

Morphometric Study of Postnatal Development of Maxillary Sinus in Normal Egyptian Individuals by CT Scan (from Birth to 21 Years)

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Abstract:

Background: Computed Tomography (CT) is used as gold standard method to evaluate the true anatomy of maxillary sinuses.

Purpose: The aim of this work is measuring dimensions of maxillary sinus in different age groups; detect difference between the size of the right and left maxillary sinuses in relation with the age & gender-related differences in maxillary sinuses. **Subjects and methods:** This study included 140 normal Egyptian individuals who had undergone mandatory head CT examination for other reasons. **Results:** After statistical analysis of the results, it was found that age showed a significant positive correlation with right and left maxillary sinus volumes ($p < 0.001$) among studied subjects. There were no significant differences between males and females in all age groups and no significant differences between right and left sides in all age groups **Conclusion:** CT scan is a useful tool to evaluate dimensions of maxillary sinuses, maxillary sinuses could be utilized to assign the age.

Keyword: Paranasal sinuses, postnatal development, morphometry.

Introduction

Anatomy of maxillary sinus

The maxillary sinus is the largest of the paranasal sinuses and is located just behind the anterior bony surface of the midface fill the body of the maxilla⁽¹⁾. It is pyramidal in shape its base is medial and forms much of the lateral wall of the nasal cavity which carries the inferior nasal conchae on the nasal side⁽²⁾. The apex may extend to zygomatic processes of maxillary bones and can occupy most of

zygomatic bone. The roof forms the floor of the orbit, considerably ridged over the infraorbital canal⁽³⁾.

The floor is formed by the maxillary alveolar process and partially by the hard palate. The level of the maxillary sinus floor (MSF) varies with age. At the age around 20 years MSF reaches the most inferior level with the eruption of the maxillary third molars⁽⁴⁾.

The anterior wall of the maxillary sinus is formed by the facial surface of the maxilla and is internally grooved by the canalis sinuosus (which houses the anterior superior alveolar nerve and vessels). The anterior wall has three major landmarks; the thin canine fossa, the infraorbital foramen located in the midsuperior region and the infraorbital groove. The posterior wall is formed by the infratemporal surface of the maxilla. It forms the anterior border of the pterygopalatine fossa ⁽⁵⁾.

Subjects and methods

This study is clinical observational research approved by the Research Ethics Committee of Faculty of Medicine, Benha University. This study was conducted from April 2022 to July 2022 (4 months) at Benha University Hospitals, Benha Teaching Hospital and Alfouad radiological center.

This study was carried out on 140 living human Egyptian individuals of both sexes who were not exposed to unnecessary radiation and had normal maxillary sinuses. Cases aged from birth to 21 years old were chosen and were divided into seven age groups; each group included 10 males and 10 females. First group was from birth to 3 years, Second group was from (4–6) years, Third group was from (7–9) years, fourth group was from (10-12) years, fifth group from (13-15) years, sixth group from (16-18) years, seventh group from (19-21) years. Parameters measured on right and left maxillary air sinuses in different age groups were as follows:

1. Maxillary sinus width:

Maximum horizontal diameter of the maxillary sinus was measured in the axial sections ^(6,7).

2. Maxillary sinus height:

The maximum vertical diameter of the maxillary sinus was defined as the longest distance from the lowest point of the inferior wall to the highest point of the superior wall as presented on the sagittal image ^(6,8).

3. Maxillary sinus length:

The maximum antero-posterior diameter of the maxillary sinus was defined as the longest distance from the most anterior point of the anterior wall to the most posterior point of the posterior wall on the axial image ⁽⁹⁾.

4. The volume of the maxillary sinus:

The three dimensions of maxillary sinus were measured to calculate the volume of each maxillary sinus (MSV) using the following equation width x height x length x 0.5 ⁽¹⁰⁾.

The measurements were taken using the RadiAnt DICOM viewer 4.6.9 software and were using the Statistical package for Social Science (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.)

Statistical analysis:

The collected data were revised, coded, and tabulated using the Statistical package for Social Science (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.). Data were presented and suitable analysis was done according to the type of data obtained for each parameter. $P \leq 0.05$ was deemed significant.

