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The Correlation of the Maxillary Sinus Volume with Age and Mid Face Parameters using Computed Tomography

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Abstract

Background: The maxillary sinus is valuable for the clinician; specially the dentists and the surgeons.

Aim of the Study: The current study aimed to investigate the relationship between the maxillary sinus volume, age and mid face parameters using CTs.

Subjects and Methods: Sixty healthy individuals of both sexes aged from 5 years to 72 years used in this study. The subjects were divided into six age groups (10 subjects each): From 5 to 10 years old was group 1, from 11 to 15 years old was group 2, from 16 to 20 years old was group 3, from 21 to 30 years old was group 4, from 31 to 50 years old was group 5 and more than 50 years old was group 6. The maxillary sinus volume (MSV) was calculated and the following measurements were done: Zygion to zygion (zy-zy), Zygomaxillary (zm-zm), nasion to prothion (N-Pr), nasospinal to prothion (Ns-Pr). Nasospinal to (p) point (Ns-P). Nasion to nasospinal (N-Ns). The anatomical results of CT were correlated with age and sex. The data was statistically analyzed.

Results: There was statistically significant difference in MSV between the age groups in females but not in males. There was significant positive correlation between the maxillary volume and some of mid face parameters.

Conclusion: We concluded that the shape and size of maxillary sinus could affect the mid face anatomy.

Key Words: *Maxillary sinus volume – Mid face parameters – CT – Correlation.*

Introduction

THE maxillary sinus (MS) is the largest Para nasal sinus and lies within the maxillary bone. At twenty years old the sinus reaches its mature size; this occurs with full maturation of permanent teeth. So, any tooth loss may affect the shape and size of the sinus **[1,2]**. Dentists care about the maxillary sinuses because they are close to the area where they work **[3]**. The maxillary sinus can be utilized in forensic medicine to determine sex and age in circumstances where the entire body has been lost. The maxillary sinuses remain intact in cases of extensive loss of the skull such as explosions **[4,5]**. Good examination of para nasal sinuses is valuable before any operations in the head and neck **[6]**.

The shape and size of maxillary sinus are variable **[7]**. Furthermore, the growth of paranasal sinuses varies greatly depending on the individual and age **[8]**. Understanding the relation between the maxillary sinus volume and the age of the individuals helps in detection of its anomalies. The maxillary sinus volume measurement can confirm the response to chemotherapy and radiation in malignancies **[9]**. The maxillary sinus volume affected by many environmental factors. The size of the sinus is variable and depends on facial morphology **[10,11]**. The shape of the middle face can be determined by the shape and size of the maxillary sinus as it affects the development of bony structures, also it has a role in the building up the facial features **[12]**. Apert syndrome, Goldenhar syndrome, and Williams syndrome are examples of viscerocranium anomalies show a decrease in maxillary sinus volume **[10]**. As a result, identifying the dimensions of the maxillary sinus help in understanding the relation between the maxillary sinus and anatomy of mid face **[13]**.

CT scan is the method of choice for imaging the para nasal sinuses as it gives detailed data and an accurate view **[14]**. Previous research has demonstrated that CT scan measurements of the maxillary sinus correlate to measurements on human skulls. As a result, computed tomography (CT) is regarded as a better tool for morphometric examination of the maxillary sinus **[15]**.

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The aim of the present study was to investigate the relationship between the maxillary sinus volume, age, and midface parameters.

Subjects and Methods

The present study was done on sixty healthy individuals of both sexes aged from 5 years to 72 years. These individuals were evaluated for the correlation of maxillary sinus volume with the age and the mid face parameters using Multi-slice Computed Tomography (MSCT). The individuals were chosen from CT scanning units of Radiology Department in Mansoura University Hospital. Individuals were chosen with good general health and they didn't suffer from any disorders that could alter sinus measurements. The protocol of the study was approved by the research ethics committee in Faculty of Medicine, Mansoura University. The study was performed between November 2019 and November 2020. The subjects were divided into six age groups (10 subjects each) each group included 5 male and 5 female subjects: From 5 to 10 years old was group 1, from 11 to 15 years old was group 2, from 16 to 20 years old was group 3, from 21 to 30 years old was group 4, from 31 to 50 years old was group 5 and more than 50 years old was group 6.

