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Title: EFFECT OF VERTICAL GROWTH PATTERN ON MAXILLARY AND FRONTAL SINUS SIZE

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ABSTRACT

Objective: The purpose of this study is to investigate the size of frontal and maxillary sinus sizes of individuals with different vertical growth pattern by using lateral and posteroanterior cephalometric radiographs. **Methods:** In the study conducted on 60 individuals selected from male and female patients between the ages of 15-17, lateral and posteroanterior cephalometric radiographs were divided into three groups by vertical skeletal classification. The radiographs of 20 patients with increased vertical growth (Sella-Nasion Plane, Gonion-Gnathion Plane (Sn-GoGn)>38°) were included in Group 1 of this study, the radiographs of 20 patients with decreased vertical growth (Sn-GoGn <26°) in Group 2 and the radiographs of 20 patients with normal growth (Sn-GoGn:32±6°) in Group 3. The measurements of maxillary and frontal sinus sizes were taken via Image J software. **Results:** The differences between the groups for all measurements in both lateral and PA radiographs (p>0.005) were not statistically significant. **Conclusion:** The different vertical growth pattern was not effective on maxillary and frontal sinus sizes. Future controlled trials conducted with larger samples are needed to support and extend the findings.

Keywords: frontal sinus, maxillary sinus, posteroanterior radiography, lateral cephalometric radiography, sinus size

INTRODUCTION

The largest of the paranasal sinuses defined as bone cavities filled with air opening to the nasal cavity is the maxillary sinus. The base of the maxillary sinus is formed by the alveolar process and the hard palate, and its adjacency to the upper posterior teeth continues for life (1). The maxillary sinus reaches its mature size at the age of 12-15, in conjunction with the maxillary growth period (2). The frontal sinus, one of the paranasal sinuses, does not exist at birth, it starts to develop after the age of two. Its development continues until late puberty and is completed at the age of approximately 20 (3).

The human skeleton is a balanced and dynamic system influenced by various mechanical stresses. Studies to determine the factors affecting the functions, morphologies and sizes of paranasal sinuses taking up space in the skull have been drawing attention for a long time (4). It is thought that the development of the maxillary sinus, which has a close relationship with the maxillary structure and the upper posterior teeth, can be affected by skeletal malocclusions (1). The frontal sinus size may be affected by factors such as bone density, forces of the masticatory muscles, occlusal relations and jaw relations (4).

In the literature, there are various studies investigating the relationship between maxillary sinus size and malocclusions. Oktay (1) reported that female individuals with Angle Class II malocclusion have broader maxillary sinuses than other malocclusions. Tikku et al. (2) reported that the sinus size of individuals who breathing through their mouth is smaller than that of individuals with normal respiration. On the other hand, Oksayan et al. (5) suggested that high angle individuals have smaller maxillary sinuses than low angle individuals. It was reported that maxillary sinus size is important in terms of providing an opinion on clinical subjects, such as the impacted upper tooth's angle and depth, determination of location in mini-implant applications, and planning orthognathic surgery (5).

The number of studies investigating the relationship between the frontal sinus size and malocclusion is few. There are studies reporting that the frontal sinus may be used as an indicator for growth (6-8) and compatible anterior occlusion (4). However, there is no study in the literature investigating the effects of vertical growth direction on both frontal and maxillary sinus size and assessing the correlation between them. The purpose of this study designed on the basis of such deficiency is to investigate the frontal and maxillary sinus sizes of individuals with different vertical growth patterns using lateral and posteroanterior (PA) cephalometric radiographs.

METHODS

Lateral and PA cephalometric films with skeletal Class 1 relationship and different vertical growth patterns, (ANB: 0-4°) taken from systemically healthy patients without craniofacial deformities, such as cleft lip or palate, kept in the archive of the Department of Orthodontics at University's Faculty of Dentistry were included in this study. For this retrospective study, an approval was obtained from University's Clinical Trials Ethics Committee. (29.03.2018/14) Written informed consent was obtained from patients who participated in this study. The power analysis sample size determination revealed that for the ANOVA on three groups with an effect size of 0.90 for the frontal sinus area, an alpha level of 0.05, and a power of 0.85, a minimum of 19 subjects in each group was required.

