Türkiye Klinikleri Diş Hekimliği Bilimleri Dergisi
Turkiye Klinikleri Journal of Dental Sciences Turkiye Klinikleri J Dental Sci. 2023;29(2):254-63

ORİJİNAL ARAŞTIRMA ORIGINAL RESEARCH DOI: 10.5336/dentalsci.2022-93397

Investigation of the Relationship Between Maxillary Growth Direction and Anatomical Variations of the Sinonasal Region Case-Control Research Maxillary Growth Direction and Sinonasal Anatomic Variations

Maksiller Büyüme Yönü ile Sinonazal Bölgenin Anatomik Varyasyonları Arasındaki İlişkinin İncelenmesi Vaka-Kontrol Araştırması Maksiller Büyüme Yönü ve Sinonazal Varyasyonlar

Meryem ETÖZ[a], Firdevs AŞANTOĞROL[b], Kübra Gülnur TOPSAKAL[c], Fatma Ezgi CAN[d]

[a]Department of Oral and Dentomaxillofacial Radiology, Erciyes University Faculty of Dentistry, Kayseri, Türkiye
[b]Department of Oral and Dentomaxillofacial Radiology, Gaziantep University Faculty of Dentistry, Gaziantep, Türkiye
[c]Department of Orthodontics, University of Health Sciences Gülhane Faculty of Dentistry, Ankara, Türkiye
[d]Department of Biostatistics, İzmir Kâtip Çelebi University Faculty of Medicine, İzmir, Türkiye

ABSTRACT Objective: This study investigated the frequency of anatomic variations in the sinonasal region with septal deviation and the relationship of these anatomic variations with the developmental direction of the maxilla in cone-beam computed tomography images. **Material and Methods:** Forty-eight patients who underwent orthognathic surgery were included in this study. These patients were divided into 3 groups: normal maxilla (n=16), prognathic maxilla (n=16), and retrognathic maxilla (n=16) by determining the position of the maxillae in relation to the skull base on lateral cephalometric radiographs. The anatomic variations of the sinonasal region and the presence of maxillary sinus ostium (MSO) obstruction were studied in all groups. The relationship between the anatomical variations and the different developmental aspects of the maxilla was analyzed. **Results:** The most common anatomical changes in all patients were: hypertrophy of the inferior turbinate (68.8%), deviation of the nasal septum (66.7%), and concha bullosa (62.5%). No statistically significant difference was found between the groups with different skeletal deformities based on the position of the maxilla in relation to the skull base (p>0.05). While there was a statistically significant difference between gender distribution and hypertrophy of the middle concha (p=0.016), no statistically significant difference was found between other anatomical variations and gender distribution (p>0.05). **Conclusion:** In conclusion, in this study, we investigated the relationship between the anatomical variations of the sinonasal region and the direction of maxillary growth. There was no significant relationship between the above anatomical variations and MSO obstruction between the groups.

Keywords: Anatomic variation; maxillary sinus; nasal cavity; cone-beam computed tomography

ÖZET Amaç: Bu çalışmada, sinonazal bölgedeki anatomik varyasyonların septal deviasyon ile birlikte görülme sıklığı ve bu anatomik varyasyonların lateral sefalometrik radyograflarda belirlenen maksiller gelişim yönü ile ilişkisi konik ışınlı bilgisayarlı tomografi görüntülerinde araştırılmıştır. **Gereç ve Yöntemler:** Ortognatik cerrahi operasyonu gereken 48 hasta çalışmaya dâhil edildi. Bu hastalar, lateral sefalometrik radyograflarda maksillaların kafatası tabanına göre konumları belirlenerek normal maksilla (n=16), prognatik maksilla (n=16) ve retrognatik maksilla (n=16) olmak üzere 3 grupta sınıflandırıldı. Sinonazal bölgenin anatomik varyasyonları ve maksiller sinüs ostiyumunun tıkanıklığının varlığı tüm gruplarda araştırıldı. Anatomik varyasyonlar ile maksillanın farklı gelişimsel yönleri arasındaki ilişki analiz edildi. **Bulgular:** Tüm hastalarda en sık görülen anatomik varyasyonlar; alt konka hipertrofisi (%68,8), nazal septum sapması (%66,7) ve konka büllozaydı (%62,5). Kafatası tabanına göre maksillanın pozisyonuna bağlı olarak farklı iskeletsel deformitesi olan gruplar arasında istatistiksel olarak anlamlı bir fark bulunmadı (p>0,05). Cinsiyet dağılımı ile orta konka hipertrofisi arasında istatistiksel olarak anlamlı fark bulunurken (p=0,016), diğer anatomik varyasyonlar ile cinsiyet dağılımı arasında istatistiksel olarak anlamlı bir fark bulunmadı (p>0,05). **Sonuç:** Sonuç olarak bu çalışmada, sinonazal bölgenin anatomik varyasyonlarının maksiller büyüme yönü ile arasındaki ilişkiyi araştırdık. Gruplar arasında yukarıdaki anatomik varyasyonlar ve maksiller sinüs ostiyum obstrüksiyonu arasında anlamlı bir ilişki bulunmadı.

Anahtar Kelimeler: Anatomik varyasyon; maksiller sinüs; nazal kavite; konik ışınlı bilgisayarlı tomografi

Correspondence: Meryem ETÖZ
Department of Oral and Dentomaxillofacial Radiology, Erciyes University Faculty of Dentistry, Kayseri, Türkiye
E-mail: meryemetoz@hotmail.com

Peer review under responsibility of Turkiye Klinikleri Journal of Dental Sciences.

