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Research Article

DIMENSIONS OF MAXILLARY SINUSES IN CORRELATION TO GENDER BY COMPUTED TOMOGRAPHY SCAN

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Abstract: ***Introduction:*** Maxillary sinus measurements have significant differences between males and females, mainly because males exhibit higher and wider maxillary sinuses than females. Even in the same person, both maxillary sinuses may develop in different ways. Most bones used for sex determination are recovered in incomplete state but maxillary sinus remains intact even when the skull and other bones are badly disfigured which is useful for supporting gender determination in forensic medicine. **MATERIALS AND METHODS**: This hospital based, cross-sectional, prospective and observational study was conducted in the Department of Anatomy & Radiodiagnosis of Government Medical College Jammu. The study consisted of CT images of 118 patients. All the maxillary sinus parameters including height, width, depth, and volume of the right and left sides in males and females were measured using CT scan. Non-Contrast CT was performed on either Siemens SOMATOM Definition Flash (256-slice). **RESULTS**: In males there were statistically significant variation in morphometric indices of maxillary sinus such as volume, height, width and depth which were noticeably larger on the right side in comparison to females whereas on the left side males showed higher height, depth, and volume but there was no statistically significant difference in width. **CONCLUSIONS**: CT based morphometric analysis of maxillary sinus is a gold standard imaging modality for gender determination in forensic identification. The clinicians reviewing head and neck CT scans such as dentists, maxillofacial and ENT surgeons should be vigilant of maxillary sinus measurements while interpreting CT scans of the maxilla and patients should be followed up appropriately.

Keywords: Maxillary sinus | Computed Tomography | Gender identification | FESS

INTRODUCTION

The developmental pattern of paranasal sinuses varies widely according to the gender and the age. Even in the same person, both maxillary sinuses may develop in different ways. The analysis of the diverse morphology of maxillary sinus as well as classification of its developmental pattern is of great importance to anthropologists and clinicians (Jun et al., 2005).

Maxillary sinus is a pyramidal shaped pneumatic space that fills the body of maxilla. It is the largest bilateral air sinus that opens in the middle meatus of the nasal cavity with single or multiple openings (Standring, 2008).

The maxillary sinuses are of different shapes such as triangular, leaf like, scapular and kidney shaped. The triangular shaped sinus is the most common in females and males. It differs widely in size, shape and site not only between different individuals but also between both sides of the same individual (Sidhu et al., 2014).

The walls of maxillary sinus, when viewed from inside are seen to be irregular and exhibit projections ranging from small ridges to large crescentic septa. These irregularities occur mostly on the floor and are much more frequent and conspicuous in large sinuses. Their presence results in the formation of pockets which often interfere with drainage (Formby, 1960).

At birth maxillary sinus measures less than 7 mm in antero posterior depth, less than 4 mm in height and less than 2.7 mm in width. The rapid growth of sinus extends laterally past the infraorbital canal and inferiorly to the middle aspect of middle meatus. The roof of the sinus presents a more inferolateral position in childhood, before assuming its more horizontal position in adulthood due to progressing pneumatization (Duncavage, 2011).

Complete maxillary sinus evaluation by an otolaryngologist, including nasal endoscopy is recommended for all patients with a history of sinus disease as it may also be beneficial to fully evaluate patients with asthma, acid reflux and severe allergies because these conditions are often associated with chronic sinusitis and may predispose patients to infection and possible graft failure. The maxillary sinus is pneumatised in partial or complete edentulous patients and often requires grafting. So the visualization of maxillary sinus and its surrounding structures by various radiographic modalities are pivotal for proper diagnosis and treatment (Quazi et al., 2017).

Maxillary sinus measurements have significant differences between males and females, mainly because males exhibit higher and wider maxillary sinuses than females. Males need correspondingly bigger lungs to support their relatively more massive muscles and body organs, they need a larger airway which begins with the nose and nasopharynx (Enlow, 1990).

In forensic science, the primary components of any skeletal analysis are age and sex determination. As most bones used for sex determination are recovered in incomplete state, it is often necessary to use bones such as maxillary sinus that remain intact even when the skull and other bones are badly disfigured in victim who are incinerated (Masri, 2013).

