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The prevalence of nasal septum deviation and its association with maxillary sinus mucosal thickening using cone-beam computed tomography

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***Abstract*---**Introduction: Maxillary sinus mucosal thickening is a very common disease that is attributed to several reasons including environmental and anatomical. The aim of this study was to investigate the prevalence and relationship between nasal septum deviation and maxillary sinus mucosal thickening using cone-beam computed tomography imaging. Methods: The nasal cavities and maxillary sinuses of 226 patients (169 women and 57 men) were retrospectively examined using cone beam computed tomography. Statistical analysis was done to determine the prevalence and relationship between the nasal septum deviation and maxillary sinus mucosal thickening regarding gender and age. The level of significance was set at 0.05 and statistical analysis was done using the SPSS version 26. Results: The average age of the participants was 43.7 ± 13.3 years. The prevalence of deviated nasal septum was 87.6% (95% CI, 82.6-91.3%), and no significant relationship between nasal septum deviation and age and gender was observed. The highest frequency of nasal septum deviation according to the Meladina classification

modified by Rao et al. was assigned to type 7 (36%). Mucosal thickness > 2 mm was found in the right and left maxillary sinuses, 36.7%, and 34.5%, respectively. The maxillary sinus mucosal thickening did not show a significant relationship with age and gender. Conclusion: In general, the nasal septum deviation is not an influential factor to create the maxillary sinus mucosal thickening. Also, changes in the anatomical shape of the middle turbinate by nasal septum deviation can cause maxillary sinus mucosal thickening on the ipsilateral side.

Keywords---*Cone-beam computed tomography, maxillary sinus, nasal septum, sinusitis.*

Introduction

Nasal septum deviation (NSD) is defined as the disruption of the component arrangement of the nasal septum. The deviation of either the bony or the cartilaginous septum or both from the midline, may leading to respiratory disease [1,2].
From early stages of fetal development, the structure of the nasal cavity and maxillary bone have a close anatomical connection with each others[2]. Therefore, the NSD may cause nasal obstruction[3]. The nasal obstruction may cause turbulent nasal airflow, precipitating in dryness and crusting of the nose, frequent nosebleeds, and recurrent sinusitis[4,5]. Studies indicated that NSD are common among the research populations[5-7].

On the other hand, sinus diseases are considered one of the major and common health issues in different societies. The maxillary sinus mucosal thickening (MSMT) is an inflammatory reaction with hyperplasia of the sinus mucosa[8]. This condition may be caused by trauma, infection, chemical agents, foreign body reaction, neoplasm, or altered airway conditions such as allergies, rhinitis, or asthma[3]. The normal and healthy thickness of the maxillary sinus mucosa (Schneiderian membrane) is considered to be approximately 1 mm[9,10]. The MSMT is pathological when it is more than 2 mm and can cause maxillary sinusitis[11]. Sinusitis is a common disease of the maxillary sinus that reduces the quality of life and is characterized by symptoms such as nasal discharge, nasal congestion, and pain[7,12]. one study expressed the prevalence of sinusitis as 10.9% which was based on data from 12 countries.[13]. Another study conducted on the Iranian population reported the prevalence of sinusitis at 28.4%[14]. Common causes of sinusitis have been reported as upper respiratory tract infections, vasomotor rhinitis, nasal septum deviation, and bacterial sinusitis[15].

Since sinusitis and NSD are common in the population, and also sinusitis may lead to complications such as meningitis, orbital cellulitis, and cavernous sinus thrombosis, early observation of these cases by radiography can improve the process of preventing and treating complications[16].

The several diagnostic methods currently used to investigate the NSD and MSMT[7,17]. The introduction of the CBCT provided the possibility of detecting

anatomical abnormalities and pathologic areas within the nasal cavity and paranasal sinuses surrounding them for dentists and ENT specialists. Inflammation of the mucosa can be easily diagnosed using the CT scan. So, this method is a standard radiographic technique for evaluating the nasal cavity and paranasal sinuses accurately[7]. The image quality of the CBCT system, and it's relatively lower dose and cost compared to conventional CT scan, provides the possibility of 3-dimensional evaluation of craniofacial structures in dentistry[18]. Compared to spiral CT, CBCT provides a comparatively higher resolution (spatial resolution of 0.1 mm homogeneous voxels)[19].

