

## GENDER IDENTIFICATION FROM MAXILLARY SINUS USING MULTI-DETECTOR COMPUTED TOMOGRAPHY

*BY*

**Afaf M. Attia, Adel M. El-Badrawy\* and Haytham M. Shebel\*\***

*Departments of Forensic Medicine and Clinical Toxicology, \*Diagnostic Radiology, \*\*Radiology in Urology and Nephrology Center, Faculty of Medicine, Mansoura University, Egypt*

### ABSTRACT

*Identification of corpses is a difficult forensic procedure. The present study aimed to study the accuracy and reliability of maxillary sinus (MS) dimensions measurement in gender identification. Seventy three persons (39 men and 34 women) with age range 17-50 years were included in the study. Maxillary sinus (MS) measurements for both right and left sinuses (width, length & height), and total distance across both sinuses were measured from axial and coronal sections (4-mm slice thickness) multi-detector CT (MDCT) scanner (SOMATOM Emotion 6, Siemens). The mean value for the maximum height of maxillary sinus for male group was  $40.03 \pm 6.84$  mm for the right side and  $39.14 \pm 6.75$  mm for the left side and in comparison to female group that had statistically significant lower values for both right and left sides ( $35.65 \pm 4.86$  and  $35.22 \pm 6.48$  mm respectively) as  $p$  value = 0.003 and 0.01 for right and left sides respectively. The mean value for the total distance across both sinuses was  $79.48 \pm 9.68$  mm for male group and  $75.90 \pm 6.11$  for female group and a significant difference was recorded between both groups with a  $p$  value = 0.05. On the other hand, there were no significant right and left side differences for male and female groups regarding MS width, length and height. Multiple regression equations revealed that among all MS measurements the right MS height was the best discriminate variable between genders [ $B = -0.121$ ,  $p$  value (0.005\*) and Constant = 4.451,  $p$  value (0.007\*)] with overall accuracy 69.9% (71.8% for men and 67.6% for women). It can be concluded that Maxillary sinus dimensions measurements, especially the right height, are valuable in studying sexual dimorphism using MDCT image as it can provide valuable measurements for maxillary sinuses.*

**Key Words:** Gender, Maxillary Sinus, CT Scan, Sexing.

### INTRODUCTION

Identification of skeletal and decomposing human remains is one of the most difficult skills in forensic medicine. Sex determination is also an important problem in the identification. Skeletal remains have

been used for sexing the individual as bones of the body are last to perish after death, next to enamel of teeth (Deshmukh and Deversh, 2006). Radiography is used in forensic pathology for the identification of humans especially in cases where the body is decomposed, fragmented, or

burned (Rainio et al., 2001). When the skeleton exists completely, sex can be determined with 100% accuracy. This estimation rate is 98% in existence of pelvis and cranium, 95% with only pelvis and long bones, and 80–90% with only long bones. However, in explosions, warfare, and other mass disasters like aircraft crashes, identification and sex determination are not easy tasks (Ramanlal and Ariyo, 2005).

Next to the pelvis, the skull is the most easily sexed portion of the skeleton, but the determination of the sex from the skull is not reliable well until after puberty. Sex estimation can be accomplished using either morphological or metric methodologies. Statistical methods utilizing metric traits are becoming more popular, with most of the bones having been subjected to linear discriminate classification (Fernandes, 2004).

It has been reported that maxillary sinuses remain intact, although the skull and other bones may be badly disfigured in victims who are incinerated, and therefore, that maxillary sinuses can be used for identification (Wind and Zonneveld, 1989).

Computer tomography (CT) scans are an excellent imaging modality used to evaluate the sino-nasal cavities. They provide an accurate assessment of the paranasal sinuses, craniofacial bones, as well as

the extent of pneumatization of the sinuses (Teke et al., 2007). CT measurements of maxillary sinuses may be useful to support gender determination. The width, length, and height of maxillary sinus together can be used for gender determination when the whole skeleton is not available (Badger et al., 1998). This study was designed to determine the reliability and accuracy of maxillary sinus dimensions measurement as a method for gender identification.

## **MATERIAL AND METHODS**

### **Subjects:**

The sample consisted of 73 persons (39 men and 34 women) with age range from 17 to 50 years. They were referred to Mansoura Emergency Hospital for the purpose of CT scanning of paranasal sinuses. All participants were supplied with informed consent. Prior to imaging, the patient was informed about the investigation and instructed not to move or swallow during scanning. To determine the reliability and reproducibility of the maxillary sinus measurements, inter- and intra-examiner calibrations were carried out. These calibrations were carried out by comparing the greatest measurements of the randomly selected 10 multi-detector CT by the same radiologist after 2 weeks from the first reading for intra-examiner calibration and by another senior general radiologist for inter-examiner calibration.