Sinus radiography has been used for identification of remains and determination of gender. CT scans are excellent imaging modality in the identification of unknown remains as they provide an accurate assessment of the paranasal sinuses and craniofacial bones (Kanthem et al., 2015). CT measurements of maxillary sinus such as length, width, height and volume may be useful for supporting gender determination in forensic medicine.

Due to significant correlation between the maxillary sinus volume and the inter-zygomatic buttress distance in both males and females, the transverse mid-facial skeletal size appears to be one of the influential factors. It is a definitive technique used in detection of simulated lesions of all surfaces of the maxillary sinus, allowing access to all the walls of the sinus and should be used when there is definite evidence of maxillary sinus pathologies (Ariji et al., 1994).

Clinicians reviewing head and neck CT scans such as dentists, general medical practitioners, maxillofacial and ENT surgeons should be vigilant of maxillary sinus measurements while interpreting CT scans of the maxilla and patients should be followed up appropriately

AIMS AND OBJECTIVES

To determine the dimensions and volume of the maxillary sinuses on CT scan.
To compare the dimensions and volume of the maxillary sinuses on either side.
To compare the dimensions and volume of the maxillary sinuses according to gender.

MATERIALS AND METHODS

This hospital based, cross-sectional, prospective and observational study was conducted in the Department of Anatomy & Radiodiagnosis of Government Medical College Jammu over a period of 1 year. The various parameters like height, width, depth and volume were measured using CT scan of Paranasal Sinuses (PNS).

The study will consist of Computed Tomographic images of 118 patients.

Inclusion Criteria

- Individuals in the age group of 20-50 years.
- Individuals undergoing CT scan for pathologies other than maxillary sinus
- Individuals with complaints of headache or with suspicion of sinusitis but without pathological findings in maxillary sinuses on CT scan

Exclusion Criteria

Individuals with pathological conditions affecting the maxillary sinuses (Tumours, inflammation, residual root fragments, extrusion of endodontic filling materials).

Non-Contrast CT of Paranasal sinuses (PNS) will be performed on either Siemens SOMATOM Definition Flash (256-slice) CT SCAN or Siemens SOMATOM Spirit (Dual slice) CT scan. All measurements of maxillary sinus dimensions (Antero posterior, width and height) will be done on computer screen of workstation of CT machine.

Maxillary sinus Height (Cranio-caudal diameter)- It was measured from the inner wall of the anterior borders of maxillary sinus, as the longest distance from the lowest point of the sinus floor to the highest point of the sinus roof in the coronal view as shown in (Image-1) and (Image-2).

Maxillary sinus Width (Transverse diameter) - It was measured as the longest distance perpendicular from the medial wall of the sinus to the most lateral wall of the lateral process of the maxillary sinus in the axial view as shown in (Image-5) and (Image-6).
Maxillary sinus Depth (Antero-posterior diameter)- It was measured as the longest distance from the most anterior point to the most posterior point of the medial wall in the axial view as shown in (Image-3) and (Image-4).

Maxillary sinus Volume- It was calculated manually by using the equation: Volume = (Width × Depth × height × 0.52), proven mathematical formula in which the maximum dimensions of maxillary air sinuses were taken that give approximate volume of each sinus.
All the measured parameters were then subjected to statistical evaluation in order to determine mean difference, t-value, p-value between males and females maxillary sinus from right and left sides of CT scans for evaluation.

