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Volumetric analysis of the maxillary sinus in pediatric patients with nasal septal deviation

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Abstract

Objective: Reasons such as nasal deviation, which reduces airflow in nose and impairs oxygenation, may affect the maxillary volume. In this study, we aimed to perform a retrospective study between the degree of nasal septal deviations and maxillary sinus volume.

Methods: The files of 103 male and 124 female patients (total n=227) who applied to otorhinolaryngology clinic with nasal septal deviation without coexisting sinonasal morbidity were investigated, and compared with those without nasal septal deviation and coexisting sinonasal morbidity. Three-dimensional paranasal sinus CTs were performed for the diagnosis (CTs were found to be normal, and etiology of chronic intracranial headache could not be determined) and they were evaluated retrospectively. Maxillary sinus volume was calculated for each case in the groups. The relationship between nasal septal deviation and maxillary sinus volume was evaluated.

Results: Our study determined that there was statically no significant difference between the maxillary volumes of the group with (29.34±7.46 cm^3) or without nasal septal deviation (27.89±8.51 cm^3) ($p>0.05$). No matter what the right nasal septal deviation angle is, it did not affect the right, left and total maxillary sinus volumes. Both left- and right-sided nasal septal deviations did not have any effect on the right, left and total maxillary volumes.

Conclusion: Any difference was not observed between the maxillary sinus volumes of the children in the pediatric age group with and without nasal septal deviations, and it was concluded that the existence or severity of the septal deviation did not have any effect on the maxillary sinus volume.

Keywords: Maxillary sinus volume, nasal septal deviation, computed tomography.

Özet: Nazal septum deviasyonu olan pediatrik hastalarda maksiller sinüsün volümetrik analizi

Amaç: Nazal hava akımını azaltan ve oksijenasyonu bozan septal deviasyon gibi sebepler, maksiller sinüs hacmini etkileyebilir. Çalışmamızda, retrospektif olarak nazal septal deviasyonların maksiller sinüs hacmini nasıl etkilediğini araştırmayı amaçladık.

Yöntem: Kulak burun boğaz polikliniğinde kronik başağrısı etiyolojisini aydınlatmak üzere paranazal sinüs bilgisayarlı tomografisi çekilen ve intrakraniyal bir sebep bulunamayan 103'ü erkek ve 124'ü kız olmak üzere toplam 227 olgu, nazal septal deviasyonu olup ilave sinonazal bulgusu olmayanlar ile nazal septal deviasyonu ve ilave sinonazal bulgularından hiçbiri olmayanlar olarak iki gruba ayrıldı. Maksiller sinüs hacmi gruplarda her olgu için hesaplandı. Nazal septum deviasyonu ile maksiller sinüs hacmi arasındaki ilişki araştırıldı.

Bulgular: Çalışmamızda nazal septum deviasyonu olan grubun maksiller sinüs hacimleri ile (29.34±7.46 cm^3) ve nazal septum deviasyonu olmayan grubun maksiller hacimleri (27.89±8.51 cm^3) arasında istatistiksel fark olmadığı tespit edildi ($p>0.05$). Nazal septal deviasyon açısı ne olursa olsun sağ, sol ve toplam maksiller sinüs hacimlerinin etkilenmediği gözlendi. Hem sol hem de sağ taraflı nazal septum deviasyonunun sağ, sol ve toplam maksiller sinüs hacimlerine herhangi bir etkisi yoktu.

Sonuç: Nazal septum deviasyonu olan ve olmayan pediatrik yaş grubundaki çocukların maksiller sinüs hacimleri arasında herhangi bir fark gözlenmemiştir. Nazal septum deviasyonu varlığı veya şiddetinin de maksiller sinüs hacminin üzerinde herhangi bir etkisi olmadığı sonucuna varılmıştır.

Anahtar sözcükler: Maksiller sinüs hacmi, nazal septal deviasyon, bilgisayarlı tomografi.

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Emerging on the 17th day of intrauterine life, the volume of maxillary sinus is 7×4×4 mm at birth.[1] The development of sinus is biphasic. Its first development is completed at the age of 3 and the second and main development is completed between the ages of 7–18 in connection with the emergence of permanent teeth. The mean sinus dimensions and volume in adults are approximately 34×33×23 mm and 14.75 ml, respectively.[2,3] The maxillary sinus is similar to three-wall pyramid and its base is formed by the lateral wall of the nasal cavity.

