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RESEARCH ARTICLE

CORRELATION BETWEEN MAXILLARY SINUS VOLUME ANDFACIAL PATTERN OF ADULTS USING CONE BEAM COMPUTED TOMOGRAPHY VIA PLANMECCAROMAXIS SOFTWARE PROGRAM

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Abstract

Introduction: Knowledge about the maxillary sinus is of great importance for orthodontists as it both affects and is affected by orthodontic treatment. Cone-beam computed tomography (CBCT) madeevaluating the maxillary sinus become more accurate.
Aim: to investigate if there is a relation between the maxillary sinus volume and facial pattern in adults using cone beam computed tomography.
Methods: CBCT scans of 36 adults were obtained. They were divided equally into three groups: Normal facialpattern, Long face and Short face. The volume of the maxillary sinus on both the right and left sides were measured in each group using PlanmeccaRomaxis software program.
Results: The results of this study were that there is no significance difference between the maxillary sinus volume in the different groups of facial pattern. There is no significance between the volume of the maxillary sinus on the right and left side.
Conclusions: There is no correlation between the maxillary sinus volume and the vertical growth pattern. The right and left maxillary sinus are corresponding to each other in volume.

Introduction:-

Inspectingthe maxillary sinus during orthodontic diagnosis is crucial since it may affect the orthodontist's treatment plan. Precautions should be taken so that the line of treatment chosen would not encroach on the integrity of the maxillary sinus[1].Orthodontic treatment plan is affected by the size and position of the maxillary sinus. Likewise, the maxillary sinus may be affected by different malocclusions either dental or skeletal, anteroposterior or vertical in terms of size and position[2,3].

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With the emergence of cone beam computed tomography (CBCT) and its advantages in the world of radiography appreciated, orthodontists are using it more and more frequently. Studying the maxillary sinus became more accurate and with a 3D approach thus the volume of the sinus could be evaluated[4].

Several researches were made to pinpoint whether there is a relation between maxillary sinus volume and malocclusion. Some studies show that there was a correlation between the maxillary sinus volume and vertical malocclusion however there were other studies that contradicted these findings.[5-8]

The purpose of the present study was to find out if there is a correlation between the maxillary sinus volume and different facial patterns in adults using cone beam computed tomography.

Materials and Methods: -

This is a retrospective study to correlate the volume of the maxillary sinus and vertical facial pattern on CBCT. The study was approved by the department of orthodontics, the Faculty of Dentistry, Suez Canal University. After the approval of the ethical committee, unidentified CBCT films were obtained from the archive of the Radiology department, Faculty of Dentistry, Suez Canal university.

According to sample size calculation, CBCTs were selected and attained.

Sample size calculation

The sample size calculation was based on the results of **Okşayan et al (2017)[5]**utilizing sinus volume as the primary outcome. Using the formulas:

Power = 1- F(f_α; k-1,ν,λ) and$\lambda = \frac{n \times \sum_{i=1}^{k}\{2\times(\mu_i-(\bar{\mu}))^2\}}{\sigma^2}$ where k is the number of levels, n is the sample size at each level, α is the significance level, σ is the standard deviation, ν is the degree of freedom of error, f_α is the critical value, $\mu_i$is the mean response at level I ; The effect size for the difference between the three facial types was found to be (1.05), using alpha (α) level of (5%) and Beta (β) level of (10%) i.e. power = 90%; the minimum estimated sample size was 10 subjects per group for a total of 30 subjects. To compensate for the use of non-parametric tests, the sample size was increased by 15% to be 36 subjects (12 subjects per group). Sample size calculation was performed using IBM® SPSS® SamplePower® Release 3.0.1

Sample selection

Sample includedunidentified full skull CBCTs of adults (20-40 years old)., Radiographs free of artefacts and of good quality. Radiographs showing no deformity in mid-face region. No pathological findings in maxillary sinus. Radiographs of subjects who had no previous orthodontic treatment.