Results:

Group (1): comparison between right and left maxillary sinuses regarding their height, length, width and volume as shown in table (1):

In male cases (10 cases) and female cases (10 cases) with ages from birth to 3 years old. In the right maxillary sinus, males had slightly higher mean values for height (2.18 cm) and length (1.38 cm) compared to females (2.05cm), (1.34 cm) respectively, and a slightly lower mean width (0.94 cm) compared to females (0.95 cm). While in the left maxillary sinus, males have slightly higher mean values for height (2.18 cm), length (1.41cm) and width (0.98 cm) compared to females the mean values for height (2.07 cm), for length (1.35 cm) and for width (0.97 cm). The mean right maxillary sinus

volume in males was (0.98 cm³) while in females was (0.89 cm³). The mean left maxillary sinus volume in males was (0.89 cm³) while in females was (0.80 cm³).

Group (2): comparison between right and left maxillary sinuses regarding their height, length, width and volume as shown in table (1):

In male cases (10 cases) and female cases (10 cases) with ages from 4 to 6 years old. In the right maxillary sinus, males had slightly higher mean values for length (2.28 cm) and width (1.44 cm) compared to females (2.01cm) , (1.42cm) respectively, and a slightly lower mean height (3.13cm) compared to females (3.23cm), while in the left maxillary sinus, males had slightly higher mean

values for length (2.28 cm) , width (1.50 cm) compared to females the mean values for length (1.98 cm) and for width (1.49cm) and a slightly lower mean value for height (3.14 cm) compared to females (3.21cm). The mean right maxillary sinus volume in males was (5.63cm³) while in females was (5.54cm³). The mean left maxillary sinus volume in males was (5.54cm³) while in females was (5.45cm³).

According to maxillary sinus measurements in these age groups, a significant increase in length, width & height with increase in age ($p < 0.001$) in both right and left sides. No statistically significant differences between male & female in these groups ($p > 0.001$).

Table 1: Maxillary sinus dimensions in group 1 & 2 (from birth to 3 years) & (from 4 to 6 years) related according to gender

	Male n=10 From birth to 3 years	Female n=10 From birth to 3 years	Male n=10 From 4 to 6 years	Female n=10 From 4 to 6 years
Right Maxillary sinus	Mean \pm (SD)	Mean \pm (SD)	Mean \pm (SD)	Mean \pm (SD)
Height (cm)	2.18 \pm (0.60)	2.05 \pm (0.68)	3.13 \pm (0.32)	3.23 \pm (0.32)
Length (cm)	1.38 \pm (0.55)	1.34 \pm (0.51)	2.28 \pm (0.34)	2.01 \pm (0.32)
Width (cm)	0.94 \pm (0.29)	0.95 \pm (0.36)	1.44 \pm (0.21)	1.42 \pm (0.23)
Volume (cm³)	0.98 \pm (0.44)	0.89 \pm (0.44)	5.63 \pm (1.45)	5.54 \pm (1.45)
Left Maxillary sinus	Mean \pm (SD)	Mean \pm (SD)	Mean \pm (SD)	Mean (SD)
Height (cm)	2.18 \pm (0.64)	2.07 \pm (0.67)	3.14 \pm (0.33)	3.21 \pm (0.37)
Length (cm)	1.41 \pm (0.50)	1.35 \pm (0.54)	2.28 \pm (0.35)	1.98 \pm (0.41)
Width (cm)	0.98 \pm (0.30)	0.97 \pm (0.39)	1.50 \pm (0.22)	1.49 \pm (0.29)
Volume (cm³)	0.89 \pm (0.44)	0.80 \pm (0.44)	5.54 \pm (1.45)	5.45 \pm (1.45)

Group (3): comparison between right and left maxillary sinuses regarding their height, length, width and volume as shown in table (2)

