RESEARCH PAPER

Changes in Dimensions of Inferior Turbinate and Maxillary Sinus in Rhinosinusitis in Relation to Shapes of Nasal Septum Deviation

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ABSTRACT

Background: Nasal septal deviation (NSD) may be developmental or traumatic and can cause compensatory inferior turbinate hypertrophy, leading to airflow obstruction and increased risk of sinusitis. The aim of this work was to find the effect of different types of NSD on the nasal clinical presentation and on the maxillary sinus and inferior turbinate dimensions.

Methods: This cross-sectional observational study included 117 patients aged >18 years of both sexes attending an otorhinolaryngology clinic with NSD and at least one symptom (nasal obstruction, discharge, or paranasal sinus tenderness). All patients were subjected to endoscopic nasal examinations and CT nose and paranasal sinuses.

Results: Nasal obstruction, headache or facial pain, nasal discharge, sneezing, throat discomfort and halitosis by history and nasal mucosal congestion & nasal polyps by endoscopy all showed significant difference between different Mladina types of NSD (P> 0.05), while other parameters were not significant. Significant bilateral differences in inferior turbinate and maxillary sinus dimensions were observed across NSD types, with mostly contralateral enlargement of the inferior turbinate and decreased ipsilateral measurements of maxillary sinus and type-specific variations in height, width, and depth, indicating compensatory anatomical remodeling.

Conclusions: The Mladina types of deviated septum variations were associated with variations in clinical symptoms and patterns of maxillary sinusitis, which reflects the maxillary sinus and turbinate's dimensions' affection.

Keywords: Inferior Turbinate, Maxillary Sinus, Rhinosinusitis, Nasal Septum Deviation

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BACKGROUND

Nasal septal deviation (NSD) is very common among population, that is usually congenital but sometimes due to trauma. It includes deviations in the anteroposterior and cephalocaudal dimensions [1]. Mladina classification for NSD is considered the gold standard for clinical research regarding nasal septum, which classified deviations into 7 types, vertical deformities for the four types (I, II, III, IV), horizontal ones for types (V, VI) and type VII for combination between both [2]. NSD affects the inferior turbinate dimensions [3], that is due to compensatory hypertrophy of the inferior turbinate as a protective mechanism from cold and dry air [4]. Maxillary sinus is also affected because it is related anatomically to the hard palate and the lateral nasal wall [5]. As a result of nasal septum deviation and thurbinate hypertrophy, osteomeatal complexes become more prone to obstruction, leading to chronic rhinosinusitis. Patients with NSD are usually complaining of chronic rhinosinusitis, nasal obstruction, nasal discharge and headache [6].

The aim of this work was to find the effect of different types of NSD on the nasal clinical presentation and on the maxillary sinus and inferior turbinate dimensions.

Methods:

This observational, cross-sectional study was carried out on 117 patients aged >18 years old, both sexes, who presented to the otorhinolaryngology outpatient clinic with various shapes of nasal septum deviation and at least one of the following clinical features: paranasal sinus tenderness, nasal obstruction, or nasal discharge at the time of presentation were included.

The study was done from February 2025, and January 2026 after approval from the Ethical Committee Our University Hospital. An informed written consent was obtained from the patients.

Exclusion criteria were patients with diffuse sinonasal polyposis, as the presence of extensive polyps could have significantly altered sinonasal anatomy, obscured endoscopic visualization, and affected computed tomography (CT) based measurements of both inferior turbinate's and maxillary sinuses, patients with history of previous nasal or paranasal sinus surgery (such as septoplasty, functional endoscopic sinus surgery, turbinectomy, or polypectomy) were excluded, because prior surgical alteration could have modified the natural anatomical relationship between the nasal septum, inferior turbinates, and maxillary sinuses, patients with nasal or

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paranasal tumors (benign or malignant) were excluded, as mass lesions could have distorted normal anatomy or induced secondary changes in adjacent structures and patients with congenital anomalies affecting the sinonasal region, such as cystic fibrosis and other syndromic craniofacial malformations, were excluded because these conditions could have independent effects on mucociliary function, sinus development, and overall sinonasal dimensions.

All patients were subjected to complete history taking, clinical examination, endoscopic nasal examination and radiological investigation [CT nose and paranasal sinuses].

