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Anatomical Changes Related to Age in Maxillary Sinus

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Abstract

Objective: The paranasal sinuses consist of four paired cavities: maxillary, ethmoid, frontal, and sphenoid, which are air-filled, mucosa-lined spaces within the maxillofacial region, connected to the nasal cavity. The maxillary sinus, the largest of these, occupies the body of the maxilla and has a pyramidal shape.

Methods: In this study, CBCT scans from 35 subjects (18 males and 17 females) who visited the University Dental Hospital in Tikrit and a private CBCT center in Samarra were analyzed. Subjects were categorized into four groups (A, B, C, and D). Measurements focused on determining the dimensions of the right maxillary sinus, including height (distance from the superior wall to the inferior wall in the coronal plane), width (distance from the lateral to the medial wall), and depth (antero-posterior distance in the axial plane). Mean values for each dimension were calculated.

Results: The study results revealed that the length and height of the right maxillary sinus (RMS) increased up to Group C and then began to decline in Group D. Male subjects showed larger sinus dimensions compared to females. In females, the maxillary sinus length and height were variable across Groups A and B, with an increase in Group C followed by a decrease in Group D, while width showed an initial fill in Group A and then a gradual decline through Groups B, C, and D. In males, length, width, and height of the sinus increased in Groups A and B, peaked in Group C, and declined in Group D.

Keywords: Maxillary sinus age changes, CBCT maxillary sinus measurements, Maxillary sinus dimensions by age, Gender differences in sinus size

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Introduction

The paranasal sinuses, comprising maxillary, ethmoid, frontal, and sphenoid sinuses, are air-filled, mucosa-lined cavities in the maxillofacial region that communicate with the nasal cavity [1,2]. Initially illustrated by Leonardo da Vinci in 1489 and later detailed by anatomist Nathaniel Highmore in 1651, the maxillary sinus—or antrum of Highmore—is the largest and earliest to develop among the paranasal sinuses [3]. It occupies the maxilla, with its floor formed by the alveolar process, which supports the dentition, particularly the second premolar and first molar roots [4].

Anatomically, the maxillary sinus has a pyramidal shape with a medial base adjacent to the nasal cavity, an apex extending into the zygomatic process, and a capacity of approximately 15 mL in adults, making it the largest paranasal sinus [5]. Bone expansion during paranasal sinus development occurs at varying rates and can result in significant variability in sinus shape and size [6,7]. With age, sinus volume increases until around 20 years of age before gradually declining, a process further influenced by tooth loss and aging [8]. The purpose of this study was to investigate the age-related changes in dimensions of the maxillary sinus, a study using computed tomography [9].

Material and Methods

Subjects

CBCT scans were analyzed from 93 subjects, comprising 49 males and 44 females, who presented to the University Dental Hospital in Sharjah. The CBCT images were acquired using the Galileos, Sirona CBCT Dental System (Bensheim, Germany) with an SIDEXIS operating system set at 85 kVp and

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7 mA. Assessment was conducted directly on a 1920 x 1080 pixel, 23-inch DELL monitor. This dataset, obtained from the University Dental Hospital at the University of Sharjah, included measurements of six specific features of the paranasal sinuses for both male and female subjects [10,11]. The study encompassed patients aged 20 to 70 years. CBCT scans from edentulous subjects, those with a history of mid-facial trauma, maxillary sinus cysts or tumors, or scans with incomplete coverage of the maxillary sinus area, were excluded [12].

To minimize observer bias, two experienced maxillofacial radiologists, each with 10 years of clinical practice, evaluated the sinus dimensions. Mean values for each measurement were calculated, with assessments repeated after 15 days to control for intra-observer variability.

Additionally, CBCT scans from 35 subjects (18 males and 17 females) who presented to the University Dental Hospital in Tikrit and a private CBCT center in Samarra were reviewed. These scans were acquired using the CS 8200 3D (12 x 10 Edition) and assessed on the same DELL monitor specifications as in Sharjah. This subset included subjects aged 20 to 60 years and followed similar exclusion criteria.

