

Evaluation of Gender by Measuring the Size of Maxillary Sinus using Computed Tomographic Scan in Indian Population

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Abstract:

Background: Establishing the identity of a person is an essential step for medico-legal purpose and is required for a person, social and legal reason. Maxillary sinus remains intact although the skull and other bones may be badly disfigured in victims, therefore, maxillary sinuses can be used for identification. Study was done to determine the gender of an individual for forensic identification.

Materials and Methods: About 40 patients, of age ranged from 20 to 60 years were subjected to non-contrast coronal computed tomography (CT) scan to visualize the maxillary sinuses using hi-speed single slice CT scanner.

Results: The right and left maxillary sinus in males have overall larger dimensions than females and the mediolateral dimensions are higher in the age group of 20-30 years.

Conclusion: Maxillary sinus can be used as a means of identification in forensic odontology.

Key Words: Computed tomography, forensic odontology, forensic science, gender determination, maxillary sinus

Introduction

Establishing identification is necessary for unknown deceased person in homicide, suicide, accident, mass disasters, and for culprits hiding their identity.¹ The present study was done to evaluate the gender of a person by measuring the size (width, length, and height) of maxillary sinuses. The shape and size of maxillary sinuses remain intact although the other bones

may be badly disfigured in victims who are incinerated and therefore, the maxillary sinuses can be used for identification.² It has been reported that the gender can be determined with an accuracy of 100% if entire skeleton is available. 98% accuracy can be achieved from the pelvis and the skull, 95% from only or the pelvis and the long bones, 90-95% from both the skull and the long bones and 80-90% from long bones only.^{2,3} There are many modalities to measure the size of maxillary sinus such as conventional and digital radiography.⁴ Computed tomography (CT) provides an excellent method for examining the maxillary sinus, providing three-dimensional information.⁵ Some studies have shown a significant difference in size and shape of the maxillary sinus in males and females.² Very few studies have been carried out in this regard.

Materials and Methods

The present study was conducted in the Department of Oral Medicine and Radiology, Institute of Dental Sciences, Bareilly, Uttar Pradesh, India and Rohilkhand Medical College and Hospital, Bareilly, Uttar Pradesh, India. This study comprised of 40 individuals (20 males and 20 females) with the age range from 20 to 60 years in age. The subjects were divided into three groups i.e., 21-30 years, 31-40 years, and 41-60 years. Patients with 20-60 years of age and having permanent teeth. Patients with clinically healthy maxillary sinuses were included in the study. Patients with any pathology of maxillary sinus seen on CT scan; patients with facial deformity involving maxilla, patients who had undergone previously a surgery of maxillary sinus were excluded from the study.

The purpose and procedure of evaluating maxillary sinus were explained to the patient, the consent was obtained. Ethical clearance was taken from Ethical Committee of Institution. A detailed history of the patient and clinical examination of the maxillary sinus was done to rule out any pathology. Patients were instructed to remove all metallic objects from head and neck region and positioned on CT table in prone position. Patient's neck was hyperextended with the chin resting on the pad for stabilization. The pad was inserted on both sides of the head. The gantry was angulated to make it perpendicular to the hard palate.

No contrast media or sedation was used for CT scan. The image of the maxillary sinus was taken by using CT scan in the coronal plane. Sections of 3 mm thickness were planned on the preliminary scout view extending from the anterior margin of

the frontal sinus to the posterior margin of the sphenoid sinus with the reconstruction matrix size 512 × 512 at 120 Kv and 100 mA. The width and height measurements (Figures 1 and 2) were made where the maxillary sinus was in its widest position, with the help of software (IREX) in CT scan. The length of the maxillary sinus was detected by marking the first and the last slice of the sinus in CT scans, and the number of sections between them was determined. The number of slices obtained was multiplied by 3 to find the length of the sinus.

Results

The study consisted of total 40 subjects, 20 were males and 20 females. The individuals were divided into three groups, i.e., 20-30 years, 31-40 years, 41-60 years. There were 5 males and 5 females in first two groups and 10 males and 10 females in third age group. Distribution of study samples were done by gender and age groups (Table 1 and Graph 1).

