Original Article

Study to Correlate Deviated Nasal Septum and Middle Ear Ventilation

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Abstract

Background: Deviated Nasal Septum (DNS) is a common anatomical abnormality that may impair nasal airflow and alter nasopharyngeal dynamics. Because the Eustachian tube connects the middle ear to the nasopharynx, structural abnormalities of the nasal cavity may influence middle ear ventilation and contribute to Eustachian tube dysfunction (ETD). The aim is to study the correlation between Deviated Nasal Septum and middle ear. **Material and Methods:** This cross-sectional study was conducted over two years in the Department of Otorhinolaryngology, Era's Lucknow Medical College and Hospital, Lucknow. A total of 120 patients aged ≥18 years with DNS were included. Patients with allergic rhinitis, chronic sinusitis, nasal polyposis, upper respiratory tract infection, prior nasal or ear surgeries, or sleep apnea were excluded. Assessment included NOSE score, ETDQ-7 score, diagnostic nasal endoscopy, CT scan of nose and paranasal sinuses, tympanometry, pure tone audiometry, and Eustachian tube function tests (Valsalva, Toynbee, Williams). Statistical analysis included chi-square test and Student's t-test. **Results:** Majority of patients were aged 18–30 years (46.7%), with male predominance (53.3%). Congestion (75%) was the most common nasal symptom. Cracking/popping sounds (50%) were the most common ETD symptom. Type 1 DNS (20%) was most frequent. Type A tympanogram was seen in 65.8%, Type B in 24.2%, and Type C in 10%. ET dysfunction was present in 77.5% of patients. A significant association was found between laterality of DNS and side of ET dysfunction (χ^2=16.727; p=0.001). NOSE and ETDQ-7 scores were significantly higher in patients with ET dysfunction (p=0.012 and p<0.001 respectively). **Conclusion:** Deviated nasal septum is associated with Eustachian tube dysfunction and altered middle ear ventilation. Severity of nasal obstruction correlates with ETD symptom scores.

Keywords: Deviated Nasal Septum (DNS), Middle Ear Ventilation, Eustachian Tube Dysfunction, Tympanometry, Nasal Obstruction, Middle Ear Pressure.

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Introduction

The Eustachian tube (ET) is a dynamic anatomical channel that connects the middle ear cavity to the nasopharynx and plays a pivotal role in middle ear ventilation, pressure equalization, and clearance of secretions. Proper functioning of the ET maintains middle ear pressure close to atmospheric levels, ensures optimal tympanic membrane mobility, and preserves normal hearing physiology. Dysfunction of the ET leads to negative middle ear pressure, tympanic membrane retraction, accumulation of effusion, and predisposition to chronic otitis media and conductive hearing loss. ET dysfunction (ETD) may be mechanical or functional in origin, with mechanical obstruction being commonly attributed to nasal and nasopharyngeal pathologies.[1]

The nasal cavity and middle ear share close anatomical and physiological continuity through the nasopharynx. The mucosal lining of the nose, paranasal sinuses, Eustachian tube, and middle ear cleft is composed of pseudostratified ciliated columnar epithelium, forming a unified mucociliary clearance system. Consequently, structural abnormalities or inflammatory conditions within the nasal cavity may adversely influence ET function. Among structural abnormalities, Deviated Nasal Septum (DNS) is one of the most frequently encountered anatomical variations in otorhinolaryngology practice.

DNS has been reported to occur in a significant proportion of the population and may lead to impaired nasal airflow, increased nasal airway resistance, and altered pressure dynamics within the nasopharynx.[2] Turbulent airflow and chronic mucosal irritation secondary to septal deviation can cause edema around the pharyngeal opening of the ET, potentially compromising tubal patency. The resulting impairment in middle ear ventilation may manifest as tympanometric abnormalities and conductive hearing

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changes.

According to Awan et al. (2025), deviated nasal septum is significantly associated with Eustachian tube dysfunction, primarily due to altered nasal airflow and increased nasopharyngeal resistance. They further reported that correction of nasal obstruction results in significant improvement in Eustachian tube function and middle ear ventilation parameters.[3] Their findings established that progressive nasal obstruction was associated with increasingly negative middle ear pressure values, thereby reinforcing the mechanical linkage between nasal airflow resistance and middle ear ventilation.