Sample Grouping

Only data from the right maxillary sinus were included in this study due to incomplete data for the left maxillary sinus, which led to its exclusion. Data collection was organized using a chart (refer to Figure 2). Subjects were categorized into age-based groups, with each group comprising both male and female participants, as follows:

- Group (A): Ages 20-29 years

- Group (B): Ages 30-39 years

- Group (C): Ages 40-49 years

- Group (D): Ages 50-59 years

Statistical Analysis

The mean value for each measurement was calculated. For statistical analysis, an independent samples t-test was employed to compare means between males and females, while an ANOVA test was used to evaluate mean differences across age groups. In all tests, a P-value of less than 0.05 was considered statistically significant. Data organization was conducted in Microsoft Excel 2020, with subsequent analysis in SPSS version 27[13].

Exclusion Criteria

1. Patients with a history of mid-facial trauma.

2. Presence of tumors or cysts in the maxillary sinus.

3. CBCT scans lacking complete coverage of the maxillary sinus area were excluded from the study.

Figure 1. X-ray computed tomography.

			Lift sinus				Right sinus			
Hight	Width		Length	Hight	Width		Length	sex	Age	N

Figure 2. Chart for data collection.

Measurements

The measurements of the right maxillary sinus were conducted on CBCT sections to ensure precision and consistency, with measurements taken parallel or

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perpendicular to the hard palate as specified.

1. Height: The height of the maxillary sinus was measured in the coronal CBCT section, perpendicular to the hard palate. This distance extended from the uppermost point of the superior wall to the lowest point of the inferior wall, as illustrated in Figure 3A.

2. Width: The width of the right maxillary sinus was assessed in the coronal CBCT section, also parallel to the hard palate. This measurement spanned from the outermost point on the lateral wall to the medial wall of the maxillary sinus, as shown in Figure 3A.

3. Depth: The depth of the sinus was measured on the axial CBCT section as the longest antero-posterior distance, as depicted in Figure 3B.

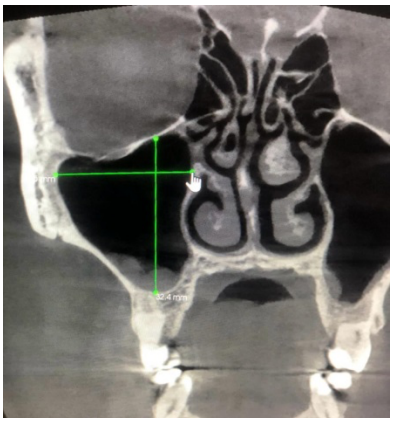

Figure 3. Measurements on CBCT images.

- A: Measurement of the height and width of the maxillary sinus on the coronal CBCT section.
- B: Measurement of the depth (length) of the maxillary sinus on the axial CBCT section.

Results

The distance from the uppermost point of the superior wall to the lowest point of the inferior wall of the maxillary sinus was measured in the coronal section, oriented perpendicular to the hard palate. The width of the right maxillary sinus was also assessed in the coronal CBCT section, parallel to the hard palate, spanning from the outermost point on the lateral wall to the medial wall. Depth was measured in the axial CBCT section as the longest antero-posterior distance. Mean values for each measurement were calculated for each age group, separately for males and females, with measurements taken exclusively from the right side.

MS Measurements in Different Age Groups

Mean and standard deviation for the length, width and height in both sexes of different age groups are shown in Table 1.

Table 1. Average measurements of right maxillary sinus parameters between age groups (N=35) in (mm).

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Variable	GA 20-29		GB 30-39		GC 40-49		GD 50-59		P-value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Length	37.1	3.8	37.0	5.5	38.8	4.7	36.2	3.2	>0.05
Width	23.9	4.5	24.2	3.7	23.6	2.8	24.2	2.6	>0.05
Height	33.3	5.5	33.2	5.9	34.2	7.2	31.2	6.8	>0.05

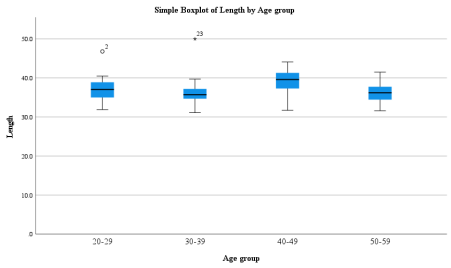

Figure 4. Length of MS by age groups.

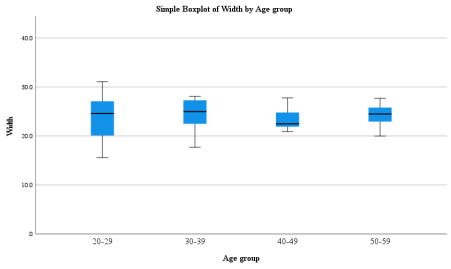

Figure 5. Width of MS by age groups.