Received: 19 Sep 2022 ***Received in revised form:*** 03 Mar 2023 ***Accepted:*** 15 Mar 2023 ***Available online:*** 21 Mar 2023

2146-8966 / Copyright © 2023 by Türkiye Klinikleri. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

The primitive nasal septum and nasal cavities are connected to the oral cavity until the 8th week of formation of the posterior palate. Therefore, the nasal structures and maxillary bone have an important anatomical connection from their earliest stages of growth.[1,2] While some authors report that the nasal septum plays more of a role as a growth center, others claim that the growth of the nasal septum has a supporting effect on facial development.[1,3-6] Kang et al. found that the nasal septum has a primary effect on the enlargement of the premaxilla and an indirect effect on the enlargement of the maxilla, and reported that deviation of the nasal septum may lead to facial asymmetry during the developmental period.[7]

Many studies have been conducted to investigate the relationship between facial asymmetry and nasal septal deviation (NSD). These studies have shown that there is a positive relationship between facial growth and NSD.[8-10] Poublon reported in his study that the cartilaginous nasal septum affects the growth of the nasal, maxillary, and cranial bones.[11] Pirsig stated that some sections of the septolateral cartilage may influence maxillary growth in early childhood.[9] Previous studies have indicated that there is a close relationship between the nasal septum and the premaxillary region, as the growing nasal septal cartilage exerts tension on the premaxillary suture by binding the septopremaxillary ligament.[12] In addition, obstruction of the nasal passage secondary to deviation of the nasal septum affects the morphology and structure of the maxilla. It is known that septal deviation (SD) causes partial or complete airway obstruction, depending on its severity, and leads to narrowing of the maxillary arch and the deep palatal arch.[13] Thus, nasal breathing, which is a prerequisite for proper growth and development of the craniofacial complex, is compromised.

As a result, nasal obstruction leading to mouth breathing leads to a reduction in nasal permeability caused by nasal stenosis and expansion of the turbinate, resulting in a reduction in the size of the nasal airway.[2,14] Paraseptal structural changes in the lateral nasal wall and middle turbinate are thought to be a compensatory mechanism against the reduction in nasal airflow through the NSD.[15]

When the literature on the relationship between NSD and facial growth was reviewed, it was not possible to specify whether NSD leads to asymmetric facial growth or facial dissymmetry causes NSD based on all these studies. It was concluded that both NSD and facial asymmetry strongly influence each other.[7] However, the studies performed so far were limited to evaluating only SD, and only one study included concha bullosa (CB) with SD. From this point of view, it can be said that the relationship between the anatomical variations of the nasal cavity and even the maxillary sinus and facial development has not been studied yet.

Despite its disadvantages such as limited imaging area and lack of soft tissue, cone-beam computed tomography (CBCT) has a widespread use in dentistry practice due to its low radiation dose and easy accessibility. In this reserge it was aimed to determine, via 3D CBCT sections, the incidence of other anatomical variations in the sinonasal region along with NSD and the relationship of these anatomical variations with the direction of maxillary development.

MATERIAL AND METHODS

This retrospective research was performed in Erciyes University Faculty Division of Dentomaxillofacial Radiology. It was endorsed by the Clinical Researches Ethics Committee (date: March 20, 2019; no: 2019/193). Forty-eight patients who admitted to the Oral and Maxillofacial Surgery Hospital and needed undergoing orthognathic surgery operation were included in this study. All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008. The exclusion and inclusion criteria for the study were determined as:

Exclusion criteria:

- Past maxillofacial neoplasia history.
- History of trauma or surgery in the maxillofacial region.
- Presence of any systemic disease affecting the sinonasal region.

- The presence of craniofacial deformities affecting the mid-face region.

Inclusion criteria:

- Individuals who have CBCT and lateral cephalometric radiographs with the indication of orthognathic surgery planning.
- Sufficient diagnostic quality for the diagnosis of CBCT images.
- The absence of serious pathological findings that prevent the examination of the sinonasal region in CBCT images.

The lateral cephalometric radiographs of the patients in the study, taken before treatment, were examined by a specialized orthodontist (KGB) and 3 groups of 16 patients each were formed. The groups were divided based on the SNA angle measurement (82°±2°) of the Steiner analysis, which determines the positions according to the skull base of the maxilla.

Group 0 (G-0): Patients with a normal relationship between the maxilla and the skull base with an SNA angle in the range of 82°±2°.

Group 1 (G-1): Patients with maxillary prognathism with an SNA angle greater than 82°±2°.

Group-2 (G-2): Patients with maxillary retrognathia whose SNA angle was less than 82°±2°.

Examination of images:

CBCT examinations were conducted using NewTom 5G CBCT-Scanner (QR, Verona, Italy). All images were taken at 18x16 cm FOV, size which would allow detailed examination of maxilla, mandible and paranasal sinuses. Axial slice thickness was 0.25 mm. In the evaluation of the nasal cavity and maxillary sinus, multiplanar reformat images containing axial, coronal and sagittal sections were used. NNT programme (QR, Verona, Italy) was used to analyze CBCT images on the monitor (E190S; Dell, Round Rock, TX, USA), and 16 bits (65,636 grey tones), in a dark, quiet room.