Sample grouping

Sample was divided into three groups according to their growth pattern to Normal facial pattern, long faceand Short face. Angles used was Y-axis angle, Facial axis angle, Gonial angle and Mandibular plane angle **Fathallah et al (2017)[9] and Oksayan et al (2017)[5].**

Table 1:- Classification of growth pattern according to values of Y axis angle, Facial angle, Gonial angle and Mandibular plane angle.

	Group 1: Normal facial pattern group	Group 2: Long Face group	Group 3: Short Face group
Y-axis angle	61˚± 6˚	>67˚	<55˚
Facial axis angle	90˚±3˚	>93˚	<87˚
Gonial angle	124˚± 5˚	>129˚	<119˚
Mandibular plane angle	32 ˚ ± 4 ˚	>38 ˚	<26 ˚

Using the PlanmeccaRomexis Viewer 5.3.3.5 software; virtual lateral cephalometric radiograph 2D image was extracted from the 3D cone beam radiograph (Figure 1).

Figure 1:- Extracting lateral cephalometric radiograph from CBCT using Romexis softwarePoints and lines used were outlined using the draw tool from the tool bar. (SN line, Mandibular plane (Go-Gn& Go-Me), Ar-Go, Facial line, Y axis (S-GN), and Frankfurt Horizontal plane (Po-Or)) (Figure 2).

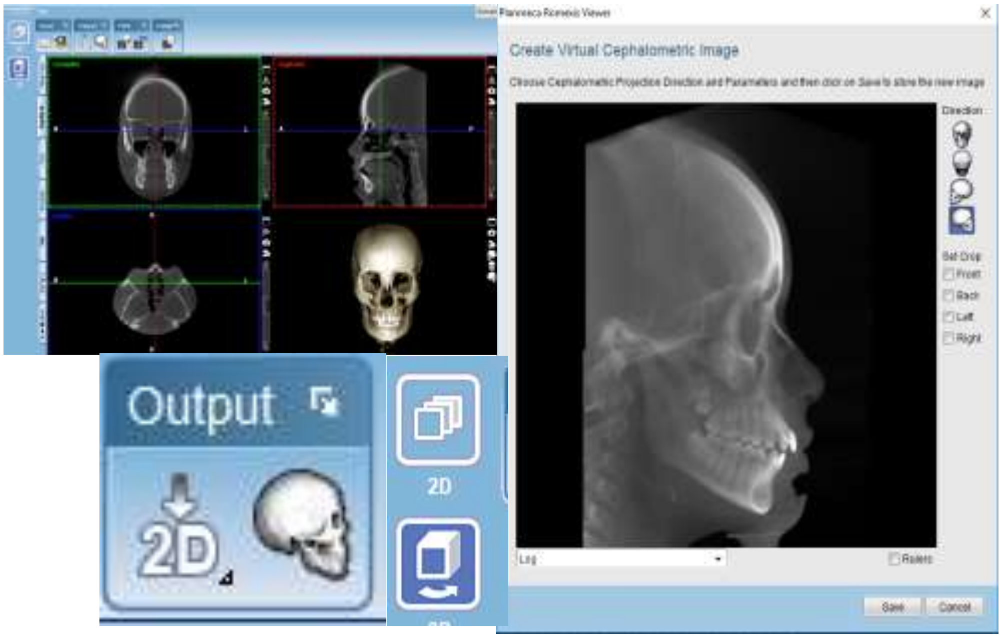
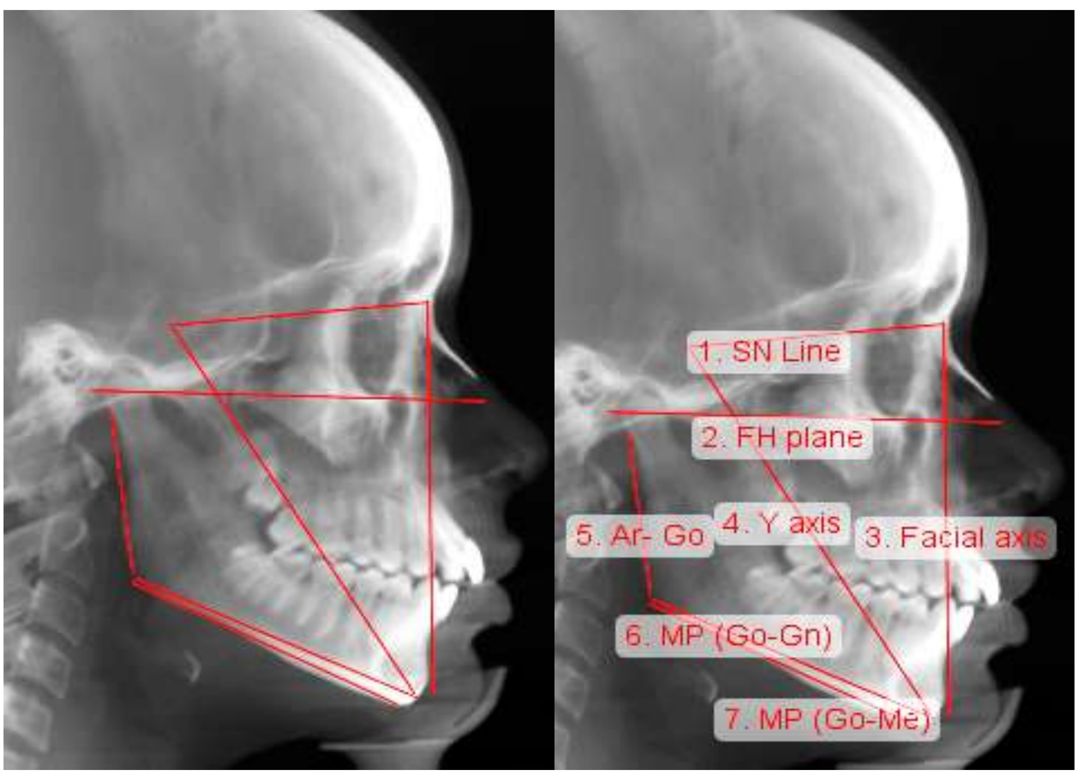


