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Maxillary Sinus Dimensions of Different Human Age Groups by CT Scan Imaging

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Abstract

Background: The maxillary sinus is an air-filled space, situated in maxillary bones and may be recognized with different shapes and sizes, its walls are obviously thin, and its apex can extend to zygomatic processes of these bones and can occupy most of zygomatic bone. **Materials and methods:** A prospective study of 330 healthy human individuals who attending to radiology section during the period from December 2018 to October 2019 to do CT scans for maxillary sinuses. Various CT images were taken to calculate the three dimensions of the maxillary sinuses. **Results:** The mean value for right maxillary human sinus anteroposterior length, width, and height for males were 40.2 ± 4.2mm, 25.2 ± 4.2mm, and 45.0 ± 5.1mm respectively; while for the left was 39.2 ± 3.9mm, 24.5 ± 4.5mm, and 47.2 ± 4.5mm respectively. Whereas, the mean value for right maxillary human sinus length, width, and height in females were 38.7 ± 4.0mm, 24.3 ± 4.0mm, and 42.6 ± 5.0mm respectively; while for the left was 38.3 ± 4.0mm, 23.6 ± 4.2mm, and 44.1 ± 4.7mm respectively. High significant differences ($p \leq 0.05$) recorded among age groups for length of both sides of both genders, width in left sinus of both genders, height of right side of both genders, and finally height of left side in females. **Conclusion:** Maxillary sinus dimensions measured by CT scans revealed a precise recognition of 3D configuration for the sinus that may be useful as a specific identification feature of any human individual.

Keywords: Computed tomography (CT), dimensions, human paranasal sinuses, maxillary sinus.

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INTRODUCTION

The maxillary sinus is a cavity within the maxillary bone body that is defined as the largest paranasal sinus[1]. It is continuously growing downward in association with the maxillary alveolar bones pneumatization to reach the floor of nose at age of twelve years[2]. It reaches the mature size at about twenty years old as the full development of permanent teeth had been established; therefore, during adulthood, its shape and size alter particularly because of any tooth loss[3,4].

In addition, after the period of maximum growth, the human maxillary sinus volume of decreases in both sexes, due to minerals loss from the bones matrix of whole body structures which surrounding that sinus in all directions and contracting it causing volume decrement[5-7]. The two sinuses are usually equal in size but are not necessarily so, rarely one sinus is absent completely[8].

The maxillary sinus is a pyramidal-shaped cavity consists of apex, base with four sides[9], the apex may extend to zygomatic processes of maxillary bones and can occupy most of zygomatic bone[10]; the base comprises a thin lateral border of adjacent nasal cavity to form the hiatus semilunaris[11]. The roof forms the floor of the orbit, considerably ridged over the infraorbital canal [12]. In adults, the floor of sinus is about 1.2 - 1.5cm under the nasal cavity floor level [13], and most cases with bony septa radiating on that sinus floor located at different intervals between the adjoining teeth roots, and that floor is indeed perforated by apices of relative teeth [14,15]. The upper teeth number whose roots found in direct association with maxillary sinuses is not constant due to personal variations in air space size [16], but upper molar is most consistently in nearby vicinity [17]. The sinus medial wall is limited by nasal surfaces of maxillary body and by portions from lacrimal, palatine, inferior turbinate, and ethmoidal bones [18,19].

A CT scan image is produced by directing an x-ray through a slice plane in numerous directions and estimating their eventual intensity decrement [20]. It had been regarded as the method of choice to the human paranasal sinuses imaging by supplying detailed data with a perfect view for these sinuses [21], particularly their bony anatomy, craniofacial bone structures in addition to the pneumatization extension pattern of any paranasal sinus [22,23].

CT images exhibit considerably improved contrasts despite decreased spatial resolutions[24], these images clarify a series of neighboring cross-sections, and eventually, they give precise three-dimensional data [25].

This study aimed to measure the anteroposterior length, width, and height for the maxillary paranasal sinus in different age groups of both genders in axial, sagittal, and coronal CT scans.