In male cases (10 cases) and female cases (10 cases) with ages from 7 to 9 years old, the right maxillary sinus, males had slightly higher mean values for height (3.41cm), length (2.68cm) and width (1.97 cm) compared to females (3.39cm), (2.28cm) and (1.76cm) respectively, while in the left maxillary sinus, males had slightly higher mean values for length (2.70cm) and width (1.98 cm) compared to females the mean values for length (2.29 cm) and for width (1.72 cm). Males had slightly lower value for left mean

maxillary sinus height (3.36 cm) compared to females (3.42cm). The mean right maxillary sinus volume in males was (8.61cm³) while in females was (8.52cm³). The mean left maxillary sinus volume in males was (8.52 cm³) while in females was (8.43cm³), (Figs 1 & 2)

Group (4): comparison between right and left maxillary sinuses regarding their height, length, width and volume as shown in table (2)

In male cases (10 cases) and female cases (10 cases) with ages from 10 to 12 years old. In the right maxillary sinus, males had slightly higher mean values for height (3.83cm) and length (2.98 cm) compared to that of females (3.76 cm), (2.87cm)

respectively, and a slightly lower mean width (2.29 cm) compared to females (2.41cm), while in the left maxillary sinus, males had slightly higher mean values for height (3.82 cm) and length (3.00 cm) compared to females the mean values for height was (3.79 cm) and for length was (2.84 cm). Males had slightly lower value for left mean maxillary sinus width (2.26 cm) compared to females (2.40 cm). The

mean right maxillary sinus volume in males was (12.58 cm³) while in females was (12.49 cm³). The mean left maxillary sinus volume in males was (12.49 cm³) while in females was (12.40 cm³). (Figs 3&4)

However, the differences in height, length, width and volume between males and females in both sides appear to be insignificant (P>0.001).

Table 2: Maxillary sinus dimensions in group 3 & 4 (from 7 to 9 years) & (from 10 to 12 years) related according to gender

	<i>Male n=10 from 7 to 9 years</i>	<i>Female n=10 From 7to9 years</i>	<i>Male n=10 10 to 12 years</i>	<i>Female n=10 10 to 12 years</i>
Right Maxillary sinus	<i>Mean ± (SD)</i>	<i>Mean ± (SD)</i>	<i>Mean ± (SD)</i>	<i>Mean ± (SD)</i>
Height(cm)	3.41 ± (0.27)	3.39 ± (1.15)	3.83 ± (0.20)	3.76 ± (0.26)
Length(cm)	2.68 ±(0.53)	2.28 ± (0.78)	2.98 ±(0.33)	2.87 ± (0.24)
Width(cm)	1.97 ± (0.44)	1.76 ± (0.61)	2.29 ± (0.28)	2.41 ± (0.39)
Volume(cm³)	8.61± (3.20)	8.52 ± (3.20)	12.58 ± (2.19)	12.49 ± (2.19)
Left Maxillary sinus	<i>Mean ±(SD)</i>	<i>Mean ± (SD)</i>	<i>Mean ± (SD)</i>	<i>Mean ± (SD)</i>
Height(cm)	3.36 ± (0.29)	3.42 ± (1.13)	3.82 ± (0.22)	3.79 ± (0.32)
Length(cm)	2.70 ± (0.57)	2.29 ± (0.80)	3.00 ± (0.34)	2.84 ± (0.25)
Width(cm)	1.98 ± (0.41)	1.72 ± (0.62)	2.26 ± (0.26)	2.40 ± (0.43)
Volume(cm³)	8.52 ± (3.20)	8.43 ± (3.20)	12.49 ± (2.19)	12.40 ± (2.19)

Group (5): comparison between right and left maxillary sinuses regarding their height, length, width and volume as shown in table (3)

In male cases (10 cases) and female cases (10 cases) with ages from 13 to 15 years old. In the right maxillary sinus, males had slightly lower mean values for height (3.76 cm), length (2.86 cm) and width (2.60 cm) compared to females which were (3.81cm) for height, (3.01cm) for length and (2.67cm) for width respectively. Also, in the left maxillary sinus, males had slightly lower mean values for height (3.74 cm), length (2.84 cm) and width (2.62 cm) compared to females the mean values for height (3.83cm), for length (2.97cm) and for width (2.67 cm) respectively. The mean right maxillary sinus volume in males was (14.41cm³) while in females was (14.50 cm³). The mean left maxillary sinus volume in males was (14.32cm³) while in females was (14.41 cm³).