The pathophysiological mechanisms linking DNS and ET dysfunction are multifactorial. First, septal deviation can increase nasal resistance and generate negative nasopharyngeal pressure during inspiration. This negative pressure may affect ET opening dynamics, especially during swallowing or yawning. Second, chronic mucosal inflammation resulting from turbulent airflow may lead to peritubal edema and lymphatic congestion. Third, structural asymmetry in nasal cavities may alter pressure distribution across the nasopharynx, influencing ET function on the ipsilateral side.

Despite growing evidence, the association between DNS and middle ear ventilation dysfunction remains a subject of debate. Variations in study design, heterogeneity in ET function assessment tools, and differences in septal deviation classification have contributed to inconsistent conclusions. While some studies demonstrate significant correlation and postoperative improvement following septal correction, others report variable outcomes. Therefore, further systematic evaluation using objective diagnostic modalities remains essential.

Tympanometry is widely used to assess middle ear pressure and compliance. A type A tympanogram indicates normal middle ear ventilation, type C suggests negative middle ear pressure due to ET dysfunction, and type B indicates middle ear effusion. Correlating septal deviation with tympanometric findings provides a non-invasive method to assess the functional impact of nasal structural abnormalities on middle ear physiology.

Understanding the correlation between DNS and middle ear ventilation dysfunction has important clinical implications. Patients presenting with nasal obstruction and unexplained aural symptoms such as ear fullness, mild conductive hearing loss, or recurrent effusion may benefit from comprehensive nasal evaluation. Early identification and correction of septal deviation may potentially prevent progression to chronic middle ear disease.

Given the anatomical continuity between the nasal cavity and middle ear, and the accumulating evidence from previous studies demonstrating varying degrees of association, it becomes clinically relevant to evaluate this relationship in a structured manner. The present cross-sectional study aims to assess the correlation between Deviated Nasal Septum and Middle Ear Ventilation Dysfunction using objective clinical and tympanometric parameters. Establishing a significant association may reinforce the importance of addressing nasal pathology as part of holistic management of middle ear disorders.

Aim and objectives: The aim is to study the correlation between Deviated Nasal Septum and middle ear ventilation

Materials and Methods

This is a hospital-based cross-sectional analytical study which was conducted over a period of two years and was carried out in the Department of Otorhinolaryngology at Era's Lucknow Medical College and Hospital, Lucknow.

The inclusion criteria were patients aged 18 years or older, patients diagnosed with deviated nasal septum on clinical and endoscopic evaluation, and patients willing to participate and provide informed written consent and the exclusion criteria were patients with nasal polyposis, patients diagnosed with allergic rhinitis, patients suffering from chronic rhinosinusitis, patients with active upper respiratory tract infection at the time of evaluation, patients with diagnosed obstructive sleep apnea, and patients with a history of previous septoplasty, functional endoscopic sinus surgery (FESS), or any prior ear surgery.

All eligible and consenting patients underwent a structured and comprehensive evaluation protocol. A detailed clinical history was obtained, including symptoms of nasal obstruction, nasal discharge, headache, ear fullness, hearing difficulty, and duration of complaints. Particular attention was given to symptoms suggestive of Eustachian tube dysfunction.

A thorough ENT examination was performed, including anterior rhinoscopy and otoscopic examination. The degree and type of septal deviation were assessed clinically and confirmed with diagnostic nasal endoscopy. Symptom severity related to nasal obstruction was quantified using the Nasal Obstruction Symptom Evaluation (NOSE) score, and Eustachian tube-related symptoms were assessed using the validated Eustachian tube dysfunction Questionnaire-7 (ETDQ-7).

Diagnostic nasal endoscopy was performed to evaluate the septal deviation, presence of spur or crest, turbinate hypertrophy, and patency of the Eustachian tube orifice. Radiological assessment was carried out using computed tomography (CT) scan of the nose and paranasal sinuses to document anatomical variations and assess associated sinus pathology.

Eustachian tube patency was evaluated using functional tests including Valsalva maneuver, Toynbee test, and Williams test to assess tubal opening and pressure equalization. Audiological evaluation was conducted in all patients. Tympanometry was carried out to measure middle ear pressure, tympanic membrane compliance, and to obtain tympanic peak pressure (TPP) values.