The axial scan was parallel to orbitomeatal line and the coronal scan was perpendicular to this line. The protocol was 35 mAs, 110 kV, 4 mm slice thickness, 180 mm field of view (FOV), 512 x 512 matrix, 0.8 pitch and 0.8 sec rotation time.

Maxillary sinus (MS) measurements: width, length, height, and total distance across both sinuses were measured from axial and coronal sections (4-mm slice thickness).

The greatest measurements were taken after going through different slices in axial and coronal sections.

Edentulous patients or patients who had history of trauma, surgery, or pathological lesions in maxillofacial region were not included in this study.

The MS length was measured from axial image as the longest length anteroposteriorly (Fig. 1).

The MS width (Fig. 2) was measured

from axial image that was parallel to the hard palate as a distance from the outermost point of the lateral wall of maxillary sinus to the medial wall.

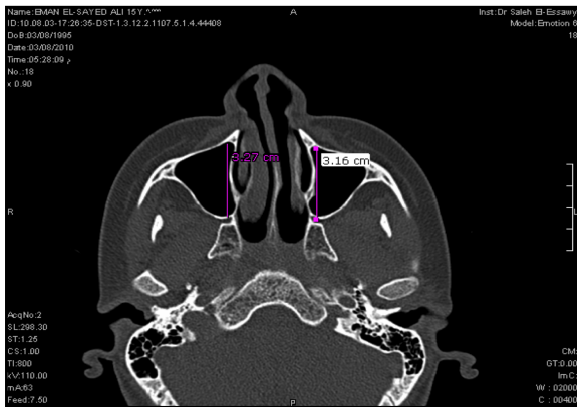
The height of maxillary sinus was represented by the distance measured from the uppermost point of the superior wall of the sinus to the lowest point of the inferior wall. The measurement was obtained from coronal section that was perpendicular to the hard palate (Fig. 3).

The total distance across both sinuses was measured from axial section as a distance from the outermost point of one maxillary sinus to the outermost point of the opposite sinus (Fig. 4).

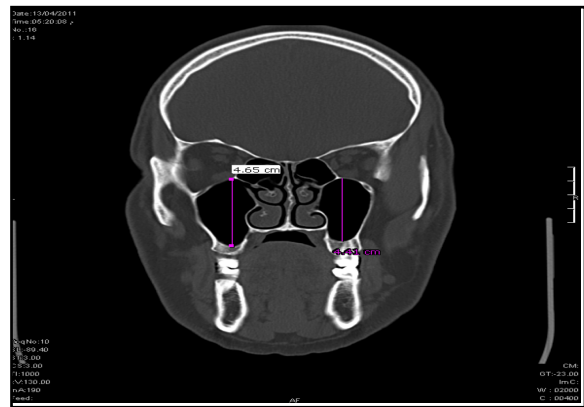
#### **Statistical analysis:**

All data were subjected to descriptive and discriminate analyses using the SPSS package (version 16; SPSS Inc., Chicago, IL).

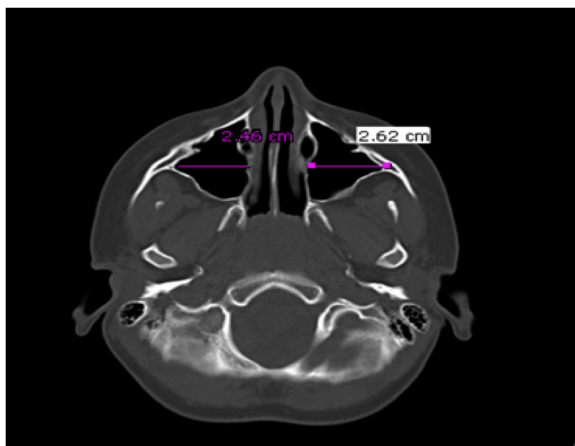
P-value was considered significant at  $\leq 0.05$  and highly significant at  $\leq 0.001$ .



