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COMPARISON OF DIFFERENT IMAGING SOFTWARE FOR MEASURING VOLUME OF THE MAXILLARY SINUS

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Introduction: *Both maxillofacial surgery and orthodontic procedures must take the maxillary sinus extension into consideration. Several software imaging packages have reported the ability to calculate the maxillary sinus's volume. This work aim was to compare two software imaging packages for measuring the maxillary sinus volume in different sagittal skeletal position of the maxilla.* ***Material and Methods:*** *A total of 90 CBCT scans were examined. Patients were divided into 3 groups according to their maxilla sagittal skeletal position into: normal maxilla group, prognathic maxilla group, and retrognathic maxilla group. The volume of the maxillary sinus on both the right and left sides were measured in each group using two different software programs: the Planmeca Romexis and OnDemand 3D software. The imaging exams were imported to the software after being converted to DICOM files. After two weeks, the same operator repeated the measurements, and the reliability tests employed the intraclass correlation coefficient.* ***Results:*** *For the two programs, the intraclass correlation coefficients showed high repeatability. The software used to calculate the maxillary sinus volume on the left and right sides did not show any appreciable changes. There was no statistically significant difference between the maxillary sinus volumes of the various skeletal groups.* ***Conclusion:*** *Upon measuring the volume of both the right and left maxillary sinus using the Planmeca Romexis and OnDemand3D software programs no significant differences were found.*

Keywords: *Software, Cone beam computed tomography, Maxillary sinus Volume, Skeletal position.*

Introduction:

Evaluation of the maxillary sinus during orthodontic diagnosis is crucial since it may affect the orthodontist's treatment plan. The conventional radiographs allow the evaluation of the anatomical structures only in two-dimensions. The images of the maxillary sinus might differ from the actual size as well as the superimposition of the adjacent structures on the sinus borders that cannot be defined completely in some cases. [1]

With the emergence of cone-beam computed tomography (CBCT) for3-D imaging in orthodontics, it provides detailed and essential data about dento-maxillofacial structures.[2] When comparing to CT and MRI, CBCT imaging offers a number of benefits, including lower radiation exposure, quicker acquisition times, and easier accessibility. [3]

As CBCT scan has gained the interest and became well-accepted as an oral and maxillofacial diagnostic imaging tool, A variety of programs were created to analyze anatomical structures in detail.[4] The interactive CBCT software and its different functional tools made volumetric measurements more vivid.[5,6]Digital imaging and communications in

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medicine (DICOM)files are used by such software programs.[7]Additionally, a lot of those software programs offer optional capabilities for segmenting and measuring intricate hollow structures, such the upper airway space.[8]

Studies have looked for a connection between sinus dimensions and cleft lip and palate. In patients with cleft lip and palate, they discovered that the maxillary sinus volume was adversely affected. [9,10]

Some studies were done on comparison of different software programs for upper airway space measurements. El and Palomo[11] evaluated three different commercially available manual segmentation algorithms using semiautomatic segmentation and discovered that while each program produced considerably different results, they all displayed high correlations. Weissheimer et al.[12] evaluated the precision of 6 imaging software packages for estimating upper airway volumes and found that all of them were trustworthy, despite the fact that their results varied noticeably from one another.

According to the available studies, there is no study that compare these software programs in measurement of the maxillary sinus volume in different skeletal groups. Therefore, the aim of this study was to compare between two imaging software packages, the Planmecca Romexis software and OnDemand3D software programs for measuring the maxillary sinus volume in different skeletal group.

Material and method

According to sample size calculation ninety (CBCT) images were found to be sufficient to be used in this study using G*Power software version 3.1.9.2. detect a power of 80% at a significant level of 5% ($p<0.05$).

Ninety CBCT images were retrieved from the Oral Radiology archive, Department of Oral Radiology, Faculty of Dentistry, Suez Canal University. After being waved from the approval of our research ethical committee number (2022/588), since it was conducted on unidentified CBCT images.

The Sample included unidentified full skull CBCTs of adults (20-40) years old. Radiographs free of artifacts, with good quality and clear maxillary sinus view with fully erupted permanent dentition. The Radiographs showing deformity in mid-face region and that with any pathological findings in maxillary sinus were excluded from our present study.

Radiographic Evaluation:

The CBCT images taken from Oral radiology archive were radiographed using Scanora 3Dx Cone Beam Computed Tomography scanner (Scanora 3DX, Soredex, Finland). The field of view was set at 240x165mm for all images using standard resolution mode. The operating parameters were 90 KVp, 10mA and the effective exposure time was 3.2 seconds. The voxel size was 0.5 mm using a flat panel detector. The projection data was reconstructed with the machine dedicated On Demand 3D (Cybermed.Co., Seoul, Korea) software application.