Comparison of right maxillary sinus dimensions in males and females

There is higher supero-inferior dimension (SID) and anteroposterior dimension of right (APD-R) maxillary sinus in males as compared to females. For the right maxillary sinus, the mean value of the mediolateral dimension (MLD-R)

was found to be 28.37 ± 7.60 in males and 26.82 ± 6.25 in females. The SID of right (SID-R) was 33.93 ± 5.78 in males and 28.19 ± 7.65 in females and the APD-R was 38.06 ± 3.84 in males and 32.69 ± 4.77 in females (Table 2).

A significant difference was observed between male and females with respect to supero-inferior of right maxillary sinus ($t = 2.6768, P < 0.05$) and anteroposterior of right maxillary sinus ($t = 3.9193, P < 0.05$) at 5% level of significance. It means that, the male subjects have significant higher supero-inferior of right maxillary sinus and anteroposterior of the right maxillary sinus as compared to females (Table 2 and Graph 2).

Comparison of left maxillary sinus dimensions in males and females

Comparison of male and female with respect to MLD, SID and APD of left (APD-L) maxillary sinus was done. Male subjects have significant higher SID of left (SID-L) maxillary sinus and anteroposterior of left maxillary sinus as compared to females. For the left maxillary sinus, the mean value of the MLD-L was found to be 27.15 ± 8.41 in males and 27.18 ± 6.40 in females. The SID-L was 34.13 ± 5.24 in males and 30.65 ± 4.81 in females and the APD-L was 36.89 ± 3.69 in males and 33.92 ± 4.80 in females (Table 3 and Graph 3).

A significant difference was observed between male and females with respect to supero-inferior of left maxillary sinus ($t = 2.1917, P < 0.05$) and antero-posterior of left maxillary sinus ($t = 2.1972, P < 0.05$) at 5% level of significance (Table 3).

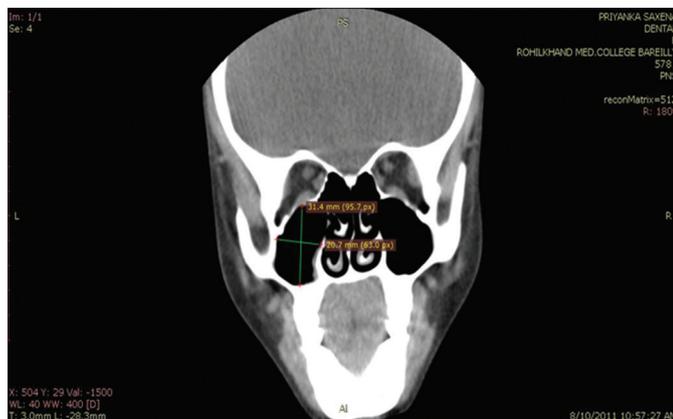


Figure 1: Coronal section showing supero-inferior and mesio-lateral dimension of the right maxillary sinus.

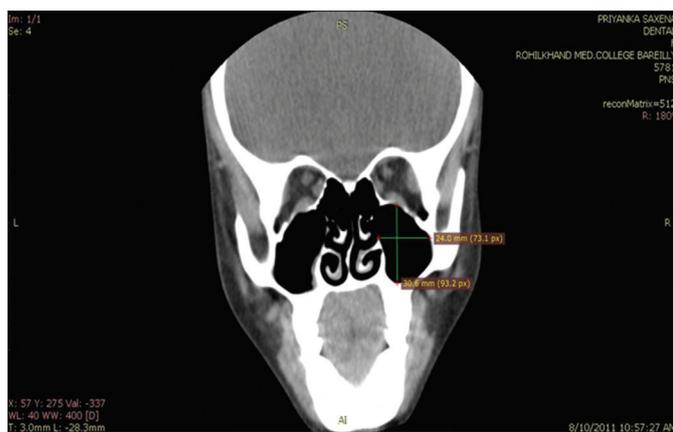


Figure 2: Coronal section showing supero-inferior and mesio-lateral dimension of left maxillary sinus.

Table 1: Distribution of study samples by gender and age groups.

Age groups	Male	Female	Total
20-30 years	5	5	10
31-40 years	5	5	10
41+ years	10	10	20
Total	20	20	40

Table 2: Distributions of right maxillary sinus dimensions measured on CT scan and their SD.