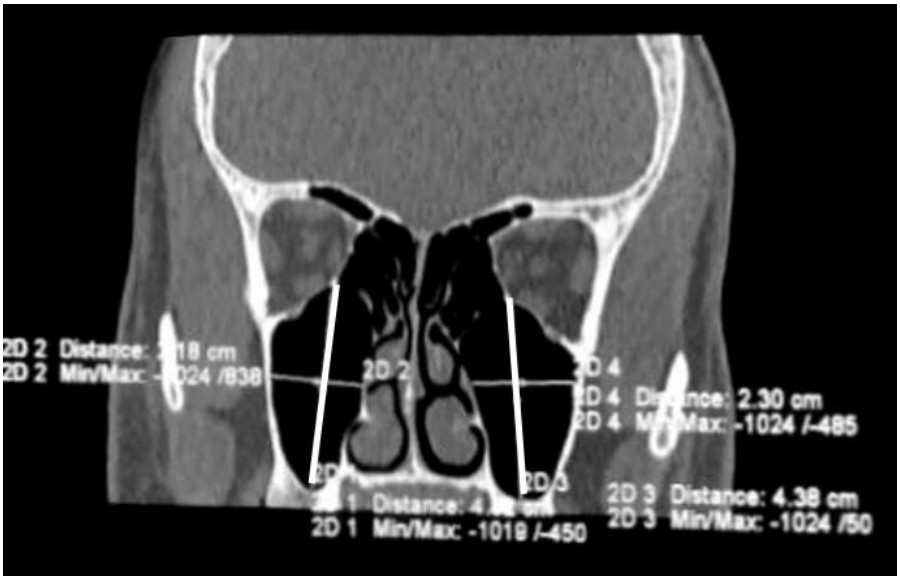

Image 1- CT Coronal view showing the Measurements of maximum Height of Maxillary Sinus of right and left side in males

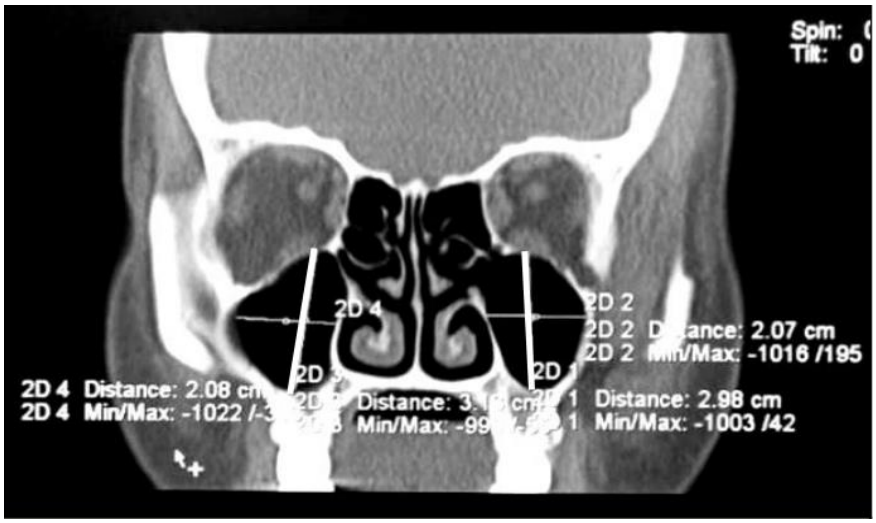

Image 2- CT Coronal view showing the Measurements of maximum Height of Maxillary Sinus of right and left side in females

Image 3- CT Axial view showing the Measurements of maximum Depth of Maxillary Sinus of right and left side in males

Image 4- CT Axial view showing the Measurements of maximum Depth of Maxillary Sinus of right and left side in females

Image 5- CT Axial view showing the Measurements of maximum Width of Maxillary Sinus of right and left side in males

Image 6- CT Axial view showing the Measurements of maximum Width of Maxillary Sinus of right and left side in females

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RESULTS

TABLES

Table: (1) Sex distribution among study sample.

Sex	Frequency	Percentage
Male	65	55.09%
Female	53	44.91%
Total	118	100%

Table: 1 represents the study material comprising of CT scans of 118 individuals including 65 males and 53 females. The percentage of males and females are 55.09 % and 44.91 % respectively.

Table: (2) Comparison of different measurements of Right Sided Maxillary Sinus between males and females in study group.

Variables	Gender	N	Mean	Std. Deviation	Significance	
					t-value	p-value
HEIGHT (cm)	Males	65	3.63	0.42	4.548	0.000
	Females	53	3.30	0.33		
WIDTH (cm)	Males	65	2.50	0.31	3.244	0.002
	Females	53	2.32	0.28		
DEPTH (cm)	Males	65	3.60	0.39	2.867	0.005
	Females	53	3.4170	0.32		
VOLUME (cm^3)	Males	65	16.56	4.77	4.271	0.000
	Females	53	13.22	3.40		