Group (6): comparison between right and left maxillary sinuses regarding their

height, length, width and volume as shown in table (3)

In male cases (10 cases) and female cases (10 cases) with ages from 16 to 18 years old. In the right maxillary sinus, males had slightly lower mean values for height (4.07cm) compared to that of female (4.11 cm). Males and females have nearly same value for length (3.22 cm) while males have a slightly higher value of mean width (2.87 cm) compared to that of females (2.81cm). In the left maxillary sinus, males had slightly higher mean values for height (4.11cm), length (3.29 cm) and width (2.90 cm) compared to females the mean values for height (4.05cm), for length (3.20 cm) and for width (2.83 cm). The mean right maxillary sinus volume in males was (19.36 cm³) while in females was (19.27 cm³). The mean left maxillary sinus volume in males was (19.27 cm³) while in females was (19.18 cm³).

However, the differences in height, length, width and volume between males and females in both sides appear to be insignificant (P>0.001).

Table 3: Maxillary sinus dimensions in group 5 & 6 (from 13 to 15 years) & (from 16 to 18 years) related according to gender

	<i>Male n=10 from 13 to 15 years</i>	<i>Female n=10 from 13 to 15 years</i>	<i>Male n=10 from 16 to 18 years</i>	<i>Female n=10 from 16 to 18 years</i>
Right Maxillary sinus	Mean (SD)	Mean SD	Mean SD	Mean SD
<i>Height(cm)</i>	3.76 (0.09)	3.81 (0.21)	4.07 (0.16)	4.11 (0.16)
<i>Length(cm)</i>	2.86 (0.27)	3.01 (0.31)	3.22 (0.24)	3.22 (0.46)
<i>Width(cm)</i>	2.60 (0.22)	2.67 (0.18)	2.87 (0.17)	2.81 (0.20)
<i>Volume(cm³)</i>	14.41 (2.32)	14.50 (2.32)	19.36 (1.64)	19.27 (1.64)
Left Maxillary sinus	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
<i>Height(cm)</i>	3.74 (0.16)	3.83 (0.25)	4.11 (0.20)	4.05 (0.15)
<i>Length(cm)</i>	2.84 (0.26)	2.97 (0.33)	3.29 (0.24)	3.20 (0.43)
<i>Width(cm)</i>	2.62 (0.21)	2.67 (0.20)	2.90 (0.21)	2.83 (0.20)
<i>Volume(cm³)</i>	14.32 (2.32)	14.41 (2.32)	19.27 (1.64)	19.18 (1.64)

Table 4: Maxillary sinus dimensions in group 7 (from 19 to 21 years) related according to gender

	<i>Male n= 10</i>	<i>Female n= 10</i>
Right Maxillary sinus	Mean (SD)	Mean SD
<i>Height(cm)</i>	4.09 (0.26)	3.97 ±0.12
<i>Length(cm)</i>	3.41 (0.51)	2.90 ± 0.18
<i>Width(cm)</i>	2.98 (0.11)	2.75 ±0.17
<i>Volume(cm³)</i>	22.53 (4.62)	22.44 ±4.62
Left Maxillary sinus	Mean (SD)	Mean SD
<i>Height(cm)</i>	4.19 (0.26)	4.00 (0.20)
<i>Length(cm)</i>	3.41 (0.37)	2.87 (0.16)
<i>Width(cm)</i>	2.98 (0.04)	2.72 (0.29)
<i>Volume(cm³)</i>	22.44 (4.62)	22.35 (4.62)

In the right maxillary sinus, males have slightly higher mean values for height (4.09cm) , length (3.41cm) and width (2.98 cm) compared to that of females the mean values for height was (3.97cm) ,for length was (2.90cm) and for width was (2.75 cm) respectively. Also in the left maxillary sinus, males have slightly higher mean value for height was (4.19cm) , for length was (3.41cm) and for width was (2.98cm) compared to females the mean values for height was (4.00cm) , for

length was(2.87cm) and for width was (2.72cm). The mean right maxillary sinus volume in males (22.53 cm³) while in females (22.44 cm³). The mean left maxillary sinus volume in males (22.44 cm³) while in females (22.35 cm³). However, the differences in height, length, width and volume between males and females in both sides appear to be insignificant (P>0.001).