Figure 2:- Point and lines drawn on extracted lateral cephalometric radiograph 1. SN line, 2. Frankfurt Horizontal plane(FHP), 3. Facial axis (N-Pog), 4. Y-axis (S-Gn), 5. Ar-Go, 6. Mandibular plane (MP)(GO-Gn), 7. Mandibular plane(MP)(Go-Me).



Y-axis angle was measured between FH plane and Y-axis. Facial axis angle was measured between FHP and Facial axis. The Gonial angle was measured between Mandibular plane (Go-Me) and Ar-Go. The mandibular plane (Go-Gn) was drawn and translated to meet the SN line and the angle between them measured. (Figure 3).

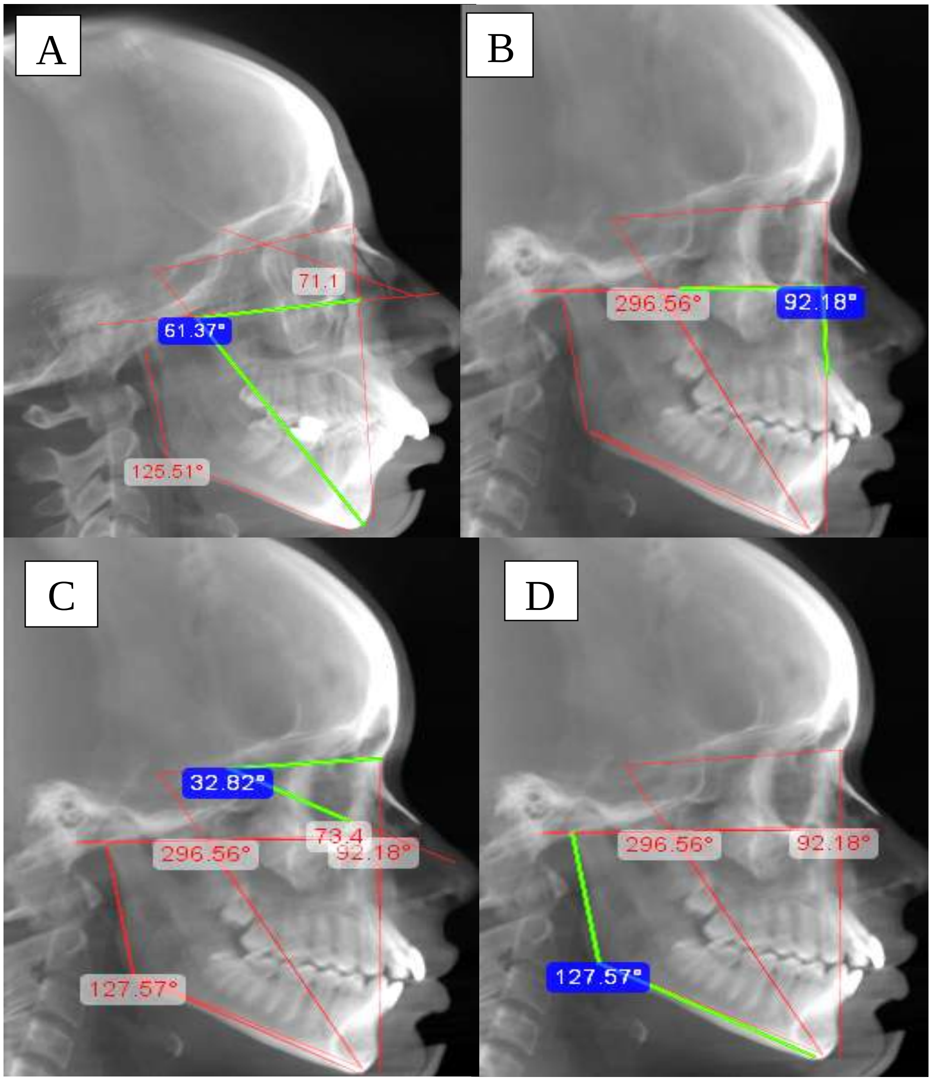


Figure 3:- Vertical angles; A.Y-axis angle (green), B. Facial angle, C. Mandibular plane angle, D. Gonial angle.

Volumetric measurements of the maxillary sinus

The right and left maxillary sinuses volume were measured and calculated on CBCT images usingPlanmeccaRomexis Viewer 5.3.3.5 softwaresoftware system.

Slice thickness was set 0.5 mm which is the smallest thickness the software provides and the free region grow tool is used for manual segmentation. (figure 4)

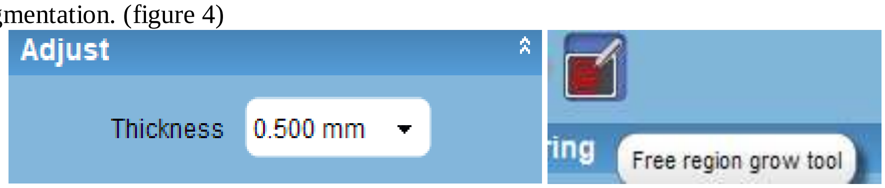


Figure 4:- slice thickness set to 0.5mm, free region grow tool.

Then the maxillary sinus was outlined in each slice (0.5mm) for manual segmentation. (figure 5)