Data collection and study tools

The study primarily relied on quantitative measurements and systematically recorded clinical findings. Demographic variables, clinical symptoms, endoscopic findings, and radiological measurements were recorded in structured data sheets and later entered into an electronic database for analysis. Qualitative clinical observations (such as presence or absence of discharge, edema, or polyps) were coded numerically to facilitate statistical analysis.

Endoscopic nasal examination

All patients underwent diagnostic nasal endoscopy. The procedure was performed using a rigid nasal endoscope (commonly 0° and/or 30°, 4 mm in adults) under topical anesthesia and decongestion. A standardized technique was followed:

Topical nasal decongestion was achieved by applying cotton pledgets soaked in a mixture of a topical vasoconstrictor and local anesthetic into the nasal cavity for several minutes. This reduced mucosal edema, improved visualization, and minimized patient discomfort. Patients were briefed about the procedure to reduce anxiety and improve cooperation. The endoscope was gently introduced into each nasal cavity, starting from the floor and then systematically moving to inspect the inferior, middle, and superior meatuses protocols. Endoscopic findings recorded presence or absence of nasal polyps (isolated or diffuse) and its laterality were recorded.

Computed tomography protocol:

CT scans were performed using a multidetector CT scanner in both coronal and axial planes. Thin section images (approximately 0.5–1.0 mm slice thickness) were acquired to allow precise visualization and measurement of sinonasal structures. Images were obtained without contrast enhancement, as noncontract CT is routinely sufficient for anatomical evaluation in chronic rhinosinusitis. Patients were positioned supine, and the standard sinus CT protocol of the radiology department was followed to ensure consistency. CT image analysis included: Classification of nasal septum deviation by Mladina type, side of nasal septum deviation, inferior turbinate dimensions (anteroposterior length, width/transverse diameter, and height/vertical diameter) on both ipsilateral and contralateral sides, maxillary sinus measurements (height/vertical diameter, width/transverse diameter, and anteroposterior depth) on both ipsilateral and contralateral sides and presence of ipsilateral or contralateral maxillary sinusitis relative to septal deviation

All measurements were performed using the digital caliper tools available within the CT viewing software and recorded in millimeters. Each key measurement was performed at least twice, and the mean value was used for analysis. Interobserver variability was reduced by having measurements crosschecked by a second observer for a subset of patients.

Data handling

All clinical and radiological variables were assigned specific codes in a predesigned data sheet (for example, numerical codes for Mladina types, presence/absence of sinusitis, presence/absence of polyps). Data were entered into a computerized database using a statistical software package.

Sample Size Calculation:

The sample size was calculated using EpiInfo 7 statistical software, based on data from a previous study. According to Gopika Kalsotra et al. [7] the percentage of cases with deviated nasal septum grade 7 associated with ipsilateral maxillary sinusitis was 76.78%.

The following assumptions were used for calculation: [Confidence limits: 5% and confidence level: 80%]. Based on these parameters, the minimum sample size required for this study was calculated to be 117 cases. The study aimed to reach at least this number to ensure adequate power for detecting significant associations between septal deviation patterns and maxillary sinus / inferior turbinate changes.

Statistical analysis

Statistical analysis was done by SPSS v26 (IBM Inc., Chicago, IL, USA). Quantitative variables were presented as mean and standard deviation (SD) and compared between the two groups utilizing unpaired Student's t-test. Qualitative variables were presented as frequency and percentage (%) and analyzed using the Chi-square or Fisher's exact test when appropriate. A two-tailed P value < 0.05 was considered statistically significant.

Results:

Baseline demographic, clinical characteristics and nasal septum deviation characteristics were enumerated in **Table 1.**

There was a statistically significant difference in the prevalence of nasal obstruction, headache/facial pain, sneezing, nasal discharge, throat discomfort, halitosis, nasal mucosal congestion/edema, and nasal polyps among the different Mladina types of nasal septal deviation ($P < 0.05$). However, no statistically significant difference was observed in the prevalence of paranasal sinus tenderness among the studied groups ($P = 0.072$).

Table 2.