The following figures showing dimensions of maxillary sinuses in different age groups via CT imaging:

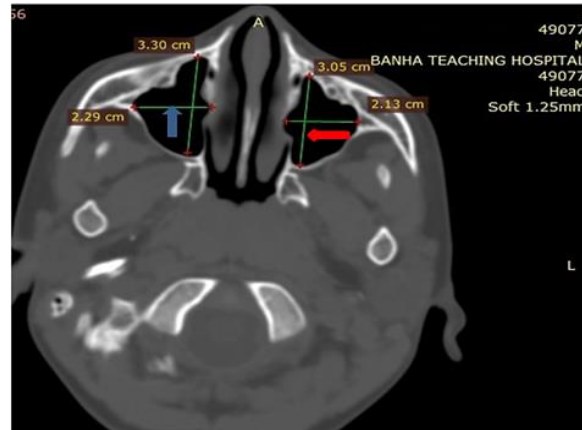


Figure (1): an axial CT image of maxillary sinuses of male aged 8 years showing measurement of maxillary sinus length (red arrow) and width (blue arrow).

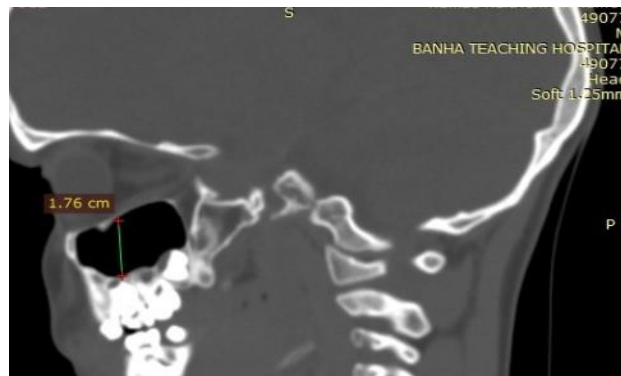


Figure (2): a sagittal CT image of maxillary sinuses of male aged 8 years showing measurement of maxillary sinus height.

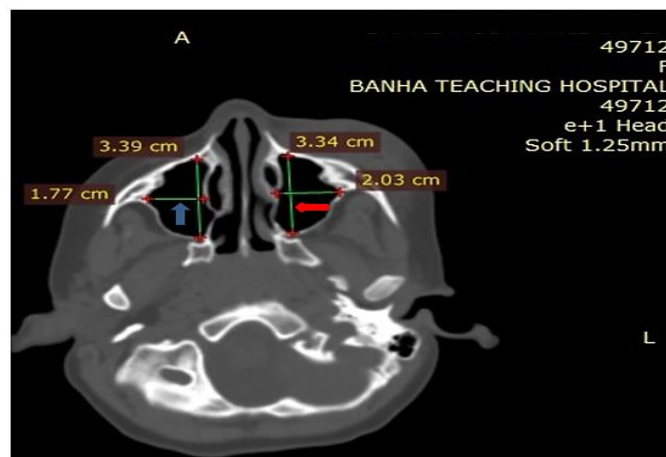


Figure (3): an axial CT image of maxillary sinuses of female aged 10 years showing measurement of maxillary sinus length (red arrow) and width (blue arrow).

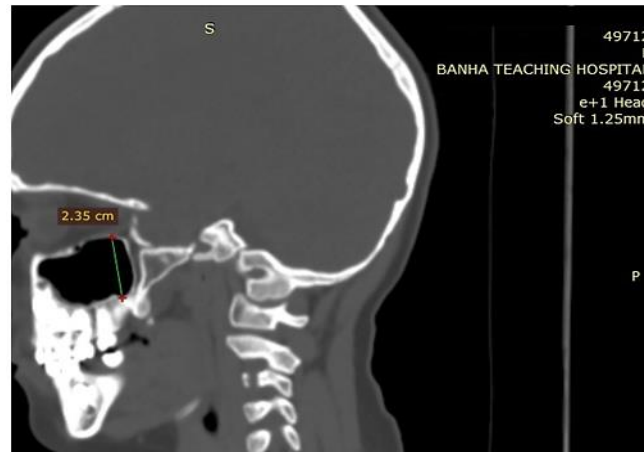


Figure (4): a sagittal CT image of maxillary sinuses of female aged 10 years showing measurement of maxillary sinus height.