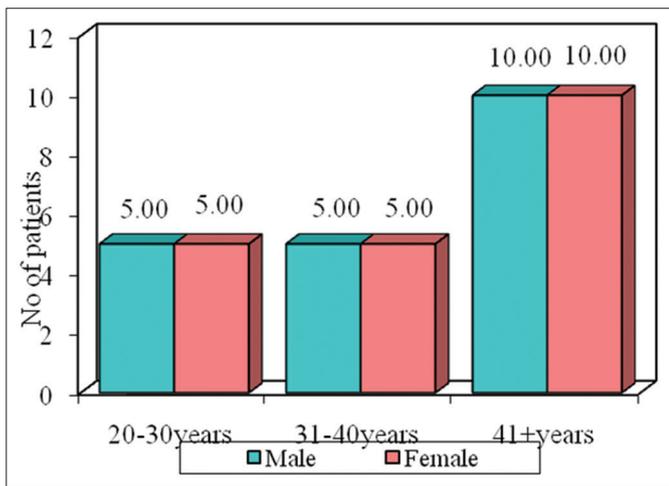
Dimensions	Male		Female		t-value	P-value
	Mean	SD	Mean	SD		
Mesio-distal dimension of right maxillary sinus	28.37	7.60	26.82	6.25	0.7065	0.4842
SID-R maxillary sinus	33.93	5.78	28.19	7.65	2.6768	0.0109*
APD-R maxillary sinus	38.06	3.84	32.69	4.77	3.9193	0.0004*

*Statistically significant, SD: Standard deviation, CT: Computed tomography, SID: Supero-inferior dimension of right, APD-R: Antero-posterior dimension of right

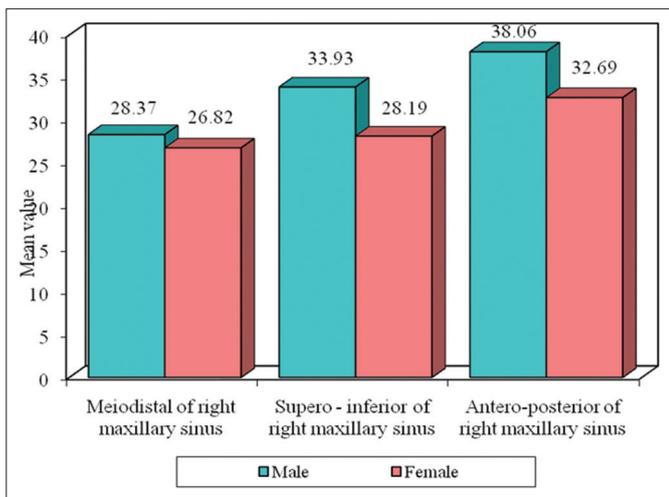
Table 3: Comparison of gender with respect to medio-distal, SID-R and APD-L maxillary sinus by t-test.

Dimensions	Male		Female		t-value	P-value
	Mean	SD	Mean	SD		
MLD-L maxillary sinus	27.15	8.41	27.18	6.40	-0.0165	0.9869
SID-L maxillary sinus	34.13	5.24	30.65	4.81	2.1917	0.0346*
APD-L maxillary sinus	36.89	3.69	33.92	4.80	2.1972	0.0342*

*Statistically significant, SD: Standard deviation, SID-L: Supero-inferior dimension of left, APD-L: Antero-posterior dimension of left, MLD-L: Medio-lateral dimension of left



Graph 1: Distribution of study samples by gender and age groups.



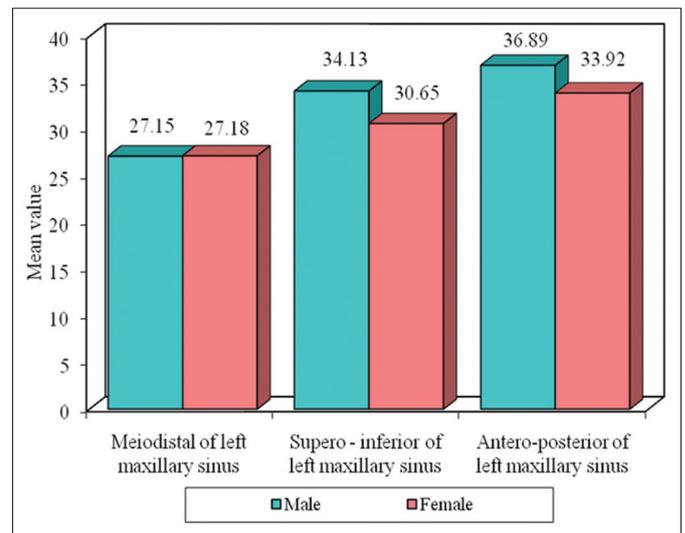
Graph 2: Distributions of right maxillary sinus dimensions measured on computed tomography scan and standard deviation.