Using the virtual lateral cephalometric radiographs that were extracted from 3D CBCT using the Planmecca Romexis Viewer

5.3.3.5 software. According to the maxillary skeletal position, the CBCT radiographs were divided into three groups: normal maxilla group, prognathic maxilla group and retrognathic maxilla group. As The distance from N perpendicular to A point was measured to determine anteroposterior skeletal position of the maxilla(Figure1) &(Table 1).

Table 1: Classification of the sagittal skeletal position of the maxilla according to the values of McNamara index**:**

McNamara index	Normal maxilla	Prognathic maxilla	Retrognathic maxilla
N-Prependicular to A point	A point is 0 or 1mm to N perpendicular.	A point is more than 1mm anterior to N perpendicular.	A point is more than 1mm posterior to N perpendicular.

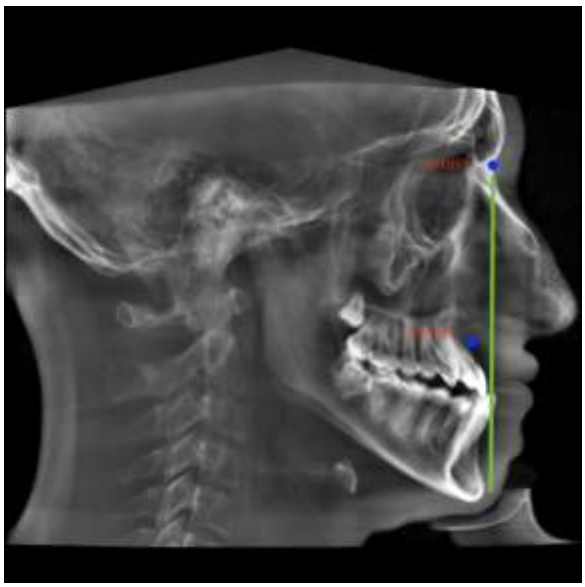

Figure 1: Lateral cephalometric radiograph extracted from 3D CBCT using the Planmecca Romexis showing the distance from A point to N perpendicular to determine sagittal position of the maxilla according to Macnemara index.

Maxillary sinus volumetric measurements:

Using the software programs Planmecca Romexis Viewer 5.3.3.5 (Planmeca, Helsinki, Finland) and Using on demand 3D software 1.0.10.7462 (Cybermed.Co., Seoul, Korea), the volume of the right and left maxillary sinuses were measured and calculated on CBCT images

Digital imaging and communications in medicine, or DICOM, files were created from the imaging exams and entered into the software programs.

On Demand 3D software:

From the 3D window coronal, sagittal and axial views image were translated to the maxillary sinus in one side. After image was translated to the maxillary sinus in all three

dimensions, slice thickness was 0 mm which is the smallest thickness the software can provide to ensure standardization in all cases. 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. The software then calculated the volume of the highlighted maxillary sinus (figure 2). The same process was repeated to calculate the volume of the sinus on the other side.