MATERIALS AND METHODS:

A prospective study comprised a randomized sample of three-hundred-thirty cases that were apparently healthy normal individuals, who attending the Radiology Section of both Baghdad Medical City and Salah Al-Deen Teaching Hospitals during the period from December 2018 to October 2019 to do CT scans of the paranasal sinuses. These human subjects are males, females, and arranged in groups as in Table 1.

The Medical Ethics Committee of Tikrit University College of Medicine had approved this study with the code number (IQ.TUCOM.REC.2019.173). Ethical standard agreement statements were earned from all participated individuals in this study, regarding Helsinki Declaration by the World Medical Association, which was revised in 2000 at Edinburgh.

Table 1. Distribution of participating individuals according to age and gender.

Groups	Age	Male No.	Female No.	Total No.
Group 1	20 – 29 years	45	40	85
Group 2	30 – 39 years	42	41	83
Group 3	40 – 49 years	40	38	78
Group 4	50 – 59 years	43	41	84
Total		170	160	330

The present study included human individuals who had complained of headache and were referred into radiology section to have CT scans for brain and paranasal sinuses in which no pathological findings were detected in the paranasal sinuses.

On the other hand, individuals who had any history of surgical procedure, trauma, or pathological lesion at the maxillofacial area were definitely excluded from the study. Besides, more than one tooth loss at the posterior maxillary area, because sizes and shapes of maxillary sinus alter principally as a result of any tooth loss.

All the patients were exposed by spiral CT scan without using sedation or contrast medium, and CT

scanning of paranasal sinuses had been obtained from the coronal and axial planes. The coronal images were measured at either supine or prone position where the individual's chin was supported on the fixed head holder and his/her head was extended back as far as possible with angling for scanning gantry to a closely related coronal plane of that sinus. On contrary, the axial scanning was acquired by individual supine over the table of scanning with maintenance to a neutral situation for scanning gantry.

For individuals who cannot bear the prone situation or position that is desired for coronal sections, computer-generating reconstructed coronal images may be created from previously found thin axial images. A suitable positioning for the examined individual's head was necessary in order to acquire CT views. For axial images, the individual's hard palate was sited perpendicular to the underlying CT scanning table. The views should be taken when the external auditory canal was at the same line with an inferior rim of the orbit. The coronal views were captured, as the gantry was perpendicular to the individual's hard palate. It should keep in mind that any rotation or misalignment might cause disfigurement to the real anatomy over the films.

The 5mm sections were usually enough to evaluate many sinonasal and basal skull structures, but more thinly sectioning (3 mm) was utilized for identifying small structures and evaluating ostiomeatal units. In terms of filming, the recommend intermediate window width/level (W/L) technique was (2500/250, W/L). Improvements that recognized in CT scanning images for the maxillary sinus supported with multi-slice technology including quick coverage of the interest volume and acquisition of almost isotropic voxels.

A using for a 3D program of the CT Siemens workstations with a resolution maximum 1280 × 1042 full-screen format, and a picture size 360mm × 288mm. The workstation permitted simultaneous viewing for a certain reference point in three scanning views; the axial, coronal, and sagittal imaging views, and takes the images with JPEG formats utilized in a section of illustrations. Then those images are usually downloaded on CD for transfer. Specimens digitally photographed using a Panasonic HDD-H80 camera.

The information was transferred to a database computer and inputted by utilizing SPSS version 26. The frequency distribution of selected sample variables was carried out first. Then the quantitative variables outcome (measurements) put in a normal distribution curve and tabulated with mean, standard deviation, and statistical parametric tests for significance employed. T- test of independent samples and ANOVA test was utilized for evaluation of any statistical significance and p-value ≤0.05 level regarded as statistically significant.

RESULTS

The Length of Maxillary Sinus:

In males, the mean of anteroposterior length for right human maxillary sinus was (40.2 ± 4.2mm), while the left was (39.2 ± 3.9mm). On other hand, in female cases, the mean length for right human maxillary sinus was (37.1 ± 3.7mm), and of the left was (37.3 ± 3.9mm). The mean values for right human maxillary sinus length in males exhibited higher significant levels than females (p≤0.05), while the mean values for left maxillary sinus length in males recorded higher levels than that of females but not statistically significant as seen in Table 2.

Table 2. Maxillary sinus measurements for both genders done by CT scan.

