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CT SCAN IMAGES ANALYSIS OF MAXILLARY SINUS DIMENSIONS AS A FORENSIC TOOL FOR SEXUAL AND RACIAL DETECTION IN A SAMPLE OF KURDISH POPULATION

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Abstract

Despite the fact that the skull and other bones may be badly disfigured in victims who are incinerated, it became an urgent necessity to gender determination using maxillary sinuses as a useful tool of human skeletons in forensic medicine. The aim of the study: to determine the reliability and accuracy of maxillary sinus dimension measurement as a method for gender and racial identification through the use of reconstructed helical CT images.

Material and Methods:

This prospective study included cranial computerized tomography images (CT) of 119 (M: 57 and F: 62) of the Kurdish population of Sulaimani city of Iraq with an age range (20 - 75) years.

All patients were examined on Spiral Computed Tomography Scanner from October 2014 to March 2015.The greatest measurements were taken from the width, length, and height of the maxillary sinuses. The descriptive and discriminate analyzes were performed by using the SPSS package program.

Results

The mean of the length, the width, and the height of maxillary sinus in males on both right and left sides were (35.90± 4.71, 36.63 ± 5.34) (25.74 ± 5.69 , 25.36 ± 6.03) and (32.86 ± 7.00 , 33.13± 6.87) mm, respectively but in females were (34.58 ± 4.21, 35.60 ± 3.94), (22.54 ± 4.74 and 21.53 ± 4.47) and (29.16 ± 7.20,29.25 ± 6.17)mm respectively. The present study showed

that the left maxillary sinus width was the best discrimination parameter, that could be used to study sex dimorphism with Prediction of 69.4% for female and 52.6% for male (overall accuracy = 61. 3%). The discriminative analysis showed that the accuracy of maxillary sinus measurements-i.e the ability of the maxillary sinus size to identify gender-was 71% in females and 56.1% of males (overall accuracy = 63.9%).

Conclusion

The study showed that the diameters of the maxillary sinus can be used as a guide and a useful tool for racial and sex determination.

Keywords: CT scan, maxillary sinus, forensic, Kurdish population

Introduction

Despite development and progress in various diagnostic methods, still identification of skeletal remnants and decomposing of human parts is the most difficult skills in forensic medicine. Determination and age estimation are also considered problematic in many medico-legal issues such as cases of unknown skulls (Jasim and AL-Taei, 2013).

It is known that maxillary sinuses are two cavities situated in the maxilla; they have different sizes and shapes. Their walls are thin while the tip of the sinuses extends into the zygomatic process and sometimes occupy the zygomatic bone. The base formed by the alveolar process of the maxilla that holds the upper posterior teeth. Maxillary sinuses appear at the end of the second embryonic month, they extend to the roof of the permanent teeth when deciduous teeth fall off; moreover the sinuses originate as invagination of the nasal mucosa into maxilla bone. This unique development describes the massive quantity of anatomical variation (Kiruba *et al.*, 2014).

It is acknowledged that the maxillary sinuses are appearing in most individuals up to the age of five when the sinus area undergoes changes in shape and volume until the age of 18-20 due to the development of the permanent dentition (Park *et al.*, 2010)

However, it has been reported that maxillary sinuses stay intact in severely disfigured victims, whereas the skull, and other bones may be not. Therefore, the maxillary sinuses can be used for identification of these victims (Teke *et al.*, 2007)

Radiography was used as forensic tool for identification of human, especially in cases where the body is decomposed, fragmented, or burned. Images can assist in measuring accurate dimensions for which certain formulae can be applied for sex determination (Kiruba *et al.*, 2014).

It is evident that Computer Tomography (CT) scan is an excellent imaging modality used to assess the sino-nasal cavities. They make available

an accurate evaluation of the paranasal sinuses, craniofacial bones, in addition to the extent of pneumatization of the sinuses (Attia *et al.*, 2012).

Several studies have investigated; Measurements of the maxillary sinus dimension by (CT) scans, which can be used for determination of age and sex when other methods are inconclusive. The axial, sagittal and coronal sections obtained by CT and MR enable better evaluation of these structures (Jehan *et al.*, 2014).

In fact, researchers revealed that the shape and size of the maxillary sinus vary among individuals, moreover between males and females. Furthermore, maxillary sinus found to be different according to ethnic group. (Fernandes, 2004; Fernandes, Dec 2004)

The purpose of this study was to determine the reliability and accuracy of maxillary sinus dimension measurement as a method for sex and race identification through the analysis of CT images for a group of Kurdish people in Sulaimani - Iraq.