All images were analyzed by an oral radiologist (FA) with 3 years of CBCT experience. The examiner was blind to clinical data of the participants. The anatomical variations and parameters investigated are shown below:

Nasal cavity variations (Figure 1, Figure 2, Figure 3):

- NSD severity; on coronal CBCT scans, the NSD angle was recorded by measuring the angle between the most deviated point of the septum and the midline that passing through the anterior nasal spine and the crista galli. Patients were grouped based on NSD angles according to the grading system of Elahi et al. mild; NSD≤9°, moderate; 9<NSD≤15° and severe; NSD>15°.[16]
- Presence of septal spur (Sspur) together with the SD, categorized as yes/no.
- Middle concha hypertrophy (MCH) and inferior concha hypertrophy (ICH), categorized as yes/no.
- CB: the pneumatization of the middle concha, categorized as yes/no.
- Paradoxical middle concha (PMC), categorized as yes/no.
- Uncinate process pneumatization (UPP), categorized as yes/no.

Maxillary sinus variations: hypoplasia, hyperplasia, aplasia, and septation of the maxillary sinus (Figure 2, Figure 3). Obstruction of maxillary sinus ostium (MSO) (Figure 2).

STATISTICAL ANALYSIS

The variations mentioned above and pathologies were recorded retrospectively on CBCT images. To determine intraobserver consistency, 20% of all data was reevaluated after 1 week. Statistical analyses were performed using IBM SPSS Statistics v 22.0 software (IBM Corp., Armonk, NY, USA). For continuous variables, descriptive statistics were given median (minimum-maximum), and categorical variables were given descriptive statistics with frequency and related percentage values. Kruskal-Wallis test, Pearson chi-square, and Fisher-Freeman-Halton test were used in comparisons between groups. Cohen's kappa coefficient was used for the evaluation of intra-observer compliance. The level of significance was obtained as α=0.05.

RESULTS

When the correlation between the values obtained first and those obtained one week later for the rele-

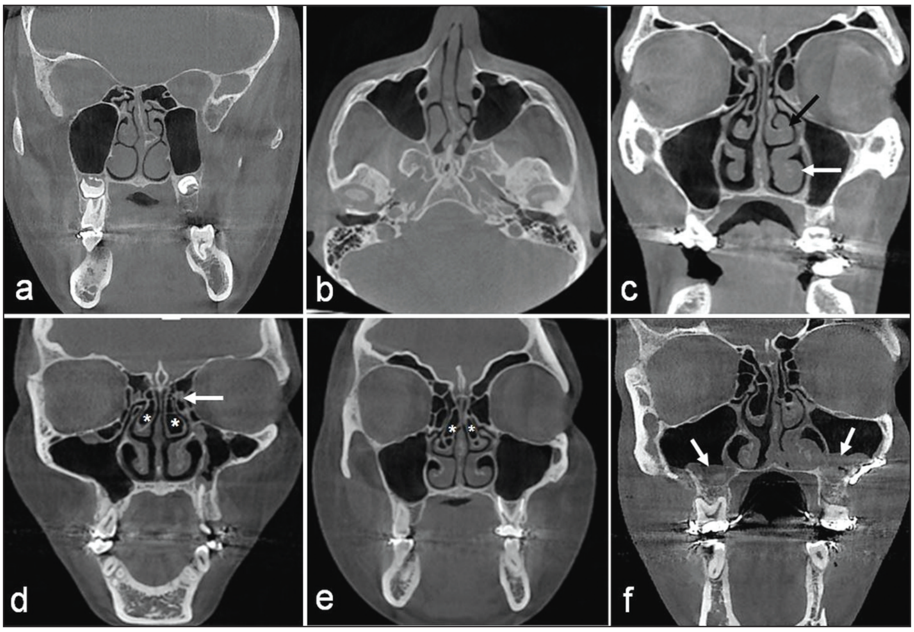

FIGURE 1: CBCT images of some of the sinonasal anatomical variations and pathologies observed. **a, b)** Coronal and axial scans; NSD with septal spur; **c)** Coronal scan; unilateral MCH (black arrow) and ICH (white arrow); **d)** Coronal scan of a patient with normal maxilla position; right UPP (arrow) and bilateral CB (asterisks); **e)** Coronal scan of a patient with maxillary prognathia; bilateral CB (asterisks); **f)** Coronal scan of a patient with maxillary retrognathia; bilateral CB with together the mucosal thickening of the both maxillary sinuses (arrows).

CBCT: Cone-beam computed tomography; NSD: Nasal septal deviation; MCH: Middle concha hypertrophy; ICH: Inferior concha hipertrophy; UPP: Uncinate process pneumatization; CB: Concha bullosa.

