Research Article / Araştırma Makalesi

The Effect of Nasal Septal Deviation on Maxillary Sinus Volume in Patients Undergoing Septoplasty Surgery

Septoplasti Ameliyatı Yapılan Hastalarda Nazal Septum Deviasyonunun Maksiller Sinüs Hacmine Etkisi

Servet ERDEMES [1], Müslüm AYRAL [2], Osman ERDOĞAN [3], Mahmut AĞIRTMIŞ [1]

[1]Department of Otorhinolaryngology, Harran University Faculty of Medicine, Sanliurfa, TURKIYE
[2]Clinic of Otorhinolaryngology, Şanlıurfa Training and Research Hospital, Sanliurfa, TURKIYE
[3]Şanmed Hospital, Department of Otorhinolaryngology, Head and Neck Surgery, Sanliurfa, TURKIYE

Abstract

Background: In this sudy, we aimed to determine the association between nasal septal deviation and maxillary sinus volume in patients undergoing septoplasty.
Materials and Methods: Paranasal sinus computed tomography (PNS CT) of 164 patients (80 females, 84 males) over 18 years of age who underwent septoplasty surgery between September 2022 and September 2023 were retrospectively evaluated. Bilateral maxillary sinuses volüme (MSV) and septal deviation angle(SDA) were calculated using the computed program. SDA was divided into right and left, also was described as mild, moderate, or severe.
Results: The mean of right MSV was measured as 14.34 ± 3.91 (7.45-23) and the mean of left MSV was 15.11 ± 4.29 (6.34-24.3). The average SDA of all patients was 15.51 ± 5.22 (6.7-34). The difference between right and left MSV was measured lower in patients with mild septal deviation than in patients with moderate or severe septal deviation (p=0.016, p=0.024, respectively). In the evaluation made according to MSV, the difference values between ipsilateral MSV, contralateral MSV, total MSV and right-left MSV according to the side of septal deviation were found to be higher in men than in women (p=0.011, p=0.001, p=0.004, p<0.001, respectively).
Conclusions: We could not clearly obtain the effect of nasal septal deviation on maxillary sinus volume. However, MSV in women was found to be lower than in men

Key Words: Maxillary sinus, Septum deviation, Sinus volume

Öz

Amaç: Bu çalışmada septoplasti uygulanan hastalarda nazal septal deviasyon ile maksiller sinüs hacmi arasındaki ilişkiyi belirlemeyi amaçladık.
Materyal ve Metod: Eylül 2022 ile Eylül 2023 tarihleri arasında septoplasti ameliyatı geçiren 18 yaş üzerindeki 164 hastanın (80 kadın, 84 erkek) paranazal sinüs bilgisayarlı tomografisi (PNS BT) retrospektif olarak değerlendirildi. Bilateral maksiller sinüs hacmi (MSV) ve septal deviasyon açısı (SDA) bilgisayar programı kullanılarak hesaplandı. SDA sağ ve sol olarak ikiye ayrıldı ve hafif, orta ve şiddetli olarak da tanımlandı.
Bulgular: Sağ MSV ortalaması 14,34 ± 3,91 (7,45-23) ve sol MSV ortalaması 15,11 ± 4,29 (6,34-24,3) olarak ölçüldü. Tüm hastaların ortalama SDA 15,51 ± 5,22 (6.7-34) idi. Sağ ve sol MSV arasındaki fark, hafif septal deviasyonu olan hastalarda, orta ve şiddetli septal deviasyonu olan hastalara göre daha düşük ölçüldü (sırasıyla p=0,016, p=0,024). MSV' ye göre yapılan değerlendirmede septal deviasyon tarafına göre ipsilateral MSV, kontralateral MSV, total MSV ve sağ-sol MSV arasındaki fark değerleri erkeklerde kadınlara göre daha yüksek bulunmuştur (sırasıyla p=0,011, p=0,001), p=0,004, p<0,001,).
Sonuç: Nazal septal deviasyonun maksiller sinüs hacmi üzerine etkisini net olarak elde edemedik. Ancak kadınlarda MSV' nin erkeklere göre daha düşük olduğu bulundu

Anahtar Kelimeler: Maksiller sinüs, Septum deviasyonu, Sinüs hacmi

Corresponding Author / Sorumlu Yazar

Dr. Müslüm AYRAL
Clinic of Otorhinolaryngology, Şanlıurfa Training and Research Hospital, Sanliurfa, TURKIYE