	Male		Female		
	Range	Mean±SD	Range	Mean±SD	P value
Right Maxillary sinus length (mm)	(29.0 – 50.1)	40.2±4.2	(23.5 – 50.1)	38.7±4.0	**p≤0.05
Left Maxillary sinus length (mm)	(32.3 – 51.2)	39.2±3.9	(26.0 – 51.2)	38.3±4.0	*p>0.05
Right Maxillary sinus width (mm)	(15.4 – 36.1)	25.2±4.2	(11.6 – 36.1)	24.3±4.0	*p>0.05
Left Maxillary sinus width (mm)	(16.1 – 35.8)	24.5±4.5	(13.2 – 35.8)	23.6±4.2	*p>0.05
Right Maxillary sinus height (mm)	(31.4 – 51.4)	45.0±5.1	(24.2 – 51.4)	42.6±5.0	**p≤0.05
Left Maxillary sinus height (mm)	(36.8 – 53.1)	47.2±4.5	(24.4 – 53.1)	44.1±4.7	**p≤0.05

**p>0.05 = statistically not significant, **p≤0.05 = statistically significant*

In the present study, the maximum anteroposterior length of human maxillary sinus for males found in group 2 of right side with (42.2 ± 3.9mm), but the minimum anteroposterior length reported in group 3 of left side with (35.8 ± 3.6mm). Whereas, in female cases the maximum anteroposterior length of sinus recorded in group 2 of right side with (41.2 ± 3.9mm) and the minimum anteroposterior length appeared in group 4 of right sinus with (32.1 ± 4.5mm). The difference in mean recorded values among the four age groups for each gender was statistically significant (p≤0.05), as ANOVA test applied for them, as shown in Table 3.

The width of maxillary sinus:

For males, the mean for right human maxillary sinus width was (25.2 ± 4.2 mm), and for left was (24.5 ± 4.5mm). While in female cases, the mean for right human maxillary sinus width was (23.4 ± 3.5 mm) and for the left was (22.7 ± 3.9mm). Concerning sex differences, the mean values for human maxillary sinus width of males reported higher levels than females but did not reveal any statistical significant difference (p>0.05) as demonstrated in Table 2.

This study revealed that the maximum width for human maxillary sinus of male cases distinguished in group 2 of left side (27.0 ± 3.9mm), but the minimum width reported in group 1 of left sinus with (22.2 ± 4.1mm). On contrary, in female cases the maximum width for sinus was recorded in group 2 on left side (24.3 ± 3.6mm) and the minimum value of width represented in group 4 on left side with (21.7 ± 4.1mm). Using ANOVA test, showed that the difference in mean among the four age groups for each gender was not statistically significant for right maxillary sinus (p>0.05). On contrary for left maxillary sinus for both genders, it was statistically significant with (p≤0.05) as shown in Table 3.

The height of maxillary sinus:

For males, the mean for right human maxillary sinus height was (45.0 ± 5.1mm) and of left was (47.2 ± 4.5mm); whereas for female cases, the mean value for height of right human maxillary sinus was (40.1 ± 4.8mm) and for left was (41.1 ± 4.6mm). Males' recordings were significantly higher than that of females (p≤0.05), regarding gender difference, as seen in Table 2.

Table 3. Age difference groups for maxillary sinus measurements for both genders done by CT scan.

