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Does Nasal Septum Deviation with Different Locations and Different Angular Features Affect Maxillary Sinus Volumes?

ABSTRACT

Objective: The aim of this study was to investigate the isolated effect of moderate-to-severe, lower, middle, and upper nasal septum deviation (NSD) and NSD angle on maxillary sinus volume (MSV).

Methods: The retrospective study included 94 NSD patients (mean age, 27.95 ± 12.01 years). NSD diagnosis and the measurements of NSD angle and MSV were performed using paranasal sinus computed tomography (PNS CT). The NSD angle was divided into 2 groups as moderate (≤9 to <15) and severe (≥15) according to its degree on PNS CT. Each group was divided into 3 subgroups as lower, middle, and upper NSD based on the localization of NSD. MSV was measured both on the affected and unaffected sides using volume-measuring software.

Results: Mean MSV was 13.76 ± 4.81 mL on the affected side as opposed to 14.46 ± 4.95 mL on the unaffected side in 94 patients (P = .03). The increase in the NSD angle had a significant effect on both MSVs (P = .037, for severe NSD). No significant difference was found between the side with lower, middle, or upper NSD and the contralateral side in terms of MSV (P > .05).

Conclusion: We consider that NSD and an angular increase in NSD may play a role in MSV, while NSDs in different locations do not affect MSVs.

Keywords: Maxillary sinus volume, nasal septum deviation, paranasal sinus tomography

INTRODUCTION

The nasal septum divides the nasal cavity into 2 passages and provides symmetry between these passages. Nasal septal deviation (NSD) occurs as a result of dislocation, deviation, or bending in the cartilage and/or bone forming the roof of the septum caused by deformities such as congenital, traumatic, or other reasons.[1] The incidence of NSD ranges from 14.1% to 90.4% and shows an increasing trend with age.[2] The severity, degree, and direction of nasal trauma determine the size and shape of NSD. NSD may cause symptoms such as nasal congestion, headache, increased secretion, crusting, bleeding, mucosal damage, and taste and smell disorders.[3] Nasal anatomical structures equalize the amount of air passing through the nasal passages. In the case of NSD, the nasal aerodynamics is disrupted and the amount of nasal airflow on the convex side decreases. Nasal airflow has an effect on the development of paranasal sinuses and the craniofacial skeleton.[4] Positive air pressure in the nasopharynx plays an important role in the development of paranasal sinuses by allowing air to pass into these sinuses. Therefore, a nasal obstruction may also affect the development of the facial skeleton.[5,6]

After the final rapid growth phase of the maxillary sinus (MS), numerous chronological and pathological events may affect MS volumes.[7] Differences in the airflow between the nasal passages initiate the differentiation of paraseptal structures, and although the nasal cavity volume decreases on the deviated side, this volume increases on the contralateral side. In turn, paraseptal structural changes occur in an attempt to compensate for such volume changes.[8] Based on these notions, we aimed to examine the isolated effect of moderate and severe lower, middle, and upper NSD on maxillary sinus volume (MSV) and to investigate the correlation between NSD angle and MSV using paranasal sinus computed tomography (PNS CT).

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METHODS

The retrospective study included 94 patients (59 men and 35 women, aged 18-66 years, mean age 27.95 ± 12.01 years, range 18-66 years) who were presented to our otorhinolaryngology outpatient clinic with nasal complaints and moderate-to-severe NSD and underwent PNS CT.

The study protocol was approved by the Hacı Bektaş Veli University Scientific Research Ethics Committee (Date: May 14, 2020; No: 2020.11.116) and the study was conducted in accordance with the Helsinki Declaration and ethical standards. No informed consent was obtained from the participants due to the retrospective nature of the study.

The PNS CT images were retrieved from the picture archiving and communication system (PACS). Both the medical records and PACS images of the patients were reviewed by a radiologist and an otolaryngologist. All the PNS CT images were obtained in axial and coronal planes using a 16-slice multidetector CT device (Alexion, Toshiba, Tokyo, Japan). The convex side of the nasal septum was accepted as the direction of deviation. The NSD diagnoses, types, localizations, angles, and MSV measurements were evaluated using PNS CT. Patients were divided into 2 groups based on the NSD angle described by Elahi et al.[9] classification: moderate (≤9 to <15) and severe (≥15). Each group was divided into 3 subgroups as lower, middle, and upper NSD based on the localization of NSD.