E-mail: muslum_ayral@hotmail.com

Received / Geliş tarihi: 20.05.2024

Accepted / Kabul tarihi: 12.08.2024

DOI: 10.35440/hutfd.1486503

Introduction

The maxillary sinuses (MS) were first described in 1489 by Leonardo da Vinci. In 1651, English anatomist Nathaniel Highmore documented. The MS is located within the body of the maxillary bone. It is also the largest and first-developed of the paranasal sinuses. The volume of the maxillary sinüs (MSV) at birth is around 6-8 cm^3 and is filled with fluid. Initially it has a rounded or slender appearance and gradually takes on a pyramidal shape over time. It reaches adult size with the completion of dental development. The average volume then is about 10-25 cm^3 (1). After reaching maximum growth volume, MSV begins to decrease with age in both genders (2). The alveolar process of the maxilla contributes to dentition and forms the lower wall of the MS. The superior wall, made of a thin bone lamella, forms the majority of the orbital floor and separates the orbit and the MS. The posterior wall of the MS, which is adjacent to the pterygomaxillary fossa, that separates the sinus from the infratemporal fossa. The lateral wall is bounded by the posterior maxilla and the zygomatic process. The medial wall also contributes to forming the lateral wall of the nasal cavity (3).

Studies have been conducted on the effects of adenotonsillar hypertrophy and allergic rhinitis on MSV and craniofacial growth (4). However, the effect of nasal septal deviation(NSD) on MSV has been a subject of debate. In this study, we aimed to investigate the effect of septal deviation on MSV.

Materials and Methods

Images of patients who underwent the paranasal sinus CT scans due to septoplasty operations at the Harran University Faculty of Medicine Hospital between September 2022 and September 2023 were retrospectively examined. A total of 164 patients were included in the study. Patients over the age of 18 with a deviated septum who underwent septoplasty surgery due to nasal obstruction were included. Patients with active sinonasal infection, patients with mucosal thickening, retention cyst, mucocele, any space-occupying mass in the sinuses on paranasal sinus CT, patients who had previous sinus surgery, and patients who had maxillofacial trauma were excluded from the study. The study was approved by the Harran University Clinical Research Ethics Committee with the decision dated 27.11.2023 and numbered 2023/22/09..

Images of all patients were examined with multislice computed tomography (MSCT, Philips Brilliance ICT 256; Philips Medical Systems, The Netherlands) (image setting 120 kV, 150 mAs). The slice thickness was 1 mm increments. The images were evaluated using hospital software which is capable of calculating the volume of the MS and the angle of septal deviation (Sectra ids7, Teknikringen 20 SE-58330, Linköping, Sweden). The MSV was calculated by evaluating it in axial, coronal and sagittal planes (Figure 1). The angle of septal deviation was calculated by drawing a straight line from the crista galli to the maxillary spine and another line from the crista galli to the convex corner of the septal deviation (Figure 2). Patients were classified into three groups according to the classification of nasal septal deviation angles as proposed by Elahi et al. (5): mild (<9), moderate (9-15), and severe (≥15).