Although the formation and growth of maxillary sinus could not be understood exactly yet, nasal air flow, brain growth and shrinkage of muscle mass are the possible reasons.[4–7] Therefore, reasons such as nasal deviation, which reduces air flow in nose and impairs oxygenation, may affect the maxillary volume.[8] Volume changes may occur also as a result of the sinusitis caused by bacterial reproduction and reduced cilia motility.[9] Computed tomography is a suitable modality for analyzing paranasal sinus measurements. In particular, three-dimensional computed tomography (CT) volume measuring techniques can be easily performed for this purpose.[10] There are some studies on volumetric measurements during maxillary sinus development.[9,11] Although the effect of the nasal septal deviation on maxillary sinus volume was investigated in adult patients, there is no study on the effects of the nasal septal deviation on maxillary sinus volume in children.[11]

As an occasional subject in the literature, we designed a retrospective study about how nasal deviations affected maxillary volume. And for this, we reviewed the files of the children who were referred to the otorhinolaryngology department with etiology of chronic headache and underwent three-dimensional paranasal sinus CT and then compared the maxillary sinus volumes of the children with and without deviation.

Materials and Methods

For the study, approval from the Non-Invasive Clinical Investigations Ethics Committee of the Faculty of Medicine, Selçuk University was obtained (Meeting No: 2015/10; Decision No: 2015/178).

The files of 103 male and 124 female patients (total n=227) between ages of 5–16 (12.02±2.71) years who were referred to the Otorhinolaryngology polyclinic of Konya Training and Research Hospital between January 2008 and April 2015, for etiology of chronic headache and underwent three-dimensional paranasal sinus CT for diagnosis, were evaluated retrospectively. The volume of maxillary sinus of each patient was calculated with three-dimensional paranasal CT and the existence of nasal septal deviation and nasal angle were determined.

The study involved 102 children with nasal septal deviation detected with paranasal CTs formed the study group (SD+) and 125 children without nasal septal deviation formed the control group (SD-). After dividing the patients with nasal septal deviation into 2 groups as right and left nasal deviations, the nasal septal deviations of each side (right, left) were divided into 3 groups as mild (<9°), moderate (9–15°) or severe (>15°).[12]

The coronal CT image that best correlates with the ostiomeatal complex was utilized for the calculation of the degree of septal deviation. The volume of each maxillary sinus was also calculated using the computer program described by Apuhan et al.[13]

Routine paranasal sinus CT imaging procedure was performed stepwise as follows: scans were performed by using a multislice computed tomographic scanner (Ingenuity CT; Philips Healthcare, Andover, MA, USA). Imaging parameters were as follows: kV, 120; mA, 160; rotation time, 0.5 s; collimation, 64×0.625; FOV, 220 mm. The iterative reconstruction technique was employed to reduce radiation dose exposed during scans. Axial images were recorded while the patient was in the supine and the head in the neutral positions. The images covered the area from the apex of the frontal sinuses to the nasal maxillary process, parallel to the hard palate. Axial CT images were obtained with a section thickness of 0.625 mm and these source data were used to obtain associated coronal and sagittal images of 0.9 mm slice thickness. Images were analyzed at a workstation and maxillary sinus volumes were automatically calculated by volume rendering technique (VRT) in the workstation (Brilliance Workspace, version 4.5.2.4031; Philips Medical Systems, Miramar, FL, USA). To measure the total volume inside the maxillary sinus bony walls, the lower and upper Hounsfield unit values were defined as -2500 and -200, respectively. The images with motion artifacts were excluded from data analysis.

Patients with congenital malformations, benign or malign tumors, sinonasal polyposis, maxillofacial trauma and the history of previously transmitted nasal or paranasal surgery were excluded from the study.

SPSS 22.0 (IBM Corp., Armonk, NY, USA) program was used in the analysis of the data. Shapiro-Wilk test and Levene's test were used respectively for the conformity of the data to normal distribution and variance homogeneity. The independent-samples t-test was used together with the Bootstrap results for the comparison of two independ-

Table 1. Demographic data of the study.

