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COMPARISON OF MAXILLARY SINUS VOLUME IN PATIENTS WITH DIFFERENT MAXILLARY ANTEROPOSTERIOR GROWTH PATTERNS USING CONE BEAM COMPUTED TOMOGRAPHY

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KEYWORDS

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ABSTRACT

Introduction: The maxillary sinus is part of the naso-maxillary complex and in close proximity to the upper teeth; it is of interest to all clinicians and practitioners in the dental field including orthodontists. Studies were conducted to evaluate how the maxillary sinus may affect the orthodontist's treatment plan. **Aim:** The present study was designed to identify whether a relation exists between the maxillary sinus volume and different anteroposterior maxillary growth patterns in adults using cone beam computed tomography. **Materials and methods:** Ninety full skull CBCT scans were divided into three equal groups according to the anteroposterior maxillary growth pattern; normal maxilla, excess maxilla and deficient maxilla. The maxillary sinus volume was measured in both the right and left side using OnDemand3D. **Results:** The results of the study revealed no significant difference between the maxillary sinus volume in the different groups of anteroposterior maxillary growth pattern. Additionally, there was no significance difference between the volume of the maxillary sinus between the right and left sides. **Conclusions:** Different anteroposterior maxillary growth patterns do not affect the total adult volume of the maxillary sinus. The right and left maxillary sinus in adult populations show similar volumes with negligible differences between both sides.

INTRODUCTION

With the maxillary sinus being part of the naso-maxillary complex and in close proximity to the upper teeth; it is of interest to all clinicians and practitioners in the dental field including orthodontists [(1)]. A lot of studies were conducted to evaluate how the maxillary sinus may affect the orthodontist's treatment plan and what precautions should be made so that the line of treatment chosen does not encroach on the integrity of the maxillary sinus. Additionally, regarding treatment, it was speculated whether malocclusion affects the maxillary sinus both in size and in position. Several studies were carried out to correlate the maxillary sinus area and dimensions with different malocclusions either dental or skeletal, anteroposterior or vertical [(2-4)].

With the emergence of cone beam computed tomography (CBCT) and its well-known advantages in the field of radiography being more appreciated, orthodontists started using it more and more frequently. The study of the maxillary sinus started taking a 3D approach with

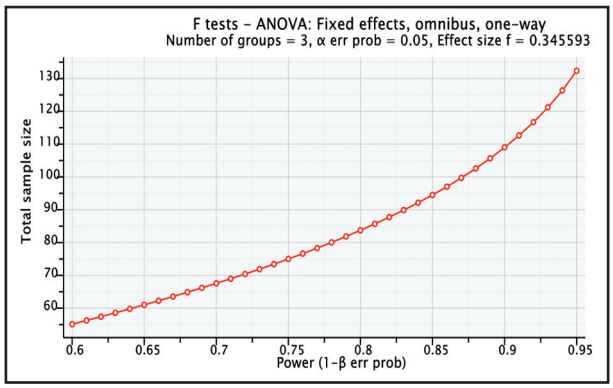
the ability of assessment of the volume of the maxillary sinus rather than its area and in the three dimensions. The volume of the maxillary sinus was compared in different malocclusions, and several researches were made to pinpoint whether a relation existed or not between maxillary sinus volume and malocclusion. Some studies showed that there was a correlation between the maxillary sinus volume and vertical malocclusion, on the other hand, other studies contradicted that finding.[5-8] As only a few studies were conducted to assess anteroposterior malocclusion, therefore, the present was set to study whether a relation existed between maxillary sinus volume and different anteroposterior growth patterns.

MATERIALS AND METHODS

The present study was conducted after the approval of the Research Ethics Committee (REC) of the Faculty of Dentistry, Suez Canal University (263/2020). Maxillary sinus volume was measured from CBCT scans obtained from the archives of the Oral and Maxillofacial Radiology department, Faculty of Dentistry, Suez Canal University. Lateral cephalograms were extracted from CBCT scans and from which growth pattern markers (anteroposterior growth pattern) were measured.

Sample size calculation

The sample size calculation was based on a previous study by **Yassaei *et al,*** [9] comparing the total maxillary sinus area (TMSA) measured by digital lateral cephalometry according to G* Power 3.0.10. A sample size of 90 cases was considered sufficient. Therefore, 30 radiographs were included in each study group.



The 90 CBCT scans were chosen to fulfil the following eligibility criteria:

Inclusion criteria

- Unidentified full skull CBCTs of adults (20-40 years old).
- Radiographs showing a clear view of the maxillary sinus.
- Radiographs of patients with fully erupted permanent dentition.
- Radiographs free from artefacts and of good quality.