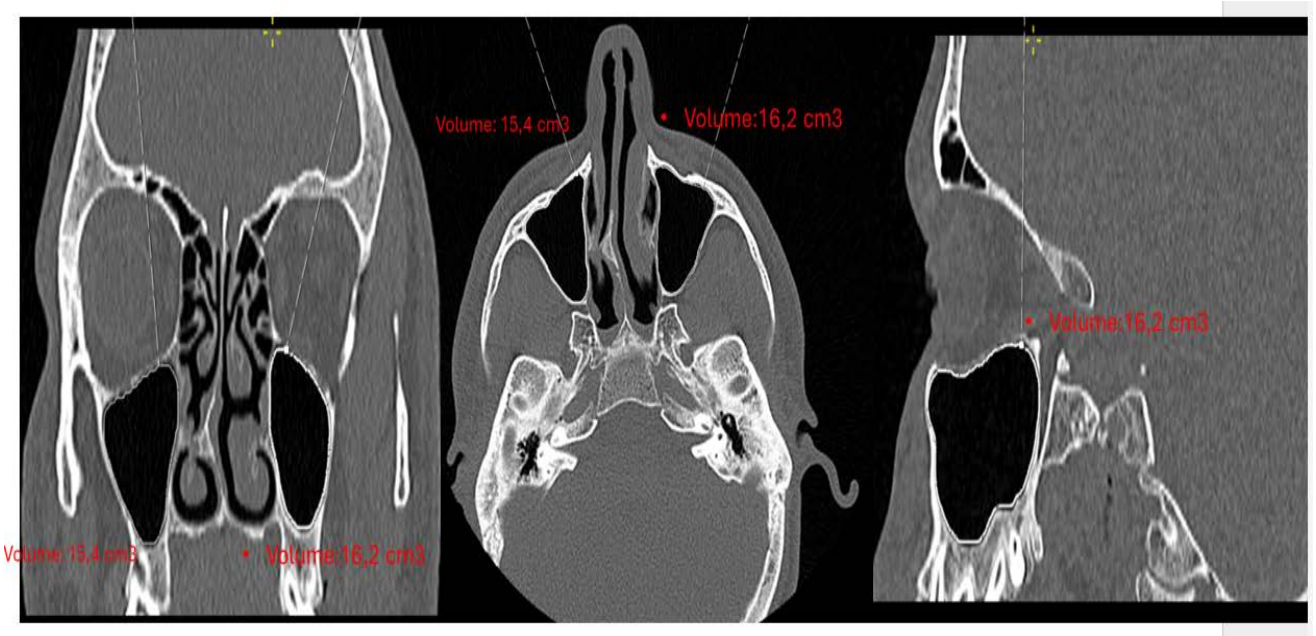

Figure 1. Calculating maxillary sinuses volüme in axial, coronal and sagittal planes

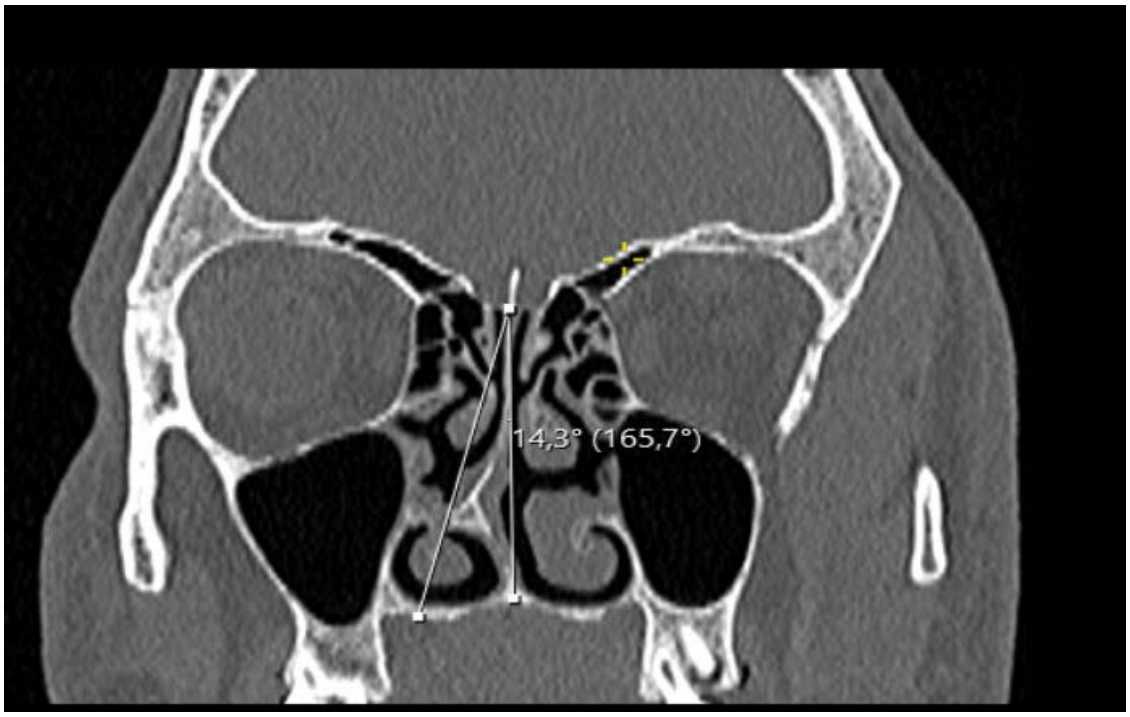

Figure 2. Calculating the angle of septal deviation, drawing a straight line from the crista galli to the maxillary spine and another line from the crista galli to the convex corner of the septal deviation