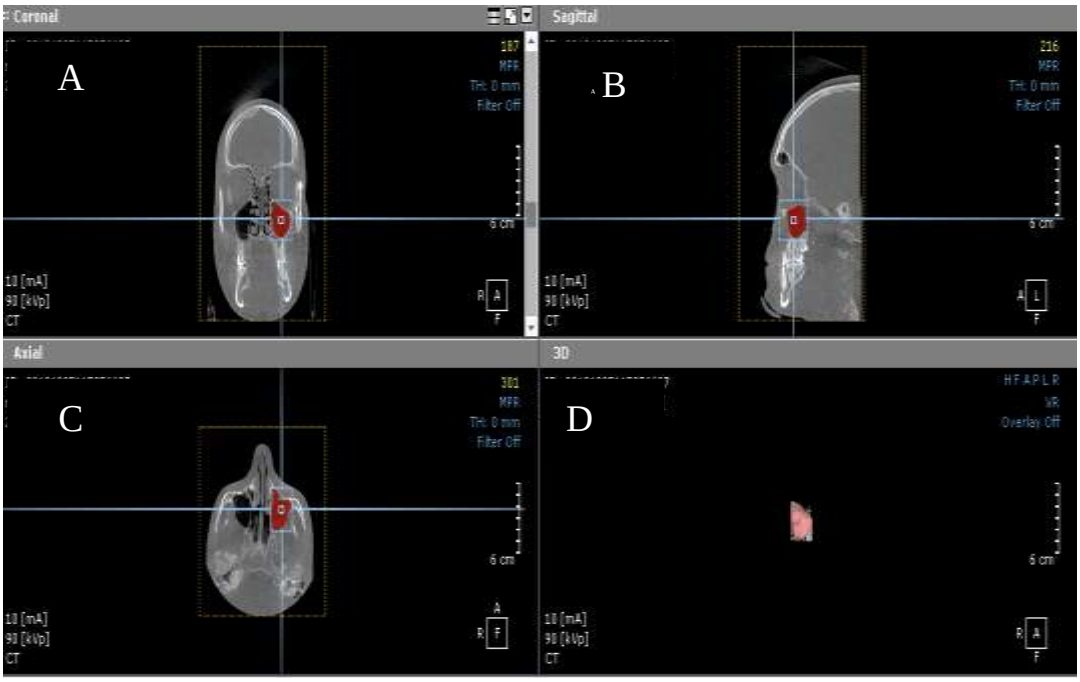

Figure 2: Image showing the outlined and selected Maxillary sinus (On Demand software) A)Coronal view B)Sagittal view C)Axial view D) 3D view from the 3D window

Planmecca Romexis software:

Slice thickness was set at 0.5 mm which is the smallest thickness the software can provide, and the free region grow tool is used for manual segmentation. Then the maxillary sinus was outlined in each slice (0.5mm) for manual segmentation to create region and calculate its volume. Manual segmentation was performed slice for slice by the operator; then, the software combined the segmented slices to create a 3D volume. The maxillary sinus was outlined in coronal, sagittal and axial views showing the volume of the maxillary sinus in one side (figure3). The same process was repeated to calculate the volume of the sinus on the other side. The images were re-measured by the same operator2 weeks after the last examination, to obtain data for intra-operator reliability assessment.

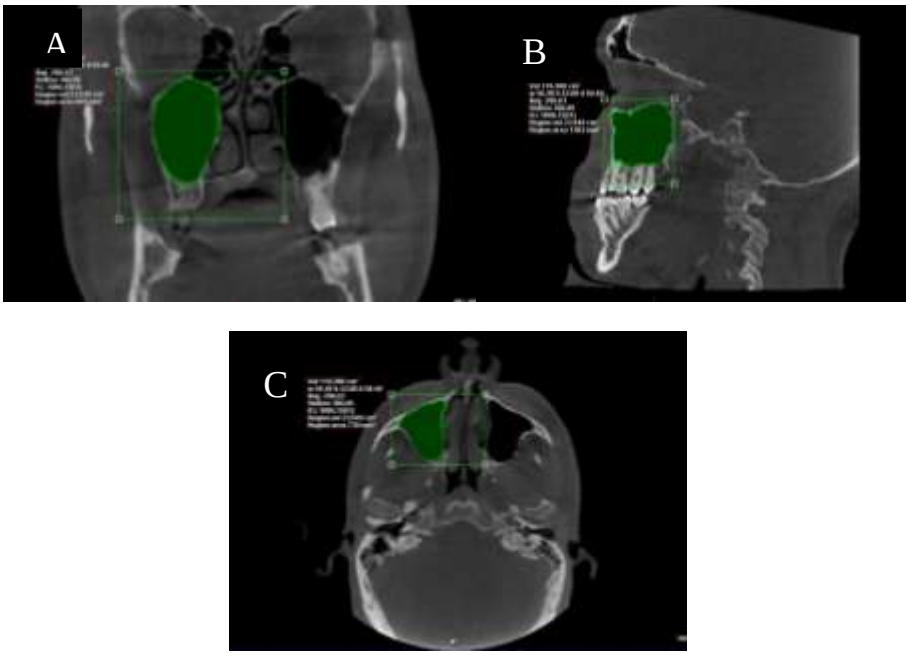

Figure 2: Image showing the regional volume of the maxillary sinus in A)coronal, B)sagittal and C)axial views (PlanmeccaRomexis software).

Statistical Analysis:

The information was gathered, processed, and statistically examined. Using the IBM SPSS software package, version 20.0 (IBM Corp., Armonk, New York). Number and percentage were used to describe qualitative data. To compare the measurement of the maxillary sinus volume across the software and between the groups, statistical analyses were performed using the Chi-square test, one-way ANOVA, and Wilcoxon signed ranks tests. For all statistical tests, a p-value of 0.05 was utilized as the level of significance. It was decided to employ the intra-class coefficient (ICC) to assess intra-observer compliance.