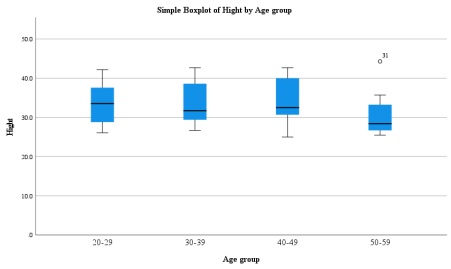

Figure 6. Height of MS by age groups.

MSM in Both Sexes Related to Aging

Table 2 revealed that maxillary sinus length of females in GA was (35.3+2.4), GB was (34.0 + 2.5), GC was (36.2+4.1), and finally GD was (35.4+ 3.0).

The present study showed that all the dimensions of MS in males were larger than in females. There was no significant difference between groups of males and females (P>0.05).

Table2. Average measurements (in mm) of right maxillary sinus parameters between sex and age groups (N=35).

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Variable			Age group GA 29		GB 30-39		GC 40-49		GD 50-59		P-value
			Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Sex	Female (n=17)	Length	35.3	2.4	34.0	2.5	36.2	4.1	35.4	3.0	>0.05
		Width	23.6	4.9	23.1	5.4	22.5	2.0	22.1	1.9	>0.05
		Height	29.6	3.8	29.5	3.0	32.5	7.5	27.6	2.5	>0.05
	Male (n=18)	Length	38.4	4.3	39.3	6.3	42.7	2.0	37.4	3.7	>0.05
		Width	24.1	4.6	25.0	1.7	25.2	3.7	23.1	3.3	>0.05
		Height	36.0	5.0	36.2	6.1	36.7	8.5	35.9	8.3	>0.05

Discussion

In this study, CBCT scans of 100 patients (72 males and 28 females) aged 1 to 90 years were examined at the Radiology Department of Vydehi Institute of Medical Science & Research Centre, Bangalore, focusing on coronal and axial sections of the maxillary sinuses [14,15]. Volume and dimensions, along with anatomical variations, were assessed, with mean values, standard deviations (SD), and significant differences across age and gender calculated. Notably, the greatest sinus growth in males occurred in the 11-20 and 41-50 age groups for height, width, and volume, while depth peaked in the 21-30 and 31-40 age groups. Growth generally decreased after 61-70 years in height and further in 81-90 years across depth, width, and volume. These findings align partially with the current study, where maxillary sinus (MS) length, width, and height in males peaked in Group C (40-49 years) before decreasing in Group D (50-59 years). In females, the highest growth was observed in the 21-30 and 51-70 age ranges for height, depth, and volume, with width peaking in the 11-20 and 51-60 age groups, followed by a decrease in all dimensions post-61 years, which also partially corresponds to our findings showing height and length increases in Group A (20-29 years) and declines by Group D.

A retrospective observational study at Royal Care Hospital, Khartoum, Sudan [16,17]. evaluated CT scans of Sudanese adults (ages 17-78 years, 46 males and 35 females) with normal paranasal sinuses (PNS). The study found a negative correlation between age and maxillary sinus volume, with sinus dimensions decreasing in both genders as age advanced. This aligns with our findings, where the right maxillary sinus (RMS) length and height peaked in Group C and decreased in Group D. However, the Sudanese study noted no significant gender differences in sinus volume, a contrast to the present study where all maxillary

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sinus dimensions were larger in males than females [18].

Another study of 200 patients at Dicle University, Faculty of Dentistry, Department of Oral and Maxillofacial Radiology, involved CBCT images analyzed via MIMICS software, categorizing patients into five age groups [19]. Results revealed a significant male-female difference in maxillary sinus volume, with volumes diminishing with age—findings that align with the current study's conclusions [20].

Finally, an analysis of 133 individuals (84 females, 49 males) aged 8 to 51 years assessed maxillary sinus volume (MSV) via MIMICS 21.0 software, with SPSS 21.0 used for statistical analysis. While this study found no significant relationship between gender, age, and maxillary sinus volume, differing from our results, which show male measurements consistently larger and RMS length and height peaking in Group C before declining in Group D [21,23].

Recommendations

1. Increase the interval of samples to study younger and older age groups.

2. Using longitudinal study by taking groups of childes and take their morphometric measurements then after a period take the measurements of the same people and study their aging changes.

Conflicts of interest

The authors declare no competing interest.

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