From Table: 2 the comparison of the right maxillary sinus dimensions including 65 males and 53 females are drawn and the results are obtained. The mean values of the right side maxillary sinus height, width, depth, and volume in males are 3.63 cm, 2.50 cm, 3.60 cm and 16.56 cm^3, respectively, whereas in case of females it is 3.30 cm, 2.32 cm, 3.41 cm, and 13.22 cm^3 respectively. The standard deviation of the right maxillary sinus height, width, depth, and volume in males are 0.42, 0.31, 0.39 and 4.77 respectively and in females the values are 0.33, 0.28, 0.32 and 3.40 respectively. The t-values are 4.548, 3.244, 2.867 and 4.271. There is a statistically significant difference between the mean dimension of height, width, depth, and volume of the right maxillary sinus with p-values 0.000, 0.002, 0.005, and 0.000, respectively.

Table: (3) Comparison of different measurements of Left Side Maxillary Sinus between males and females.

Variables	Gender	N	Mean	Std. Deviation	Significance	
					t-value	p-value
HEIGHT (cm)	Males	65	3.61	0.38	4.875	0.000
	Females	53	3.29	0.29		
WIDTH (cm)	Males	65	2.46	0.32	1.470	0.144
	Females	53	2.37	0.29		
DEPTH (cm)	Males	65	3.64	0.36	3.502	0.001
	Females	53	3.43	0.25		
VOLUME (cm^3)	Males	65	16.20	4.35	3.677	0.000
	Females	53	13.59	3.04		

Table: 3 illustrates the comparison of the left maxillary sinus dimensions including 65 males and 53 females and the results are presented. The mean values of the left maxillary sinus height, width, depth, and volume in males are 3.61 cm, 2.46 cm, 3.64 cm and 16.20 cm^3, respectively, whereas in females the values are 3.29 cm, 2.37 cm, 3.43 cm, and 13.59 cm^3, respectively. The standard deviation of the left maxillary sinus height, width, depth, and volume in males are 0.38, 0.32, 0.36 and 4.35, respectively and in case of females it is 0.29, 0.29, 0.25 and 3.04, respectively. The t-values are 4.875, 1.470, 3.502 and 3.677 respectively. There is a statistically significant correlation between the mean dimension of height, depth,

and volume of the left maxillary sinus with p - values 0.000, 0.001 and 0.000, respectively. The maxillary sinus width is statistically insignificant with p- value 0.144.

MALE-PEARSON CORRELATION	RIGHT HEIGHT
RIGHT WIDTH	0.47
RIGHT DEPTH	0.28
RIGHT VOLUME	0.76

Table: 4

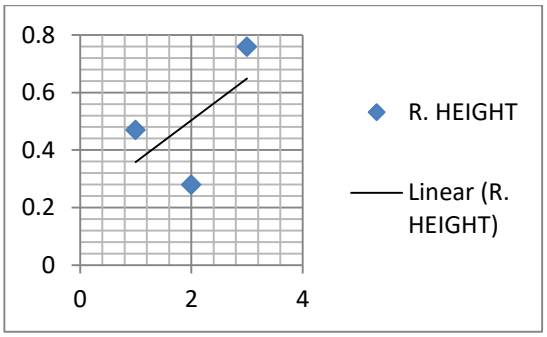

Fig: 1

Table 4 and Fig 1: Shows Pearsons Correlation (r) between right side maxillary sinus height with right side maxillary sinus width, depth and volume, where r is 0.47, 0.28 and 0.76. The right sinus width shows moderate degree of association, the right sinus depth shows low degree of association and the sinus volume shows high degree of association. The scatter plot in Fig 1 shows positive trend line.

FEMALE-PEARSON CORRELATION	RIGHT HEIGHT
RIGHT WIDTH	0.31
RIGHT DEPTH	0.36
RIGHT VOLUME	0.74

Table: 5

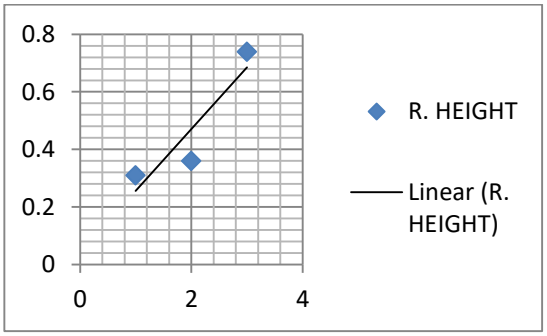

Fig: 2

Table 5 and Fig 2: Shows Pearsons Correlation (r) between right side maxillary sinus height with right side maxillary sinus width, depth and volume, where r is 0.31, 0.36 and 0.74. The right sinus width and depth shows moderate degree of association, the right sinus volume shows high degree of association. The scatter plot in Fig 2 shows positive trend line.