The radiographs used in the study were obtained via X-ray (Planmeca EC Proline PM 2002) at the Department of Oral Diagnosis and Radiology within University's Faculty of Dentistry, under standard conditions. Exposure parameters were 68-74 kVp, 12 mA, and 0,4-0,5 seconds. In addition, magnification ratio was 1:1. 102 individuals with skeletal Class I relationship were selected randomly from male and female patients between the ages of 15-17 in the archive. The frontal and maxillary sinuses of individuals were assessed in terms of their anatomic and physiological integrity from the cephalometric radiographs. Patients with a history of orthodontics treatment or orthognathic surgery, who had experienced trauma or undergone skull surgery and had endocrine disorders or hereditary facial asymmetry were excluded from the study. Also, it was taken care in the selection of radiographs that the films

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were acquired without rotation. After this procedure was completed, 60 individuals' radiographs were divided into three groups by vertical skeletal classification.

The lateral and PA cephalometric radiographs of 20 patients with increased vertical growth (Sella-Nasion Plane, Gonion-Gnathion Plane (Sn-GoGn)>38°) were included in Group 1 (high angle) of this study, radiographs of 20 patients with decreased vertical growth (Sn-GoGn <26°) in Group 2 (low angle), and radiographs of 20 patients with normal growth (Sn-GoGn: 32±6°) in Group 3 (medium angle).

Maxillary and frontal sinus size measurements were taken using Image J Software 1.48v (National Institutes of Health, Bethesda, Maryland, USA) after the images were calibrated (GBB). For calibration, the ruler was used in the lateral cephalometric radiographs, and the ear rods were used in the PA radiographs. After the images to be assessed were transferred to the software using the size calculation feature, the borders of the maxillary and frontal sinuses were determined and their areas were calculated in cm^2, and their height and width in cm. Said et al.'s (4) studies for drawings of frontal sinus area, and Sidhu et al.'s (9) studies for drawings of maxillary sinus area were taken as a reference. The frontal sinus was measured by calculating the average of the right and left sinus measurements taken separately. Rectangular coordinates which were described in Endo et al.'s (10) study were selected for the assessment of the height and width sinuses. x-axis is parallel to the Frankfort horizontal plane (Pr-Or) and the y-axis is perpendicular to the Frankfort horizontal plane through the sella. The maximum height, width, and area of the sinuses were measured in the lateral and PA cephalometric radiographs as shown in Figure 1 and Figure 2.

Statistical analysis was performed using SPSS Version 21 (SPSS Inc., Chicago, Illinois, USA) and a p value < 0.05 was accepted as statistically significant. The normality of the distribution of continuous variables was tested using the Shaphiro-Wilk Test. The One-way ANOVA and LSD Test were used to compare variables between the groups when data was normally distributed and Kruskal Wallis Analysis was used when data was not normally distributed. Data is expressed as mean±std.deviation. To determine the method error 5 lateral and 5 PA cephalometric radiographs, the final records were randomly selected and retraced and digitized at a 15-day interval by the same operator (GBB). The Intraclass Correlation Coefficient (ICC) and 95% confidence interval were used to the test harmony of values and intra-rater reliability. ICC ranged from 0 to 1, where 0 represented no agreement and 1 indicated perfect agreement. $P < 0.05$ was considered significant.