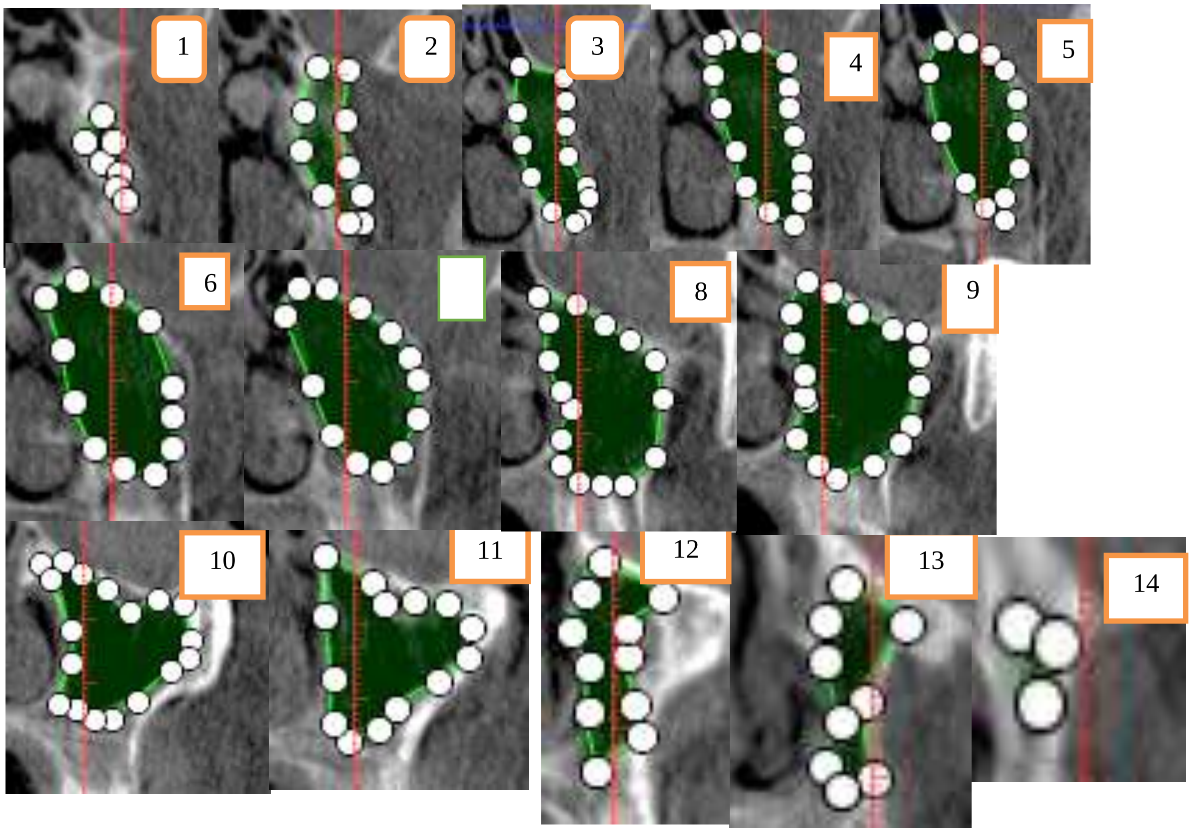


Figure 5:- A sample of the outlined maxillary sinus in different CBCT slices.1 to 14 from anterior to posterior

The segmented area was the grown and the region created and its volume calculated. (figure 6)