In the supine position, all individuals were evaluated using a 16 slice multi-detector CT scanner (GE, CT revolution 16 EVO Asir-v 2018, USA). All subjects were examined without fasting or the use of intra-invasive contrast material. The usual slice thickness was 0.5mm. On a personal computer (PC) workstation, the measurements were taken using the RadiAnt DICOM viewer 4.6.9 software **[16]**.

Determination of maxillary sinus volume:

The three dimensions of maxillary sinus were measured according to Lorkiewicz-Muszyn´ska et al., **[17]** to calculate the volume of each maxillary sinus (MSV) using the following equation Width x height x length x 0.5 **[13]** (Fig. 1).

Midface parameters: Some points; nasion (n), nasospinale (ns), prosthion (pr), zygion (zy), zygomaxillary(zm) and P point were detected in each subject on CT image to determine the linear measurements within the mid face **[18]**. The following measurements were done: Zygion to zygion (zy-zy), Zygomaxillary (maxillary width) (zm-zm), nasion to prothion (upper facial height) (N-Pr), nasospinale to prothion (alveolomaxillary height) (Ns-Pr). Nasospinale to (p) point (Ns-P). Nasion to nasospinal (N-Ns) (Figs. 2,3).

The anatomical results of CT were correlated with age and sex.

Data were provided into the computer and analyzed using IBM SPSS Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp. Quantitative data were described using mean, standard deviation for parametric data after testing normality using Kolmogrov-Smirnov test. Significance of the obtained results was judged at the (0.05) level. One Way ANOVA test was used to compare more than 2 independent groups with Post Hoc Tukey test to detect pair-wise comparison. The Spearman's rank-order correlation is used to determine the strength and direction of a linear relationship between variables.

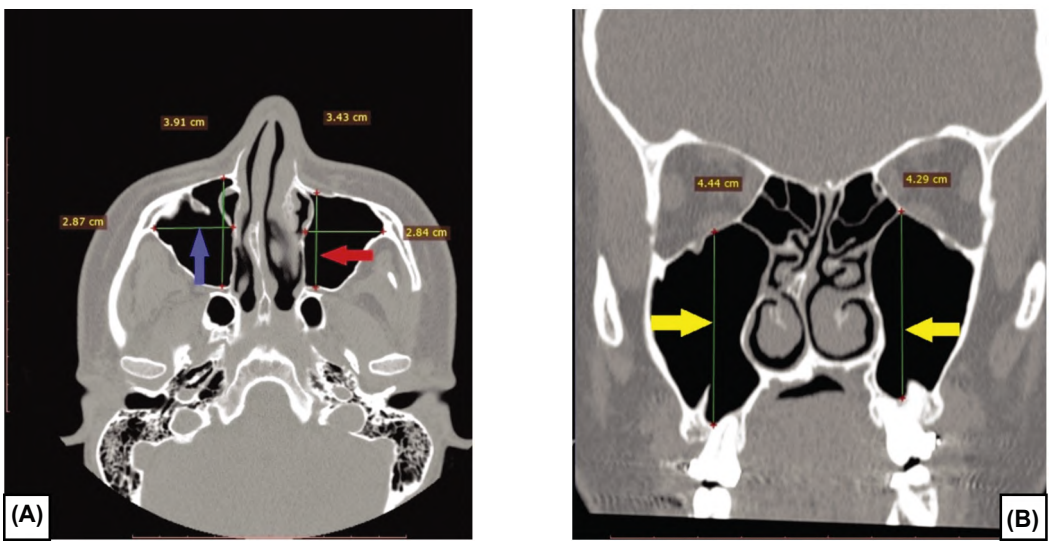

Fig. (1): (A) An axial CT image showing measurement of maxillary sinus length (red arrow) and measurement of maxillary sinus width (blue arrow). (B) A coronal CT image showing measurement of maxillary sinus height (yellow arrows).