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RESULTS

The average age of individuals included in the study was 16.06 ± 0.18 years for the high angle group, 16.21 ± 0.17 years for the low angle group and 16.09 ± 0.16 years for the medium angle group. The differences in average age between groups were not statistically significant (p=0.805). There were 13 females and 7 males in the Group 1; 11 females and 9 males in the Group 2 and 10 females and 10 males in Group 3. The difference between the groups in terms of gender was not statistically significant (p=0.627). The correlation coefficient results were higher than 0.89 for intra-examiner reliability, which shows high positive correlations and indicates the reliability of the measurements. Area, width and height measurements of the maxillary sinus and the frontal sinus, which are the measurements from the lateral cephalometric radiographs, are provided in Table 1. The p values of comparisons among groups of these values are provided in the same table. The area, width and height measurements of PA radiographs and statistical comparison results between the groups are provided in Table 2. According to the results, the difference between the groups in all of the measurements in both lateral and PA radiographs was not statistically significant (p>0.005). The ICC value of 0.831 suggested a high level of harmony between the frontal sinus area lateral and the PA radiograph values [r=0.831, p<0.001].

DISCUSSION

In our study aiming to assess frontal and maxillary sinus sizes in adolescent individuals with different vertical growth patterns, both frontal and lateral cephalometric radiographs were used. In the study, the error ratio was planned to be decreased by reducing the superimposition rate, which is one of the known disadvantages of two-dimensional radiographs created through the joint use of radiographs taken based on two different directions. This study is important as it attempts to develop a diagnosis with cheaper two-dimensional radiographs (11) that are routinely used without the need of three-dimensional radiographs exposing the patient to more radiation.

According to our study results, the difference in the age and the gender of the individuals included was not statistically significant between the groups. When considering the effect of age and gender differences on sinus sizes (1, 12), the presence of homogenization is one of the superior aspects of the study. Therefore by minimizing the individual differences, we tried to provide vertical growth patterns as the only variable.

When examining studies assessing maxillary sinus in the literature, it was seen that most used lateral cephalometric radiography as two-dimensional radiography. The difficulty of drawing the maxillary sinus with PA radiography due to superposition was given as a reason. Although this condition prevented drawing on two films, as is the case with frontal sinus values, this study is a first as there is no study where the correlation between two sinuses is assessed by drawing two sinuses together.

According to the results of our study, a high correlation was found between the measurement values of the frontal sinus area in lateral and PA cephalometric radiographs. Preliminary information was obtained regarding the usability of one radiograph type in place of another in cases where taking two radiographs is not possible due to economic, physical and other reasons.

Said et al. (4) reported that frontal sinus size is affected by vertical skeletal measurements. However, they did not observe a significant difference in the sinus sizes of individuals with different skeletal sagittal oriented malocclusion. They thought that the larger frontal sinus in individuals with open bite malocclusion resulted from the occlusal forces that were transmitted poorly along the nasal pillars associated with the reduced muscular activity in hyper-divergent individuals. Endo et al. (10) reported that there is no significant relationship between maxillary sinus size and sagittal skeletal bone, while reporting that there is a positive correlation between them and upper face height. From these findings, the effects of different vertical patterns on sinus sizes were investigated.

At our study, the statistical difference between the groups was not significant in the measurements in both lateral and PA radiographs. This result is not consistent with that of Endo et al. (10). In parallel with Oksayan et al. (5), it was suggested that the difference is the result of using the total height instead of using the upper and lower heights separately as in Endo et al.'s method (10) in determining the vertical face sizes.

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Oksayan el al. (5) identified significant differences in maxillary sinus lengths and widths, contrary to our study. This is considered to be the result of the difference between the average age of the individuals included in the groups in the two studies.

Said et al. (4), reporting that the effect of facial height on frontal sinus size is statistically significant, also took the U1-L1 angle in the grouping of individuals into consideration. They suggested that anterior occlusion is important in the transmission of the masticatory forces to the frontal sinuses. It is thought that the difference in the results is due to the fact that this value was not standardized because of the scarcity of samples available when determining the groups in our study. It is considered that this is due to the limitations of the study. We hope that the subject can be enlightened in further detail in more comprehensive future studies in the light of this article’s findings.