Material and Methods

The study included cranial computerized tomography images (CT) of 119 Kurdish patients aged between 20-75 years. These patients underwent CT examination for other medical problems that are not related to the maxillary sinus.

All patients were examined on Spiral Computed Tomography scanner at Sulaimani Teaching Hospital and Sulaimani Radiology Center by using computed tomography system (SOMATOM AR.STAR VB41A H-PR-CR). The X-ray machine was used with exposure parameters of (130) KV, (105) MA, TI 1.9, GT -2.0, SL 3.0/7.0 The study was established in October 2014 to March 2015.

Patients with a history of surgical procedure, trauma, facial asymmetry, septal deviation, cleft palate, ectopic teeth and supernumerary teeth were excluded from the study.

The greatest measurements were taken after going through different slices in axial and coronal sections. (Attia *et al.*, 2012; Jehan *et al.*,2014; Masri1 *et al.*,2013). The measurements of the width, length, and height of the maxillary sinuses were measured as follows:

1- The length dimension was measured on axial section as the longest distance anteroposteriorly from the most anterior point to the most posterior point. (Fig.1)

2- The width was measured on axial section as the longest perpendicular distance from the medial wall of the sinus to the outermost point of the lateral wall of the lateral process of the maxillary sinus. (Fig.1)

3- The height was estimated as the longest distance from the lowest point of the sinus floor to the highest point of the sinus roof in the coronal view that was perpendicular to the hard palate. (Fig.2)

The statistical analysis within sex comparison for all parameters was done using a t-test to compare these values in two groups. Also, a discriminating analysis was performed by using the SPSS package program (version 16 SPSS). Inform consent of all patients was obtained and the study approved by the ethical committee of Faculty of Medical Sciences, University of Sulaimani.

Fig.1: Length and width of the maxillary sinus in axial section as measured on CT images.

Fig.2: Height of the maxillary sinus in coronal section as measured on CT images.

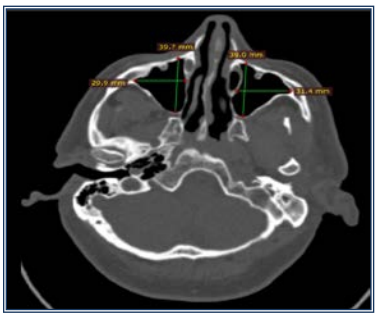

Fig.1

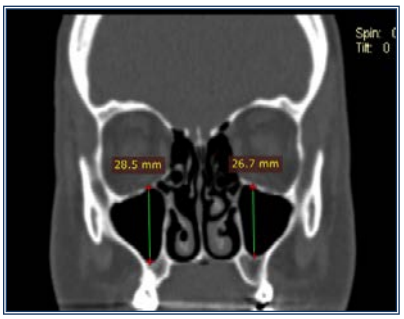

Fig.2

Results

The total sample composed of 119 patients of Kurdish population of Suliamani city of Iraq; the results were based on two study groups: the male group (composed of 57 patients) and female group (composed of 62 patients).

Maxillary sinus length MSL

The present study showed that the mean values of **MSL** for both right and left sides parameters were greater in males (35.90± 4.71, 36.63 ± 5.34 mm) than females (34.58 ± 4.21, 35.60 ± 3.94 mm) respectively, but no-significant differences of sexual dimorphism in both (right and left) sides (*p*-value = 0.109 for right side and 0.230 for left side). (Table1).

Maxillary sinus width MSW

The mean value of **MSW** for the right side of the male group was 25.74 ± 5.69 mm and 25.36 ± 6.03 mm for the left hand. Female group had statistically significantly lower values for both right and left sides (22.54 ± 4.74 and 21.53 ± 4.47 mm, respectively) in comparison to the male group (p-value = 0.001 for right and 0.000 for left side)(Table1).

Maxillary Sinus Height MSH

The mean value for **MSH** recorded (32.86 ± 7.00 mm) for male group on the right side and (33.13± 6.87 mm) on the left side which was significantly larger than that recorded for female group which was (29.16 ± 7.20) for the right side and (29.25 ± 6.17 mm) for the left side (Table1).