Results:

Intra class Correlation coefficient (ICC):

Interclass Correlation Coefficient (ICC) values greater than 0.90 indicate excellent similarity. A high ICC, 0.998. indicates high similarity and agreement between the two readings. Table (2) summarizes Intra class Correlation coefficient between the two readings for both OnDemand 3D software and Planmecca Romexis software systems.

Table (2): Comparison between 1st reading and 2nd reading for OnDemand 3D and PlanmeccaRomexis software systems according to volume (cm^3) of the maxillary sinus left and right sides in the three groups.

	Volume (cm^3)	1st reading (n = 90)	2nd reading (n = 90)	ICC	p	Level of agreement
OnDemand	**Normal maxilla**					
	Right	17.13 ± 2.73	17.12 ± 2.72	0.998	<0.001*	Excellent
	Left	17.08 ± 2.77	17.06 ± 2.78	0.998	<0.001*	Excellent
	Prognathic maxilla			0.998		
	Right	17.15 ± 2.56	17.00 ± 2.59	0.996	<0.001*	Excellent
	Left	16.90 ± 2.39	16.91 ± 2.40	0.998	<0.001*	Excellent
	Retrognathic maxilla			0.998		
	Right	17.40 ± 2.46	17.42 ± 2.45	0.998	<0.001*	Excellent
	Left	17.37 ± 2.48	17.38 ± 2.47	0.998	<0.001*	Excellent
Planmeca	**Normal maxilla**			0.998		
	Right	16.98 ± 2.99	16.92 ± 2.97	0.998	<0.001*	Excellent
	Left	16.90 ± 2.69	16.98 ± 2.71	0.998	<0.001*	Excellent
	Prognathic maxilla			0.998		
	Right	17.05 ± 2.82	17.05 ± 2.82	0.998	<0.001*	Excellent
	Left	17.98 ± 2.39	16.98 ± 2.37	0.996	<0.001*	Excellent
	Retrognathic maxilla					
	Right	17.90 ± 3.45	17.86 ± 3.42	0.998	<0.001*	Excellent
	Left	17.37 ± 2.48	17.38 ± 2.47	0.998	<0.001*	Excellent

Data was expressed using Mean ± SD. SD: **Standard deviation**
ICC: **Intra class Correlation coefficient**p: p value for comparing between **1st reading and 2nd reading***: Statistically significant at $p \leq 0.05$

Planmeca Versus OnDemand

There was a statistically insignificant difference between the right and left sides when comparing Planmeca software with OnDemand software based on the maxillary sinus volume (cm3) in the three groups (table 3 and figure 2).

Table (3): Comparison between Planmeca and OnDemand according to volume (cm^3) in the three groups (n = 90)

Volume (cm^3)	Planmeca	OnDemand	Z	p
Normal maxilla				
Right	16.92 ± 2.97	17.12 ± 2.72	1.479	0.139
Left	16.98 ± 2.71	17.06 ± 2.78	1.007	0.314
Average	16.95 ± 2.82	17.09 ± 2.75	1.800	0.072
Prognathic maxilla				
Right	17.05 ± 2.82	17.0 ± 2.59	0.801	0.423
Left	16.98 ± 2.37	16.91 ± 2.40	0.624	0.533
Average	17.01 ± 2.56	16.95 ± 2.48	0.988	0.323
Retrognathic Maxilla				
Right	17.86 ± 3.42	17.42 ± 2.45	1.434	0.152
Left	17.60 ± 3.28	17.38 ± 2.47	0.511	0.609
Average	17.73 ± 3.33	17.40 ± 2.45	0.915	0.360

SD: **Standard deviation** Z: **Wilcoxon signed ranks test**
p: p value for comparing between **Planmeca** and **OnDemand** in software for each group
Statistically significant at $p \leq 0.05$

The results showed that no statistically significant differences exist between the two software programs in the present study.