CONCLUSIONS

Lateral and PA cephalometric radiographs can be used in the calculation of sinus sizes as an effective material and no significant difference in terms of the effect of different vertical growth tendencies on maxillary and frontal sinus sizes was found.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of University.

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Peer-review: Externally peer-reviewed.

Author contributions: Concept - M.G., A.G.; Design - M.G, G.B.B, A.G; Supervision - M.G., A.G.; Resource - M.G., G.B.B.; Materials - G.B.B; Data Collection and/or Processing - M.G., G.B.B.; Analysis and/or Interpretation - M.G., A.G; Literature Search - M.G., G.B.B., A.G.; Writing - M.G.; Critical Reviews - M.G., A.G.

Conflict of Interest: No conflict of interest was declared by the authors.

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TABLES

Table 1: Means, standard deviations and p values for the lateral cephalometric radiographs measurements between groups

	Groups			*P*
	High Angle (1) (Mean±SD)	**Low Angle (2)** (Mean±SD)	**Medium Angle (3)** (Mean±SD)	
Max Area (cm^2)	8.19 ± 0.23	7.63 ± 0.34	7.83 ± 0.20	0.330
Frontal Area (cm^2)	1.56 ± 0.95	2.02 ± 0.17	1.59 ± 0.11	0.093
Max Width (cm)	3.51 ± 0.07	3.28 ± 0.07	3.39 ± 0.06	0.095
Max Height (cm)	3.77 ± 0.08	3.75 ± 0.10	3.84 ± 0.06	0.754
Frontal Width (cm)	0.87 ± 0.03	0.95 ± 0.08	0.85 ± 0.05	0.501
Frontal Height (cm)	2.58 ± 0.07	2.74 ± 0.08	2.55 ± 0.09	0.228

SD: standard deviation

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Table 2: Means, standard deviations and p values for the posteroanterior cephalometric radiographs measurements between groups

	Groups			*P*
	High Angle (1) (Mean±SD)	**Low Angle (2)** (Mean±SD)	**Medium Angle (3)** (Mean±SD)	
Frontal Area (cm^2)	8.56 ± 0.50	9.71 ± 0.68	9.05 ± 0.56	0.631
Frontal Height (cm)	2.57 ± 0.09	2.78 ± 0.11	2.67 ± 0.09	0.614
Frontal Width (cm)	4.88 ± 0.19	5.23 ± 0.27	4.89 ± 0.21	0.483

SD: standard deviation

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FIGURE LEGENDS

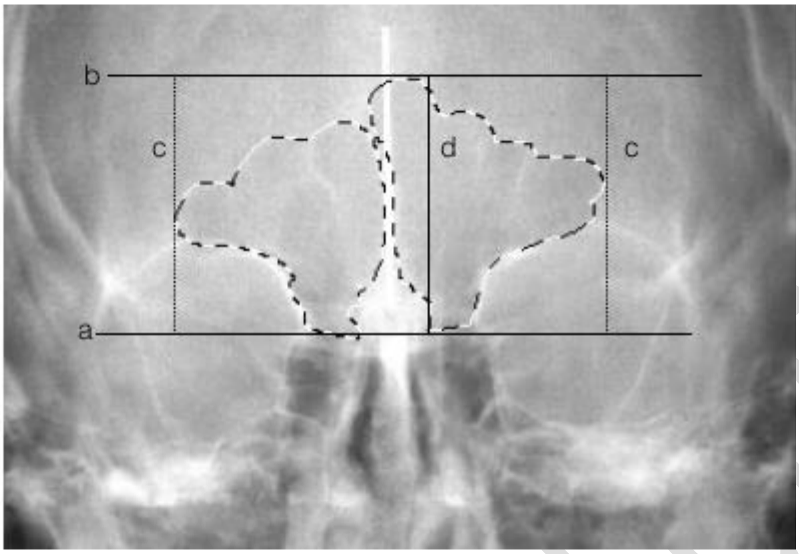

Figure 1: a) A line has drawn through the lateral limit of orbital cavities, at the nasofrontal suture. b) The line which parallels to the nasofrontal line has drawn at the highest point of the frontal sinus. c) Lines that delineate the maximum lateral limits of the right and left sinuses; d) Distance between a and b line

