

CORRELATION BETWEEN MAXILLARY SINUS VOLUME AND DIFFERENT FACIAL PATTERNS USING CONE BEAM COMPUTED TOMOGRAPHY IN ADULTS

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KEYWORDS

Maxillary Sinus,
CBCT, Facial pattern

ABSTRACT

Introduction: The maxillary sinus both affects and is affected by orthodontic treatment thus knowledge about it is of great value. With the emergence of Cone-beam computed tomography (CBCT) studying the maxillary sinus became more accurate. **Aim:** to find out if there is a correlation between the maxillary sinus volume and facial pattern in adults using cone beam computed tomography. **Methods:** Cone-beam computed tomography (CBCT) scans of 36 adults were obtained. They were divided equally into three groups: Normal facial pattern, hyper-divergent facial pattern and hypo-divergent facial pattern. The volume of the maxillary sinus on both the right and left sides were measured in each group using OnDemand3D 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

Evaluation of the 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 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).

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 becomes more accurate and with a 3D approach and 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 that findings⁽⁵⁻⁸⁾.

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The purpose of the present study was to find out if there is a correlation between the maxillary sinus volume and vertical growth pattern 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, 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* ⁽⁵⁾ utilizing sinus volume as the primary outcome. Using the formulas:

Power = 1- F(f_{α} ; k-1,v, λ) and 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, v is the degree of freedom of error, f_{α} is the critical value, 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 included unidentified 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, hyper-divergent facial pattern and hypo-divergent facial pattern. Angles used was Y-axis angle, Facial axis angle, Gonial angle and Mandibular plane angle Fathallah *et al* ⁽⁹⁾ and Oksayan *et al* ⁽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 growth pat- tern group	Group 2: hyper-diver- gent facial pattern	Group 3: hypo-diver- gent facial pattern
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 Planmecca Romexis Viewer 5.3.3.5 software; virtual lateral cephalometric radiograph 2D image was extracted from the 3D cone beam radiograph (Figure 1).

Points 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).

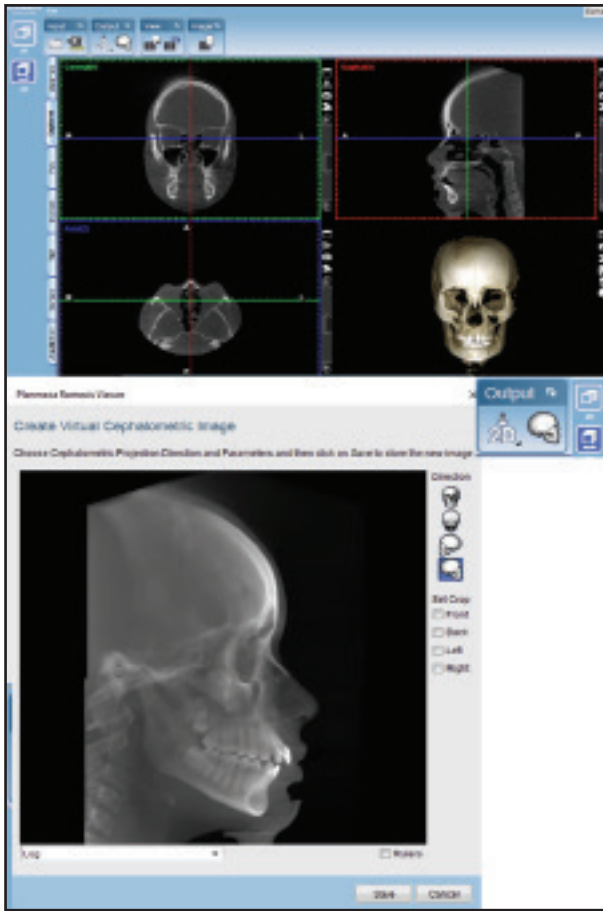


Fig. (1) Extracting lateral cephalometric radiograph from CBCT using Romexis software