		Group 1		Group 2		Group 3		Group 4		P value
		Range	Mean± SD	Range	Mean± SD	Range	Mean± SD	Range	Mean± SD	
Male	Right Maxillary sinus length (mm)	(29.0 – 47.2)	38.6±5.0	(31.2 – 50.1)	42.2±3.9	(31.0 – 49.8)	39.5±4.3	(30.2 – 49.8)	40.5±4.5	**p≤0.05
	Left Maxillary sinus length (mm)	(33.0 – 49.6)	40.8±4.4	(32.3 – 50.2)	39.2±3.8	(32.9 – 51.2)	35.8±3.6	(34.1 – 50.6)	41.0±3.8	**p≤0.05
	Right Maxillary sinus width (mm)	(17.2 – 35.4)	24.1±3.9	(16.2 – 36.1)	25.3±4.4	(15.4 – 33.8)	25.8±4.2	(16.3 – 35.7)	25.6±4.1	*p>0.05
	Left Maxillary sinus width (mm)	(16.8 – 33.2)	22.2±4.1	(17.0 – 34.8)	27.0±3.9	(16.1 – 35.2)	24.1±4.4	(17.4 – 35.8)	24.7±4.2	**p≤0.05
	Right Maxillary sinus height (mm)	(31.4 – 48.2)	43.2±5.5	(34.6 – 50.2)	47.1±5.3	(33.3 – 49.1)	45.5±4.1	(33.0 – 51.4)	44.2±5.5	**p≤0.05
	Left Maxillary sinus height (mm)	(38.1 – 48.4)	46.5±5.6	(36.8 – 50.2)	47.9±4.2	(38.1 – 50.5)	46.1±4.8	(37.3 – 53.1)	48.3±3.4	*p>0.05
Female	Right Maxillary sinus length (mm)	(25.1 – 42.5)	38.6±5.0	(25.6 – 41.6)	41.2±3.9	(26.1 – 43.0)	36.5±4.3	(23.5 – 39.2)	32.1±4.5	**p≤0.05
	Left Maxillary sinus length (mm)	(27.1 – 44.1)	37.3±3.1	(26.8 – 43.0)	37.5±4.0	(26.0 – 42.5)	39.0±4.5	(27.5 – 44.6)	35.4±4.0	**p≤0.05
	Right Maxillary sinus width (mm)	(14.3 – 30.1)	22.8±3.6	(16.3 – 32.4)	24.2±3.2	(15.2 – 31.1)	23.1±4.0	(11.6 – 28.1)	23.6±3.2	*p>0.05
	Left Maxillary sinus width (mm)	(15.2 – 31.7)	22.4±4.0	(16.0 – 30.1)	24.3±3.6	(13.2 – 29.6)	22.6±3.7	(15.0 – 32.4)	21.7±4.1	**p≤0.05
	Right Maxillary sinus height (mm)	(26.1 – 48.1)	37.5±5.5	(24.2 – 45.8)	38.1±4.3	(27.1 – 48.3)	43.6±5.2	(25.7 – 49.3)	41.2±4.2	**p≤0.05
	Left Maxillary sinus height (mm)	(27.3 – 48.9)	37.8±5.2	(26.2 – 50.1)	41.5±3.8	(28.1 – 48.4)	42.0±4.0	(25.4 – 49.1)	43.1±5.4	**p≤0.05

In the present study, when cases were grouped according to age, the maximum height for human maxillary sinus of male cases found in group 4 on left side (48.3 ± 3.4mm), but the minimum height recorded in group 1 on right side sinus (43.2 ± 5.5mm). On the other hand, in female cases the maximum height for sinus was revealed in group 3 on right side (43.6 ± 5.2mm), but the minimum height was demonstrated in group 1 on right side (37.5 ± 5.5mm). As the ANOVA test was used, the mean values between the four age groups for each gender exhibited a statistical significant difference with ($p \leq 0.05$), except that for left maxillary sinus height in males which registered a non-statistical significant difference with ($p > 0.05$) as demonstrated in Table 3.

DISCUSSION

The present study recorded that the mean values for the human maxillary sinus measurements in males were significantly greater in length, width, and height than that of female cases. This study agrees with Park[26] study, which registered the mean values of human maxillary sinus dimensions in normal Korean individuals for the sinus width, length, and height in adult males (29.67 ± 6.18 mm), (40.67 ± 4.53 mm), (47.88 ± 5.98 mm), but in adult female cases (27.18 ± 4.35 mm), (38.86 ± 3.23mm), (45.5 ± 4.47 mm) respectively. The results of his study demonstrated higher values than those that recorded in the present study, which can be a result of different ethnicity.