		Nasal septal deviation (-)	Nasal septal deviation (+)			p
			Mild	Moderate	Severe	value
Age (years)		11.78±3.07	12.50±3.25	12.19±1.97	12.90±1.35	0.127
Gender n (%)	Female	65 (52)	5 (62.5)	30 (55.6)	24 (60)	0.805
	Male	60 (48)	3 (37.5)	24 (44.4)	16 (40)	

ent groups, whilst one-way ANOVA (Robust Test: Brown-Forsythe) was used together with the Bootstrap results in the comparison of more than two groups. In the comparison of categorical data, Pearson chi-square was used together with the Monte Carlo Simulation test results. The quantitative data were expressed as the mean ± standard deviation values in the tables, whilst categorical data were expressed as numbers (n) and percentages (%). The data was analyzed within 95% confidence interval and p value was accepted significant when it was less than 0.05.

Results

The demographic data of the patients were evaluated in Table 1. Based on these data, it was determined that the groups were homogenous in terms of age and gender and there was not a statistically significant difference between the groups (p>0.05).

Whether the patients had nasal septal deviations or not (SD+, SD-), and the connection between the maxillary volumes (right and left) were evaluated in Table 2.

It was determined that the maxillary volumes (29.34±7.46 cm^3) of the ones with nasal septal deviations (SD+) were not statistically significantly higher than the maxillary volumes (27.89±8.51 cm^3) of the ones without nasal septal deviations (p=0.193).

The deviation angles varied between 5° and 29°. When the patients were classified according to deviation angle, mild (<9°), moderate (9–15°) and severe (>15°) septal deviations were determined respectively in 8, 54 and 40 patients. The mean deviation angle was found 14.2±3.66 degrees in the group with right side deviation and 14.87±4.02 degrees in the group with left side deviation.

Mean maxillary volumes of the patients with mild, moderate and severe right side nasal septal deviations (15.56±7.03 cm^3, 14.40±3.97 cm^3 and 15.56±3.98 cm^3, respectively) were not statistically significantly higher than the mean right maxillary volume (14.02±4.30 cm^3) of the group without nasal septal deviation (p=0.590) (Table 3).

Mean maxillary volumes of the patients with mild, moderate and severe right side nasal septal deviations (15.85±6.81 cm^3, 14.17±3.86 cm^3 and 15.45±3.76 cm^3, respectively) were not statistically significantly higher than the mean left maxillary volume (13.87±4.47 cm^3) of the group without nasal septal deviation (p=0.488) (Table 3).

The maxillary volumes of the group with mild right side septal deviation (31.41±13.71 cm^3) were remarkably higher than the other groups (SD-, moderate and severe), without any statistical significance (p=0.528) (Table 3).

The difference between the mean right maxillary volumes of the patients with mild, moderate, severe right side nasal septal deviation (13.97±4.32 cm^3, 14.44±2.49 cm^3 and 14.77±4.13 cm^3, respectively) and the mean right maxillary volume (14.02±4.30 cm^3) of the group without nasal septal deviation was not statistically significant (p=0.864) (Table 4).

The difference between the mean right maxillary volume of the patients with mild, moderate, severe right side nasal

Table 2. The comparison between nasal septal deviation and maxillary volume.

		Nasal septal deviation (-) (n=125)	Nasal septal deviation (+) (n=102)	p value
Maxillary sinus volume (cm^3 ± standard deviation)	Right	14.02±4.30	14.79±3.86	0.178
	Left	13.87±4.47	14.56±3.83	0.217
	Total	27.89±8.51	29.34±7.46	0.193

Table 3. The comparison of right-sided nasal septal deviation and maxillary sinus volume.

		Nasal septal deviation (-) (n=125)	Right-sided nasal septal deviation (+) (n=53)			p value
			Mild (n=7)	Moderate (n=26)	Severe (n=20)	
Maxillary sinus volume (cm³ ± standard deviation)	Right	14.02±4.30	15.56±7.03	14.40±3.97	15.56±3.98	0.590
	Left	13.87±4.47	15.85±6.81	14.17±3.86	15.45±3.76	0.488
	Total	27.89±8.51	31.41±13.71	28.57±7.64	31.01±7.55	0.528

septal deviation (12.57±2.45 cm³, 14.57±2.32 cm³ and 13.78±4.42 cm³, respectively) and the mean left maxillary volume (13.87±4.47 cm³) of the group without septal nasal deviation was not statistically significant (p=0.848) (Table 4).

The maxillary volumes of the group with moderate right side septal deviation (29.02±4.42 cm³) were remarkably higher than the other groups (SD-, moderate and severe), without any statistically significant difference (p=0.907) (Table 4).

Discussion

Considering this rarely investigated subject particularly among children, we deemed it suitable to conduct a retrospective study about how nasal deviations affect the maxillary volume of children, who were referred to the otorhinolaryngology department for the etiology of chronic headache and underwent three-dimensional paranasal sinus CT examinations.