Significant differences were observed across several NSD types. Inferior turbinate anteroposterior length was greater on the contralateral side in Types III, V, and VI ($P \leq 0.007$). Inferior turbinate height differed in Types I, V, and VII ($P \leq 0.048$), with Type I showing greater ipsilateral height, while Types V and VII showed contralateral hypertrophy. Width differences were significant only in Type V ($P=0.002$), with greater contralateral width. **Table 3.**

Maxillary sinus height showed significant differences in Types I and III ($P<0.001$), with increased ipsilateral height in Type I and reduced ipsilateral height in Type III. Sinus width asymmetry was noted in Types I, III, and VII (P≤0.003), all favoring the contralateral side. Anteroposterior sinus depth differed in Types I, III, V, VI, and VII (P≤0.042), with Types I, III, V, and VI showing greater contralateral depth, while Type VII showed greater ipsilateral depth, indicating complex compensatory and developmental asymmetries associated with septal deviation. **Table 4.**

Table 1: Baseline demographic, clinical characteristics and nasal septum deviation characteristics of the study population

		N=117
Age (years)		36.91 ± 11.94
Sex	**Male**	52 (44.4%)
	Female	65 (55.6%)
Smoking history		41 (35.0%)
Nasal Septum Deviation Characteristics		
Mladina type	**Type 1**	32 (27.4%)
	Type 2	21 (17.9%)
	Type 3	27 (23.1%)
	Type 4	6 (5.1%)
	Type 5	12 (10.3%)
	Type 6	10 (8.5%)
	Type 7	9 (7.7%)
Side of deviation	**Left**	69 (59.0%)
	Right	48 (41.0%)

Data are presented as mean ± SD or frequency (%).

Table 2: Prevalence of rhinosinusitis symptoms and clinical signs by Mladina type of nasal septum deviation

	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	Type 7	P
Prevalence of rhinosinusitis symptoms								
Nasal obstruction	7(21.9%)	3(14.3%)	24(88.9%)	6(100%)	12(100%)	7(70.0%)	3(33.3%)	**<0.001***
Headache/facial pain	21(65.6%)	18(85.7%)	21(77.8%)	3(50.0%)	12(100%)	10(100%)	6(66.7%)	**0.041***
Sneezing	18(56.3%)	15(71.4%)	6(22.2%)	0(0.0%)	6(50.0%)	6(60.0%)	6(66.7%)	**0.003***
Nasal discharge	7(21.9%)	3(14.3%)	24(88.9%)	6(100%)	12(100%)	7(70.0%)	3(33.3%)	**<0.001***
Throat discomfort	14(43.8%)	0(0.0%)	24(88.9%)	0(0.0%)	6(50.0%)	10(100%)	3(33.3%)	**<0.001***
Halitosis	11(34.4%)	3(14.3%)	11(40.7%)	0(0.0%)	6(50.0%)	6(60.0%)	6(66.7%)	**0.020***
Clinical Signs								
Nasal mucosa congestion/ edema	25(78.1%)	12(57.1%)	27(100%)	3(50.0%)	12(100%)	7(70.0%)	6(66.7%)	**0.002***
Paranasal sinus tenderness	14(43.8%)	6(28.6%)	14(51.9%)	3(50.0%)	0(0.0%)	3(30.0%)	3(33.3%)	0.072
Nasal polyps	7(21.9%)	3(14.3%)	4(14.8%)	3(50.0%)	0(0.0%)	0(0.0%)	0(0.0%)	**0.047***

*Data are presented as mean ± SD or frequency (%). * Significant P value <0.05.*

Table 3: Inferior turbinate anteroposterior length, height (vertical diameter) and width (transverse diameter)

		Ipsilateral	Contralateral	P
Inferior Turbinate Anteroposterior Length	**I**	51.50 ± 3.81	50.63 ± 5.18	0.184
	II	45.14 ± 2.41	45.86 ± 3.12	0.109
	III	44.74 ± 5.54	49.04 ± 2.39	**0.001***
	IV	46.00 ± 0.00	46.50 ± 0.55	0.076
	V	40.50 ± 6.95	42.75 ± 5.79	**0.007***
	VI	44.40 ± 3.20	49.90 ± 4.56	**0.006***
	VII	45.00 ± 0.87	45.33 ± 0.50	0.081
Inferior Turbinate Height (Vertical Diameter)	**I**	13.59 ± 3.86	12.76 ± 4.55	**0.048***
	II	14.21 ± 2.51	14.43 ± 2.11	0.379
	III	12.89 ± 3.75	12.96 ± 3.04	0.875
	IV	14.50 ± 4.93	12.50 ± 1.64	0.196
	V	9.75 ± 2.38	13.25 ± 3.41	0.000*
	VI	11.70 ± 3.50	14.30 ± 3.64	0.121
	VII	13.00 ± 0.87	14.33 ± 0.50	0.000*
Inferior Turbinate Width (Transverse Diameter)	**I**	7.78 ± 2.17	7.56 ± 1.56	0.638
	II	8.79 ± 2.01	9.14 ± 2.15	0.083
	III	9.89 ± 2.85	10.56 ± 3.91	0.152
	IV	8.00 ± 0.00	9.00 ± 1.10	0.076
	V	8.00 ± 2.45	9.75 ± 1.14	**0.002***
	VI	8.00 ± 1.63	9.30 ± 2.36	0.169
	VII	10.00 ± 0.87	9.67 ± 1.32	0.594