Patients who were classified as having moderate or severe, unilateral, anterior or posterior, and upper, middle, or lower NSD based on classification and patients who had no additional symptoms in other otorhinolaryngological examinations were included in the study. The PNS CT images of 1538 patients were retrieved from PACS. Of these, 1444 patients were excluded from the study based on the following exclusion criteria: age under 18 years, previous nasal and paranasal sinus surgery, non-NSD, mild NSD, bilateral NSD, S-shaped septum, maxillofacial anomalies, sinonasal trauma, usage of intranasal decongestants and steroids, mucosal thickening, nasal polyposis, sinusitis, antrochoanal polyp, allergic rhinitis, septal perforation, middle turbinate variations, severe conchal hypertrophy, nasopharyngeal diseases, and paranasal sinus tumors. As a result, 94 patients were included in the study. MSV measurements were obtained and recorded in sagittal, axial, and coronal planes using Toshiba Vitrea Workstation LT vital version 4.1.14. Third-dimensional (3D) volume measurement of the MS area was performed manually with a volume measurement tool (Figures 1 and 2). The volume was calculated by defining the MS boundaries in each slice and combining them with the fillers created by the software program.

The NSD angle was assessed by measuring the angle between a line drawn between the crista galli and the crista nasalis of the maxilla and the most prominent point of deviation, using Image J software (Figures 3 and 4).

Considering that the individuals having the same anatomical and physiological features could contribute to the accuracy of

MAIN POINTS

- Increase in the NSD angles had a significant effect on both MSVs in patients with severe NSD.
- Moderate-to-severe NSD with a lower, intermediate, and upper location had no significant effect on both MSVs.
- The MSV on the deviated side was significantly smaller than the MSV on the non-deviated side.
- Men had significantly higher MSV on both sides compared to women.
- There was a significant negative correlation between age and both MSVs, whereby both MSVs decreased as the age increased.

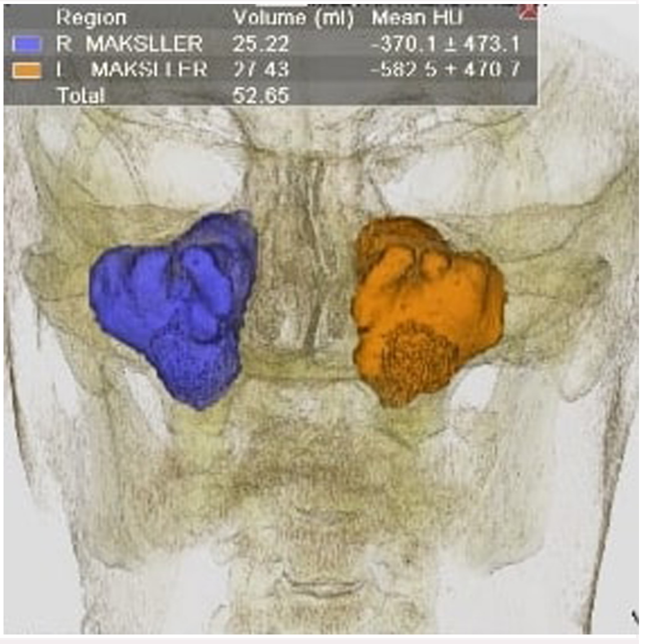

Figure 1. Three-dimensional reconstruction of maxillary sinus volumes on both sides.