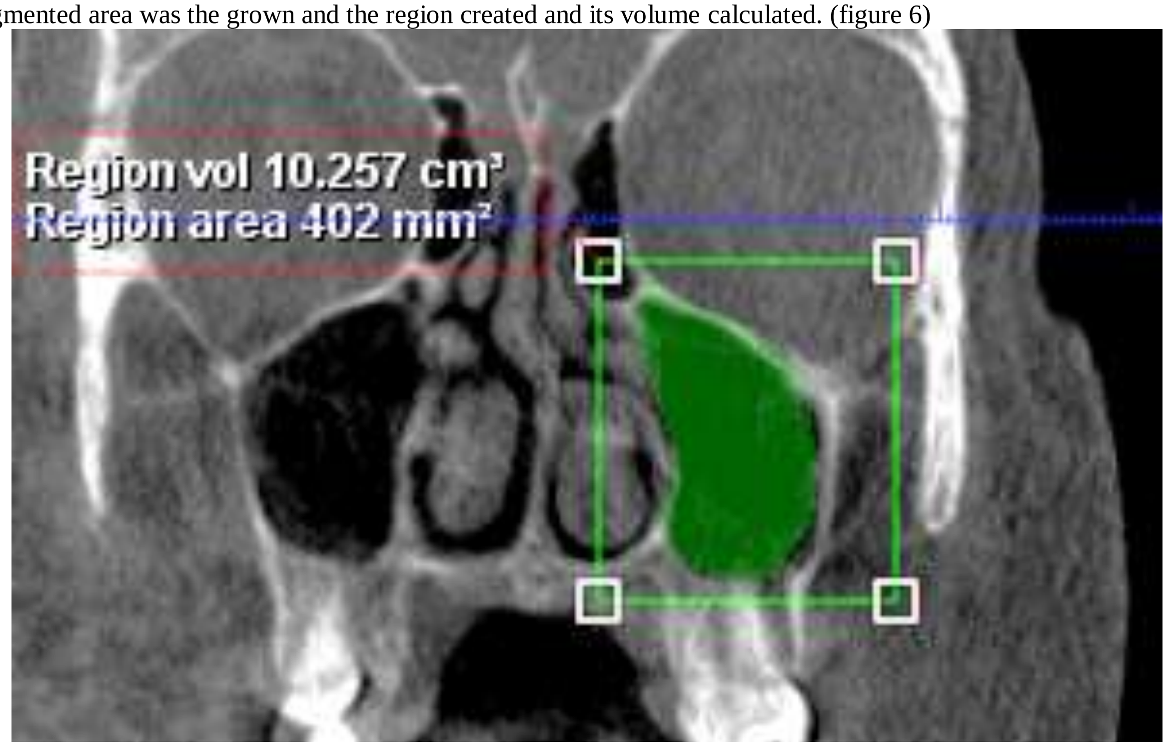


Figure 6:- Created region and calculated volume.

The same process was repeated to calculate the volume of the sinus on the other side.

Statistical Analysis
The obtained readings were tabulated and subjected to the following statistical tests.

Numerical data were explored for normality by checking the distribution of data and using tests of normality (Kolmogorov-Smirnov and Shapiro-Wilk tests). All data showed normal (parametric) distribution. Data were presented as mean, standard deviation (SD) and 95% Confidence Interval for the mean (95% CI) values. One-way ANOVA test was used to compare between the groups. Bonferroni's post-hoc test was used for pair-wise comparisons.

Results:-

There was no statistically significant difference between sinus volume measurements at the right and left sides within each group (*P*-value = 0.507, Effect size = 0.062), (*P*-value = 0.180, Effect size = 0.12) and (*P*-value = 0.099, Effect size = 0.093), respectively.

Table 2:- Descriptive statistics and results of paired t-test for comparison between sinus volume measurements (mm^3) at the right and left sides using Romexis modality.

1) Group	*2) Right side 3) (n = 12)*	*4) Left side 5) (n = 12)*	*6) -value*	*7) ffect size (d)*
Normal pattern			*8) .507*	*9) .062*
Mean (SD)	*10) 16.5 (3.9)*	*11) 16.8 (4.2)*		
95% CI	*12) 14 – 19*	*13) 14.1 – 19.4*		
14) Vertical pattern			*15) .180*	*16) .12*
Mean (SD)	*17) 16.9 (5)*	*18) 16.3 (5.2)*		
95% CI	*19) 13.7 – 20*	*20) 13 – 19.6*		
21) Horizontal pattern			*22) .099*	*23) .093*
Mean (SD)	*24) 17.8 (4.9)*	*25) 18.5 (5.7)*		
95% CI	*26) 14.7 – 21*	*27) 14.9 – 22.1*		

**: Significant at P ≤ 0.05*

There was no statistically significant difference between sinus volume measurements in the three groups at the right side, left side as well as mean of the two sides (*P*-value = 0.768, Effect size = 0.016), (*P*-value = 0.536, Effect size = 0.037) and (*P*-value = 0.659, Effect size = 0.025), respectively.

Table 3:- Descriptive statistics and results of one-way ANOVA test for comparison between sinus volume measurements (mm^3) in the three groups using Romexis modality.