Statistical Analysis

Data were presented as mean ± standard deviation (minimum - maximum values). The distribution of the data was evaluated using the Shapiro-Wilk test, which indicated a non-normal distribution. Therefore, non-parametric tests (The Mann-Whitney U test for comparison of two independent variables and Kruskal-Wallis test for comparison of more than two independent variables) were used. Significance values for multiple testing were adjusted using Bonferroni correction. Categorical variables were tested using the Pearson chi-square test. P<0.05 value was determined as the level of statistical significance. All data analyses were performed using the SPSS 24 (IBM, Armonk, NY) software.

Results

In our study, the mean age of the 164 patients whose computed tomography images were evaluated was 25.23 ± 8.38 years (17-61), with a female-to-male ratio of 80:84. The mean bilateral maxillary sinus volume (MSV) of the patients was 29.45 ± 7.69 (14-47.1), while the mean right MSV was 14.34 ± 3.91 (7.45-23) and the mean left MSV was 15.11 ± 4.29 (6.34-24.3). It was detected that the left MSV was higher than the right MSV in patients with right septal deviation (p=0.033). However, we observed no significant difference in MSV between the two sides in patients with left septal deviation (p=0.861) (Table 1).

Table 1. Right and left maxillary sinuses volüme (MSV) values according to septal deviation (SD) side

	Right MSV	Left MSV	P
Right SD	14,28 ± 4,16 (7,45-23)	15,53 ± 4,61 (6,46-24,3)	0,033*
Left SD	14,42 ± 3,58 (7,78-22,8)	14,55 ± 4,01 (6,34-21,8)	0,861
Total	14,34 ± 3,91 (7,45-23)	15,11 ± 4,29 (6,34-24,3)	0,079

MSV: Maxillary sinuses volüme, SD: Septal deviation

The mean septal deviation angle (SDA) for all patients was 15.51 ± 5.22 (6.7-34). It was observed that patients with right septal deviation had a higher mean SDA compared to those with left septal deviation (p=0.011). Analysis based on the side of septal deviation showed similar values for gender, age, right MSV, left MSV, and total MSV (p>0.05). The data for this analysis are shown in Table 2.

No significant differences observed in terms of age, gender, and side of septal deviation among patients categorized into three groups based on the severity of septal deviation angle (mild, moderate, and severe). However, a significant difference was observed among these three groups in terms of the difference between right and left MSV (p=0.016). Subsequent pairwise comparisons revealed that the difference between right and left MSV was lower in patients with mild septal deviation compared to those with moderate or severe septal deviation (p=0.016, p=0.024, respectively). There was no significant difference between right and left MSV among patients with moderate and severe septal deviation (p>0.05) (Figure 3).

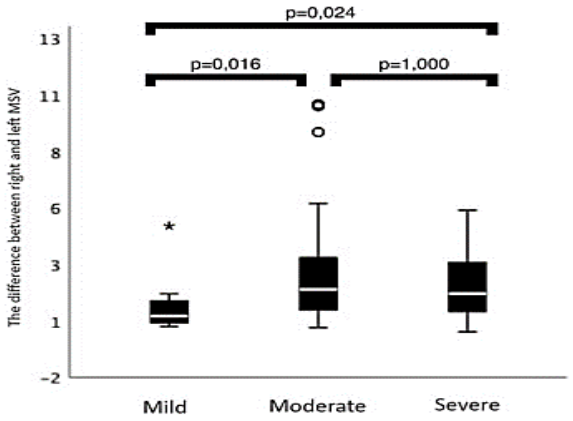

Figure 3. MSV: Maxillary sinuses volume

Data for patients with mild, moderate, and severe septal deviation are shown in Table 3. Among patients with severe (≥15 degrees) septal deviation, no significant difference was observed between contralateral (15.48±4.34, min-max 6.46-24.2) and ipsilateral (14.86±4.44, min-max 7.57-23) maxillary sinus volumes (p=0.327).