This study aimed at measuring the prevalence of NSD and MSMT in an Iranian population and also evaluating the relationship between NSD and MSMT along with factors such as age and gender using CBCT imaging.

Methods

This cross-sectional-analytical study was conducted on 226 CBCT images in January 2022. The study was approved by the Ethics Committee of Kashan University of Medical Sciences (IR.KAUMS.MEDNT.REC.1400.135). Patients received CBCT scans for various treatment purposes such as dental implants, oral and maxillofacial surgeries, and others**.** The inclusion criteria were considered as patients who were referred to an oral and maxillofacial radiology center in Kashan city from September 2017 to August 2021. Randomly 498 CBCT images were selected in this time frame. The exclusion criteria were considered as the periapical lesions, sinus cysts (Retention pseudocyst, etc.), the paradoxical curvature or concha bullosa in samples that had simultaneous NSD and MSMT, patients less than 8 years old, and improper Field of View (FOV). Finally, a total of 226 patients (169 females and 57 males) passed the exclusion criteria. The flowchart of the study steps is shown in figure 1.

The cases with NSD were selected, and the prevalence of NSD was assessed according to age and gender in the research population. Also, NSDs were classified in seven types from I to VII by using Meladina's classification modified by Rao et al[20] which is categorized as follows:

Type I: Mild deviations in the vertical or horizontal plane without extension throughout the vertical length of the septum,

Type II: Moderate anterior vertical deviation of the septum in full length,

Type III: 'C'-shaped, posterior vertical deviation at the level of OM or middle turbinate area,

Type IV: 'S'-shaped, posterior to one side and anterior to another side,

Type V: Horizontal spur on one side with or without high deviation to the opposite side,

Type VI: Type V with a deep groove on the concave side,

Type VII: Combination of septal deformity types I to VI.
After that, the samples were evaluated in terms of MSMT in the coronal and axial sections and were classified into the following three groups based on age and gender: the thickness of maxillary sinus mucosa < 1 mm as a normal thickness, MSMT between 1 and 2 mm, and MSMT > 2 mm as a pathologic condition. Maxillary sinus mucosa thickness was measured by Romexis 3D Dental software. The maximum visible thickness of the maxillary sinus in the coronal view was considered as the basis for measurements. In the following, the relationship between NSD and MSMT was examined in three ways. 1) NSD regardless of the direction of its deviation and MSMT of left and right sinuses, 2) NSD according to the direction of septal deviation and MSMT on the ipsilateral side, 3) NSD in the middle turbinate area which has led to a change in its anatomical shape and MSMT on the ipsilateral side.