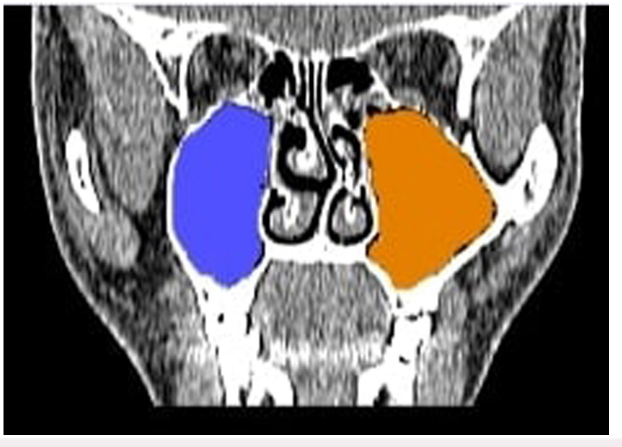

Figure 2. Appearance of maxillary sinus volume measurements in coronal section paranasal sinus tomography.

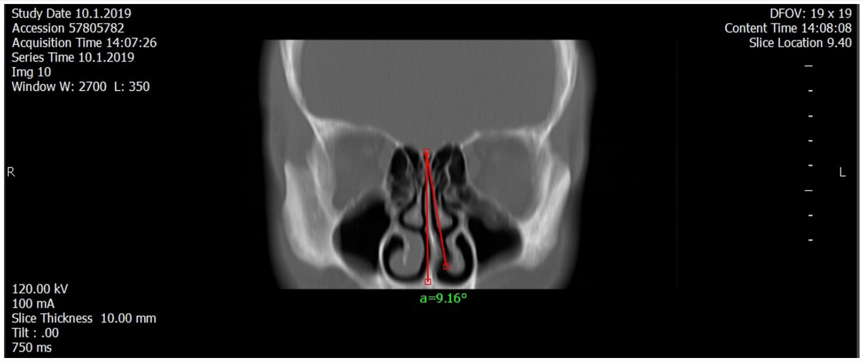

Figure 3. Angular representation of middle (9≤-<15) degree nasal septum deviation on paranasal sinus tomography.

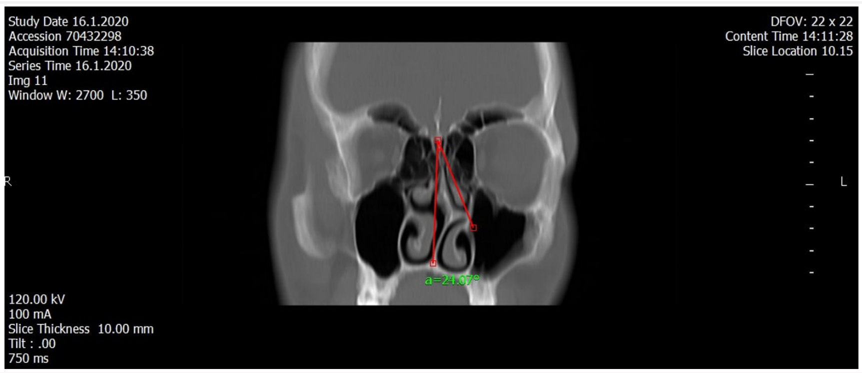

Figure 4. Angular representation of advanced (≥15) degree nasal septum deviation on paranasal sinus tomography.

the study results, the subjects in the control group were selected based on the MSVs on the non-deviated sides of the patients. The MSVs on the deviated and non-deviated sides were statistically compared using different variables.

Statistical Analysis

Data were analyzed using SPSS for Windows version 23.0 (Armonk, NY: IBM Corp.). Descriptives were expressed as mean ± standard deviation (SD). The normal distribution of continuous variables was assessed using Shapiro–Wilk test. Independent variables with normal distribution were compared using independent-samples *t*-test and variables with non-normal distribution were compared using Mann–Whitney *U*-test. Dependent variables were compared using Paired sample *t*-test. Differences among measurements were assessed using Pearson correlation coefficient. A *P* value of < .05 was considered significant.

RESULTS

Table 1 contains the clinical and demographic parameters of 94 patients. No patient had additional symptoms that could cause nasal obstruction other than NSD on PNS CT and nasal endoscopy. The mean NSD angle was calculated as 18.22°± 4.87 (range, 9-25) which was 12.32°± 1.40 in 34 (36.2%) patients that had an NSD angle between ≤9 and <15 and was 21.56°± 2.22 in 60 (63.8%) patients that had an NSD angle of ≥15. The increase in the NSD angles had a significant effect on both MSVs (*P* = .037 for severe NSD) (Figure 5) (Table 2).