A radiological measurement analysis based on gender showed no significant difference in SDA (p=0.843). However, in the evaluation based on MSV, the difference values between ipsilateral MSV, contralateral MSV, total MSV, and right-left MSV according to the side of septal deviation were higher in males compared to females (p=0.011, p=0.001, p=0.004, p<0.001, respectively). The data for the measurements are shown in Table 4.

Table 2. Demographic and radiological data of patients grouped by the side of septal deviation

	Right SD (n=94)	Left SD (n=70)	p
Female	50	30	0,190
Age	25,06 ± 8,44 (17-61)	25,46 ± 8,35 (17-49)	0,942
Right MSV	14,28 ± 4,16 (7,45-23)	14,42 ± 3,58 (7,78-22,8)	0,651
Left MSV	15,53 ± 4,46 (6,46-24,3)	14,55 ± 4,01 (6,34-21,8)	0,188
Total MSV	29,81 ± 8,34 (14-47,1)	28,96 ± 6,74 (15,55-44,4)	0,515
Septal Angle	16,28 ± 5,21 (6,7-27,2)	14,46 ± 5,08 (7,5-34)	0,011*

MSV: Maxillary sinuses volüme, SD: Septal deviation

Table 3. Demographic and radiological data of patients grouped by the severity of septal deviation

	Mild(<9) (n=18)	Moderate(9-15) (n=64)	Severe (≥15) (n=82)	p
Ipsilateral MSV	12,48±2,71(8,04-16,46)	14,34±3,81(6,34-21,6)	14,86 ± 4,44(7,57-23)	0.066
Contralateral MSV	13,73 ± 3,16(8,74-19)	14,88±4,07(6,55-24,3)	15,48± 4,34(6,46-24,2)	0.230
Total MSV	26,21±5,73(16,78-33,3)	29,22±6,96(14-45,5)	30,33±8,43(14,03-47,1)	0.141
Difference between right and left MSV	1,25 ± 1,35(0,25-4,7)	2,65±2,64(0,20-10,1)	2,07 ± 1,43(0,01-5,4)	0.016*

MSV: Maxillary sinuses volüme

Table 4. Radiological data of patients evaluated based on gender

	Male(n=80)	Female(n=84)	p
SA	15,41 ± 4,60 (6,9-27,2)	15,60 ± 5,78 (6,7-34)	0.843
Ipsilateral MSV	13,46 ± 3,49 (7,57-20,4)	15,28 ± 4,43 (6,34-23)	0.011*
Contralateral MSV	14,00 ± 3,80 (6,46-22,4)	16,06 ± 4,21 (6,55-24,3)	0.001*
Total MSV	27,46 ± 7,02 (14,03-42,4)	31,34 ± 7,85 (14-47,1)	0.004*
Difference between MSV	1,57 ± 1,27 (0,01-5)	2,81 ± 2,39 (0,3-10,1)	<0.001*

MSV: Maxillary sinuses volüme, SA: Septal angle

Discussion

Asymmetries in the shape and size of the MS are common. While aplasias are extremely rare compared to asymmetries, hypoplasias are also infrequent. The frequency of unilateral hypoplasia in adults is 7-8%, whereas bilateral hypoplasia is observed at a rate of 2% (6,7). The presence of a concha bullosa, lateralization of the uncinate process, and septal deviation are factors that may cause unilateral MS hypoplasia (8). The effect of the nasal septum on the growth of the facial skeleton remains unresolved. While some researchers present evidence that the nasal septum serves as a significant growth center, others suggest that septal growth plays more of a supportive role in facial development (9). According to a study by Earwaker, nasal septal deviation (NSD) has been observed in 14% of the population and affects both genders equally (10). Wee et al. found NSD to be more common in males (79%) than in females (68%) (11). In our study, 51.2% of patients were male and 48.8% were female, consistent with previous studies. Similarly, the number of patients with deviated septum to the right was 57.3%, while those with deviated septum to the left was 42.7%, consistent with the literatüre (12). Muszyńska et al. determined in their study that the growth and development of