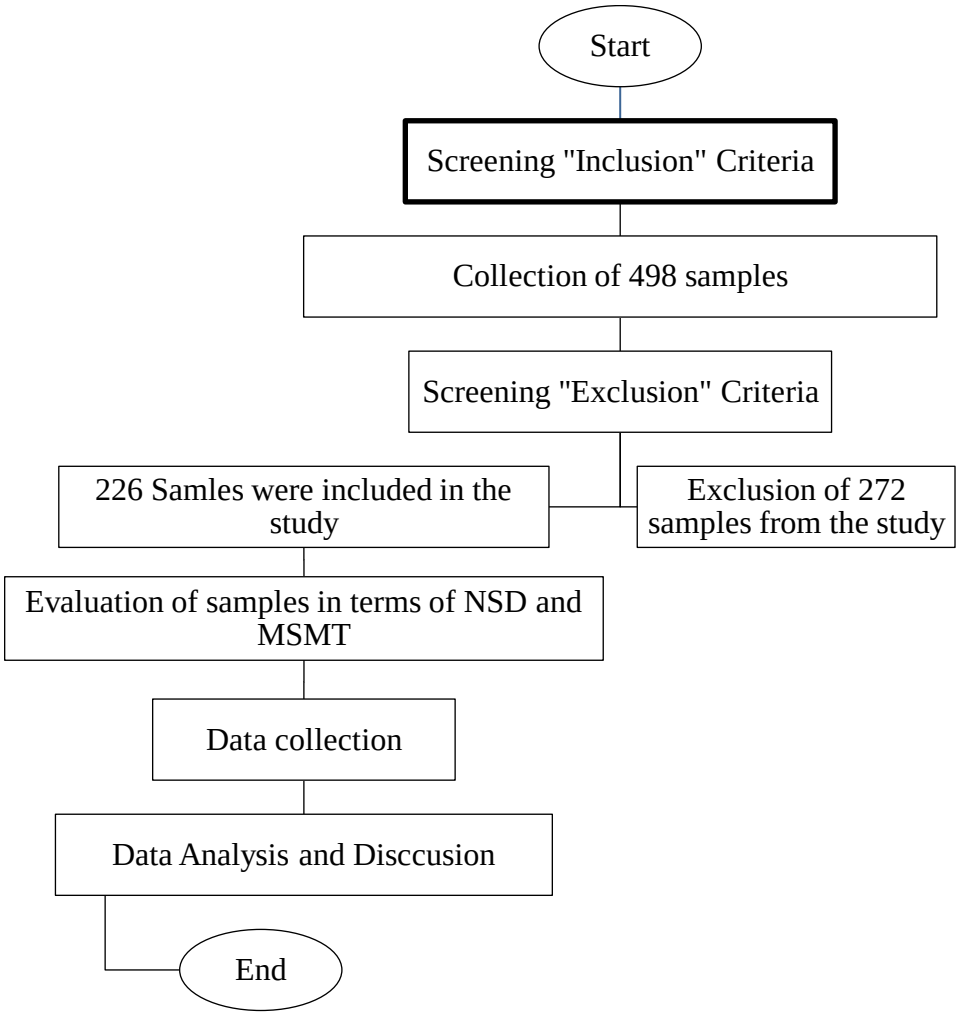

Figure 1. Flowchart of study steps.

The images of the patients were taken using Planmeca 3D (Helsinki Finland) High resolution, Voxel size: 130 mm, mA: 6, kVp: 89, FOV: 6×8 cm^2. The data were entered in the Romexis 3D Dental software and then, the images were viewed on a 14" SONY LCD monitor with a resolution of 1024×1208 pixels and 32 bits by two oral and maxillofacial radiologists.

Statistical analysis was performed by the SPSS version 26 (IBM Corp, University of Chicago, Illinois, USA). Descriptive statistics included percentages, frequencies, mean and standard deviation were used. The level of significance was set at 0.05. Chi-square and Fisher's tests were used to evaluate the relationship between NSD and MSMT. The kappa agreement coefficient was used to show the agreement between the results obtained by the two observers.

Results

In the present study, the samples consisted of 498 cases, of which 226 (169 [74.8 %] females and 57 [25.2 %] males) were eligible to be included in the study. The mean age of the patients was 43.7 ± 13.3 years, ranging from 9 to 80 years. Before performing the statistical analysis, the validity of the diagnosis which was done by two observers regarding the presence/absence and type of NSD was evaluated. The kappa agreement coefficient was obtained at 0.87, which was more than 0.7, so it indicated good validity. Then statistical analysis was done after the agreement between the experts, in the cases of disagreement. Radiologists had the same opinions regarding the assessment of the MSMT and the direction of the NSD.

The NSD was found in 87.6 % (95 % CI, 82.6 - 91.3 %) of the research population. Age and gender were not associated with NSD (P > 0.05). The details of the prevalence of NSD and its relation to gender and age are shown in Table 1.

Table 1. The prevalence of NSD and its relation to gender and age.

Variable		Total N	No NSD (N)	NSD (N)	Prevalence of NSD (%)	95% CI	P-value
Gender	Female	169	22	147	87	80.9 - 91.3	0.62
	Male	57	6	51	89.5	78.3 - 95.2	
Age (year)	8-19	5	3	2	40	8.2 - 83.3	0.14
	20-29	24	2	22	91.7	71.3 - 98	
	30-39	67	8	59	88	77.7 - 94	
	40-49	52	6	46	88.5	76.4 - 94.8	
	50-59	49	5	44	89.8	77.5 - 95.7	

	≥ 60	29	4	25	86.2	68 - 94.8	
Total		226	28	198	87.6	82.6 -91.3	

CI: Confidence Interval, N: Number.

Investigation of the frequency of NSD based on Meladina's classification modified by Rao et al. is shown in Table 2. The highest and lowest frequency of NSD was assigned to type 7 (35.8 %) and type 2 (0.4%), respectively.

Table 2. Frequency of nasal septum deviation in females and males.