Table (1): Gender differences in maxillary sinus parameter from CT images

Parameters (mm)	Side	Sex	Mean	S.D	SE	*P*-value
Maxillary sinus dimension Length	Right	Male	35.90	4.71	0.62	0.109
		Female	34.58	4.21	0.53	
	Left	Male	36.63	5.34	0.70	0.230
		Female	35.60	3.94	0.50	
Maxillary sinus dimension Width	Right	Male	25.74	5.69	0.75	0.001*
		Female	22.54	4.74	0.60	
	Left	Male	25.36	6.03	0.79	0.000*
		Female	21.53	4.47	0.56	
Maxillary sinus dimension Height	Right	Male	32.86	7.00	0.92	0.005*
		Female	29.16	7.20	0.91	
	Left	Male	33.13	6.87	0.91	0.002*
		Female	29.25	6.17	0.78	

*P-value is significant at $p < 0.05$; S.D is the standard deviation; SE is a standard error.

The current study also showed significant differences in length and width parameters of maxillary sinus between the right and the left side in females, whereas there were no significant differences between these parameters in males (Table 2, 3).

Table (2): Correlation of maxillary sinus parameters in male for both sides

Maxillary sinus	Correlation	*P*-value
Length Right& Left	0.807	0.089
Width Right& Left	0.799	0.446
Height Right& Left	0.716	0.700

*P-value is significant at $p < 0.05$.

Table (3): Correlation of maxillary sinus parameters in female for both sides

Maxillary sinus	Correlation	*P*-value
Length Right& Left	0.801	0.003*
Width Right& Left	0.842	0.004*
Height Right& Left	0.729	0.882

*P-value is significant at $p < 0.05$.

A discriminating analysis was performed among all maxillary sinus measurements, the left maxillary sinus width was the best discriminate parameter that was 69.4% of female and 52.6% for male (overall accuracy =61. 3%) (Table 4).

Table (5) shows discriminate analysis using alone right or left maxillary sinus measurements discriminate between males and females.

By combining the right with the left sinus measurements, the overall classification accuracy was improved to 71% for female and 56.1 % for male (overall efficiency =63.9%) (Table 6).

In this study, we obtained the formula that can be used for gender determination from measurements on the left (Lt) and the right (Rt) maxillary sinuses, together: Gender = D = -2.784 + (0.043 x LMSR) + (-0.020 x WMSR) + (0.025 x HMSR) + (-0.130 x LMSL) + (0.174 x WMSL) + (0.051x HMSL).

Table (4): a Discriminate analysis using right or left maxillary sinus measurement distinguish between males and females.

	Predicted Male percent	**Predicted Female percent**	**Predicted Overall percent**
Length of maxillary sinus right(LMSR)	52.6%	56.5%	54.6%
D = -7.9 + 0.224 x LMSR			
Wilks' lambda = 0.978 ; p= 0.109; classified as male if D > 0.148			
Length of maxillary sinus left(LMSL)	43.9%	69.4%	57.1%
D = - 7.737 + 0.214 x LMSL			
Wilks' lambda = 0.988 ; p= 0.230; classified as male if D > 0.111			
Width of maxillary sinus right(WMSR)	52.6%	71%	62.2%
D = - 4.615+ 0.192 x WMSR			
Wilks' lambda =0.913 ; p= 0.001; classified as male if D > 0.295			
Width of maxillary sinus left(WMSL)	52.6%	69.4%	61.3%
D = - 4.430 + 0.190 x WMSL			
Wilks' lambda = 0.882 ; p= 0.000; classified as male if D > 0.343			
Height of maxillary sinus right(HMSR)	59.6%	67.7%	63.9%
D = - 4.352 + 0.141 x HMSR			
Wilks' lambda = 0.936 ; p= 0.005; classified as male if D > 0.254			
Height of maxillary sinus left(HMSL)	59.6%	64.5%	62.2%
D = - 4.771+ 0.153 x HMSL			
Wilks' lambda = 0.918 ; p= 0.002; classified as male if D > 0.287			

Table (5): Discriminate analysis using alone right or left maxillary sinus measurements to distinguish between males and females.