*Data are presented as mean ± SD. * Significant P value <0.05.*

Table 4: Maxillary sinus height (vertical diameter), width (transverse diameter) and maxillary sinus anteroposterior depth

		Ipsilateral	Contralateral	P
Maxillary Sinus Height (Vertical Diameter)	**I**	36.28 ± 7.63	35.38 ± 7.99	**0.000***
	II	35.43 ± 2.50	35.57 ± 3.63	0.811
	III	30.37 ± 4.92	32.37 ± 5.70	**0.000***
	IV	38.50 ± 2.74	39.50 ± 1.64	0.076
	V	34.50 ± 2.15	33.25 ± 5.03	0.521
	VI	32.50 ± 4.38	33.00 ± 7.92	0.863
	VII	35.33 ± 0.50	32.67 ± 3.28	0.052
Maxillary Sinus Width (Transverse Diameter)	**I**	22.28 ± 6.67	24.13 ± 8.75	**0.003***
	II	23.29 ± 4.77	22.29 ± 5.50	0.083
	III	19.44 ± 5.02	22.22 ± 5.93	**0.000***
	IV	22.00 ± 4.38	23.00 ± 4.38	--
	V	20.25 ± 2.90	19.00 ± 4.49	0.163
	VI	18.20 ± 4.44	22.40 ± 8.30	0.175
	VII	19.00 ± 2.29	23.00 ± 0.87	**0.001***
Maxillary Sinus Anteroposterior Depth	**I**	31.84 ± 4.98	32.09 ± 4.60	0.037
	II	33.86 ± 4.19	33.29 ± 4.23	0.258
	III	34.11 ± 3.59	35.56 ± 4.41	**0.000***
	IV	33.50 ± 1.64	34.50 ± 1.64	--
	V	28.00 ± 4.49	32.50 ± 5.65	**0.042***
	VI	31.20 ± 3.71	33.90 ± 0.88	**0.038***
	VII	37.00 ± 0.87	33.33 ± 2.78	**0.014***

*Data are presented as mean ± SD. * Significant P value <0.05.*

DISCUSSION

NSD may potentially contribute to sinus disease by narrowing the osteomeatal complex which could affect the amount of adequate ventilation [8].

In our result, contralateral inferior turbinate dimensions showed slightly higher means across all measurements compared to ipsilateral sides, with AP length at 47.44 ± 4.63 mm versus 46.75 ± 5.55 mm, width at 9.03 ± 2.59 mm versus 8.70 ± 2.37 mm, and height at 13.26 ± 3.32 mm versus 13.21 ± 3.54 mm. Ranges were broadly similar, though contralateral width extended to 18.0 mm maximum. There was no significant difference in inferior turbinate dimensions between ipsilateral and contralateral sides in rhinosinusitis patients with nasal septum deviation. This was in consistent with Bekin Sarikaya et al. [9] stated that there were no significant differences between ipsilateral and contralateral inferior turbinate diameters (p > 0.05).