As a result of our study, we determined that (i) our study was homogeneous in terms of age and gender, (ii) the difference between the maxillary volumes of the groups with and without nasal septal deviation was not significant (iii) no matter what the right nasal septal deviation is (mild, moderate and severe), it did not have any effect on the right, left and total maxillary volumes, (iv) although it was remarkable the maxillary volumes of the group with mild right side septal deviation were higher than the other groups (SD-, moderate and severe) without any statistically significant difference (v) no matter what the left nasal septal deviation is (mild, moderate and severe), it did not have any effect on the right, left and total maxillary volumes and (vi) in total, the maxillary volume of the group with moderate right side septal deviation was not significantly higher than the other groups (SD-, mild and severe).

The development of maxillary sinuses may vary by age and person and they may show different development patterns in right and left sides. The maxillary sinus shows two active pneumatization periods during its development after birth and increases in volume. The first of these periods is the term following the birth and up to the age of 3, and the second rapid development period is term between the ages of 7–12.[14] In our day, with the developments in the field of screening, different and detailed measurement procedures such as CT and MRI have started to be used in measuring the paranasal sinus volumes.[15,16] After Kawarai et al.'s evaluation of the volumes of paranasal sinuses with axial, coronal and sagittal section CT, different researchers performed their measurements with the same method.[10,17,18] In our study, we considered it suitable to research the effect of the nasal septal defect angle on the maxillary volume by making use of the three-dimensional paranasal CT results.

Table 4. The comparison of left-sided nasal septal deviation and maxillary sinus volume.

		Nasal septal deviation (-) (n=125)	Left-sided nasal septal deviation (+) (n=49)			p value
			Mild (n=1)	Moderate (n=28)	Severe (n=20)	
Maxillary sinus volume (cm³ ± standard deviation)	Right	14.02±4.30	13.97±4.32	14.44±2.49	14.77±4.13	0.864
	Left	13.87±4.47	12.57±2.45	14.57±2.32	13.78±4.42	0.848
	Total	27.89±8.51	26.54±2.39	29.02±4.42	28.55±8.25	0.907

The mean maxillary sinus volumes were reported between 11.1±4.5 cm^3 and 23.0±6.7 cm^3 in the literature.[19] Odita et al. informed that the maxillary sinus volumes were not different on the right and left sides in infants and children in Nigerian population.[20] Barghouth et al. did not find any difference between right and left maxillary sinus volumes in all age groups they investigated.[21] We performed our measurements by using multiplanar CT and found mean maxillary sinus volumes in accordance with the literature findings.

In some studies performed, researchers evaluated the effects of nasal septal deviations on the sinus diseases via CT and endoscopy. As a result of these studies, they found that nasal septal deviation led to an increase in the incidence and severity of bilateral chronic sinusitis.[22,23] Oshioma at al. emphasized that nasal septal deviation sped up the nasal air flow and this might increase the inhalation of the fungus balls.[24] Fadda et al. stated that it was necessary to pay attention to nasal and sinusoidal anatomic variations in the examination of CTs of the patients with recurrent chronic rhinosinusitis and the rate of infection in maxillary sinus might increase in cases that may cause trouble in air flow such as nasal deviation.[25] In our study, we researched the effect of nasal septal deviation on the maxillary volume. In the end of the study, we determined that the nasal deviation had no effect on the maxillary volume.

Nasal respiration is in the forefront for children. Mouth breathing in case of nasal obstruction may give rise to severe respiratory problems. The nasal septal deviation is the most frequent reason for nasal obstruction. In the experimental study they performed, Shin and Heo closed the unilateral nasal cavity surgically and reported anatomic and histologic changes at the side of obstruction.[26] In our study, we measured the maxillary volumes of the patients with nasal septal deviation and nasal obstruction and investigated the effect of nasal septal deviation on the maxillary volume. Ultimately, we determined that the existence of nasal deviation, laterality (right or left side) or severity (mild, moderate and severe) of deviations did not create any difference in the maxillary volume.

In conclusion, any difference was not observed between the maxillary volumes of the children with and without nasal septal deviation and it was concluded that the existence or severity of septal deviation did not have any effect on the maxillary sinus volume. Since the present study investigated the effect of nasal septal deviation on the maxillary sinus volume in children, we believe that it will make a contribution to the literature.

Conflict of Interest: No conflicts declared.

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