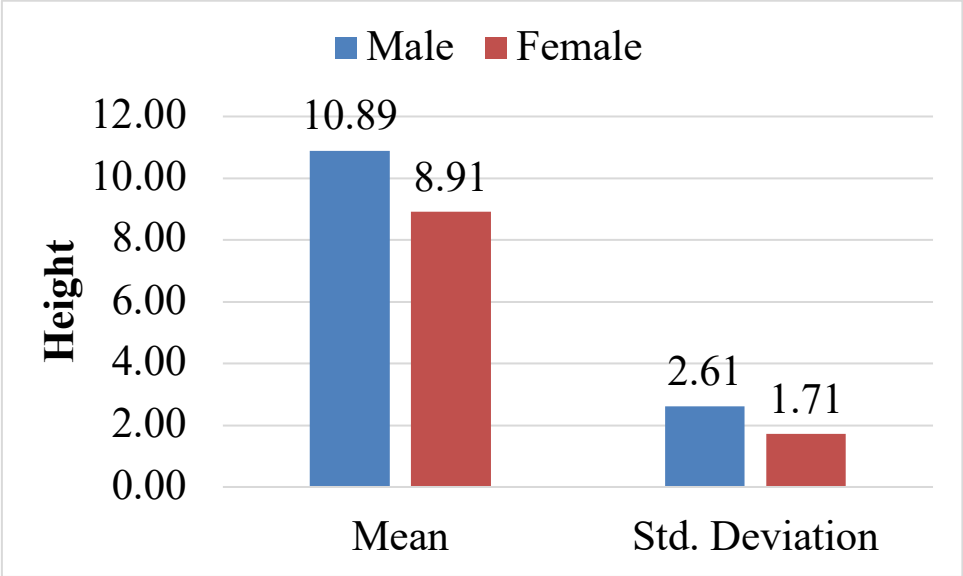
Graph 11: Comparison of maxillary sinus total distance between males and females



Graph 12: Comparison of frontal sinus width between males and females



Graph 13: Comparison of Frontal Sinus Length Between Males and Females



Graph 14: Comparison of frontal sinus height between males and females

Discussion

In studies by Spaethet al [4] stated 17.1% of frontal showed definitive size with statistically differences in later ages of both genders. In accordance with the study conducted by Mc-Laughlin et al [5] and Ertugrul et al [6] the frontal sinus continued to expand until the age of 40 years because of hormonal and mechanical stresses of mastication.

In the present study the MS right side mediolateral width AP length, maximum height and FS height showed statistical significance. Previous studies have demonstrated that frontal sinus dimensions changes due to pneumatisation however in certain diseases like sinusitis and in the elderly FS may enlarge due to bone loss. This variability has also been described in the literature and is considered to be a useful tool in forensic identification as a forensic fingerprint. These are however limitations in the use of the frontal sinus in personal identification because they are affected by craniofacial configuration hormonal levels and pathological condition and the influence of genetic and environmental factors on size of frontal sinus.

The measurement of maxillary and frontal sinus were compared with age subgroups, the highest value for maxillary and frontal sinus was observed in 31-40 age groups and the lower value is observed in 41-50 age group.

The present study results states that the size of maxillary and frontal sinus decreases as age progresses. Among the variables analysed the maxillary sinus dimensions such as Right side width, length and height and frontal sinus height were the best predictors of age allocation with statistical significance using MS right volume 42% males & 60% females were originally classified with a 51.3 % accuracy.

Using MS left Volume 53% males & 49% females were originally classified with 51.3% accuracy using MS total distance 64% males and 58% females were originally classified with a accuracy of 61.3%.

Using frontal sinus width 52% males & 69% of females were originally classified with a accuracy of 60.7%.

Using frontal sinus length 42% male and 49% females were originally classified with a accuracy of 46%.

using frontal sinus height 76% males & 58% females were originally classified with a accuracy of 67.3%.

Using regression equation, 62% males and 57% females were correctly categorized using maxillary sinus right width with a accuracy of 60%.

Using maxillary sinus left width 65% of males and 49% females were correctly categorized with a accuracy of 57.3%.

Using MS right length 61% male & 76% females were originally classified with a accuracy of 68.7%.

Using MS left length 70% of males & 46% females were originally classified with a accuracy of 58.7%.

Using MS Right height 81% of males & 82% females were originally classified with a accuracy of 82%.

Using MS left height 65% of males & 54% females were originally classified with a accuracy of 60%.

In a study conducted by Uthman et al[7] for sexual dimorphism using MS, the accuracy rate was 71.6%. A.T Uthman et al [7] emphasized the ability of the frontal sinus to identify gender was 76.9%. In a study by Belal devar et al [8] The accuracy rate was 64.6% for FS

However, gender determination with the help of skeletal remains becomes a confusing puzzule for forensic experts especially when the skeletal remains are fractured or incomptele.

In such cases the use of dental remains such as teeth is an excellent piece of evidence that can be used to determine gender.

Conclusion

Computed tomography provides an excellent method for imaging maxillofacial region. It has been stated in literature that skull remains intact despite other bones are disfigured. Personal identification is the primary area of concern in forensic from the present study results we conclude that dimensions of frontal and maxillary sinus can be used for gender dimorphism and proves vital in identifying gender of a person in forensic anthropology.

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