Exclusion criteria

- Radiographs showing deformity in mid-face region.
- Radiographs with pathological findings in maxillary sinus.
- Radiographs of subjects who appeared radiographically to have had previous orthodontic treatment.

Sample grouping:

Lateral cephalometric radiographs extracted from CBCT were used in grouping. The 90 CBCTs were divided into three equal groups according to

Table (1) *Classification of the growth pattern according to the values of McNamara index:*

McNamara index	Normal maxilla Group I	Maxillary excess Group II	Maxillary deficiency Group III
N - Perpendicular to A point.	A point is 0 or 1 mm anterior or posterior to N perpendicular.	A point is more than 1mm anterior to N perpendicular.	A point is more than 1mm posterior to N perpendicular.

their anteroposterior growth pattern into normal maxillary growth, maxillary excess and maxillary deficiency. Classification of the different growth patterns was made according to the values of McNamara index [10] (Table 1):

Group I: Normal maxilla, A point is 0 or 1 mm anterior or posterior to N perpendicular.

Group II: Maxillary excess, A point is more than 1mm anterior to N perpendicular.

Group III: Maxillary deficiency, A point is more than 1mm posterior to N perpendicular.

Where A Point is the deepest point on the curved profile of the maxilla, and

N Perpendicular is the Vertical line constructed from nasion and perpendicular to Frankfort Horizontal plane [11].

Planmecca Romexis Viewer software was used for extraction of the lateral cephalometric view from the CBCT scans (Figure 1). Points and lines were outlined using the draw tool from the tool bar. The distance from N perpendicular to A point was measured to determine anteroposterior maxillary growth pattern and assign each scan into one of the three study groups (Figure 2).

Volumetric measurements of the maxillary sinus:

The right and left maxillary sinuses volume were measured and calculated on CBCT images using On demand 3D software 1.0.10.7462.

In the coronal, sagittal and axial views, images were translated to the maxillary sinus of one side (Figure 3). After images were translated to the maxillary sinus in all three dimensions, using the Overlay option from the tool bar, the sinus was selected and outlined. Then, the grow option in the segmentation feature was selected. The maxillary sinus was then grown as seen in (Figure 4). Using fine tuning, the threshold was changed to be from -1000 to -400 so that when calculating volume, only air in this area was measured. Then, the grow option in the segmentation feature was again selected so that the maxillary sinus volume was grown as seen in (Figure 5) and colored red. The software then calculated the volume of the highlighted maxillary sinus in cubic centimeters (cm^3) (Figure 6). The same process was repeated to calculate the volume of the sinus on the other side.

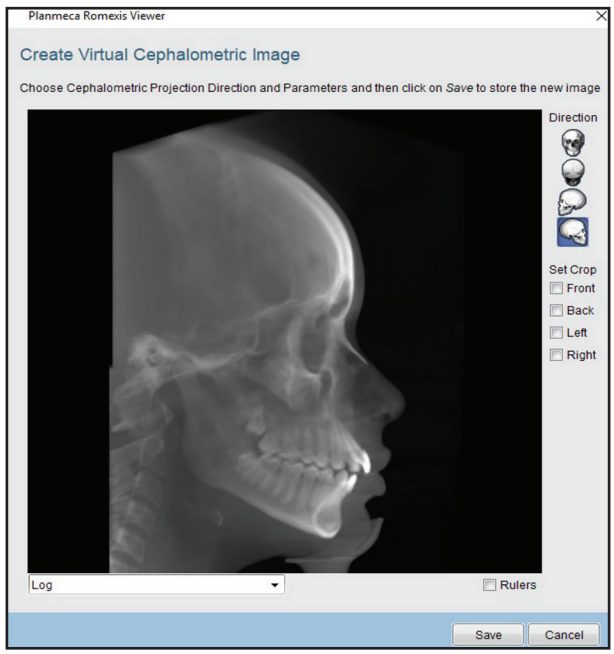


Fig. (1) Extracting lateral cephalometric radiograph from CBCT scan using Romexis software