28) inus	*29) N ormal pattern 30) (n = 12)*	*31) V ertical pattern 32) (n = 12)*	*33) H orizontal pattern 34) (n = 12)*	*35) -value*	*36) Eff ect size (Eta Squared)*
37) Right side				*38) .768*	*39) 0. 016*
M ean (SD)	*40) 1 6.5 (3.9)*	*41) 1 6.9 (5)*	*42) 17 .8 (4.9)*		
95 % CI	*43) 1 4 – 19*	*44) 1 3.7 – 20*	*45) 14 .7 – 21*		
46) Left side				*47)*	*48) 0.*

M ean (SD)	*49) 1 6.8 (4.2)*	*50) 1 6.3 (5.2)*	*51) 18 .5 (5.7)*	*.536*	*037*
95 % CI	*52) 1 4.1 – 19.4*	*53) 1 3 – 19.6*	*54) 14 .9 – 22.1*		
55) Mean of the two sides				*56) .659*	*57) 0. 025*
M ean (SD)	*58) 1 6.6 (4)*	*59) 1 6.6 (5)*	*60) 18 .2 (5.3)*		
95 % CI	*61) 1 4.1 – 19.2*	*62) 1 3.4 – 19.8*	*63) 14 .8 – 21.5*		

**: Significant at $P \leq 0.05$*

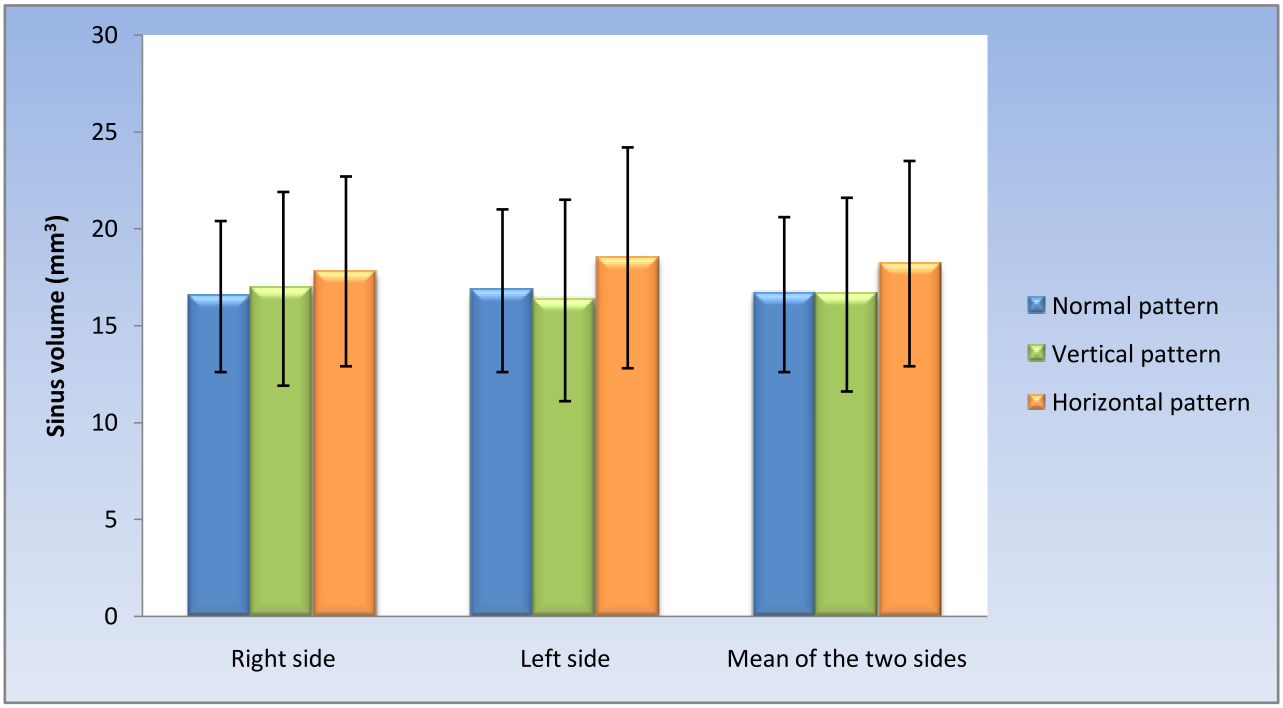


Figure 7: - Bar chart representing mean and standard deviation values for sinus volume measurements (mm^3) in the three groups using Romexis modality.