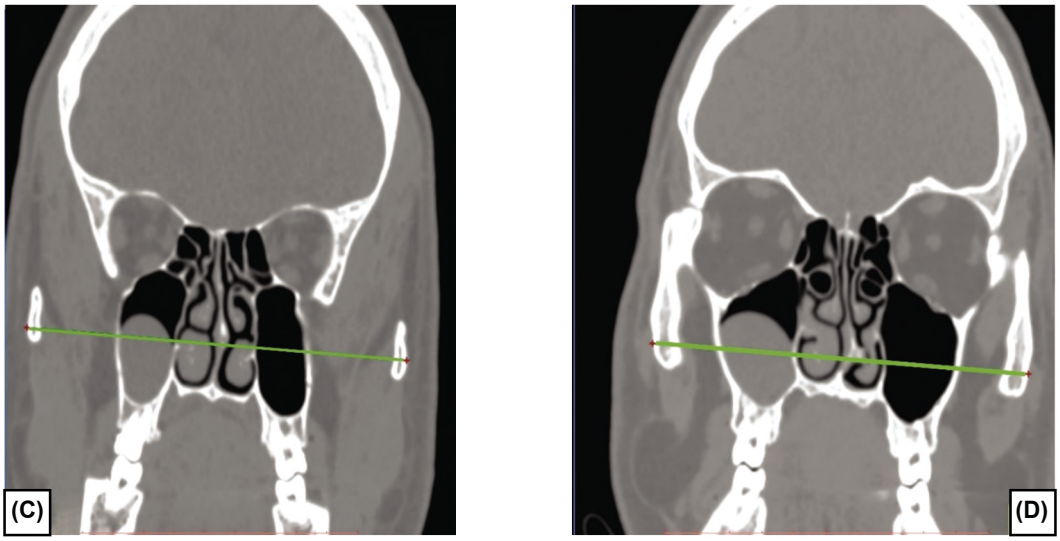

Fig. (2): (C) A coronal CT image showing zygion to zygion (inter zygomatic facial width) (zy-zy). (D) A coronal CT image showing Zygomaxillary width (zm-zm).

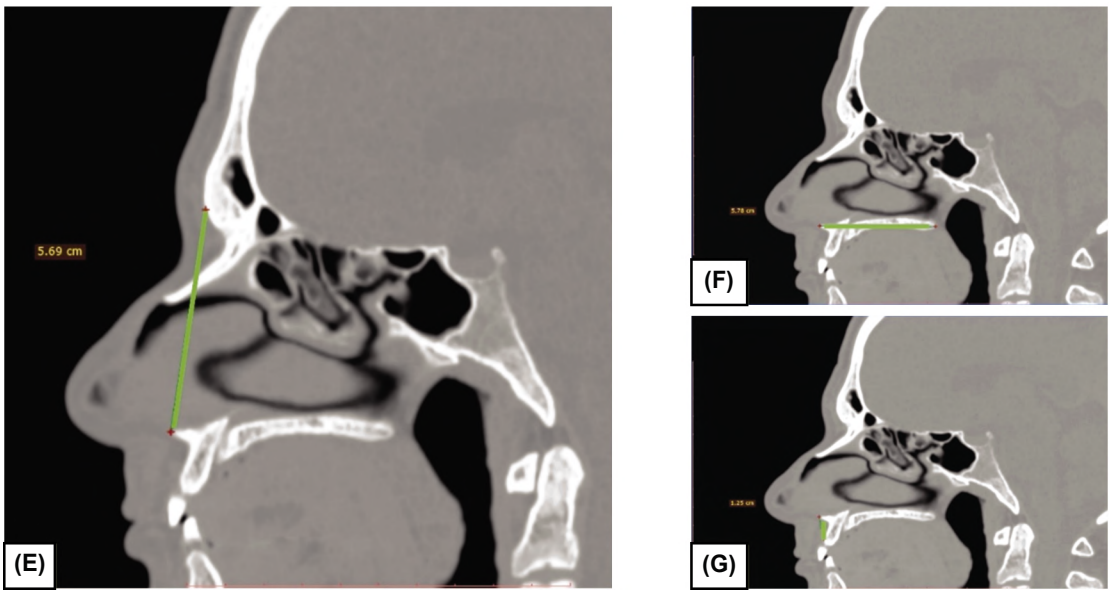

Fig. (3): (E) A sagittal section of CT image showing nasion to nasospinal (N-Ns). (F) A sagittal section of CT image showing nasospinal to (p) point (Ns-P). (G) A sagittal section of CT image showing nasospinal to prothion (alveolomaxillary height) (Ns-Pr).