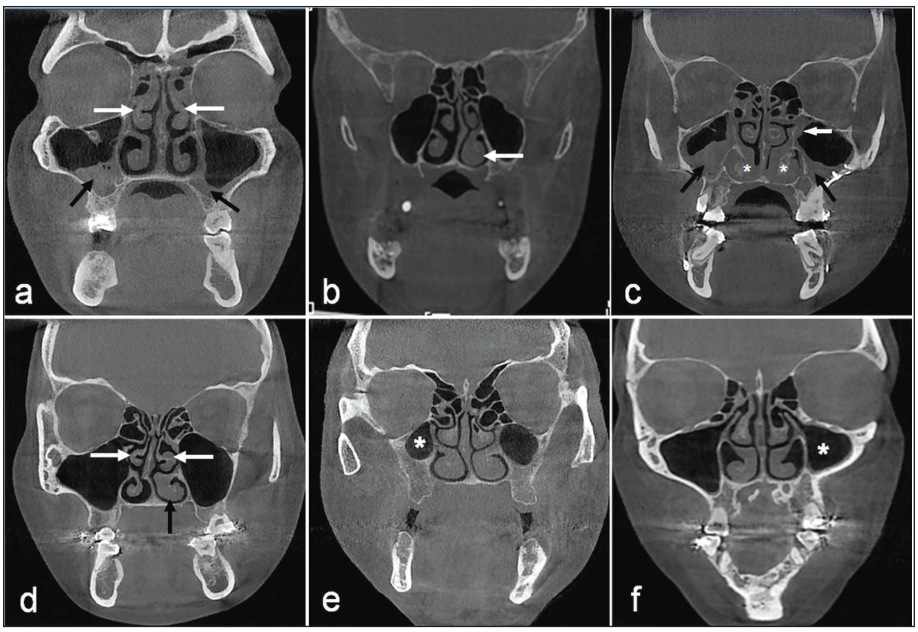

FIGURE 2: The coronal CBCT scans of some of the variations. **a)** Bilateral PMC (white arrows) and mucosal thickening of the maxillary sinuses (black arrows) in a patient with normal maxilla position; **b)** NSD and left ICH (arrow) in a patient with maxillary prognathia; **c)** ICH (asterisks) with together bilaterally mucosal thickening of maxillary sinuses (black arrows) and the obstruction of MSO (white arrow) in a patient with maxillary retrognathia; **d)** Bilateral PMC (white arrows) and left ICH (black arrow) in a patient with maxillary retrognathia; **e)** The hypoplasia of right maxillary sinus (asterisk) in a patient with normal maxilla position; **f)** The hypoplasia of left maxillary sinus (asterisk) in a patient with maxillary retrognathia.

CBCT: Cone-beam computed tomography; PMC: Paradoxic middle concha; NSD: Nasal septal deviation; ICH: Inferior concha hipertrophy; MSO: Maxillary sinus ostium.

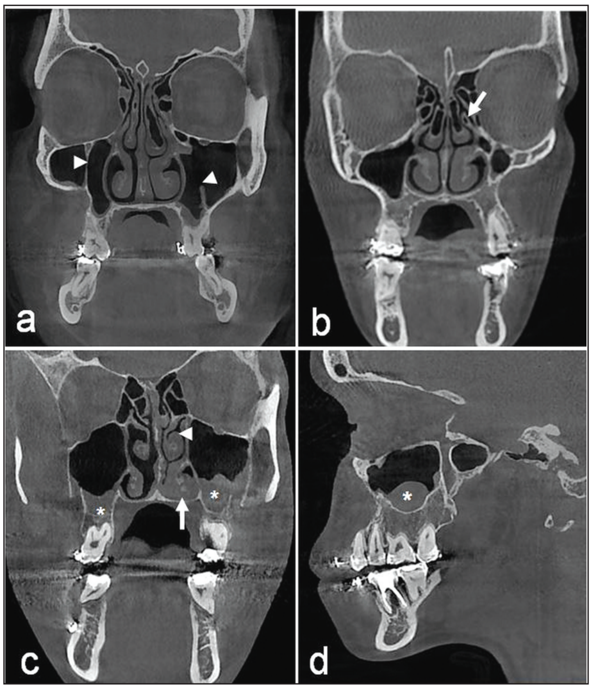

FIGURE 3: CBCT images of some of the variations. **a)** Coronal scan; the septation of maxillary sinus (arrowheads) in a patient with maxillary prognathia; **b)** Bilateral CB and left UPP (white arrow); in a patient with maxillary prognathia; **c)** The left MCH (arrowhead) and ICH (white arrow) with together bilaterally mucosal thickening (asterisks) of maxillary sinuses in a patient with maxillary retrognathia. **d)** Sagittal scan of the same patient.
CBCT: Cone-beam computed tomography; CB: Concha bullosa; UPP: Uncinate process pneumatization; MCH: Middle concha hypertrophy; ICH: Inferior concha hipertrophy.

vant parameters was examined, a moderate correlation was found between the severity of NSD, Sspur, ICH, PMC, and the presence of septa. It was also found that there was a perfect correlation between the variables CB, UPP, and obstruction of the MSO (Table 1).

TABLE 1: The results of the accuracy of intraobserver agreement.

	Kappa coefficient	p value
NSD severity	0.531	0.004
Sspur	0.737	0.016
CB	1.000	<0.001
ICH	0.722	<0.001
PMC	0.556	0.032
UPP	1.000	<0.001
Septation of MxS	0.615	0.035
Obstruction of MSO	1.000	<0.001

p<0.05: Significant difference; NSD: Nasal septal deviation; Sspur: Septal spur; CB: Concha bullosa; ICH: Inferior concha hipertrophy; PMC: Paradoxic middle concha; UPP: Uncinate process pneumatization; MxS: Maxillary sinus; MSO: Maxillary sinus ostium.

Of the 48 patients enrolled in the study, 28 were female and 20 were male (G-0: 11 female, 5 male; G-1: 8 female, 8 male; G-2: 9 female, 7 male). The age range of patients in all groups was 15 to 44 years, with an average age of 20.1 years.

The most common anatomical variations in all patients were: Hypertrophy of the inferior turbinate (68.8%), deviation of the nasal septum (66.7%), and CB (62.5%). Hypoplasia of the maxillary sinus was found in 4.2%, and the presence of septa in the maxillary sinus was 22.9%. Pathologic findings revealed obstruction of the MSO in 15 (31.6%).

No statistically significant difference was found between the groups with different skeletal malpositions based on the position of the maxilla in relation to the skull base (Table 2). Table 3 shows the distribution of the above variations in the 28 female and 20 male patients. While a statistically significant difference was found between gender distribution and MCH, no statistically significant difference was found between other anatomical variations and sex distribution (Table 3). No statistically significant difference was found between MSO obstruction and anatomic variations (Table 4).