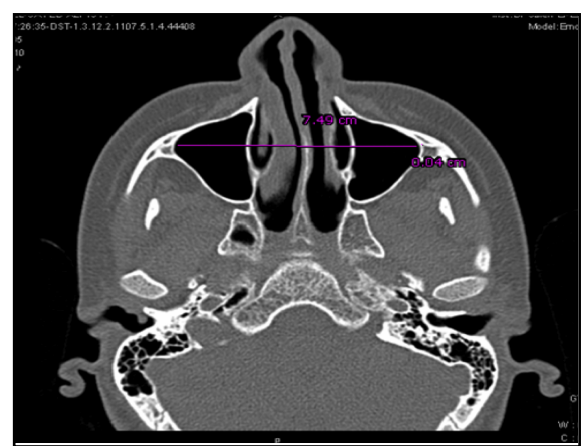
**Figure (1):** The length of both maxillary sinuses measurement (axial section).



**Figure (3):** The height of both maxillary sinuses measurement (coronal section).



**Figure (2):** The width of both maxillary sinuses measurement (axial section).



**Figure (4):** The total distance across both maxillary sinuses (axial section).

## RESULTS

The mean value for the maximum width of maxillary sinus for the right side of male group was  $24.68 \pm 5.67$  mm and  $24.62 \pm 6.09$  mm for the left side. Female group had statistically insignificant lower values for both right and left sides ( $23.27 \pm 3.47$  and  $23.05 \pm 4.42$  mm respectively) in comparison to the male group as shown in table 1.

The mean value for the maximum length of maxillary sinus for the right side of male group was  $37.86 \pm 5.18$  mm and  $37.78 \pm 5.73$  mm for the left side. Female group had statistically insignificant lower values for both right and left sides ( $36.40 \pm 4.19$  and  $37.16 \pm 4.77$  mm respectively) in comparison to the male group as shown in table 1.

The mean value for the maximum height of maxillary sinus for the right side of male group was  $40.03 \pm 6.84$  mm and  $39.14 \pm 6.75$  mm for the left side. Female group had statistically significant lower values for both right and left sides ( $35.65 \pm 4.86$  and  $35.22 \pm 6.48$  mm respectively) in comparison to the male group (p value = 0.003 for right side and 0.01 for left side) (table 1).

Regarding the total distance across both sinuses, the mean value of this parameter was  $79.48 \pm 9.68$  mm for male group and

$75.90 \pm 6.11$  for female group. In comparison to the male group, the female group showed a significant lower values regarding the total distance across both sinuses as p value = 0.05 (table 1).

There were no significant right and left side differences for male compared to female group as regards MS width, length and height (table 2).

Multiple regression equations revealed that among all MS measurements the right MS height was the best discriminate variable between genders (B= -0.121, p value (0.005\*) and Constant= 4.451, p value (0.007\*) with overall accuracy 69.9% (71.8% for male and 67.6% for female) as shown in table 3.

The Receiver Operator Characteristic analysis (ROC) was used to assess the validity of the tested variables. For each measurement, determination of cut-off value between sensitivity and specificity of MS measurements revealed that the right MS height was the most sensitive and specific variable to discriminate between gender (p value = 0.002) then the left MS height (p value =0.008) as shown in table 4 and figure 5.

As regards the accuracy of right and left MS measurements of gender groups, the right MS height was (68 % accurate measure) then the left MS height was (63% ac-

curate measure) and the total distance across both sinuses was (56% accurate measure) (table 5).

### DISCUSSION

In the field of forensic identification, maxillary sinus measurements can be taken with high speed and accuracy on the CT machine and standard instruments of measures.

The current study was designed to determine the reliability and accuracy of maxillary sinus dimensions measurement as a method for gender identification.

It was conducted on seventy three persons. The male group composed of 39 persons and the female group composed of 34 persons with age range 17-50 years.

Comparison between male and female groups showed that the female group had statistically insignificant lower values for both right and left sides as regards the MS width and length. While, the female group showed statistically significant lower values for both right and left sides as regards the MS height (p value = 0.003 and 0.01 respectively).

In comparison to the male group, the female group showed a significant lower values regarding the total distance across both sinuses as p value = 0.05.

There were no significant differences between right and left sides for both male and female groups regarding MS width, length and height.

In accordance to the current study, Uthman et al. (2011) showed no statistically significant sides difference for both gender as regards the length. While on the other hand, they found a significant right and left side differences for only male group as regards the width and the height.

In the present study, multiple regression equations revealed that among all MS measurements the right MS height was the best discriminate variable between gender [B= -0.121, p value was (0.005\*) and Constant= 4.451, p value was (0.007\*)] with overall accuracy 69.9% (71.8% for men and 67.6% for women).