Results

The age of the participant ranged from 5 to 72 years old with 50% males & 50% females.

The relation between the maxillary sinus volume and the age (Fig. 4):

In males, the mean (± SD) of the volume of right and left maxillary sinuses in age group 1 equaled 10.9 (±3.04) &10.4 (±2.15) cm^3 respectively. It increased gradually in age group 2 to reach its maximal value in age group 3 where they measured 23.3 (±11.11) & 23.14 (±10.02) cm^3 in respectively, they decreased gradually through age group 4, 5 and 6 where they reached the lowest value; 16.72 (±5.29) & 18.05 (±5.29) cm^3 respectively.

In females, the mean (± SD) of the right and left volume of maxillary sinus in age group 1 was 11.51 (±3.93), 12.39 (±4.89) cm respectively, then they increased gradually in age group 2,3 and became nearly stationary in age group 4 then reached the maximum value in age group 5 where they measured 22.24 (±5.96), 24.35 (±7.36) cm in respectively, after that they gradually decreased again in age group 6 where it reached 15.6 (±4.90), 15.24 (±6.04) cm respectively.

MSV showed no significance difference between the right and left sides and between males and females in all age groups.

The relation between maxillary sinus volume and mid face parameters:

Among studied males, there were statistically significant positive correlation between the left volume and NS-P in group 3, between ZY-ZY and left volume in group 4 and between NS-P and right volume in group 6 (Table 1).

Among studied females, there were statistically significant positive correlation between the right volume and N-PR, the left volume and both ZM-ZM & ZY-ZY among group 2. While among group 3, the correlation was found between the left volume and ZY-ZY. In group 4; the positive correlation was between N-PR and the left volume, NS-PR demonstrated a statistically significant correlation with the right volume. In group 6, a significant positive correlation was found between right volume and NS-PR (Table 2).

Correlation between age of studied groups and maxillary sinus volume and mid face parameters (Fig. 5):

There was statistically significant positive correlation between age of the studied groups and the following measurements; right MSV (r=0.306) and left MSV (r= 0.303), ZY-ZY (r=0.599), ZM-ZM (r=0.642), N-NS (r=0.82) and NS-P (r=0.443).

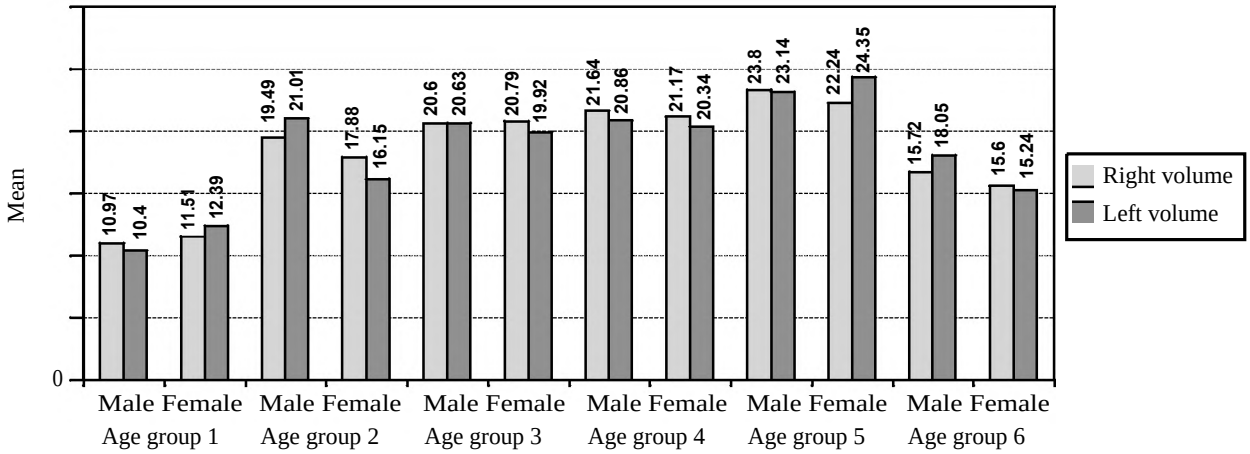

Fig. (4): Showing the comparison of maxillary sinus volume measured on head CTs according to sex of the studied age group.