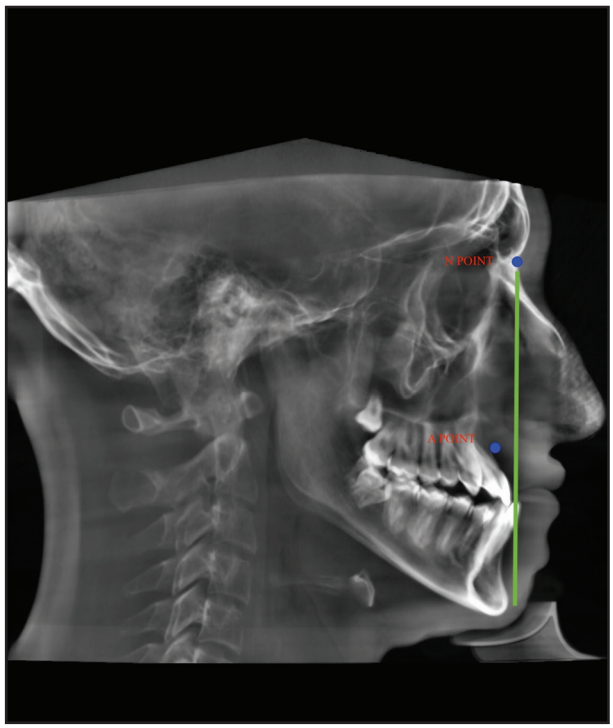


Fig. (2) The distance from A point to N perpendicular to determine the anteroposterior maxillary growth pattern according to McNamara index

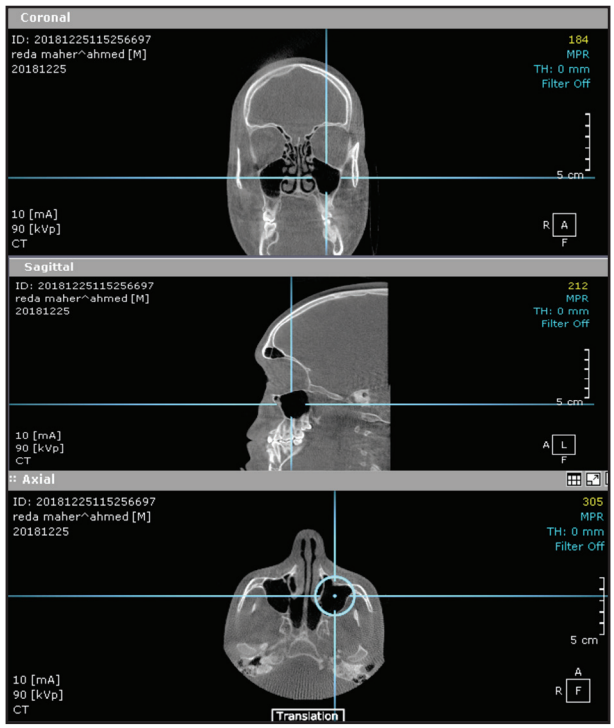


Fig. (3) Cone beam computed tomography; translation to the maxillary sinus of one side in coronal, sagittal and axial views.

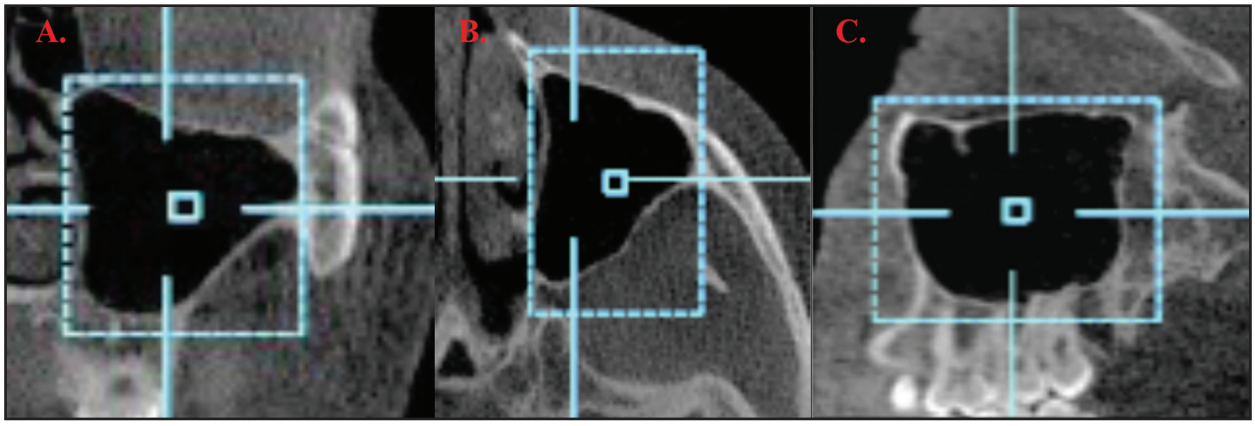


Fig. (4) Cone beam CT; Magnification of outlined and selected Maxillary sinus. A. Coronal view. B. Axial view. C. Sagittal view