the sinus are genetically determined. However, sinus volume may change with aging and environmental factors. Additionally, anatomical variants associated with the airway in the nasal cavity, such as NS or concha bullosa, may affect MSV concurrently with growth. In a study by Kapusuz Gencer et al., patients with severe NSD were found to have a smaller ipsilateral MSV (13). Kucybal´a et al. found in their study that NSD is associated with bilateral maxillary sinusitis, but its relationship with MSV could not be determined (14). In our study, it was determined that in patients with right septal deviation, the left MSV was greater than the right MSV (p=0.033). We believe that this is due to the fact that the right SDA is significantly greater than the left SDA (p=0.011). In patients with left SD, no difference was observed between the both MSVs(p=0.861). Similarly, among patients with severe (≥15 degrees) septal deviation, no significant difference was observed between contralateral and ipsilateral MSV (p=0.327). In our study, contrary to the literature, when comparing the difference in MSVs according to the severity of SDA, the difference in MSVs was significantly lower for deviations with <9 degrees compared to deviations with >9 degrees (p=0.016).

The MS, which begin to form in the prenatal period, develop through mucosal invaginations from the primitive ethmoid infundibulum starting at the 10th week of gestation. The average volume at birth is approximately 6-8 cm^3 (1). Similar to fetal life, there are two rapid development periods during childhood, occurring between 0-3 years and 7-12 years of age (15). MS reach adult size between the ages of 14-18, with an average volume of approximately 15 cm^3 (16). In a study by Przystańska et al., the mean MSV was found to be 15 cm^3, ranging from 10 to 25 cm^3 (17). In another study by Pirner et al., the MSV ranged from 11.1 ± 4.5 to 23.0 ± 6.7 cm^3 (18). In our study, consistent with the literature, the average MSV was measured as 14.72 ± 4.1 cm^3 (6,34-24,3).

In their study using CT images, Ariji et al. stated that the average MSV in patients around the age of 20 was 14.7 cm^3 and did not vary between genders. They also observed that this volume increases until the age of 20 and then begins to decrease with age, and that MSV is not related to the presence or absence of maxillary teeth (19). Jun et al., in their study evaluating changes in maxillary sinus volume with age, used CT images of 173 patients. In their volume measurements, they reported that MS ventilation increased in males until the third decade of life and in females until the second decade, but decreased thereafter. They also stated that MSV were statistically significantly greater in males than in females. The average MSV in adults was found to be 24.04 cm^3 in males and 15.85 cm^3 in females (20). Similarly, Kim et al. reported the right and left MSV in males as 21.79 cm^3 and 21.94 cm^3, respectively, and in females as 17.25 cm^3 and 17.41 cm^3, respectively, and found that sinus volumes were larger in males than in females (21). In our study, the right and left MSV were 15.35 cm^3 and 15.98 cm^3 in males, respectively, and 13.27 cm^3 and 14.18 cm^3 in females, respectively, with a statistically significant lower volume in females compared to males (p<0.001).

In conclusion, we could not clearly determine the effect of SD on MSV. However, when we grouped SDA as mild, moderate, and severe, we found that the difference between both MSV was significantly lower in patients with mild deviation (<9 degrees). Additionally, we found a significant gender-based difference in MSV. MSV was found to be lower in women than in men.

Ethical Approval: The study was approved by the Harran University Clinical Research Ethics Committee with the decision dated 27.11.2023 and numbered 2023/22/09.

Author Contributions:
Concept: S.E.
Literature Review: S.E., M.A.
Design : O.E., M.A.
Data acquisition: M.A.
Analysis and interpretation: S.E., O.E.
Writing manuscript: S.E. M.A., O.E.
Critical revision of manuscript: M.A., O.E.
Conflict of Interest: *The authors have no conflicts of interest to declare.*
Financial Disclosure: *Authors declared no financial support.*