NSD	Female		Male		Total	
	Frequency (N)	Percentage (%)	Frequency (N)	Percentage (%)	Frequency (N)	Percentage (%)
No NSD	22	13	6	10.5	28	12.4
Type I	5	3	0	0	5	2.2
Type II	1	0.6	0	0	1	0.4
Type III	47	27.8	12	21	59	26.1
Type IV	11	6.5	3	5.3	14	6.2
Type V	24	14.2	10	17.5	34	15
Type VI	2	1.2	2	3.5	4	1.8
Type VII	57	33.7	24	42.1	81	35.8

Gender	NSD Frequency (percentage)								P-value
	No NSD	Type I	Type II	Type III	Type IV	Type V	Type VI	Type VII	
Female	22 (13)	5 (3)	1 (0.6)	47 (27.8)	11 (6.5)	24 (14.2)	2 (1.2)	57 (33.7)	0.59
Male	6 (10.5)	0 (0)	0 (0)	12 (21)	3 (5.3)	10 (17.5)	2 (3.5)	24 (42.1)	
Total	28 (12.4)	5 (2.2)	1 (0.4)	59 (26.1)	14 (6.2)	34 (15)	4 (1.8)	81 (35.8)	

Further, the prevalence of MSMT was also investigated. The results indicated that the prevalence of MSMT > 2 mm in the right and left sinuses were 36.7% and 34.5 %, respectively. No statistically significant difference was reported between MSMT and gender. The relationship between MSMT and gender are presented in Table 3. Also, no relation was detected between MSMT and age. Figures 2 and 3 show the relationship between the right and left MSMT with age, respectively.

Table 3. The relationship between MSMT and gender.

Sinus	Gender	MSMT Frequency (percentage)			P-value
		<1 mm	1-2 mm	>2 mm	
Right	Female	78 (46.2)	28 (16.6)	63 (37.3)	0.92
	Male	28 (49.1)	9 (15.8)	20 (35.1)	
	Total	106 (46.9)	37 (16.4)	83 (36.7)	
Left	Female	81 (47.9)	34 (20.1)	54 (32)	0.37
	Male	24 (42.1)	9 (15.8)	24 (42.1)	
	Total	105 (46.5)	43 (19)	78 (34.5)	

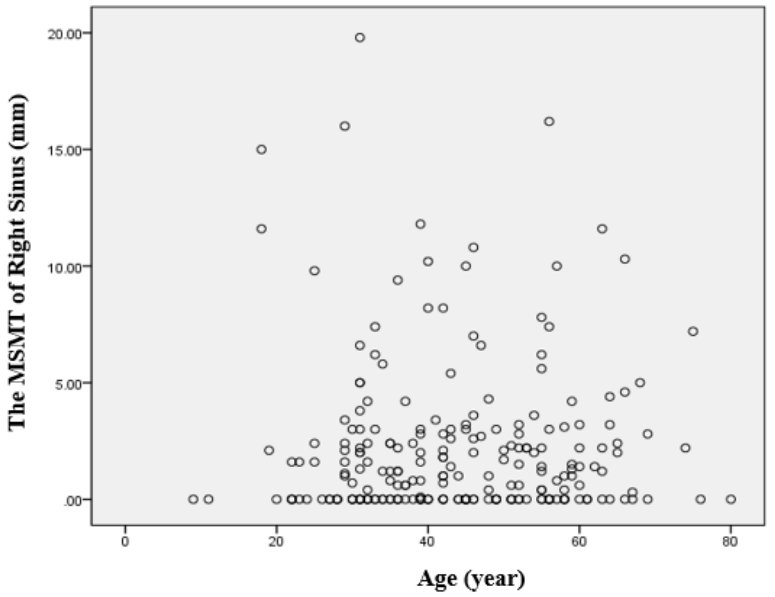

Figure 2. The relationship between the MSMT of the right sinus with age.