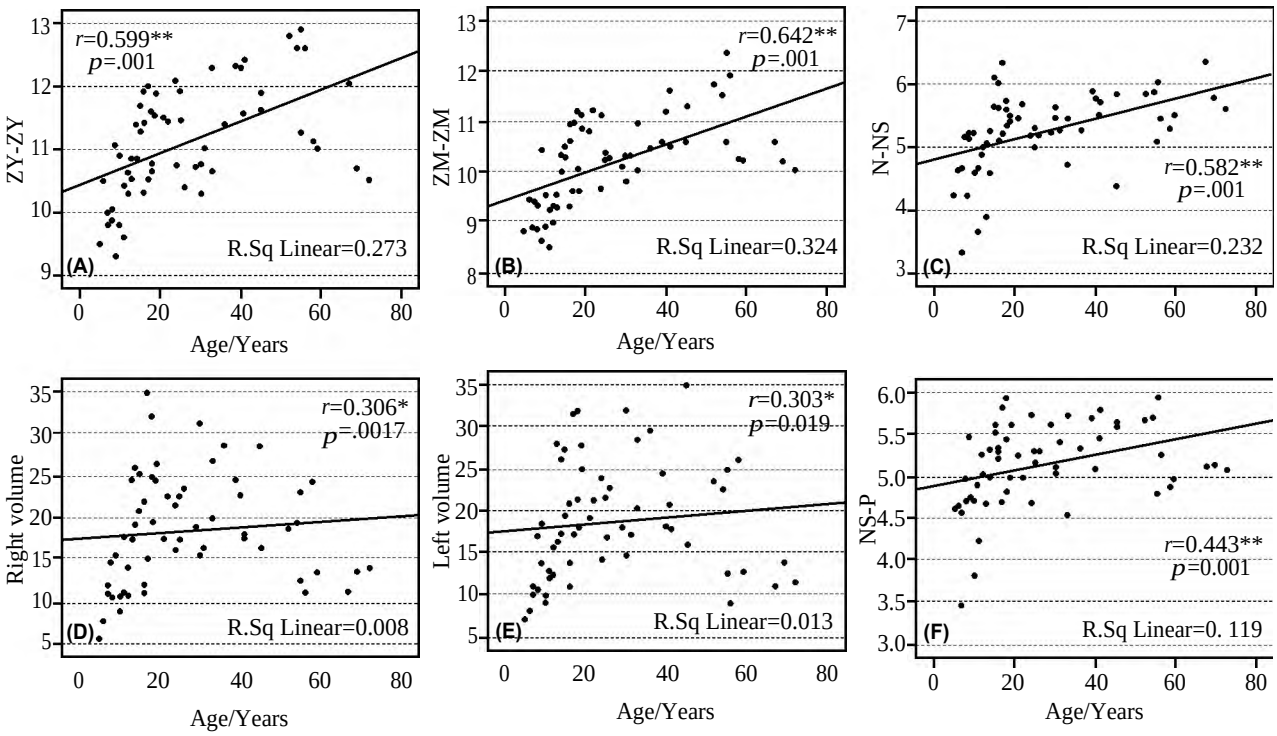

Fig. (5): Scatter diagram showing the correlation between age and maxillary sinus volume and mid face parameters among studied cases (A) Showing correlation between age and ZY-ZY (B) Showing correlation between age and ZM-ZM. (C) showing correlation between age and N-NS (D) Showing correlation between age and right volume (E) Showing correlation between age and left volume. (F) Showing correlation between age and NS-P.

Table (1): The relation between the maxillary sinus volume and mid face parameters in male.

Age/years	N-PR (cm)	NS-PR (cm)	ZY-ZY	ZM-ZM	NS-P
Male 1 *Right volume:*					
r	.500	.300	.100	.200	.500
p	.391	.624	.873	.747	.391
Left volume:					
r	.500	.300	.100	.200	.500
p	.391	.624	.873	.747	.391
2 *Right volume:*					
r	.200	–.400	.800	.800	.200
p	.747	.505	.104	.104	.747
Left volume:					
r	.300	.400	.700	.700	.300
p	.624	.505	.188	.188	.624
3 *Right volume:*					
r	.300	.600	.300	.600	.800
p	.624	.285	.624	.285	.104
Left volume:					
r	.100	.700	.000	.800	.900*
p	.873	.188	1.000	.104	.037
4 *Right volume:*					
r	.000	.000	.100	.500	–.300
p	1.000	1.000	.873	.391	.624
Left volume:					
r	–.500	.000	.900*	.500	.300
p	.391	1.000	.037	.391	.624
5 *Right volume:*					
r	-.308	.103	.100	–.800	.200
p	.614	.870	.873	.104	.747
Left volume:					
r	–.308	.103	.100	–.800	.200
p	.614	.870	.873	.104	.747
6 *Right volume:*					
r	.000	.800	.821	.600	1.000**
p	1.000	.104	.089	.285	
Left volume:					
r	.300	.700	.821	.400	.800
p	.624	.188	.089	.505	.104