Comparison of age groups

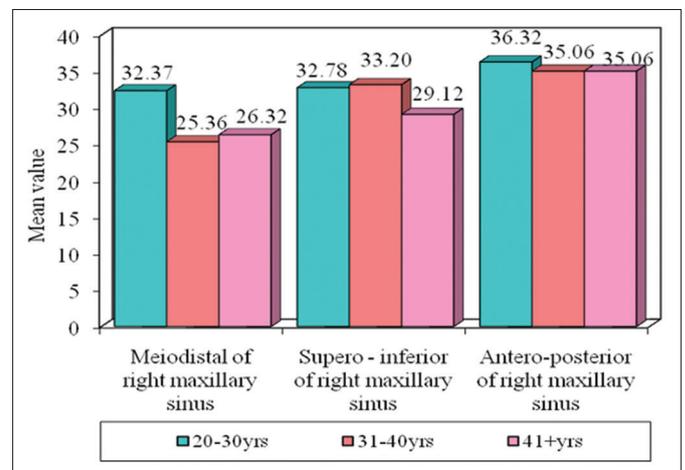
In comparison of age groups with respect to MLD, SID and APD-R maxillary sinus, it is seen that younger age group (20-30 years) of age have higher MLD as compared to other age group. The samples belong to different age groups differ significantly with respect to medio-distal of the right maxillary sinus ($F = 3.6953, P < 0.05$) at 5% level. It means that the samples belongs to 20-30 years of age group have significant higher medio-distal of the right maxillary sinus as compared to other two age groups. However, the three age groups have similar values of SID-R maxillary sinus and APD-R maxillary sinus ($P > 0.05$) (Table 4,5 and Graph 4).

Discussion

It has been reported that the gender can be determined with an accuracy of 100% if entire skeleton is available. 98% accuracy can be achieved from both the pelvis and the skull, 95% from



Graph 3: Comparison of male and female with respect to medio-distal, supero-inferior right and anteroposterior dimension of left maxillary sinus.



Graph 4: Comparisons of age groups with respect to medio-distal, supero-inferior and anteroposterior of the right maxillary sinus.

only or the pelvis and the long bones, 90-95% from both the skull and the long bones and 80-90% from long bones only.²

Comparison of right maxillary sinus dimensions in males and females

The present study measured the MLD, SID, and APD of the maxillary sinus in 40 patients. The right maxillary sinus showed an average size of 28.37, 33.93, 38.06 mm in males and 26.82, 28.19, 32.69 in females. In our study, there was a significant difference of the maxillary sinus size between males and females. This may be due to fact that men are generally larger than women and also male exhibit higher and wider maxillary sinus than females.

These finding were in agreement with authors such as Fernandes,⁶ Teke *et al.* (2007)² and Johnson *et al.*⁷ Fernandes⁶

Table 4: Comparisons of age groups with medio-distal dimension, SID and APD-R maxillary sinus.

Age groups	Medio-distal of right maxillary sinus		Supero-inferior of right maxillary sinus		Antero-posterior of right maxillary sinus	
	Mean	SD	Means	SD	Mean	SD
20-30 years	32.37	4.56	32.78	5.48	36.32	2.07
31-40 years	25.36	5.71	33.20	5.68	35.06	5.14
41-60 years	26.32	7.52	29.12	8.48	35.06	6.12
Total	27.59	6.91	31.06	7.30	35.37	5.06
F-value	3.6953		1.4469		0.2242	
P-value	0.0344*		0.2483		0.8003	

*Statistically significant, SD: Standard deviation, SID-R: Supero-inferior dimension of right

Table 5: Pairwise comparisons of age groups by Newman-Keuls multiple post-hoc procedure.