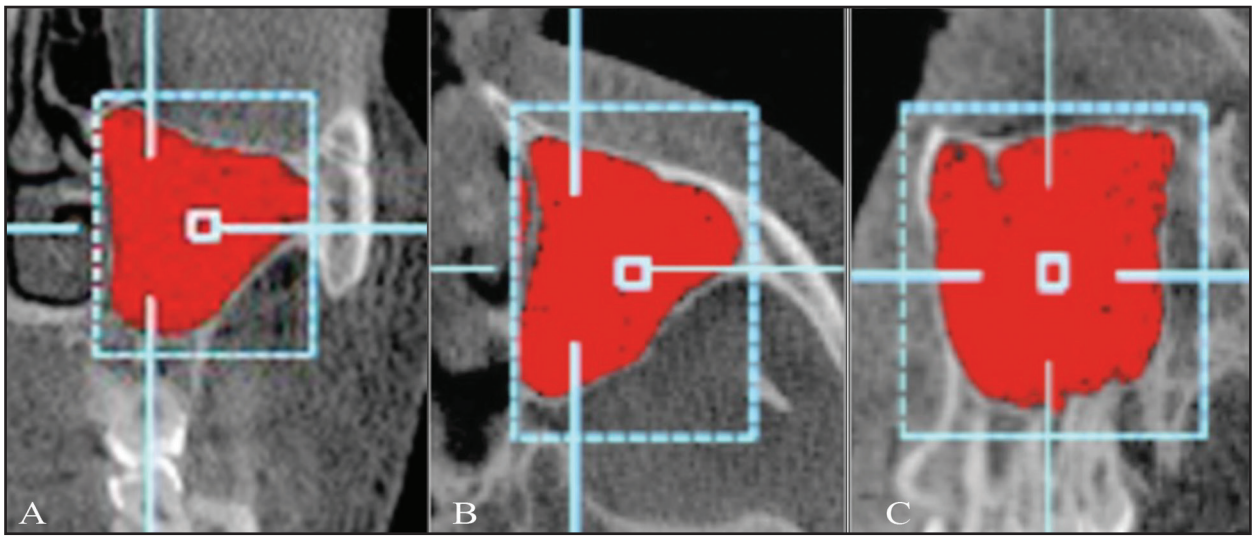


Fig. (5) Grown maxillary sinus (red). A. Coronal view. B. Axial view. C. Sagittal view

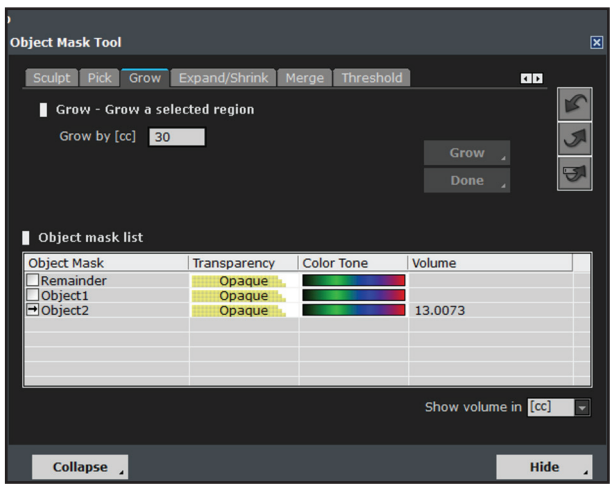


Fig. (6) The calculated volume of the maxillary sinus.

Statistical analysis

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp). Significance of the obtained results was judged at the 5% level. One way ANOVA test, Kruskal Wallis test, and Wilcoxon signed ranks test were used for comparison between the maxillary sinus volume in different anteroposterior growth groups as well as between the right and left sides.

RESULTS

Comparison between the volume of the maxillary sinus (cm^3) in the Right and Left sides in each group as calculated by OnDemand software is presented in (Table 2). In the three groups, group I group II, and group III: there was a statistically non-significant difference in the mean maxillary sinus volume between the right and left sides (***p1***=0.393,0.304 and 0.910 respectively). Similarly, comparison between the maxillary sinus volume in the three studied groups revealed that there was a statistically non-significant difference in the mean sinus volume between the three groups for the left and right sides separately as well as the average volume of both sides where (***p***= 0.658, 0.672 and 0.598 respectively).