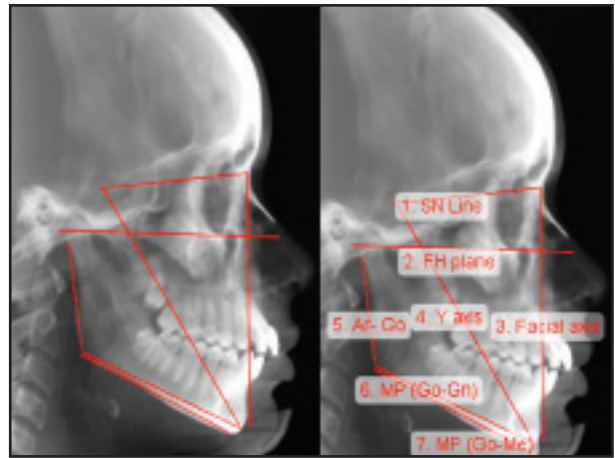


Fig. (2) Point and lines drawn on extracted lateral cephalometric radiograph 1. SN line, 2. Frankfurt Horizontal plane(FHP), 3. Facial axis (N-Pog), 4. Y-axis (S-Gn), 5. Ar-Go, 6. Mandibular plane (MP)(GO-Gn), 7. Mandibular plane(MP)(Go-Me)

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).

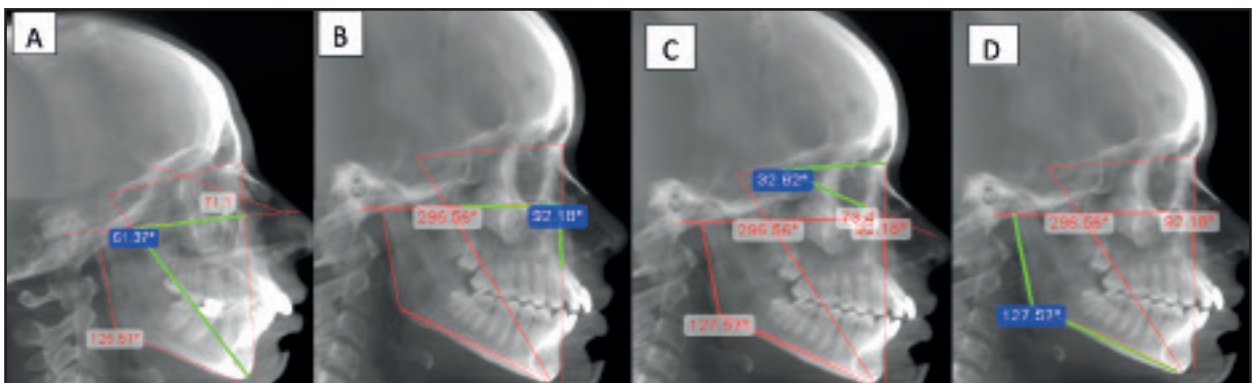


Fig. (3) Vertical angles; A.Y-axis angle (green), B. Facial angle, C. Mandibular plane angle, D. Gonial angle.

Volumetric measurements of the maxillary sinus

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

In coronal, sagittal and axial views image was translated to the maxillary sinus in one side (Figure 4).

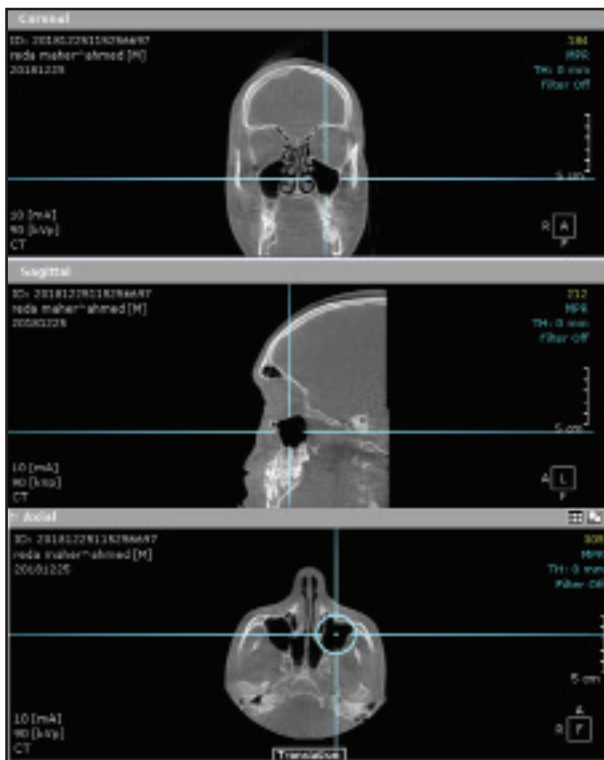


Fig. (4) Cone beam computed tomography; translation to maxillary sinus in coronal, sagittal and axial views.