Accordingly, Uthman et al. (2011) recorded the accuracy rate for both sinuses measurements to be 74.4% for men and 73.3% for women with overall accuracy of 73.9%.

On the other hand, Teke et al. (2007) reported lower accuracy rates for the same measurements, which was 69.3% for men and 69.4% for women with overall accuracy of 69.3%.

Furthermore, Deshmukh and Deversh (2006) tested maxillary sinus measure-

ments for gender assessment and they found that the average accuracy reached 80–87%.

In the current study, the Receiver Operator Characteristic analysis (ROC) was used to assess the validity of the tested variables. For each measurement, determination of cut-off value between sensitivity and specificity revealed that the right MS height was the most sensitive and specific variable to discriminate between genders (p value = 0.002) then the left MS height (p value = 0.008).

On the other hand, Uthman et al. (2011) showed that among cutoff points with highest sensitivity, the left maxillary sinus height is the best; it is associated with lowest false positive rate among all similar

cutoff values of remaining parameters.

### **CONCLUSION**

The result of the present work showed that the maxillary sinus exhibits anatomic variability between genders. Maxillary sinus dimensions measurements, especially the right height, are valuable in studying sexual dimorphism and the CT images could provide adequate measurements for maxillary sinuses that cannot be approached by other means.

### **ACKNOWLEDGEMENT**

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**Table (1) :** Statistical differences of MS measurements in the gender groups.

parameters		male		female		<i>P</i> (t-test)
		Mean (mm)	SD	Mean (mm)	SD	
Right MS	Width	24.68	5.67	23.27	3.47	0.2
	Length	37.86	5.18	36.40	4.19	0.19
	Height	40.03	6.84	35.65	4.86	0.003*
Left MS	Width	24.62	6.09	23.05	4.42	0.2
	Length	37.78	5.73	37.16	4.77	0.6
	Height	39.14	6.75	35.22	6.48	0.01*
Total distance across both sinuses		79.48	9.68	75.90	6.11	0.05*

SD standered deviation

*P* is significant if  $\leq 0.05$ .**Table (2) :** Statistical differences of MS measurements in the same gender groups.

Gender			t	<i>P</i> (paired t-test)
Male	Pair 1	Rt length - Lt length	0.133	0.895
	Pair 2	Rt width - Lt width	0.093	0.926
	Pair 3	Rt height - Lt height	1.291	0.204
Female	Pair 1	Rt length - Lt length	-.886-	0.382
	Pair 2	Rt width - Lt width	0.417	0.680
	Pair 3	Rt height - Lt height	0.634	0.531

*P* is significant if  $\leq 0.05$ .

**Table (3) :** Discriminate analysis using right MS height to discriminate between male and female.

Right height	Observed		Predicted		
			Gender		Percentage correct
			Male	Female	
	Gender	Male	28	11	71.8
		Female	11	23	67.6
	Overall percentage		69.9		
	B= -0.121, <i>p</i> (0.005*)				
	Constant= 4.451, <i>p</i> (0.007*)				

*P* is significant if  $\leq 0.05$ .

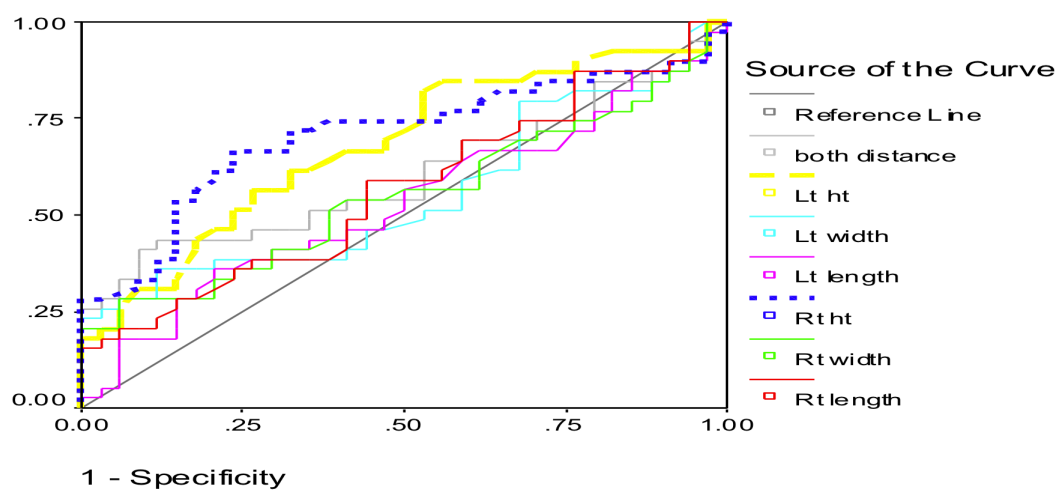
**Table (4) :** Receiver Operator characteristic analysis (ROC) of MS measurements in the gender groups.