Table (2) *Comparison between the three studied groups according to volume of the maxillary sinus (cm3) by OnDemand software*

	Group I Normal maxilla (n = 30)	Group II Maxillary excess (n = 30)	Group III Maxillary deficiency (n = 30)	H	p
Volume (cm^3)					
Right	17.12 ± 2.72	17.0 ± 2.59	17.42 ± 2.45	0.838	0.658
Left	17.06 ± 2.78	16.91 ± 2.40	17.38 ± 2.47	0.795	0.672
Z	0.854	1.027	0.113		
p1	0.393	0.304	0.910		
Average	17.09 ± 2.75	16.95 ± 2.48	17.40 ± 2.45	1.029	0.598

SD: **Standard deviation** *Z:* **Wilcoxon signed ranks test** *H: H for* **Kruskal Wallis test**
p: p value for comparing between the **three** *studied groups*
p1: p value for comparing between **Right** *and* **Left** *sides within each group*

DISCUSSION

The present study was conducted to assess the correlation between the maxillary sinus volume and anteroposterior growth patterns of maxilla in adults using CBCT. The research was performed due to the importance of the maxillary sinus, especially during performing any intervention related to the maxillary arch, therefore, it was crucial to determine whether different malocclusion patterns affect the maxillary sinus size and volume since such data may affect the orthodontic treatment plan. CBCT was chosen for assessment it is an accurate three dimensional imaging modality that produces images of high resolution with a relatively low radiation dose, in addition to the availability of several softwares that allow volumetric assessment of different anatomical structures as the maxillary sinus [12].

In the present study, a total of 90 CBCT scans were used according to the sample size calculation to assess and compare the maxillary sinus volume in different anteroposterior growth patterns, being the primary outcome of the present research. The scans were divided into 3 equal groups; Normal maxilla, maxillary excess and maxillary deficiency groups.

The study sample included unidentified full skull CBCT scans of adults, free from artefacts, to allow measurements on fully erupted permanent dentition. Planmeca Romexis software was used to extract and analyze the lateral cephalometric images and accordingly, assign the scans into the three study groups based on the anteroposterior growth patterns as described by values of McNamara index [10].

On Demand 3D software was selected to measure the maxillary sinus volume due to its reliability and high accuracy in volumetric assessments. **Weissheimer *et al*,[13] and Chen *et al*,[14]** evaluated the reliability of OnDemand 3D in comparison with other softwares in several different studies. They found it to be reliable in volumetric measurements with its results highly correlated with the gold standard, hence, the choice of the software for volumetric assessment in the study.

Results of the present study showed that there was no statistically significant difference between the left and right maxillary sinus volume in all three groups, such finding was in agreement with that of **Aktuna *et al*, [15]**. Additionally, there was no statistically significant difference between the three studied groups regarding the volume of the maxillary sinus. These results concur with those of previous studies by **Aktuna *et al*, [15]**, **Okşayan *et al*, [16]** , and **M. Gulec *et al*, [17].**

The absence of difference between maxillary sinus volume in the study groups indicate that different anteroposterior growth patterns do not affect the size or volume of the maxillary sinus. These results agree with those of studies conducted by **Endo e*t al*, [4], Oktay [18]** , **Urabi *et al*, [19]** , **Asantogrol *et al*, [20]** , **Okşayan *et al*, [16] and Abdelhamid *et al*, [21]** who also evaluated maxillary sinus volume in different vertical growth patterns using CBCT. Their results showed no statistically significant differences among the study groups which matches with the results of the present study.

However, contrary to our results, **Tikku *et al*,[22]** found statistically significant difference in the volume of the maxillary sinus between the right and left sides in the mouth breathers' group when they compared the maxillary sinus volume in normal breathing participants and mouth breathers. This difference was probably caused by the chronic inflammation and mucosal thickening of the walls of the sinus. On the other hand, **Yassaei *et al*,[9]** found that total maxillary area (TMSA) and maxillary sinus height (MSH) were higher in maxillary deficiency group in comparison with maxillary excess and maxillary normal groups, a finding which did not agree with our results but this may be due to that their measuring was done on two dimensional radiographs, contrary to the present study which used three-dimensional CBCT images for maxillary sinus assessment.

CONCLUSIONS

Based on the results of the current study, the following conclusions could be drawn:

- Different anteroposterior maxillary growth patterns do not affect the total adult volume of the maxillary sinus.
- The right and left maxillary sinus in adult populations show similar volumes with negligible differences between both sides.

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