After image was translated to the maxillary sinus in all three dimensions, using VOI Overlay option from the tool bar the sinus was selected and outlined (Figure 5).

Using fine tuning, threshold was changed to be from -1000 to -400 so that when calculating volume, only air in this area will be measured. Then the grow option in the segmentation feature was selected. The maxillary sinus was then grown as in (figure 6). The software then calculated the volume of the highlighted maxillary sinus. Then 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.

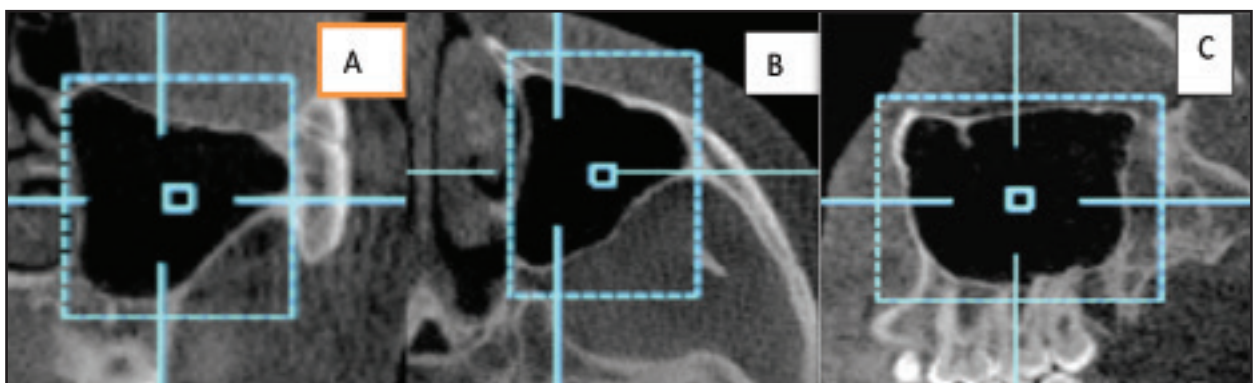


Fig. (5) Cone beam CT; Magnification of outlined and selected Maxillary

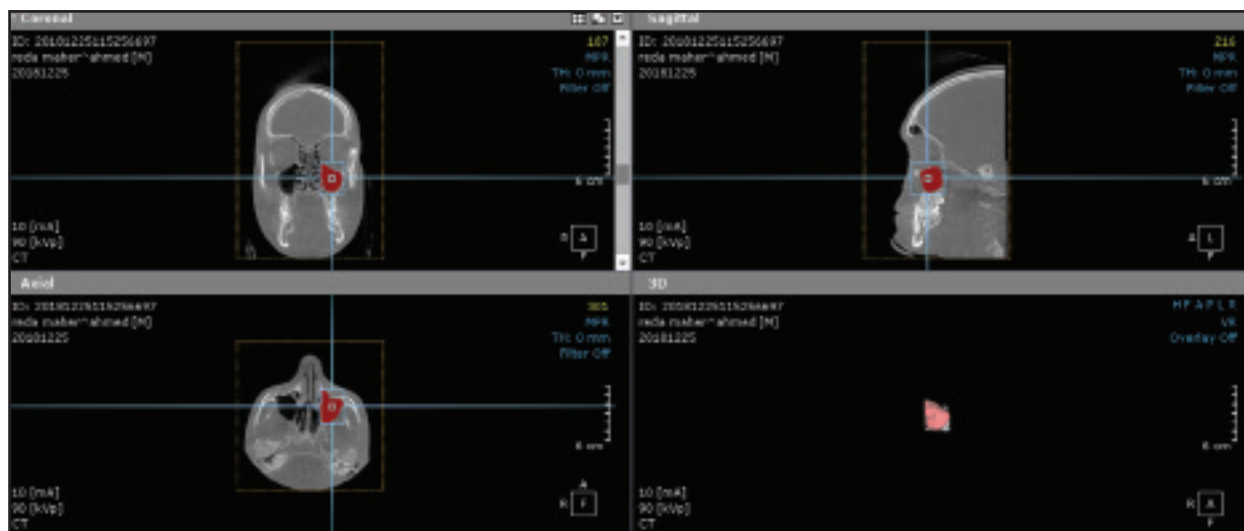


Fig. (6) Grown maxillary sinus (red).

RESULTS

There was no statistically significant difference between sinus volume measurements at the right and left sides within each group (P -value = 0.767, Effect size = 0.032), (P -value = 0.184, Effect size = 0.129) and (P -value = 0.058, Effect size = 0.155), respectively.

There was no statistically significant difference between sinus volume measurements using OnDemand3D in the three groups at the right side, left side as well as mean of the two sides (P -value = 0.943, Effect size = 0.004), (P -value = 0.366, Effect size = 0.022) and (P -value = 0.153, Effect size = 0.009), respectively.

Table (2) Descriptive statistics and results of one-way ANOVA test for comparison between sinus volume measurements (mm^3) in the three groups using On Demand modality