Table 1. Clinical and Demographic Data of All NSD Patients

Variables	Mean ± SD
Age, year	27.95 ± 12.01
Male, *n* (%)	59 (62.8)
Female, *n* (%)	35 (37.2)
Right NSD, *n* (%)	40 (42.5) → Moderate = 16 (40), Severe = 24 (60)
Left NSD, *n* (%)	54 (57.5) → Moderate = 18 (33.3), Severe = 36 (66.7)

Pearson correlation coefficient indicated that it revealed a significant negative correlation between age and both MSVs, whereby both MSVs decreased as the age increased (Table 3).

Men had significantly higher MSV on both sides compared to women (*P* < .05) (Table 4). According to the data of all patients, the mean MSV on the deviated side was 13.76 ± 4.81 mL and was 14.46 ± 4.95 mL on the non-deviated side (*P* = .03). The mean MSVs of patients with lower, middle, and upper NSD were compared with each other and with the mean MSVs on the contralateral side. The highest MSV was detected in patients with middle NSD and the lowest MSV was detected in patients with upper NSD. No significant difference was found between the side with lower, middle, or upper NSD and the contralateral side in terms of MSV (*P* > .05) (Figure 6) (Table 5).

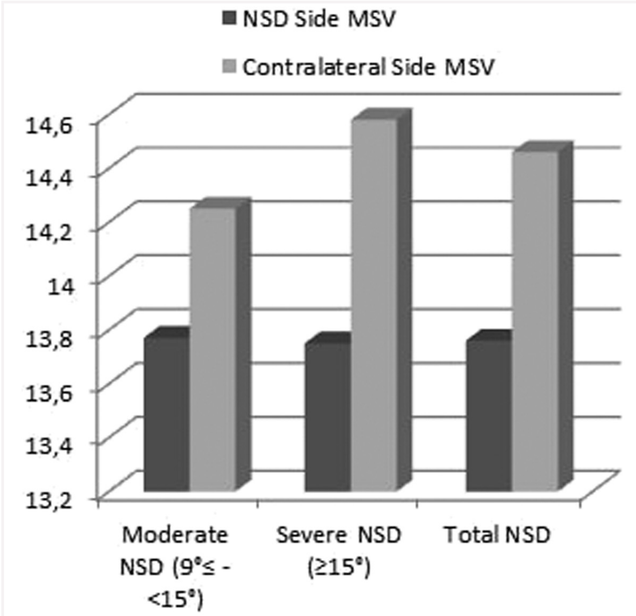

Figure 5. Graphical views of the relationship between NSD angles and MSVs.

Table 2. Comparison of Deviated and Non-deviated Sides MSVs of Patients with Moderate (9≤-<15) and Severe (≥15) NSD

	Moderate NSD (≤9 to <15), (*n* = 34)		Severe NSD (≥15),(*n* = 60)	
	Mean ± SD	*P*	Mean ± SD	*P*
Deviated side MSVs, mL	13.77 ± 4.78	.399	13.75 ± 4.86	.037*
Non-deviated side MSVs, mL	14.25 ± 4.60		14.58 ± 5.18	

NSD, nasal septum deviation; SD, standard deviation; MSVs, maxillary sinus volumes; paired sample *t*-test was used. *$P < .05$, statistically significant.