	Standardized Coefficient	Predicted Male percent	Predicted Female percent	Predicted Overall percent
Length of maxillary sinus right (LMSR)	-0.303	54.4%	69.4%	62.2%
Width of maxillary sinus right (WMSR)	0.827			
Height of Maxillary sinus Right (HMSR)	0.469			
D = -3.462 + (-0.068 x LMSR) + (0.159 x WMSR) + (0.66 x HMSR)				
Wilks' lambda = 0.900; p= 0.007; classified as male if D > 0.316				
Length of maxillary sinus left (LMSL)	-0.471	59.6%	72.6%	66.4%
Width of maxillary sinus left (WMSL)	0.863			
Height of maxillary sinus left (HMSL)	0.477			
D = -2.452 + (-0.101 x LMSL) + (0.164 x WMSL) + (0.73 x HMSL)				
Wilks' lambda=0.859; p= 0.001; classified as male if D > 0.376				

Table (6): Discriminate analysis using both right and left maxillary sinus measurements discriminate between males and females.

	Standardized Coefficient	Predicted Male percent	Predicted Female percent	Predicted Overall percent
Length of maxillary sinus right (LMSR)	**0.190**	56.1%	71.0%	63.9%
Width of maxillary sinus right (WMSR)	**-0.105**			
Height of maxillary sinus right (HMSR)	**0.177**			
Length of maxillary sinus left (LMSL)	**-0.605**			
Width of maxillary sinus left (WMSL)	**0.921**			
Height of maxillary sinus left (HMSL)	**0.335**			
D = -2.784 + (0.043 x LMSR) + (-0.020 x WMSR) + (0.025 x HMSR) + (-0.130 x LMSL) + (0.174 x WMSL) + (0.051x HMSL)				
Wilks' lambda = 0.855; p = 0.007; classified as male if D > 0.380				

Discussion

The present paper highlights the reliability and accuracy of maxillary sinus dimension measurement, as a method for sex and race identification through the analysis of CT images. According to the result achieved in the current study, the overall mean dimension for each parameter was statistically greater for males compare with females; which is consistant with numorous published reports (Jasim *et al*., 2013; Kiruba *et al*., 2014; Teke *et al*, 2007; Attia *et al*., 2012; Fernandes ,2004; Abd-alla and Mahdi, 2013; Kim *et al*., 2002; Uthman *et al*., 2011) which is probably due to sex-specific differences in energetic intake, nutrition, body composition and genetics (Teke *et al.,* 2007).

Our study study sample covered 119 Kurdish people living at East north of Iraq, the results indicate that the mean values for the maximum sinus parameters were smaller than several studies (Kiruba *et al*., 2014; Teke *et al*, 2007; Attia *et al*., 2012; Fernandes ,2004; Uthman *et al*., 2011) this implys that maxillary sinus of Kurdish people is smaller than Arab population as presented by Uthman *et al*., (2011) and a Attia *et al*., 2012 Furthermore, smaller than Turkish (Teke *et al*., 2007) and European population (Fernandes ,2004) but it was found that maximum sinus diameters of Kurdish people consistent with the results achieved by Fernandes,2004 for Zulu population.

Based on our data, the left maxillary sinus width was the best discriminate parameter with Prediction 69.4% of female and 52.6% for male (overall accuracy =61.3%). By combining both the right and the left sinus measurements between males and females, the overall classification accuracy was improved to 71% for female and 56.1 % for male (overall accuracy =63.9%). Whereas from the context of Uthman *et al*., (2011) the maxillary sinus height was the best discriminate parameter, which could be used to study sexual dimorphism with an overall accuracy of 71.6%. Using multivariate analysis, 74.4% of male sinuses and 73.3% of female sinuses were sexed correctly (overall accuracy =73.9%).Noteworthy both studies were occurred in the same country (Iraq) but with different ethnic groups and environmental factors.

Although Attia *et al*., 2012 revealed that among all MS measurements the right MS height was the best discriminators vary between genders of Egyptian people with overall accuracy 69.9% (71.8% for male and 67.6% for female).

On the other hand, Teke et al. (2007) indicate accuracy rates for Turkish people who used the same measurements, were 69.3% for males and 69.4% for females with overall accuracy of 69.3%; While for Indian people, Kiruna, *et al*., (2014) recorded that the accuracy of maxillary sinus measurements to identify gender was 55% in females and 69.5% of males.

The studies mentioned above had used CT scan images which indicate that maxillary sinus dimensions vary between genders and among racial groups.

These differences are attributed to multiple global factors among various ethnic and racial groups, these including special body stature, skeletal size, height and physique of an individual; environmental conditions and pneumatization process of sinus in varying age and sex groups (Sharan and Madjar, 2008).

Conclusion

According to this study diameters of the maxillary sinus, can be used successfully as an adjunct tool for racial and sex determination.

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