References

1. Apuhan T, Yıldırım YS, Özaslan H. The developmental relation between adenoid tissue and paranasal sinus volumes in 3-dimensional computed tomography assessment. Otolaryngology--Head and Neck Surgery. 2011;144(6):964-71.
2. Demir UL, Akca M, Ozpar R, Albayrak C, Hakyemez B. Anatomical correlation between existence of concha bullosa and maxillary sinus volume. Surgical and Radiologic Anatomy. 2015;37:1093-8.
3. Marquez S, Lawson W, Schaefer S, Laitman J. Anatomy of the nasal accessory sinuses. Minimally invasive surgery of the head, neck, and cranial base Lippincott, Philadelphia, PA. 2002:153-93.
4. D'Ascanio L, Lancione C, Pompa G, Rebuffini E, Mansi N, Manzini M. Craniofacial growth in children with nasal septum deviation: a cephalometric comparative study. International journal of pediatric otorhinolaryngology. 2010;74(10):1180-3.
5. Elahi MM, Frenkiel S, Fageeh N. Paraseptal structural changes and chronic sinus disease in relation to the deviated septum. Journal of Otolaryngology. 1997;26(4).
6. Scuderi AJ, Harnsberger HR, Boyer RS. Pneumatization of the paranasal sinuses: normal features of importance to the accurate interpretation of CT scans and MR images. AJR American journal of roentgenology. 1993;160(5):1101-4.
7. Erdem T, Aktas D, Erdem G, Miman MC, Ozturan O. Maxillary sinus hypoplasia. Rhinology. 2002;40(3):150-3.
8. Whyte A, Boeddinghaus R. The maxillary sinus: physiology, development and imaging anatomy. Dentomaxillofacial Radiology. 2019;48(8):20190205.
9. Cupero TM, Middleton CE, Silva AB. Effects of functional septoplasty on the facial growth of ferrets. Archives of Otolaryngology–Head & Neck Surgery. 2001;127(11):1367-9.
10. Earwaker J. Anatomic variants in sinonasal CT. Radiographics. 1993;13(2):381-415.

11. Wee JH, Kim DW, Lee JE, Rhee CS, Lee CH, Min YG, et al. Classification and prevalence of nasal septal deformity in Koreans according to two classification systems. Acta Otolaryngol 2012;132 Suppl 1:S52-7.
12. Al-Rawi NH, Uthman AT, Abdulhameed E, Al Nuaimi AS, Seraj Z. Concha bullosa, nasal septal deviation, and their impacts on maxillary sinus volume among Emirati people: a cone-beam computed tomography study. Imaging Sci Dent. 2019;49:45-51.
13. Kapusuz Gencer Z, Ozkırış M, Okur A, Karaçavuş S, Saydam L. The effect of nasal septal deviation on maxillary sinus volumes and development of maxillary sinusitis. Eur Arch Otorhinolaryngol. 2013;270:3069-73.
14. Kucybal´a I, Janik KA, Ciuk S, Storman D, Urbanik A. Nasal septal deviation and concha bullosa - do they have an impact on maxillary sinus volumes and prevalence of maxillary sinusitis? Pol J Radiol. 2017;82:126-33.
15. Park IH, Song JS, Choi H, Kim TH, Hoon S, Lee SH et al. Volumetric study in the development of paranasal sinuses by CT imaging in Asian: a pilot study. Int J Pediatr Otorhinolaryngol. 2010;74(12):1347-50.
16. Som PM, Lawson W, Fatterparker GM, Zinreich SJ. Embryology, anatomy, physiology and imaging of the sinosal cavities. Som PM, Curtin HD. Head and Neck Imaging. Çin: Mosby Elsevier 2011. p. 119, 23, 5.
17. Przystańska A, Kulczyk T, Rewekant A, Sroka A, Jończyk-Potoczna K, Lorkiewicz-Muszyńska D, et al. Introducing a simple method of maxillary sinus volume assessment based on linear dimensions. *Ann Anat* 2018; 215: 47–51.
18. Pirner S, Tingelhoff K, Wagner I, Westphal R, Rilk M, Wahl FM, Bootz F, Eichhorn KW (2009) CT-based manual segmentation and evaluation of paranasal sinuses. Eur Arch Otorhinolaryngol. 266:507–18.
19. Ariji Y, Kuroki T, Moriguchi S, Ariji E, Kanda S. Age changes in the volume of the human maxillary sinus: a study using computed tomography. Dentomaxillofac Radiol. 1994;23(3):163-8.
20. Jun BC, Song SW, Park CS, Lee DH, Cho KJ, Cho JH. The analysis of maxillary sinus aeration according to aging process; volume assessment by 3-dimensional reconstruction by high-resolutional CT scanning. Otolaryngol Head Neck Surg. 2005;132(3):429-34.
21. Kim J, Song SW, Cho JH, Chang KH, Jun BC. Comparative study of the pneumatization of the mastoid air cells and paranasal sinuses using three-dimensional reconstruction of computed tomography scans. Surg Radiol Anat. 2010;32(6):593-9.