		Area	<i>p</i>
Right MS	Width	0.549	0.4
	Length	0.566	0.3
	Height	0.706	0.002*
Left MS	Width	0.556	0.4
	Length	0.531	0.6
	Height	0.680	0.008*
Total distance across both sinuses		0.600	0.1

*P* is significant if  $\leq 0.05$ .

**Table (5) :** Accuracy of right and left MS measurements of gender groups.

		Sensitivity	Specificity	Accuracy	Predictive value	
		%	%	%	+ve	-ve
Right maxillary sinus	Width	56	50	53	53	53
	Length	59	44	52	51	52
	Height	74	38	68	66	70
Left maxillary sinus	Width	59	58	50	50	50
	Length	64	58	53	52	54
	Height	66	41	63	62	64
Total distance across both sinuses		69	58	56	54	58

**Figure (5) :** Receiver Operator characteristic (ROC) curve for all MS measurements.

Lt (left),      Ht (height),      Rt (right).



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## الإستعراف علي الجنس من الجيب الأنفي الصدغي بإستخدام الأشعة المقطعية المتعددة الكواشف

المشتركون في البحث

د. عفاف محمود عطية      أ.م.د. عادل محمد الب دراويي\*      د. هيثم محمد شبل\*\*

من أقسام الطب الشرعي والسموم الإكلينيكية - الأشعة التشخيصية\* - الأشعة بمركز المسالك والكلية\*\*

كلية الطب - جامعة المنصورة

حيث ان الإستعراف علي الجثث اجراء طبي شرعي صعب لذلك استهدف هذا البحث دراسة مدي الدقة والاعتماد على قياسات الجيب الانفي الصدغي في التعرف علي الجنس. وقد تناول البحث ثلاثة وسبعون شخصا (تسعة وثلاثون ذكرا و أربعة وثلاثون أنثي) في مرحلة عمرية بين 17-50 سنة. وقد تم أخذ قياسات العرض و الطول و الإرتفاع لكل من الجيبين الأيمن والأيسر و كذلك المسافة عبر الجيبين وذلك في القطاعين المداري والتاجي (سمك المقطع 4 ملليمتر) وذلك بإستخدام الاشعة المقطعية متعددة المقاطع (سيمنس 6 مقطع). وقد أسفرت النتائج علي ان متوسط قيمة ارتفاع الجيب الأنفي لمجموعة الذكور كان ( $40.03 \pm 6.84$  ملليمتر) بالنسبة للجانب الايمن و ( $39.14 \pm 6.75$  ملليمتر) بالنسبة للجانب الأيسر و كان متوسط قيمة ارتفاع الجيب الأنفي لمجموعة الإناث ( $35.65 \pm 4.86$  ملليمتر) بالنسبة للجانب الايمن و ( $35.22 \pm 6.48$  ملليمتر) بالنسبة للجانب الأيسر بقيمة ذات دلالة احصائية بالمقارنة بمجموعة الذكور. وكان متوسط قيمة المسافة عبر الجيبين الأيمن والأيسر ( $79.48 \pm 6.48$  ملليمتر) بالنسبة للذكور و ( $75.90 \pm 6.11$  ملليمتر) بالنسبة للإناث بقيمة ذات دلالة احصائية بالمقارنة بمجموعة الذكور. ولم يكن هناك اختلاف ذو دلالة احصائية بين قياسات العرض و الطول و الإرتفاع لكل من الجيبين الأيمن والأيسر داخل المجموعة المختبرة الواحدة. وأثبت التحليل الإحصائي المتعدد الإنحدار أن قياس ارتفاع الجيب الأنفي الصدغي الأيمن كان أفضل القياسات التي تميز الجنس بمعامل دقة عام 69.9% (بالنسبة للذكور 71.8% وبالنسبة للإناث 67.6%) و من هذه النتائج يمكن أن نستخلص أن قياسات الجيب الأنفي الصدغي يمكن إستخدامها في تحديد الجنس خصوصا قياس ارتفاع الجيب الانفي الصدغي الأيمن بإستخدام الأشعة المقطعية المتعددة الكواشف التي تعد مقياس ذو قيمة عالية في أخذ قياسات الجيب الأنفي الصدغي.