In the current study, ipsilateral maxillary sinus dimensions exhibited marginally lower means than contralateral sides, with width at 21.56 ± 5.53 mm versus 21.95 ± 6.48 mm, AP depth at 32.99 ± 4.40 mm versus 33.09 ± 4.54 mm, and height at 34.34 ± 5.81 mm versus 34.26 ± 5.90 mm. Ranges were comparable, with contralateral width showing greater variability (11.0-39.0 mm). There was no significant difference in maxillary sinus dimensions between ipsilateral and contralateral sides in rhinosinusitis patients with nasal septum deviation. This agrees with Erdemes et al. [10] observed that there was no significant difference in maxillary sinus volume [(MSV) between the two sides in patients with left septal deviation. Also, Rodriguez Betancourt et al. [8] highlighted that there were no statistically significant changes in ipsilateral MSV due to the presence of severe septal deviations only in 26.59% of the population with deviation angles > 15°.

This study showed significant associations between Mladina type and rhinosinusitis manifestations. Nasal obstruction, discharge, and throat discomfort were most prevalent in Types 4 and 5 (100%) and Type 3 (88.9%), but much lower in Types 1 and 2. Headache/facial pain, sneezing, and halitosis also differed significantly, with universal headache in Type 6 and highest sneezing and halitosis in Type 7. Among clinical signs, nasal mucosal congestion/edema varied significantly (P=0.002), occurring in all Type 3 and 5 cases but less frequently in Types 2 and 4. Nasal polyps also showed significant variation (P=0.047), peaking in Type 4 and absent in Types 5–7, while paranasal sinus tenderness showed no significant association despite relatively higher rates in Types 3 and 1. This came in agreement with Jafarov et al. [3] stated that functional throat symptoms can be seen in patients experiencing nasal obstruction associated with septum deviation. Moreover, Kwon et al. [11] found that SD is associated with headaches.

In our study, significant bilateral asymmetries in inferior turbinate dimensions were observed across several deviation types. Anteroposterior length was greater on the contralateral side in Types III, V, and VI. Turbinate height differed in Types I, V, and VII, with increased ipsilateral height in Type I and contralateral hypertrophy in Types V and VII. Width asymmetry was significant only in Type V, with greater contralateral width. Maxillary sinus dimensions also varied significantly: sinus height differed in Types I and III, while sinus width was reduced ipsilaterally in Types I, III, and VII. Anteroposterior sinus depth showed significant differences in Types I, III, V, VI, and VII, generally demonstrating reduced ipsilateral depth. Supporting our result, Konukoglu et al. [3] illustrated that the differences in MSV were associated with the presence and direction of NSD. Similarly, Chiesa Estomba et al. [12] highlighted that compensatory hypertrophy of the inferior turbinate in the contralateral nasal cavity is commonly observed in patients with NSD.

The current study showed that ipsilateral maxillary sinusitis was significantly associated with Mladina type, occurring universally in Types III, IV, and VI, whereas contralateral sinusitis also differed significantly, being most frequent in Types VII and V and absent in Type IV. Significant associations were observed between Mladina type and maxillary sinusitis location. Ipsilateral sinusitis showed strong significance, with universal presence in Types 3, 4, 6, and 7 (100%, n=27, 6, 10, 9) versus lower rates in Type 2 (57.1%, n=12). Contralateral sinusitis also varied significantly, peaking in Type 7 (100%, n=9) and Type 5 (75.0%, n=9) but absent in Type 4 (0.0%, n=0). In agreement with, Shoib et al. [13] illustrated that the chance of finding maxillary sinusitis on ipsilateral to the severe septum deviation was significantly increased.

Similarly, Orhan et al. [14] reported that there was a significant discrepancy observed between the ipsilateral and contralateral MSV with regard to the side of the septal deviation.

Limitations of the study included that the sample size was relatively small. The study was in a single center. The study lacked comparison with control group.

Conclusions:

The Mladina types of deviated septum variations were associated with variations in clinical symptoms and patterns of maxillary sinusitis, which reflects the maxillary sinus and turbinate's dimensions' affection. Although overall turbinate and sinus dimensions were comparable between ipsilateral and contralateral sides, several deviation types showed noticeable asymmetry, suggesting compensatory turbinate hypertrophy and variations in sinus morphology.

List of abbreviations:
Nasal septal deviation: (NSD)
computed tomography: (CT)
standard deviation: (SD)
Anteroposterior: (AP)
Maxillary Sinus Volume: (MSV)

Ethics approval and consent to participate:

The study was done from February 2025, and January 2026 after approval from the Ethical Committee Our University Hospital. An informed written consent was obtained from the patients.

Consent for publication: Not applicable

Availability of data and material: Data is available on reasonable requests from corresponding author.

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