MALE-PEARSON CORRELATION	RIGHT VOLUME
LEFT HEIGHT	0.71
LEFT WIDTH	0.38
LEFT DEPTH	0.62

Table: 6

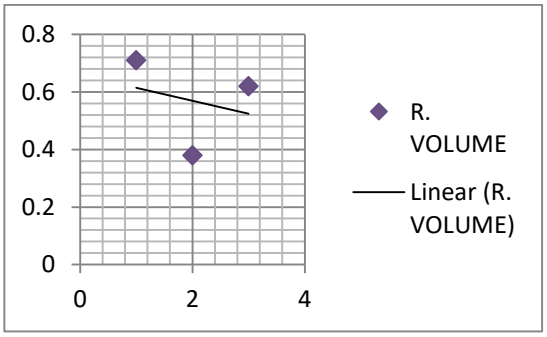

Fig: 3

Table 6 and Fig 3: Shows Pearsons Correlation (r) between right side maxillary sinus volume with left side maxillary sinus height, width and depth, where r is 0.71, 0.38 and 0.62. The left sinus height and depth shows high degree of association, the right sinus width shows moderate degree of association. The scatter plot in Fig 3 shows positive trend line.

FEMALE-PEARSON CORRELATION	RIGHT VOLUME
LEFT HEIGHT	0.71

LEFT WIDTH	**0.38**
LEFT DEPTH	**0.62**

Table: 7

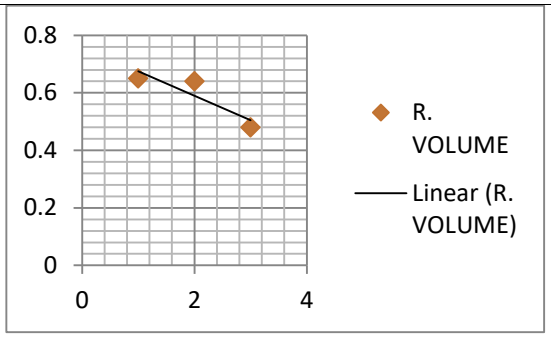

Fig: 4

Table 7 and Fig 4: Shows Pearsons Correlation (r) between right side maxillary sinus volume with left side maxillary sinus height, width and depth, where r is 0.65, 0.64 and 0.48. The left sinus height and width shows high degree of association, the left sinus depth shows moderate degree of association. The scatter plot in Fig 4 shows negative trend line.

DISCUSSION

Maxillary Sinus Height

In our study the mean maxillary sinus height for 65 males is 3.63 ±0.42 cm of right side and 3.61±0.38 cm for left side respectively. In case of 53 females, the mean maxillary sinus height for right side is 3.30±0.33cm and that of the left side is 3.29±0.29 cm. The right side maxillary sinus in males is larger than that of females.

Uthman *et al.*, (2011) estimated that the mean value of maximum sinus height for male group was 4.33 ±0.48 cm for the right side and 4.51 ± 0.41 cm for the left side which was significantly greater than that recorded for female group that was 3.9 ± 0.52 cm for the right side and 4.04 ± 0.48 cm for the left side. A statistically significant difference was seen in only male group.

Sharma *et al.*, (2014) evaluated that the mean sinus height for male was 3.60 ± 0.61 cm and 3.67 ± 0.56 cm for the right and left sides respectively and average 3.64± 0.58 cm which was not significantly ($p>0.05$) greater than that of females 3.45 ± 0.40 cm for right side and 3.46 ± 0.44 cm for left side and average 3.45 ± 0.42 cm.