Discussion:-

Studying the maxillary sinus is of great value to orthodontist. This is due to its close proximity to the teeth in the upper arch in a way that the upper alveolar process forms its lower border. Many studies were conducted to show the relationship between the maxillary sinus and different orthodontic applications. It was found that some of orthodontic treatment modalities affect the volume of the maxillary sinus such as rapid maxillary expansion, Orthognathic surgery, Uprighting upper molars and traction of deeply impacted canines increase the volume of the maxillary sinus[10,11].

Another relation between the maxillary sinus and orthodontic treatment is that when moving teeth through the sinus. When moving teeth through the maxillary sinus there was increase in the risk of root resorption and undesired tipping also treatment timewas prolonged[12,13]. Orthodontists also must be aware of the maxillary sinus especially during mini-implant placement either buccal or infra-zygomatic to avoid maxillary sinus perforation which may lead to sinusitis or mini-implant failure[14,15].

In the present study there was no statistically significant difference between the left and right maxillary sinus volume in all three groups.Likewise, **Okşayan et al (2017)**[5]found no significant difference between the right and left maxillary sinus volume when they studied it in patients with different vertical growth patterns.Also when the extension of the maxillary sinus was studied and its relation to posterior teeth there was no statistically significant difference between the right and left side [6].

Moreover, when the maxillary sinus was studied in patients with unilateral and bilateral cleft lip and palate. It was found that there was no significant difference between the volume of the right and left maxillary sinus. Even in unilateral cleft lip and palate there was no significant difference between the maxillary sinus volume in the cleft side and non-cleft side[7].

Otherwise; **Tikku et al (2013)**[8]found significant difference in the volume of the maxillary sinus on the right and left sides in the mouth breathers group when they were comparing the maxillary sinus volume in normal and mouth breathers. They claimed that this difference is caused by chronic inflammation thickening the bony walls of the sinus.

The results of the current study showed that there was no statistically significant difference in the volume of the maxillary sinus volume when comparing individuals with normal facial pattern, long face and short face. This is in accordance with **Okşayan et al (2017)**[5]who likewise compared the maxillary sinus volume in adults with vertical malocclusion using CBCT. Their findings confirm the results of this study and they concluded that there is no correlation between maxillary sinus volume and vertical growth pattern. However; they also found that there was decrease in the length and width dimensions in the high angle group. In this study the length, width and height were not compared.

On the other hand, in another research it was found that patients with short anterior facial height or in other words with hypo-divergent faces had decreased volume of the maxillary sinus when the upper airway and maxillary sinus volume were compared in different dental and skeletal malocclusions. This can also be explained by the age difference in the sample of that study and the present study. That study evaluated the CBCTs of children between 5 and 13 years old [16].

Moreover, **Ryu et al (2016)**[17]found that the cranio-caudal height of the maxillary sinus as well as the cross-sectional area were greater in those with skeletal open bite, while in the anteroposterior and mediolateral dimensions there were no significant differences between those with skeletal open bite and those with skeletal normal overbite. In their study the total volume was not measured opposite to this study the measurements were obtained from certain cuts and the overall volume was not put into consideration.

In addition to that; **Tikku et al (2013)**[8] **andAgacayak et al (2015)**[18]found that adult and growing mouth breathers who mostly have long faces had smaller sinuses than nasal breathers. However; the conflict in the results between these studies and the current study can be explained that unlike the present study the vertical growers in both studies were originally mouth breathers. As a consequence of the mouth breathing habit there is decrease in the function of nasal cavity thus decreasing the development of the maxillary sinus. Furthermore, mouth breathers are more prone to pathological conditions decreasing the sinus volume.

Conclusion:-

From this study it was concluded thatthere is no correlation between the maxillary sinus volume and the vertical growth pattern. Also that the right and left maxillary sinus are corresponding to each other in volume.

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