DISCUSSION

The nasal septum is the most important support of the nasal roof. It plays a key role in the regulation of nasal airflow and is also defined as an asymmetry of the nasal septum.[1,4] NSD is known as the main cause of numerous clinical conditions that cause nasal obstruction, such as concha bullosa, inferior turbinate hypertrophy, and nasal polyposis.[10]

Coronal PNS CT plays an important role in the evaluation of NSD and paranasal sinus anatomy. The prevalence of NSD detected on cone-beam PNS CT is reported as 90.4%.[2] Although the factors causing pneumatization variations are not fully understood, several mechanisms have been described in the development of paranasal sinuses, such as nasal airflow, brain development, the force of muscle contraction, facial structure, and migration.[11]

The 3D reconstruction of PNS CT, which is used for measuring the volume of paranasal sinus and nasal structures, has brought a new dimension to research in NSD.[12] In our study, we also utilized the 3D reconstruction of PNS CT for the volume measurement of the MS area. According to our experience, an automatic measurement often is likely to provide an unrealistic result since it may involve the mucosa or penetrate the bone walls of the sinus. For this reason, we performed a manual measurement on coronal slices to obtain an accurate measurement, although it was relatively time-consuming.

Table 3. Correlations Between Deviated and Non-deviated Sides MSVs and Age in Patients with NSD

	Age	
	r	*P*
Deviated side MSVs	−0.325	.001*
Non-deviated side MSVs	−0.285	.005*

NSD, nasal septum deviation; MSVs, maxillary sinus volumes; Pearson's correlation analysis was used. *r*, Pearson correlation coefficient. *$P < .05$, statistically significant.

Table 4. Comparison of Relationships Between Deviated and Non-deviated Sides MSVs and Gender in Patients with NSD

	Male (*n* = 59)	Female (*n* = 35)	
	Mean ± SD	Mean ± SD	*P*
Deviated side MSVs, mL	14.59 ± 5.28	12.35 ± 3.53	.016*
Non-deviated side MSVs, mL	15.30 ± 5.15	13.05 ± 4.32	.033*

NSD, nasal septum deviation; SD, standard deviation; MSVs, maxillary sinus volumes. Independent-samples *t*-test was used. *$P < .05$, statistically significant.

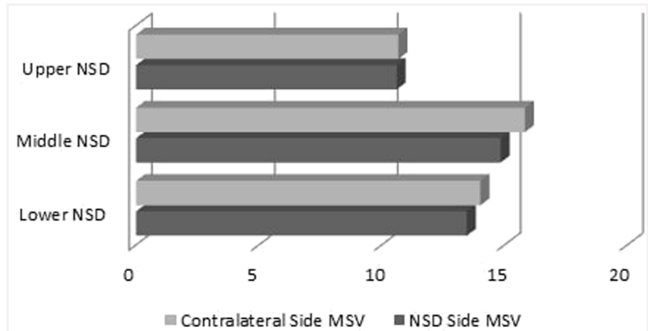

Figure 6 . Graphical views of the relationship between lower, middle and upper NSDs and MSVs. SD, standard deviation; NSD, nasal septum deviation.

Table 5. Comparison of Both Sides MSVs of Patients With Lower, Middle, and Upper NSD

	Lower NSD (*n* = 34)		Middle NSD (*n* = 47)		Upper NSD (*n* = 13)	
	Mean ± SD	*P*	Mean ± SD	*P*	Mean ± SD	*P*
Deviated side MSVs	13.46 ± 4.51	.147	14.84 ± 4.96	.067	10.61 ± 3.65	.935
Non-deviated side MSVs	14.02 ± 5.12		15.83 ± 4.43		10.68 ± 4.43	

NSD, nasal septum deviation; SD, standard deviation; MSVs, maxillary sinus volumes. Paired sample *t*-test was used.

The MSs are the first to develop and the largest paranasal sinuses.[13] Their average MSV is 15 mL and their dimensions are 33 mm in height, 23-25 mm in width, and 34 mm in the antero-posterior axis.[14] In our study, the mean MSV on the deviated side was 13.76 mL and the volumes varied between 3.75 and 28.70 mL.

The relationship between NSD and paranasal sinus disease remains debated among otolaryngologists. Moreover, although the presence of NSD may affect nasal resistance and airflow, the role of NSD on paranasal pneumatization remains unclear.[15] Nevertheless, some authors suggested that NSD can affect nasal resistance, nasal airflow, the severity of sinus disease, and MSV.[15-17]

Studies comparing the nasal structures on the deviated versus non-deviated sides indicated that pneumatization of the nasal cavity and paranasal structures was less on the deviated side.[8,16] Similarly, Orhan et al.[16] compared the MSVs of NSD patients and control subjects aged over 16 years and found that the MSVs were significantly lower on the deviated side compared to the non-deviated side in patients with NSD, whereas no significant difference was found between the MSVs on both sides in the control group.