Maxillary Sinus Width

In the present study, the mean maxillary sinus width for right side in males is 2.50± 0.31cm and 2.46 ± 0.32 cm for left side respectively, with average of 2.48 cm, which is not statistically significant ($p > 0.05$). It is greater than that of females with mean sinus width 2.32 ± 0.28 cm for right side and 2.37± 0.29 cm for left side respectively, with average of 2.3 cm. **Jehan *et al.*, (2014)** reported that average sinus width for males was 2.40 ± 0.47 cm and 2.39 ± 0.38 cm for female. The average sinus width estimated by **Baweja *et al.*, (2013)** were 2.18 ± 0.34 cm for males and 2.16 ± 0.37 cm for females which was lesser than our results**. Uthman *et al.*, (2011)** analysed that the mean value for maximum width of maxillary sinus for male group was 2.47 ± 0.04 cm for the right side and 2.56 ± 0.04 cm for the left side. Female group had statistically significant lower values for both right and left sides 2.27 ± 0.32 cm and 2.34 ± 0.04 cm respectively

($p < 0.05$). Right and left side difference was significant for only male group.

Maxillary Sinus Depth

In the present study the mean value of maxillary sinus depth for males is 3.60 ± 0.39 cm for the right side and 3.64 ± 0.36 cm for left side with an average of 3.62 cm which is greater than that recorded for females that is 3.41 ± 0.32 cm for right side and 3.43 ± 0.25 cm for left side with an average of 3.42 cm. The results are non significant for both genders with the p-value of 0.625 and 0.739. **Jehan *et al.*, (2014**) studied 191 subjects (106 males and 85 females) and found that the average sinus depth was 3.64 ± 0.42 cm for males and 3.49 ± 0.41 cm for females.

Teke *et al.*, (2007) estimated that the mean value for the maximum depth of maxillary sinus for male group was 4.25 ± 0.79 cm for the right side and 4.37 ± 0.77 cm for the left side which was significantly greater than that recorded for female group which was 3.78 ± 0.56 cm for the right side and 3.76 ± 0.06 cm for left side.

In our study the mean value of **maxillary sinus volume** in males is 16.56 ± 4.77 cc for right side and 16.20 ± 4.35 cc for left side with an average of 16.38 cc. The mean volume of female sinus is 13.22 ± 3.40 cc for the right side and 13.59 ± 3.04 cc for the left side with an average of 13.40 cc**.** The volume of the maxillary sinuses of both sides are significantly greater in males as compared to female. The range of maxillary sinus volume as described by **Ariji *et al.*, (1994)** was4.56 to 35.21 cc which is near the range of present study and are comparable. **Sahlstrand *et al.*, (2011)** studied dimensions of 120 maxillary sinuses from head CT images. The mean value of maxillary sinus volume was 15.70 ± 5.30 cc which was significantly larger in males than in females. There was no statistically significant

correlation between the volume of the maxillary sinus volume with age or side.

Sujatha et al., (2017) determined that the dimensions and volume of maxillary sinuses of right and left side were notably larger in males as compared to females revealing higher percentage of sexual dimorphism. The reason for increased volume in males was because of their increased muscle mass and larger airway to fulfill respiration needs.

Tambawala *et al*., (2016) reported that the maxillary sinus height was the most reliable discriminant parameter that could be used for the purpose of sex determination. She analysed the usability and accuracy of CBCT for evaluating maxillary sinus dimensions in the field of forensic science. She further suggested the importance of sexual dimorphism of maxillary sinus dimensions i.e. width, length, and height when other methods and procedures.

CONCLUSION

The result of the present work shows that all the parameters of maxillary sinus have highly significant difference between males and females except width (transverse diameter). Males have higher value when compared to females which is strongly in agreement to the previous findings of different authors. The minor difference in the results is attributed to different races, ethnic groups and geographic barrier and some genetic factors. CBCT provides an excellent and reliable tool for analysing maxillary sinus dimensions.

This study is helpful in evaluating the presence of any abnormality in Sinonasal area.

The dimensions of maxillary sinus are used for treatment planning procedures such as functional endoscopic sinus surgeries (FESS).

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None

Conflict of interest

None

Ethics Approval

Approved by Government Medical College**,** Jammu Institutional Ethics Committee

Data Availability Statement

The data that supports the findings of this study are available in the supplementary material of this article.

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