DISCUSSION

The sinonasal region is one of the most common sites of anatomical variations. An understanding of the variations in this region and pathologies is essential for accurate diagnosis and treatment. These variations can narrow or block the sinus ostium and the meatus. In such cases, it is thought that the tendency of patients to the mucosal diseases of the sinonasal region is increased.[16] Acquiring knowledge of anatomic variations and preoperative determination of these variations will increase the efficacy and safety of surgical procedures. In the present study, all patients were individuals with an indication for orthognathic surgery, and the majority of patients required reduction in the forward or reverse direction.

The effects of mouth breathing due to a blocked nose on dentofacial growth and development are uncertain.[17] Several studies have shown that adenoid hy-

TABLE 2: The comparison of the anatomical variations between the groups.

		Group 0 n=16 (%)	Group 1 n=16 (%)	Group 2 n=16 (%)	p value
Sex	Female	11 (68.8)	8 (50)	9 (56.3)	0.549
	Male	5 (31.3)	8 (50)	7 (43.7)	
Age (minimum-maximum)		20.50 (15-39)	19 (15-37)	21 (16-44)	0.863
NSD severity	No deviation	5 (31.2)	7 (43.8)	4 (25)	0.591
	Mild	3 (18.8)	3 (18.8)	7 (43.8)	
	Moderate	6 (37.5)	3 (18.8)	3 (18.8)	
	Severe	2 (12.5)	3 (18.8)	2 (12.5)	
Sspur	Yes	6 (37.5)	2 (12.5)	6 (37.5)	0.230
	No	10 (62.5)	14 (87.5)	10 (62.5)	
CB	Yes	8 (50)	12 (75)	10 (62.5)	0.344
	No	8 (50)	4 (25)	6 (37.5)	
MCH	Yes	1 (6.2)	1 (6.2)	5 (31.2)	0.182
	No	15 (93.8)	15 (93.8)	11 (68.8)	
ICH	Yes	11 (68.8)	11 (68.8)	11 (68.8)	1.000
	No	5 (31.3)	5 (31.3)	5 (31.2)	
PMC	Yes	5 (31.2)	4 (25)	5 (31.2)	1.000
	No	11 (68.8)	12 (75)	11 (68.8)	
UPP	Yes	4 (25)	5 (31.2)	2 (12.5)	0.572
	No	12 (75)	11 (68.8)	14 (87.5)	
Hipoplasia of the MxS	Yes	1 (6.2)	0 (0)	1 (6.2)	-
	No	15 (93.8)	16 (100)	15 (93.8)	
Septation of the MxS	Yes	4 (25)	3 (18.8)	4 (25)	1.000
	No	12 (75)	13 (81.2)	12 (75)	
Obstruction of the MSO	Yes	5 (31.2)	7 (43.7)	3 (18.8)	0.312
	No	11 (68.8)	9 (56.3)	13 (81.2)	

$p<0.05$: Significant difference; NSD: Nasal septal deviation; Sspur: Septal spur; CB: Concha bullosa; MCH: Middle concha hipertrophy; ICH: Inferior concha hipertrophy; PMC: Paradoxic middle concha; UPP: Uncinate process pneumatization; MxS: Maxillary sinus; MSO: Maxillary sinus ostium.

TABLE 3: The distribution of the anatomical variations according to genders.

		Female n=28 (%)	Male n=20 (%)	p value
NSD severity	No deviation	13 (46.4)	3 (15)	0.099
	Mild	5 (17.9)	8 (40)	
	Moderate	7 (25)	5 (25)	
	Severe	3 (10.7)	4 (20)	
Sspur	Yes	8 (28.6)	6 (30)	1.000
	No	20 (71.4)	14 (70)	
CB	Yes	18 (64.3)	12 (60)	0.762
	No	10 (35.7)	8 (40)	
MCH	Yes	1 (3.60)	6 (30)	0.016
	No	27 (96.4)	14 (70)	
ICH	Yes	18 (64.3)	15 (75)	0.430
	No	10 (35.7)	5 (25)	
PMC	Yes	7 (25)	7 (35)	0.452
	No	21 (75)	13 (65)	
UPP	Yes	8 (28.6)	3 (15)	0.319
	No	20 (71.4)	17 (85)	
Hipoplasia of the MxS	Yes	1 (3.60)	1 (5)	-
	No	27 (96.4)	19 (95)	
Septation of the MxS	Yes	7 (25)	4 (20)	0.741
	No	21 (75)	16 (80)	
Obstruction of the MSO	Yes	8 (28.6)	7 (35)	0.636
	No	20 (71.4)	13 (65)	

$p<0.05$: Significant difference; NSD: Nasal septal deviation; Sspur: Septal spur; CB: Concha bullosa; MCH: Middle concha hipertrophy; ICH: Inferior concha hipertrophy; PMC: Paradoxic middle concha; UPP: Uncinate process pneumatization; MxS: Maxillary sinus; MSO: Maxillary sinus ostium.