Sinus	Normal pattern (n = 12)	Hyper-divergent pattern (n = 12)	Hypo-divergent pattern (n = 12)	P -value	Effect size (Eta Squared)
Right side					
Mean (SD)	16.4 (4.1)	16.9 (5.2)	17 (4.7)	0.943	0.004
95% CI	13.8– 18.9	13.5 – 20.2	14 – 20		
Left side					
Mean (SD)	16.5 (4.5)	16.2 (5.4)	17.8 (5.3)	0.366	0.022
95% CI	13.7– 19.3	12.8 – 19.6	14.5 – 21.2		
Mean of the two sides					
Mean (SD)	16.4 (4.2)	16.5 (5.2)	17.4 (5)	0.153	0.009
95% CI	13.8 – 19.1	13.2 – 19.8	14.2 – 20.6		

*: Significant at $P \leq 0.05$

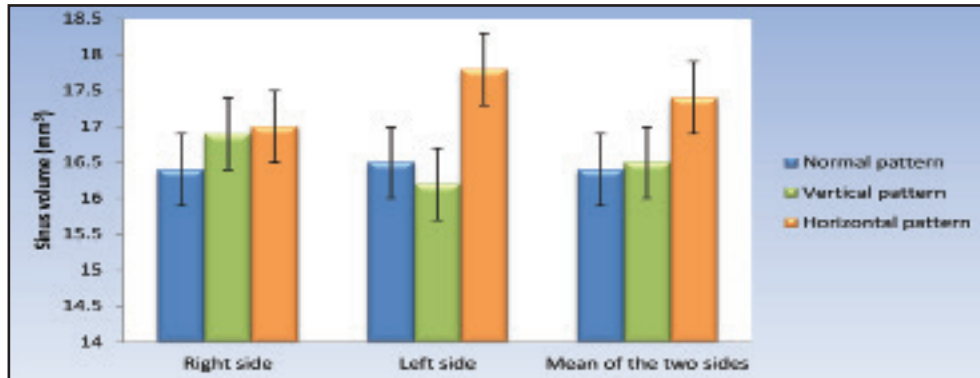


Fig. (7) Bar chart representing mean and standard deviation values for sinus volume measurements (mm³) in the three groups using On Demand modality

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 time was 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*⁽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*⁽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, hyper-divergent facial pattern and hypo-divergent facial pattern with both software programs. This is in accordance with Okşayan *et al*⁽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*⁽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*⁽⁸⁾ and Agacayak *et al*⁽¹⁸⁾ found that adult and growing mouth breathers who mostly have hyper-divergent 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 that there 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.