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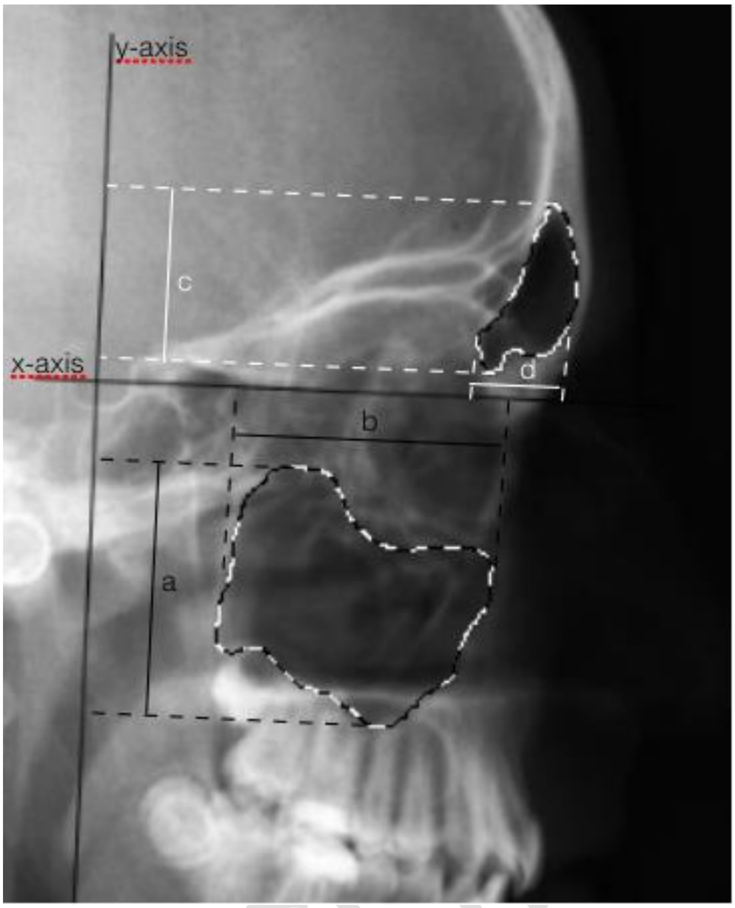

Figure 2: a) Maxillary sinus height- projected on the y-axis. b) Maxillary sinus width-projected on the x-axis c) Frontal sinus height- projected on the y-axis. d) Frontal sinus width-projected on the x-axis

TABLES

Table 1: Means, standard deviations and p values for the lateral cephalometric radiographs measurements between groups

	Groups			***P***
	High Angle (1) (Mean±SD)	**Low Angle (2)** (Mean±SD)	**Medium Angle (3)** (Mean±SD)	
Max Area (cm^2)	8.19 ± 0.23	7.63 ± 0.34	7.83 ± 0.20	0.330
Frontal Area (cm^2)	1.56 ± 0.95	2.02 ± 0.17	1.59 ± 0.11	0.093
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Table 2: Means, standard deviations and p values for the posteroanterior cephalometric radiographs measurements between groups

	Groups			***P***
	High Angle (1) (Mean±SD)	**Low Angle (2)** (Mean±SD)	**Medium Angle (3)** (Mean±SD)	
Frontal Area (cm^2)	8.56 ± 0.50	9.71 ± 0.68	9.05 ± 0.56	0.631
Frontal Height (cm)	2.57 ± 0.09	2.78 ± 0.11	2.67 ± 0.09	0.614
Frontal Width (cm)	4.88 ± 0.19	5.23 ± 0.27	4.89 ± 0.21	0.483

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