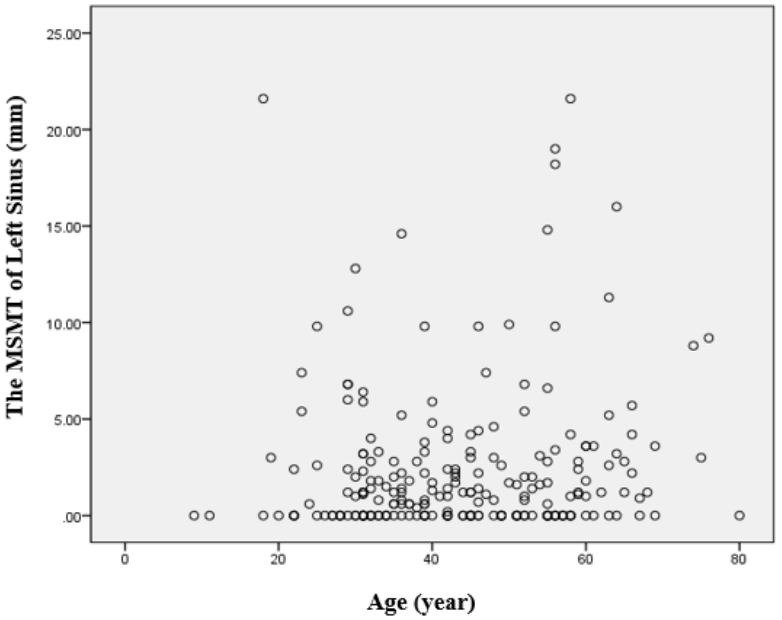

Figure 3. The relationship between the MSMT of the left sinus with age.

The relationship between MSMT and the NSD was investigated using the chi-square statistical test. The results showed that there is no statistically significant relationship between NSD and MSMT for each sinus (P=0.86 for the right sinus and P= 0.77 for the left sinus). In addition, the relationship between the NSD and MSMT was investigated according to the direction of the septal deviation, and the results showed that the two variables were not related to each other on the ipsilateral side. The details are shown in Table 4.

Table 4. The relationship between the NSD and MSMT according to the direction of the deviation.

Sinus	NSD	MSMT Frequency (percentage)				P-value
		<1 mm	1-2 mm	>2 mm	Total	
Right	No NSD to the right side	33 (47.1)	12 (17.1)	25 (35.7)	70 (100)	0.92
	NSD to the right side	59 (46.1)	20 (15.6)	49 (38.3)	128 (100)	
Left	No NSD to the left side	42 (54.5)	13 (16.9)	22 (28.6)	77 (100)	0.14

	NSD to the left side	49 (40.5)	24 (19.8)	48 (39.7)	121 (100)	

The relationship between the NSD in the middle turbinate area and MSMT was investigated according to the direction of septal deviation. The results demonstrated a statistically significant relationship between the NSD in the middle turbinate area and the MSMT on the ipsilateral side (P<0.05). It means that with the existence of NSD in any of the right or left directions, the possibility of MSMT increases on the involved side. The details are shown in Table 5.

Table 5. The relationship between the NSD in middle turbinate area and MSMT according to the direction of the septal deviation

Sinus	NSD in the middle turbinate area	MSMT Frequency (percentage)				P-value
		<1 mm	1-2 mm	>2 mm	Total	
Right	No NSD to the right side	91 (50.3)	31 (17.1)	59 (32.6)	181 (100)	0.034
	NSD to the right side	15 (33.3)	6 (13.3)	24 (53.3)	45 (100)	
Left	No NSD to the left side	93 (51.4)	36 (19.9)	52 (28.7)	181 (100)	0.001
	NSD to the left side	12 (26.7)	7 (15.6)	26 (57.8)	45 (100)	

Discussion

The studies have indicated that the prevalence of NSD is in a variable range. Taghiloo and Halimi[7] reported the prevalence of NSD as 75% and equal quantity in women and men (75.51% and 74.5%) for an Iranian population. Sumaily et al.[21] found the prevalence of NSD was 31.1% with equal proportions in women and men (50.4% and 49.6%). Bayrak et al.[5] in their research have demonstrated the prevalence of NSD was 50.6% without gender bias. Stallman et al.[6] also reported a 65% prevalence of NSD. Based on the obtained results of the present study, the prevalence of NSD was 87.6% (82.6 - 91.3: 95% CI). No significant difference was observed in women and men (87% - 89%). The NSD can be congenital or acquired (3-6), so genetic and environmental factors can play a decisive role in its prevalence. Therefore, the difference in results of studies, because of different geographical populations, can be justified.