r: Spearman correlation coefficient.
p: *P*robability.
*Statistically significant (1f *p*<0.05).

Table (2): The relation between the maxillary sinus volume and mid face parameters in female.

Age/years	N-PR (cm)	NS-PR (cm)	ZY-ZY	ZM-ZM	NS-P
Female 1 *Right volume:*					
r	.359	.308	–.100	–.100	.500
p	.553	.614	.873	.873	.391
Left volume:					
r	.359	.308	–.100	–.100	.500
p	.553	.614	.873	.873	.391
2 *Right volume:*					
r	.975**	.600	.600	.600	.700
p	.005	.285	.285	.285	.188
Left volume:					
r	.821	–.100	.900*	.900*	.700
p	.089	.873	.037	.037	.188
3 *Right volume:*					
r	–.410	–.300	.700	.667	.000
p	.493	.624	.188	.219	1.000
Left volume:					
r	–.154	–.100	.900*	.872	.100
p	.805	.873	.037	.054	.873
4 *Right volume:*					
r	.821	.900*	.359	.600	.200
p	.089	.037	.553	.285	.747
Left volume:					
r	.975**	.800	.103	.700	.400
p	.005	.104	.870	.188	.505
5 *Right volume:*					
r	–.500	.700	.500	.500	.200
p	.391	.188	.391	.391	.747
Left volume:					
r	–.200	.600	.800	.800	.500
p	.747	.285	.104	.104	.391
6 *Right volume:*					
r	.500	.900*	–.400	–.400	.300
p	.391	.037	.505	.505	.624
Left volume:					
r	.100	.300	.300	.300	.000
p	.873	.624	.624	.624	1.000

r: Spearman correlation coefficient.
p: *P*robability.
*Statistically significant (1f *p*<0.05).

Discussion

The largest predictor of maxillary hypoplasia, which is a widespread complaint in patients with craniofacial abnormalities, is the volume of the maxillary sinus (MSV) **[19,20]**. Changes in the dimensions of the maxillary sinus relative to the dimensions of the mid face could help to evaluate the maxillary sinus growth model and its correlation with facial anatomy **[21]**. The aim of the present study was to investigate the relationship between the maxillary sinus volume, age, and mid face parameters. In this study, in males, Maxillary sinus volume peaked in group 3, then decreased gradually through group 4, 5 and 6 till reached its lowest value. While in females, it gradually increased in group 2,3 and became nearly stationary in group 4, reached its maximum in group 5 then it decreased again gradually in group 6.

These results in agreement with Belgin et al., **[22]** who recorded decrease in the maxillary sinus volume with progress of the age. On the other hand, Park et al., **[23]** found that the volume of the

maxillary sinus reached its maximum value at 15 years of age with no changes were detected after that. However, Etemadi et al., [24] mentioned that there was no correlation between the age and the volume of the maxillary sinus (p=0.30).

In this study, there was no actual difference in the volume of the maxillary sinus between the left and right sides in any age group, whether male or female. Many studies greed with these results [22,25,26,27].

The current study detected variable difference of MSV between males and females with no significance. Jun et al., [8] recorded that the MSV is larger in males than in females during the developmental period only.

On the other hand, many studies reported that the MSV was larger in males than in females [24,26,28]. Moreover, Vidya et al., [29] and Ganjegunte & Clark [30] found actual difference in the right maxillary sinus volume between males and females. Furthermore, Belgin et al., [22] reported that the volume of maxillary sinuses in men was greater than in women, particularly in the 18-24 age group.