Age groups	MLD of maxillary sinus	SID-R maxillary sinus	APD-R maxillary sinus
20-30 versus 31-40	0.0311*	0.8875	0.5541
20-30 versus 41-60	0.0282*	0.2220	0.8212
31-40 versus 41-60	0.7189	0.3590	0.9982

*Statistically significant, SD: Standard deviation, SID-R: Supero-inferior dimension of right, MLD: Medio-lateral dimension, APD-R: Antero-posterior dimension of right

showed that the dimensions of maxillary sinus have a higher width ($P < 0.783$), length ($P < 0.042$) in males than females. The present study shows higher dimensions in males than females ($P < 0.05$). Teke *et al.* (2007)² showed the accuracy of right maxillary sinus in identification of gender was 59.7% in females and 67.7%, with a mean of 63.8%. Johnson *et al.*⁷ showed that the mean value is 15.7 ± 5.3 cm and significantly larger in males than in females ($P = 0.004$). In present study dimensions of maxillary sinuses are larger in males than females with mean value of 28.37, 33.93, 38.06 mm in males and 0.82, 28.19, 32.69 in females in right maxillary sinus and in left maxillary sinus the mean values 27.15, 34.13, 36.89 mm in males and 27.18, 30.65, 36.89 in females with $P < 0.05$.

The results of present study are not in accordance with Arijj *et al.*⁸ and Ezemagu *et al.*⁹ They found that the transverse dimensions were not significant in the mean value between males and females in the children and the adults. The probable reasons of difference may be, they use only two dimensions i.e. transverse and APD, there may be difference in age groups, i.e. 4-94 years, and the difference in sample size i.e. 107 individuals to evaluate gender difference but in present study we include all three dimensions, i.e. medio-distal, anteroposterior and supero-inferior, age group include 20-60 years of individuals, along with 40 individual sample size to evaluate difference between males and females.

Comparison of left maxillary sinus dimensions in males and females

The present study measured the MLD, SID, and APD of the maxillary sinus in 30 patients including both males and females. The left maxillary sinus showed an average size of

27.15, 34.13, 36.89 mm in males and 27.18, 30.65, 36.89 in females. The results are significant with $P < 0.05$ for both right and left maxillary sinus. These findings are in accordance with authors such as Fernandes,⁶ Teke *et al.* (2007)² and Johnson *et al.*,⁷ who have reported that the maxillary sinus is larger in males and females.

The results of present study are in accordance with Teke *et al.* (2007).² The accuracy rate of the left maxillary sinus measurements was 67% in both males and females. Johnson *et al.*⁷ measured dimensions of 120 maxillary and frontal sinuses from head CTs independently by two radiologists. The mean value (15.7 ± 5.3 cm) is significantly larger in males than in females ($P = 0.004$). The results of present study are not in accordance with Arijj *et al.*⁸ and Ezemagu *et al.*⁹ They found that the transverse dimensions were not significant in the mean value between males and females in the children and the adults. The probable reason of difference may be, they use only two dimensions i.e. transverse and APD to evaluate gender difference, but in present study we included all three dimensions, i.e. medio-distal, anteroposterior and supero-inferior to evaluate difference between males and females.

Comparison of age groups

The present study attempted to correlate the size of the maxillary sinus with age and found that the samples were in age group of 20-30 years have significant higher medio-distal dimension ($[F = 3.6953, P < 0.05]$ at 5% level) of right maxillary sinus as compared to other two age groups. But the three age groups have similar values of supero-inferior of right maxillary sinus and anteroposterior of the right maxillary sinus. The maxillary sinus is known to increase in size throughout the infancy and adolescence, but there are few detailed descriptions of subsequent changes in adults and the elderly.¹⁰

Conclusion

The present study demonstrates that the length, the width and the height of the maxillary sinuses predict the gender of an individual with a fair degree of accuracy. The present study also attempted to correlate the size of maxillary sinus with age group and found that, the age of 20-30 years have significant higher medio-distal dimension of maxillary sinus as compared to other age groups ($P < 0.05$). Further studies are recommended with larger sample size to be performed to evaluate size of the maxillary sinus in the determination of gender.

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