TABLE 4: The effect of anatomical variations on the obstruction of MSO.*

		Yes n=14 (%)	No n=33 (%)	p value
NSD severity	No deviation	5 (35.7)	10 (30.3)	0.971
	Mild	4 (28.6)	9 (27.3)	
	Moderate	3 (21.4)	9 (27.3)	
	Severe	2 (14.3)	5 (15.2)	
Sspur	Yes	3 (21.4)	11 (33.3)	0.503
	No	11 (78.6)	22 (66.7)	
CB	Yes	9 (64.3)	21 (63.6)	0.966
	No	5 (35.7)	12 (36.4)	
MCH	Yes	2 (14.3)	5 (15.2)	1.000
	No	12 (85.7)	28 (84.8)	
ICH	Yes	11 (78.6)	22 (66.7)	0.503
	No	3 (21.4)	11 (33.3)	
PMC	Yes	3 (21.4)	11 (33.3)	0.503
	No	11 (78.6)	22 (66.7)	
UPP	Yes	6 (42.9)	5 (15.2)	0.061
	No	8 (57.1)	28 (84.8)	
Hipoplasia of the MxS	Yes	0 (0)	2 (6.10)	-
	No	14 (100)	31 (93.90)	
Septation of the MxS	Yes	5 (35.7)	6 (18.20)	0.263
	No	9 (64.3)	27 (81.80)	

*Since only one patient has bilateral obstruction of MSO, this variable was not included in the comparisons; p<0.05: Significant difference; MSO: Maxillary sinus ostium; NSD: Nasal septal deviation; Sspur: Septal spur; CB: Concha bullosa; MCH: Middle concha hipertrophy; ICH: Inferior concha hipertrophy; PMC: Paradoxic middle concha; UPP: Uncinate process pneumatization; MxS: maxillary sinus.

pertrophy and chronic nasal obstruction in early childhood lead to dentofacial deformity.[18] Serter et al. concluded that the flattening and shallowness of the maxillary arch detected in adults with nasal polyposis showed that the bony structural changes persist into adulthood.[19] Tomer and Harvold found that induced mouth breathing resulted in a steeper mandibular plane angle and an increase in gonial angle in 8 monkeys compared with the other 8 control animals, resulting in posterior rotation of the mandible.[18] The study of 42 homozygous twins confirmed that the nasal septum affects anteroposterior growth of the maxilla.[20] However, the absence of variations of other paraseptal structures is a limitation of this study.

Previous studies have indicated that there is a relationship between facial asymmetries and NSD, but these studies were conducted using either two-dimensional photographs or dental models.[9,15,21] More recently, there have been studies using posteroanterior radiographs, computed tomography and CBCT.[1,3,7,17] However, these studies included only NSD due to anatomic variations; other studies with the exception of Hartman et al. and Akbay et al. did not evaluate the severity of NSD.[3,13] In the present study, the severity of SD was measured, but we think that the low number of patients per group and the different severity of the NSD groups (mild, moderate, severe) affected the results. Therefore, the relationship between these variations and the direction of maxillary growth should be examined in a larger sample.

Current literature reports that the prevalence of anatomic variations in the sinonasal region varies from 64.0% to 98.5%.[22,23] In this study, a prevalence of 93.75% was found, consistent with the literature. Different rates of anatomic variation may be due to differences in classification of anatomic variations or ethnicity.

One of the most common variations of the sinonasal region is SD, which expresses the left or right opening of the nasal septum. The prevalence of

NSD has been reported to range from 20% to 79%.[24] In this study, the prevalence of NSD was found to be 66.7% in all patients. The prevalence of NSD in each of the groups of 16 subjects in G-0, G-1, and G-2 was 11 (68.7%), 9 (56.2%), and 12 (75%), respectively. Many studies suggest that NSD causes sinus infection by narrowing the meatus or blocking normal mucociliary activity through contact with hypertrophied or pneumatized turbinates.[25,26] In contrast, there are studies suggesting that there is no association between NSD and sinus infection.[27,28] Fırat et al. reported that the volume of the nasal cavity was decreased on the side of the SD (convex).[15] In our study, we distinguished both anatomic variations and obstruction of the MSO with the presence of NSD. The highest NSD entity was found in patients with maxillary retrognathia and the lowest NSD entity was found in patients with maxillary prognathism; however, this result was not statistically significant. Also, no association was found between NSD and obstruction of the MSO.

We determined the severity of NSD according to the grading system of deviation angle of Elahi et al.[16] Accordingly; there were 13 (40.6%) patients with NSD≤9°, 12 (37.5%) patients with 9<NSD≤15 and 7 (21.9%) patients with NSD>15°. Akbay et al. found a significant difference between the groups with different severity of NSD in terms of the depth of maxillopalatal arches.[13] In our study, there was no difference between the different antero-posterior positions of the maxilla according to the severity of NSD. However, the relationship between the growth direction of the maxilla and the degree of NSD should be investigated in a larger number of patients. As a result; no significant difference was found between the groups in terms of the severity of NSD and also its possible relationship with MSO obstruction.

The incidence of Sspur reached up to 78%.[23] Earwaker found the rate of Sspur in NSD to be 34% and Dasar and Gokce found it to be 42.3%.[23,24] When SD and Sspur coexist, it may increase the shrinkage of the nasal passages, making endoscopic sinus surgery difficult. In the present study, the Sspur with NSD was about 43.75%, but there was no significant difference in the distribution of Sspur between the groups. Another of the most common variations of the paranasal region, CB, refers to pneumatization of the middle turbinate, which normally does not contain air. The morbidity reported in the literature ranges from 17% to 67.5%.[22,24] In this study, we set the incidence of CB at 62.5%, in accordance with the literature. The incidence of CB in G-0, G-1, and G-2 was reported as 50%, 75%, and 62.5%, respectively.

CB is effective in the development of rhinosinusitis because of its tendency to constrict the middle meatus and infundibulum. However, many studies have reported that the prevalence of CB is the same in people with and without sinus disease.[22,24,29] In the present study no significant association was found between the incidence of CB and the groups.