A study of Fernandes[27] that included the human maxillary sinuses of Zulu and European individuals using CT scanning to measure the anteroposterior length, height, and width of that sinus. The findings of European male cases were (40.53 mm), (37.8 mm), (25.26 mm), whereas of European female cases were (38.3 mm), (35 mm), (23.96 mm) respectively. On the other side, in Zulu males were (35.5 mm), (32 mm), (20.57 mm); but in Zulu female cases were (34.46 mm), (30 mm), (22.34 mm) respectively. The anteroposterior length and width for European individuals were very close to the present findings, while height of Europeans and Zulu were lower than that registered in the current study, and this can be because of ethnic group variations. In addition, Zulu sinus length and width recorded lower levels than the present study findings. Furthermore, the Zulu male cases clarified narrower human maxillary sinuses than of Zulu females that disagreed with the current study findings; also, the race clarified a high statistical significant difference since the Zulu sinuses being narrower than that of European sinuses.

Another study worked by Teke et al [28] mentioned the human maxillary sinus in CT scanning for the Turkish population with mean values for right and left side maxillary sinuses length in male cases (42.59 ± 7.9mm, 43.8 ± 7.78mm), and in female cases (37.8 ± 5.69mm, 37.6 ± 6mm) respectively. Whereas, the right and left human maxillary sinuses width for male cases recorded (27.19 ± 5.46 mm, 26.89 ± 5.52mm), but for female cases registered (24.44 ± 3.61mm, 24.29 ± 3.98mm) respectively; while right and left side maxillary sinuses height for males reported (47.6 ± 6.4mm, 47.2 ± 6.5mm), and for female cases recorded (45.1 ± 4.6mm, 43.6 ± 4.4mm) respectively. Compared to the present findings, these values were slightly higher than that of the current study that could be attributed to a result of the anatomic variation in the studied samples. Since the maxillary sinus, height was measured in Teke et al[28] study by registration for first and last scenes of the required sinus by the CT scan. Then the number for the sections situated between them was calculated and multiplied by the slice thickness in order to measure the sinus height, and the measurements obtained by this method were less precise than that technique used in this study.

The findings of the human maxillary sinus dimensions in all previously reported studies were agreed to that of the present study, but in male cases registered significantly higher levels than that in female cases (except for the Zulu population). This might a result of body composition, nutrition, energetic intake, genetics, and the sex-specific difference that was clarified in details by previous studies [29-33].

In this study, the human maxillary sinus of group 1 revealed the non-highest level among the other studied age groups, but the lowest level of it recorded in three parameters; width for left sinus in male cases and height for right side of both sex cases. From those findings, the present study may confirm that the human maxillary sinus in this group is still at the growth status and has not reached the sinus full size.

Concerning group 2 of maxillary sinus in the current study, the highest level registered among the other studied age groups with four parameters that including; length for right side sinus of both sexes and width for left side sinus of both sex cases. On contrary, group 2 was not recorded with any lowest level among the other studied age groups. Regarding the above re-

sult findings, group 2 mostly revealed the maximum growth level for the human maxillary sinus in antero-posterior length and width.

Maxillary sinus of group 3 of this study demonstrated the highest level among the other studied age groups in only one parameter, which was the height for right side sinus of female cases. Also, group 3 noted the lowest level among the other studied age groups in another single parameter, which was the length for left side sinus of male cases. Due to those findings, group 3 could partly indicate that the human maxillary sinuses reach their full height at this period of age.

Concerning the findings of the current study, group 4 of the human maxillary sinus revealed the highest level among the other studied age groups in only one parameter, which was the height for left side sinus of male cases. On Contrast, group 4 revealed the lowest level among the other studied age groups in two parameters; which were the length for right side sinus of female cases and width for left side sinus of female cases. Therefore, from these findings, group 4 could partly suggest that the human maxillary sinuses attain their full height if they failed to attain it at group 3.

CONCLUSIONS

Anatomical measurement of the human maxillary paranasal sinus dimensions was defiantly more accurate if it was done by CT images, which may provide valuable and precise measurements that cannot be approached by other means. These findings can be necessary to assess the age, sex, ethnicity, and race for different populations or even unknown skulls in forensic medicine.

Compliance with ethics requirements: The authors declare no conflict of interest regarding this article. The authors declare that all the procedures and experiments of this study respect the ethical standards in the Helsinki Declaration of 1975, as revised in 2008(5), as well as the national law. Informed consent was obtained from all the patients included in the study.

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