Kapusuz et al.[17] investigated the effect of NSD on MSV, and reported that mild and moderate NSDs did not have a significant effect on MSV and sinusitis findings, while severe NSD had a significant effect on MSVs and sinusitis symptoms. These findings suggest that in patients with severe NSD, contralateral MSV can be significantly higher than the MSV on the deviated side and the degree of NSD is associated with MSV.

Karatas et al.[18] found that moderate NSD had a significant effect on MSV while mild and severe NSD had no significant effect. The authors also noted that MSV was significantly higher in patients with moderate NSD compared to patients with mild and severe NSD both on the deviated and non-deviated sides, whereas NSD had no significant effect on frontal sinus volumes.

Şahin et al.[19] found a significant relationship between NSD and ethmoid sinus volumes in the deviated side. But they reported that the presence of NSD had no effect on the paranasal sinus volumes.

Kalabalik et al.[20] found a negative correlation between MSV and age. The authors found no significant difference between the right and left MSVs in the control group, whereas MSV was significantly lower on the deviated side compared to the contralateral side in the patient group. Additionally, although mild NSD had no significant effect on both MSVs, moderate and severe NSDs led to a significant reduction in the MSV on the deviated side.

Another study reported that MSV was significantly lower on the deviated side compared to the contralateral side and NSD did not affect the total MSV. The authors suggested that NSD was the key point in affecting MSV, and that NSD had an important role in the development of paranasal sinuses.[11]

Unlike most studies, Kucybala et al.[21] and Anbiaee et al.[22] reported that NSD had no effect on MSV. The authors did not classify their patients based on the NSD angle as in our study. In our study, we classified the patients based on the NSD angle and found that the increase in the NSD angle had a significant effect on both MSVs in patients with severe NSD.

Developmental patterns of paranasal sinuses can vary with age and from person to person. Previous studies indicated that MSs may develop differently on both sides and no significant differences were found between the MSVs and genders.[7,23] By contrast, Aktuna Belgin et al.[24] found a significant difference between genders with regard to the volumes of paranasal sinuses. Similarly, in our study, men had a significantly higher MSV on both sides compared to women.

Some previous studies reported that age and alveolar bone height are important factors affecting MSV.[7] By contrast, some other studies found no significant relationship between MSV and age in patients older than 18 years,[6,25] and Orhan et al.[16] found no significant relationship between age and MSV in individuals aged over 16 years. In our study, however, we found a significant negative correlation between the MSVs on both sides and age.

The MSs present at birth grow until the end of 18 years of age.[26] In this study, we selected patients aged 18 years and over in order to avoid false results due to the incomplete development of sinus maxillaris in individuals aged below 18 years.

To our knowledge, there has been no study in the literature investigating MSV values in patients with lower, middle, and upper NSD. For this reason, the most important feature that makes our study different from the other studies is the classification of NSD into lower, middle, and upper NSD groups and the comparison of MSVs on the deviated side with each other and also with the MSV of the contralateral side in all 3 groups.

Our study was limited due to its retrospective design and the relatively small number of patients.

We consider that an angular increase in NSD may play a role in MSV, while NSDs in different localizations do not affect MSVs. Further comprehensive studies with larger patient series investigating the effect of clinical conditions causing a nasal obstruction on MSV by comparing different measurement techniques in different patient groups are needed to better elucidate the potential factors affecting MSV such as age and genetic and racial characteristics.

Ethics Committee Approval: Ethics committee approval was received from the Nevşehir Hacı Bektaş Veli University Scientific Research Ethics Committee (Approval Date: May 14, 2020; No: 2020.11.116).

Informed Consent: Written informed consent was not obtained due to the retrospective design of this study.

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