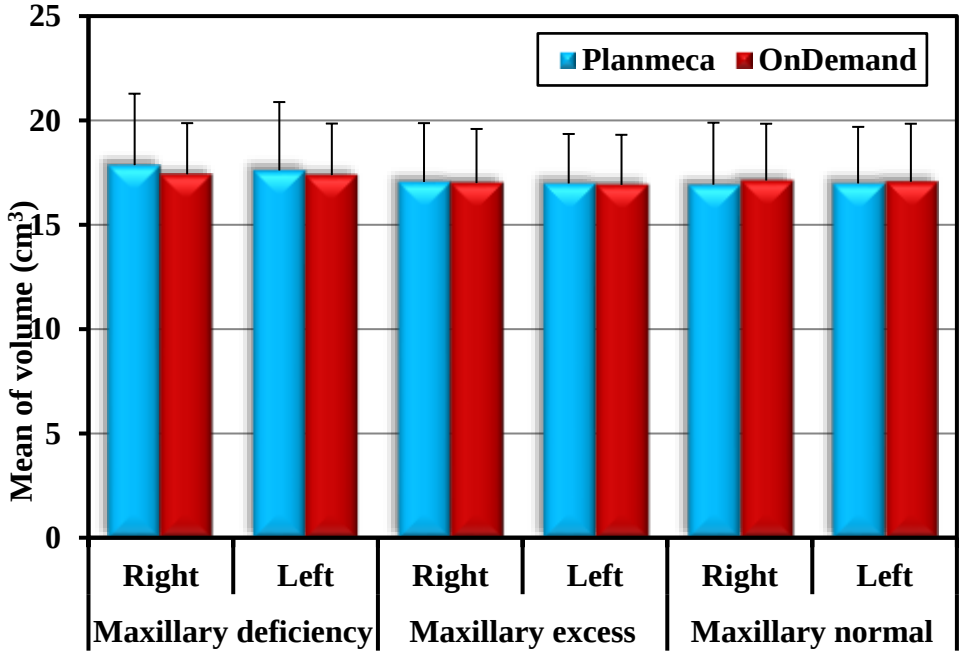

Figure (3): Comparison between Planmeca and OnDemand according to volume of the maxillary sinus (cm^3) in the three groups

Discussion

Although many software packages claim to be able to do many processes, the outcomes may vary between software packages, which could make it challenging for practitioners who wish to utilize various software yet want to compare values and communicate. In order to compare two imaging software programs for assessing the maxillary sinus volume in CBCT images, the goal of this study was to determine their relative merits.

The volumetric and dimensional measurements when placing micro screws, performing Le Fort osteotomies, or moving orthodontic teeth via the maxillary sinus, CBCT measures play the function of a pathfinder for both maxillofacial surgeons and orthodontists. Some investigations assessed the maxillary sinus diameters in connection to various malocclusion classes Utilizing cephalometric radiographs and orthopantomographs.[1,13] After conducting a study on patients with ages ranging from 12 to 16 years old, Endo et al.[1] reported that no significant correlation between maxillary sinus diameters and various sagittal skeletal jaw types was discovered.

According to Oktay[13], male individuals having an orthopantomographic examination had smaller maxillary sinuses than female subjects with Angle Class II malocclusions. As it is challenging to evaluate a clear and exact 2D determination in the complex maxillary sinus region, we employed 3D images to evaluate maxillary sinus volume in the current study in order to do an accurate investigation.

Maxillary sinus analysis using CBCT data has proven to be a helpful tool, and the results' accuracy has been confirmed. [14-16] Furthermore, Luz et al.'s[17] research demonstrated that the volume software is an effective tool for determining the maxillary sinus's size.

Regarding the right and left maxillary sinus volume, no statistically significant difference between the various skeletal groups was discovered in the current investigation. These results demonstrated that there is no relationship between the size of the left and right maxillary sinuses and the sagittal skeletal patterns of the maxilla. The present study's findings were consistent with those of Saccucci et al.[3], who claimed that the maxillary sinus volume did not alter with different sagittal skeletal patterns and that the locations of the maxilla and jaw were unrelated to the maxillary sinus' size.

Sönmez et al[18] and Kamaruddin et al[19] used PlanmeccaRomexis software to measure the volume and compared it to other software program. They found that Planmecca Romexis software provided reproducible results and any deviation in the results from the other programs was clinically insignificant.

The volume of the right and left maxillary sinuses in various sagittal skeletal positions of the maxilla was measured using the OnDemand 3D software and the Planmecca Romexis software programs in the current investigation. However, no significant differences were found between these two software programs.

Since not every practitioner will utilize the same program, the varying measurements provided by various software packages could cause communication issues. Studies[20,21] that analyzed several software programs found no statistically significant difference. The present study also showed no significant differences between the OnDemand 3D software and Planmecca Romexis software programs for measuring the volume of both the right and left maxillary sinus in different sagittal skeletal position of the maxilla. To verify our findings using more CBCT radiographs, additional research is required.

Conclusion

There is no difference between OnDemand 3D software and Planmecca Romexis software systems when used for comparison between the right and left maxillary sinus volume in different skeletal groups. If both software programs are available, they can be used interchangeably.

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