Because the inferior and superior turbinates have little influence on drainage, they do not show significant anatomic variations. Variations in the middle concha are common and affect drainage of the anterior ostiomeatal unit. Simões et al. found concha hypertrophy as 14%.[30] In our study, we found MCH as 14.5% and ICH as 68.8%. Also there was statistically significant difference between gender distribution and middle concha hypertrophy. In the current literature, ICH are associated with the presence of NSD, while other turbinate hypertrophies are associated with seasonal allergies, environmental irritations and chronic sinusitis. We think that this result should be supported by studies with higher sample numbers.

Paradoxical middle turbinate is defined as the displacement of the middle turbinate into a convex shape laterally. Stammberger and Kennedy and Wolf et al. consider the paradoxical curvature of the middle turbinate to be an etiologic factor because it may cause obliteration or change in the dynamics of the nasal airflow.[31,32] However, Dasar and Gokce found no relationship between PMC and sinonasal mucosal disease.[24] Several studies reported that the morbidity of PMC increased from 4% to 33%; Jyothi et al. 4%; Bolger et al. 26.1%; Dasar and Gokce 15.8%; Keast in Polynesians 28%; 33% in New Zealanders.[22,24,29,33] In the present study, PMC was found to be 29.2%. The distribution between groups is 31.3%, 25%, 31.3% for G-0, G-1, and G-2, respectively. However, no significant relationship was found between all groups and obstruction of the MSO.

The uncinate process (UP) is an important and guiding anatomical structure for the surgeon during surgery. It can interfere with sinus drainage by narrowing the ethmoidal infundibulum as a result of mucosal contact with the middle turbinate or adjacent ethmoidal bulla.[24,29] In the literature, Bolger et al. reported the morbidity rate for UP as 2.5%, Keast et al. as 3% in Polynesians, 2% in New Zealanders, and Dasar and Gokce as 13.8%.[22,24,29] Dasar and Gokce found a significant association between sinonasal mucosal disease and bulla uncinata.[24] In our study, the prevalence of UPP was 22.9%. Although there was no statistical difference between the 3 groups (with different developmental directions of the maxilla) with UPP incidence in Group-0 of 25%, in Group-1 of 31.4%, and in Group-2 of 12.6%, our findings were slightly higher than those reported in the literature. This may be because our patient groups were selected from individuals with skeletal disorders. Nevertheless, we believe that studies conducted with many more people will provide clearer information.

CONCLUSION

In conclusion, in this study, we investigated the relationship between the anatomical variations of the sinonasal region and the direction of maxillary growth. There was no significant relationship between the above anatomical variations and MSO obstruction between the groups.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Meryem Etöz, Firdevs Aşantoğrol;* ***Design:*** *Meryem Etöz, Firdevs Aşantoğrol, Kübra Gülnur Topsakal;* ***Control/Supervision:*** *Meryem Etöz;* ***Data Collection and/or Processing:*** *Firdevs Aşantoğrol, Kübra Gülnur Topsakal;* ***Analysis and/or Interpretation:*** *Meryem Etöz, Fatma Ezgi Can;* ***Literature Review:*** *Firdevs Aşantoğrol, Kübra Gülnur Topsakal;* ***Writing the Article:*** *Firdevs Aşantoğrol, Meryem Etöz;* ***Critical Review:*** *Meryem Etöz;* ***References and Fundings:*** *Meryem Etöz.*

REFERENCES

1. Ballanti F, Baldini A, Ranieri S, Nota A, Cozza P. Is there a correlation between nasal septum deviation and maxillary transversal deficiency? A retrospective study on prepubertal subjects. Int J Pediatr Otorhinolaryngol. 2016;83:109-12. Erratum in: Int J Pediatr Otorhinolaryngol. 2017;99:158. Fabiana, Ballanti [corrected to Ballanti, Fabiana]; Alberto, Baldini [corrected to Baldini, Alberto]; Salvatore, Ranieri [corrected to Ranieri, Salvatore]; Alessandro, Nota [corrected to Nota, Alessandro]; Paola, Cozza [corrected to Cozza, Paola]. [Crossref] [PubMed]
2. Farronato G, Giannini L, Galbiati G, Maspero C. RME: influences on the nasal septum. Minerva Stomatol. 2012;61(4):125-34. [PubMed]
3. Hartman C, Holton N, Miller S, Yokley T, Marshall S, Srinivasan S, et al. Nasal septal deviation and facial skeletal asymmetries. Anat Rec (Hoboken). 2016;299(3):295-306. [Crossref] [PubMed]
4. Nordgaard JO, Kvinnsland S. Influence of submucous septal resection on facial growth in the rat. Plast Reconstr Surg. 1979;64(1):84-8. [Crossref] [PubMed]
5. Wealthall RJ, Herring SW. Endochondral ossification of the mouse nasal septum. Anat Rec A Discov Mol Cell Evol Biol. 2006;288(11):1163-72. [Crossref] [PubMed]
6. Cupero TM, Middleton CE, Silva AB. Effects of functional septoplasty on the facial growth of ferrets. Arch Otolaryngol Head Neck Surg. 2001;127(11):1367-9. [Crossref] [PubMed]
7. Kang DH, Park KR, Chung KJ, Kim YH. The relationship between facial asymmetry and nasal septal deviation. J Craniofac Surg. 2015;26(4):1273-6. Erratum in: J Craniofac Surg. 2015;26(6):e560. Hun, Kang Dai [corrected to Kang, Dai Hun]. [Crossref] [PubMed]
8. Hafezi F, Naghibzadeh B, Nouhi A, Yavari P. Asymmetric facial growth and deviated nose: a new concept. Ann Plast Surg. 2010;64(1):47-51. [Crossref] [PubMed]
9. Pirsig W. Growth of the deviated septum and its influence on midfacial development. Facial Plast Surg. 1992;8(4):224-32. [Crossref] [PubMed]
10. Kim YM, Rha KS, Weissman JD, Hwang PH, Most SP. Correlation of asymmetric facial growth with deviated nasal septum. Laryngoscope. 2011;121(6):1144-8. [Crossref] [PubMed]
11. Poublon RML. The cartilaginous nasal dorsum and the postnatal growth of the nose thesis. 2015. [Link]
12. Siegel MI, Mooney MP, Eichberg JW, Gest T, Lee DR. Septopremaxillary ligament resection and midfacial growth in a chimpanzee animal model. J Craniofac Surg. 1990;1(4):182-6. [Crossref] [PubMed]
13. Akbay E, Cokkeser Y, Yilmaz O, Cevik C. The relationship between posterior septum deviation and depth of maxillopalatal arch. Auris Nasus Larynx. 2013;40(3):286-90. [Crossref] [PubMed]
14. Baccetti T, Franchi L, Cameron CG, McNamara JA Jr. Treatment timing for rapid maxillary expansion. Angle Orthod. 2001;71(5):343-50. [PubMed]