In the current study, among studied males, there were statistically significant positive correlation between the left volume and NS-P in group 3, between ZY-ZY and left volume in group 4 and between NS-P and right volume in group 6 while among studied females, there were statistically significant positive correlation between the right volume and N-PR, the left volume and both ZM-ZM & ZY-ZY among group 2. While among group 3, the correlation was found between the left volume and ZY-ZY. In group 4; the positive correlation was between N-PR and the left volume, NS-PR demonstrated a statistically significant correlation with the right volume. In group 6, a significant positive correlation was found between right volume and NS-PR.

These results were in accordance with Przystańska et al., [21] who confirmed that the maxillary sinus dimensions were strongly correlated with all mid face parameter except ns-pr which affected by development of permanent teeth. On the other hand, they detected weak correlation between the maxillary sinus and mid face parameters in male. They had proved that there was gender variation.

Butaric et al., [31] examined the relation between the sinus, mid face, and nasal cavity. They detected that the shape of maxillary sinus depended on the shape of nasal cavity, in addition to mid facial anatomy. The relation between the sinus and mid facial anatomy was compatible with changes in maxillary sinus function in the long run. It could indicate a link between the morphology of the maxillary sinus and the growth and development patterns of the surrounding skeletal structures [32]. furthermore, Studies on patients with mid facial hypoplasia have demonstrated the link between mid-facial structures and the MSV. Many craniofacial disorders were accompanied by mid facial or maxillary hypoplasia [33]. The maxillary sinus pneumatization is significantly connected to craniofacial characteristics. Even in the presence of severe congenital defects, this association has been established [34].

In this study, the maxillary sinus volume was measured and correlated with the age in various groups in the Egyptians. It is the first study to find out the correlation between the maxillary sinus volume and mid face parameters in various age groups from the childhood till the old age.

Limitation of our study: The small numbers of the cases used in this study in each group. This study should be done on a large scale to be used as a reference of the size of maxillary sinus volume in Egyptians to help the clinician in their work.

Conclusion:

The development of the mid facial structures is affected by the shape and the structure of the maxillary sinus. As a result, when treating the midfacial structures for trauma or congenital anomalies, the clinician must consider the maxillary sinus.

Conflict of interest:

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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العلاقة بين حجم الجيب الفكى والعمر وقياسات الوجه المتوسط باستخدام الأشعة المقطعية

الخلفية: يعد الجيب الفكى ذو قيمة فائقة بالنسبة للطبيب، وخاصة أطباء الأسنان والجراحين.

الهدف من الدراسة: تهدف الدراسة الحالية إلى بحث العلاقة بين حجم الجيب الفكى والعمر وقياسات الوجه المتوسط باستخدام الأشعة المقطعية.

مواد وطرق البحث: تم استخدام ٦٠ من الأفراد الأصحاء من الجنسين الذين تتراوح أعمارهم ما بين ٥ سنوات و٧٢ سنة فى هذه الدراسة. وتم تقسيمهم إلى ست مجموعات عمرية (كل مجموعة تشتمل على ١٠ أفراد): شملت المجموعة الأولى الأفراد من عمر ٥ إلى ١٠ سنوات، والمجموعة الثانية من عمر ١١ إلى ١٥ سنة، ومن عمر ١٦ إلى ٢٠ كانت المجموعة الثالثة، ومن عمر ٢١ إلى ٣٠ كانت المجموعة الرابعة، ومن عمر ٣١ إلى ٥٠ سنة كانت المجموعة الخامسة وأكثر من ٥٠ سنة كانت المجموعة السادسة. وقد تم حساب حجم الجيوب الأنفية الفكية (MSV) وتم إجراء القياسات التالية للوجه : (Zy-zy)، (N-Pr)، (N-Ns)، (NS-P) وقد تم تحليل البيانات إحصائياً.

النتائج: كان هناك فرق ذو دلالة إحصائية فى حجم الجيوب الأنفية الفكية MSV بين الفئات العمرية فى الإناث ولكن ليس فى الذكور. وكان هناك ارتباط إيجابى كبير بين حجم الجيوب الأنفية الفكية وبعض قياسات الوجه المتوسط.

الخلاصة: لقد خلصنا إلى أن شكل وحجم الجيوب الأنفية الفكية قد يؤثر على تشريح الوجه الأوسط.