In the present study, investigating the prevalence of NSD based on Meladina's classification modified by Rao et al. showed that the highest frequency of NSD

was assigned to type 7 (36%), and then type 3 (1 26/%). Taghiloo and Halimi[7] indicated that all 7 types of NSD except type 3 were observed, and types 1 and type 5 were the most numerous among the samples. Sam et al.[22] showed that type 7 (29%) and then type 4 (22%) were the most common NSD, and the lowest prevalence was assigned to type 5 (7%), while Rao et al.[20] showed that type 5 (45%) was the most common NSD. The comparison of different studies shows the variation in the types of NSD in different populations. Since type 7 of NSD is a combination of types 1 to 6, its highest frequency can indicate the complex shape of NSD and the impossibility of placing them in one of the types 1 to 6.

According to radiological evaluations, the acceptable threshold for pathological maxillary sinus thickness includes a wide range of numerical values[5,23,24]. Therefore, the difference in the definition of pathological maxillary sinus mucosal thickness can lead to inconsistency in the results of different studies regarding the prevalence of MSMT or sinusitis. Historically, 2 mm is considered a reliable threshold for pathological mucosal swelling, as it is stated that mucosa is visible at a thickness of 2 mm or more[25]. In the present study, in line with the study of Bayrak et al.[5], 2 mm is accepted as a threshold for the presence of pathological maxillary sinus mucosa thickness. On the other hand, the thickness of normal maxillary sinus mucosa is less than 1 mm[3]. Therefore, a thickness between 1 and 2 mm is considered an intermediate thickness between normal and pathological. Bayrak et al. in their study reported that 56.2% and 49.4% of patients had mucus thickness > 2 mm in the right and left maxillary sinus, respectively. In the present study, the thickness of the mucosa > 2 mm in the right and left maxillary sinuses was found at 36.7% and 34.5%, respectively, which did not differ in women and men. Also, no significant relationship was observed in the examination of the thickness of maxillary sinus mucosa with age.

Many studies have been conducted about the relationship between the NSD and the MSMT. Kucybata et al.[26] showed that the NSD has an influence on the development of maxillary sinusitis. Taghiloo and Halimi[7] reported that there is a significant relationship between the NSD and the MSMT. Stallman et al.[6] indicated that 78% of patients with NSD had sinus disease and 72% of individuals without NSD had sinus disease. As a result, no significant relationship between the NSD and sinus disease was observed. Bayrak et al. demonstrated that there was no significant relationship between the NSD and the MSMST > 2 mm. This study showed that the NSD is not an effective factor in the MSMT. In the present study, there was no significant relationship between the NSD and the MSMT. In addition, the relationship between the NSD and the MSMT according to the direction of the septal deviation (left and right) was investigated, and the results showed that these two variables were not related to each other on every two sides. Although the methods and results of the studies are contradictory, the present study confirms some studies[5,6,21] and contradicts other studies[7,26,27], and shows that generally, the NSD is not an influential factor in the MSMT.

Colette et al.[28] in a review study showed that the increase in the incidence and severity of sinus diseases is related to the increase in the angle of septal deviation in the osteomeatal complex area. The osteomeatal complex is located in the middle meatus area (the inferior area of the middle turbinate), as the

communication channel between the maxillary sinus and the nasal cavity. In the present study, the relationship between the NSD in the middle turbinate area and the MSMT was also studied and the results showed a significant relationship between them on the ipsilateral side ($P<0.05$). So, if there is a septal deviation in any of the right or left directions, the possibility of the MSMT increases on the ipsilateral side. Several hypotheses have been expressed about the relationship between the NSD and chronic sinusitis; one suggests the pathophysiological role of the nasal septum through a mechanical obstruction in the osteomeatal complex. So that the obstruction or narrowing of the osteomeatal canal reduces the drainage of maxillary sinus secretions. Other hypotheses attributed the sinusitis to the dysfunction of the mucociliary function of the nasal mucosa and affection of the airflow by the NSD which causes dryness of the mucosa and pressure changes in the airflow in the sinuses[21,28]. The present study strengthens the possibility of the correctness of the hypothesis of narrowing or mechanical blockage of the osteomeatal complex.

Conclusion:

The findings of the present study showed that the NSD and the MSMT were common among the research population and also gender and age no influenced the NSD and the MSMT. Although the findings indicated that the NSD is not generally an influential factor to create the MSMT, changes in the anatomical shape of the middle turbinate by the NSD can cause the MSMT on the ipsilateral side. Therefore, this finding reinforces the hypothesis of mechanical obstruction of the osteomeatal complex regarding the relationship between the NSD and the MSMT. Also, CBCT imaging is an applicable option for evaluating maxillary sinuses and nasal septum.

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