Discussion:

Regarding the height, in this study the mean maxillary sinus height for the right maxillary sinus in male was 3.49 cm and 3.47 cm in female and for left side, 3.5 cm in male and 3.48 in female, this result was similar to that of other study⁽¹⁰⁾ which was for male 3.60 ± 0.612 cm and 3.67 ± 0.56 cm for the right and left side respectively and for female was 3.45 ± 0.40 cm for right side and 3.46 ± 0.44 cm for left side. However, differed from other study⁽⁷⁾ where the mean value of maxillary sinus height (MSH) in male was 2.63 ± 0.84 cm and 2.82 ± 0.66 cm in female. There was no statistical difference in MSH between right and left maxillary sinuses in all age groups that was similar to that of set of researches^(9,7,11). There was no significant difference in male and female in all age groups that was similar to that study⁽¹¹⁾, but differed from that study⁽³⁾ in which males' recordings were significantly higher than that of females ($p \leq 0.05$).

The mean maxillary sinus length in male was 2.687 cm for right side and 2.70 for left side, while in female was 2.518 cm for right side and 2.5 cm for left side, this result was nearly similar to that study⁽⁷⁾ their mean value of maxillary sinus length (MSL) in male was 2.92 ± 0.67 cm and 2.81 ± 0.66 cm in female. But differed from other study⁽³⁾ whose mean value of

MSL was in male (4.02 ± 0.42 cm) for right side and (3.92 ± 0.39 cm) for left side. On the other hand, in female cases, the mean length for right maxillary sinus was (3.71 ± 0.37 cm), and that of the left was (3.73 ± 0.39 cm).

There is no statistical difference in MSL between right and left maxillary sinuses in all age groups that was similar to that of set of researches^(9,7,11).

There is no significant difference in male and female in all age groups that was similar to that study⁽¹¹⁾.

The mean Maxillary Sinus width (MSW) in male was 2.15 cm for right side and 2.17 cm for left side, while in female it was 2.11 cm for right side and 2.114 cm in left side, this results was nearly similar to that study⁽³⁾, where their mean value of MSW was in male 2.52 ± 0.42 cm for right side and 2.45 ± 0.45 cm for the left side. While in female cases, the mean for right maxillary sinus width was (2.34 ± 0.35 cm) and for the left was (2.27 ± 0.39 cm), and according to that study⁽¹²⁾ the mean sinus width for male was 2.43 ± 0.42 cm and 2.49 ± 0.48 cm for the right side and left sides respectively and that of female was 2.33 ± 0.38 cm for right side and 2.38 ± 0.39 cm for left side, but differed from other study⁽¹⁰⁾ where their mean value of MSW was 1.89 ± 0.47 cm for male and 1.86 ± 0.49 cm for female.

There was no significant difference between the left and right maxillary Sinus width in all age groups that was similar to that study⁽¹¹⁾.

The mean of maxillary sinus volume in males was 12.07 cm³ for right side and 11.937 cm³ for left side, while the mean of maxillary sinus volume in females was 11.9 cm³ for right side and 11.8 cm³ for left side. The comparison between female and male volume measurements revealed no significant differences in all age groups, which nearly was similar to other study⁽⁴⁾.

There was no statistically significant difference in the MSV between the left and right sides when considering all ages many studies agreed with these results such as some other papers of^(4,12).

The mean value of MSV in males was greater than that of females, but showed no significance difference between males and females in all age groups, this result agreed with some other papers^(11,7).

Conclusion and recommendation:

Finally, we concluded that maxillary sinuses could be utilized to assign the age. There is a possibility of sexual dimorphism, regarding MSV that would need further investigation on bigger and broader samples.

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