REFERENCES

1. Oishi S, Ishida Y, Matsumura T, Kita S, Kuma T, Imamura T, Ikeda Y, Kawabe A, Okuzawa M, Ono T. A cone-beam computed tomographic assessment of the proximity of the maxillary canine and posterior teeth to the maxillary sinus floor: lessons from 4778 roots. *Am J Orthod Dentofac Orthop* 2020;157:792-802.
2. Cappellette JrM, Alves F, Nagai LHY, Fujita R., Pignatari S. Impact of rapid maxillary expansion on nasomaxillary complex volume in mouth-breathers. *Dental Press J Orthod* 2017;22:79-88.
3. Oz AZ, Oz AA, El H, Palomo J. Maxillary sinus volume in patients with impacted canines. *Angle Orthod* 2017;87:25-32.
4. Carrascal N, Coll O, Gehrke A, Guirado J, Alfaro F, Albiol J. Radiological evaluation of maxillary sinus anatomy: a cross-sectional study of 300 patients. *Ann Anat* 2017;214:1-8.
5. Okşayan R, Sokucu O, Yeşildal S. Evaluation of maxillary sinus volume and dimensions in different vertical face growth patterns: a study of cone-beam computed tomography. *Acta Odontol Scand* 2017;75:345-349.

6. Kosumarl W, Patanaporn V, Jotikasthira D, Janhom A. Distances from the root apices of posterior teeth to the maxillary sinus and mandibular canal in patients with skeletal open bite: a cone-beam computed tomography study. *Imaging Sci Dent* 2017;47:157-164.
7. Barbosa G, Pimenta L, Pretti H, Golden B, Roberts J, Drake A. Difference in maxillary sinus volumes of patients with cleft lip and palate. *Int J Pediatr Otorhinolaryngol* 2014;78:2234-2236.
8. Tikku T, Khanna R, Sachan K, Srivastava K, Munjal N. Dimensional changes in maxillary sinus of mouth breathers. *J Oral Biol Craniofac Res* 2013;3:9-14.
9. Fatahalla R, Nadim M, Elkadi A. Three dimensional evaluation of facial harmony in orthodontic patients with vertical growth pattern. *SCU-MJ* 2017; 20:114-121.
10. Ozbilen E, Yilmaz H, Kucukkeles N. Comparison of the effects of rapid maxillary expansion and alternate rapid maxillary expansion and constriction protocols followed by facemask therapy. *Korean J Orthod* 2019;49:49-58.
11. Faur C, Roman R, Bran S, Dinu C, Coclici A, Rotaru H, Hedesi M. The changes in upper airway volume after orthognathic surgery evaluated by individual segmentation on CBCT images. *J Clin Med* 2019;14:213-219.
12. Sun W, Xia K, Huang X, Cen X, Liu Q, Liu J. Knowledge of orthodontic tooth movement through the maxillary sinus: a systematic review. *BMC Oral Health* 2018;81:91-106.
13. Cha S, Zhan C, Zhao Q. Treatment of Class II malocclusion with tooth movement through the maxillary sinus. *Am J Orthod Dentofac Orthop* 2020;157:105-116.
14. Motoyoshi M, Suzuki R, Uchida Y, Saiki A, Shimizu N. Maxillary sinus perforation by orthodontic anchor screws. *Int J Oral Sci* 2015;57:95-100.
15. Jia X, Chen X, Huang X. Influence of orthodontic mini-implant penetration of the maxillary sinus in the infra-zygomatic crest region. *Am J Orthod Dentofac Orthop* 2018;153:656-661.
16. Kula K, Ahn J, Halum S, Dillehay K, Ghoneima A. Three dimensional evaluation of upper airway volume in children with different dental and skeletal malocclusions. *J Biomed Graph Comput* 2013;3:116-126.
17. Ryu J, Choi S, Cha J, Lee K, Hwang C. Retrospective study of maxillary sinus dimensions and pneumatization in adult patients with an anterior open bite. *Am J Orthod Dentofac Orthop* 2016;150:796-801.
18. Agacayak K, Gulsun B, Koparal M, Aksoy O, Adiguzel O. Alterations in maxillary sinus volume among oral and nasal breathers. *Med Sci Monit* 2015;21:18-26.