15. Firat AK, Miman MC, Firat Y, Karakas HM, Ozturan O, Altinok T. Effect of nasal septal deviation on total ethmoid cell volume. J Laryngol Otol. 2006;120(3):200-4. Erratum in: J Laryngol Otol. 2006;120(8):710. Karakas, Muammer [corrected to Karakas, Hakký Muammer]. [Crossref] [PubMed]
16. Elahi MM, Frenkiel S, Fageeh N. Paraseptal structural changes and chronic sinus disease in relation to the deviated septum. J Otolaryngol. 1997;26(4):236-40. [PubMed]
17. Dalili Kajan Z, Khademi J, Nemati S, Niksolat E. The effects of septal deviation, concha bullosa, and their combination on the depth of posterior palatal arch in cone-beam computed tomography. J Dent (Shiraz). 2016;17(1):26-31. [PubMed] [PMC]
18. Tomer BS, Harvold EP. Primate experiments on mandibular growth direction. Am J Orthod. 1982;82(2):114-9. [Crossref] [PubMed]
19. Serter S, Günhan K, Can F, Pabuşçu Y. Transformation of the maxillary bone in adults with nasal polyposis: a CT morphometric study. Diagn Interv Radiol. 2010;16(2):122-4. [PubMed]
20. Grymer LF, Pallisgaard C, Melsen B. The nasal septum in relation to the development of the nasomaxillary complex: a study in identical twins. Laryngoscope. 1991;101(8):863-8. [Crossref] [PubMed]
21. Holton NE, Yokley TR, Figueroa A. Nasal septal and craniofacial form in European- and African-derived populations. J Anat. 2012;221(3):263-74. [Crossref] [PubMed] [PMC]
22. Bolger WE, Butzin CA, Parsons DS. Paranasal sinus bony anatomic variations and mucosal abnormalities: CT analysis for endoscopic sinus surgery. Laryngoscope. 1991;101(1 Pt 1):56-64. [Crossref] [PubMed]
23. Earwaker J. Anatomic variants in sinonasal CT. Radiographics. 1993;13(2):381-415. [Crossref] [PubMed]
24. Dasar U, Gokce E. Evaluation of variations in sinonasal region with computed tomography. World J Radiol. 2016;8(1):98-108. [Crossref] [PubMed] [PMC]
25. Fadda GL, Rosso S, Aversa S, Petrelli A, Ondolo C, Succo G. Multiparametric statistical correlations between paranasal sinus anatomic variations and chronic rhinosinusitis. Acta Otorhinolaryngol Ital. 2012;32(4):244-51. [PubMed] [PMC]
26. Jorissen M, Hermans R, Bertrand B, Eloy P. Anatomical variations and sinusitis. Acta Otorhinolaryngol Belg. 1997;51(4):219-26. [PubMed]
27. Kim HJ, Jung Cho M, Lee JW, Tae Kim Y, Kahng H, et al. The relationship between anatomic variations of paranasal sinuses and chronic sinusitis in children. Acta Otolaryngol. 2006;126(10):1067-72. [Crossref] [PubMed]
28. Stallman JS, Lobo JN, Som PM. The incidence of concha bullosa and its relationship to nasal septal deviation and paranasal sinus disease. AJNR Am J Neuroradiol. 2004;25(9):1613-8. [PubMed] [PMC]
29. Keast A, Yelavich S, Dawes P, Lyons B. Anatomical variations of the paranasal sinuses in Polynesian and New Zealand European computerized tomography scans. Otolaryngol Head Neck Surg. 2008;139(2):216-21. [Crossref] [PubMed]
30. Simões NM, Carneiro PMR, Silva AIV, de Souza PEA, Manzi FR. Anatomic variation of paranasal sinuses. J. Oral Diag. 2017;2(1):e20170038. [Crossref]
31. Stammberger HR, Kennedy DW; Anatomic Terminology Group. Paranasal sinuses:anatomic terminology and nomenclature. Ann Otol Rhinol Laryngol Suppl. 1995;167:7-16. [Crossref] [PubMed]
32. Wolf G, Anderhuber W, Kuhn F. Development of the paranasal sinuses in children: implications for paranasal sinus surgery. Ann Otol Rhinol Laryngol. 1993;102(9):705-11. [Crossref] [PubMed]
33. Jyothi AC, Shrikrishna BH, Sanjay G, Sandeep Samson G. Anatomical variations of the osteomeatal complex tomographic findings in 100 patients. Journal of Evolution of Medical and Dental Sciences. 2013;2(22):3966-77. [Crossref]