All clinical, endoscopic, radiological, and audiological findings were systematically recorded in a structured data collection proforma. The collected data were entered into a spreadsheet and subjected to appropriate statistical analysis using standard statistical software. Correlation analysis and relevant inferential statistical tests were applied, and a p-value of less than 0.05 was considered statistically significant.

RESULTS

Table 1: Demographic Profile of Study Population (N = 120)

Variable	Category	Frequency (n)	Percentage (%)
Age Group (Years)	18–30	56	46.7
	31–40	36	30.0
	41–50	14	11.7
	51–60	11	9.1
	61–70	3	2.5
	Total	120	100
Mean Age ± SD	33.82 ± 11.49 years		
Gender	Male	64	53.3
	Female	56	46.7
	Total	120	100

Interpretation: The study population comprised 120 patients with deviated nasal septum. The majority of participants were young adults, with 46.7% aged between 18–30 years, followed by 30% in the 31–40 years age group. The mean age was 33.82 ± 11.49 years, indicating predominance of early to middle adulthood. A slight male preponderance was observed, with males constituting 53.3% of cases (male-to-female ratio 1.14:1). The demographic distribution suggests that DNS-related middle ear dysfunction is more frequently encountered in the younger adult population.

Table 2: Distribution of Tympanometry Findings (N = 120)

SN	Tympanometry Type	Frequency (n)	Percentage (%)
1	Type A	79	65.8
2	Type B	29	24.2
3	Type C	12	10.0

Interpretation: Type A tympanogram was observed in 65.8% of patients, indicating normal middle ear pressure in the majority. However, 24.2% demonstrated Type B curves suggestive of middle ear effusion, and 10% showed Type C curves consistent with negative middle ear pressure. Thus, nearly one-third (34.2%) of patients exhibited abnormal middle ear ventilation patterns. These findings indicate that although many DNS patients maintain normal tympanometric status, a substantial proportion demonstrate objective evidence of Eustachian tube dysfunction and impaired middle ear pressure regulation.

Table 3: Distribution of Eustachian tube function Tests (N = 120)

Test	Negative (n)	Positive (n)	Negative (%)	Positive (%)
Valsalva Maneuver	93	27	77.5	22.5
Toynbee Maneuver	93	27	77.5	22.5
Williams Test	93	27	77.5	22.5

Interpretation: A high proportion of patients (77.5%) demonstrated abnormal results across all three Eustachian tube function tests—Valsalva, Toynbee, and Williams maneuvers. Only 22.5% showed normal Eustachian tube patency. The uniformity of abnormal results across different physiological testing methods strengthens the evidence of functional impairment. These findings indicate that mechanical obstruction or altered nasopharyngeal pressure dynamics secondary to DNS may significantly compromise active and passive Eustachian tube opening mechanisms, thereby affecting middle ear ventilation.

Table 4: Association of Laterality of DNS with Side of Eustachian tube dysfunction (N = 120)

ET Dysfunction	Left DNS (n=70)	%	Right DNS (n=50)	%
Left	33	47.1	9	18.0
Right	12	17.1	24	48.0
Bilateral	8	11.5	7	14.0
Asymptomatic	17	24.3	10	20.0

Chi-square (χ^2) = 16.727
p-value = 0.001

Interpretation: A statistically significant association was found between the side of septal deviation and the side of Eustachian tube dysfunction (χ^2=16.727; p=0.001). Patients with left-sided DNS predominantly exhibited left-sided ET dysfunction (47.1%), whereas right-sided DNS was significantly associated with right-sided ET dysfunction (48%). This laterality correlation supports a direct anatomical and functional relationship between septal

deviation and ipsilateral Eustachian tube compromise, suggesting that mechanical obstruction and altered airflow on the affected side contribute to localized middle ear ventilation impairment.

Table 5: Association of Eustachian tube function with NOSE and ETDQ-7 Scores

Parameter	Normal ET Function (n=27) Mean ± SD	ET Dysfunction (n=93) Mean ± SD	t-value	p-value
NOSE Score	9.08 ± 2.46	11.30 ± 2.85	-2.571	0.012
ETDQ-7 Score	11.20 ± 6.50	20.07 ± 6.49	-6.021	<0.001

Interpretation: Patients with ET dysfunction had significantly higher NOSE scores (11.30 ± 2.85) compared to those with normal ET function (9.08 ± 2.46), indicating greater nasal obstruction severity (p=0.012). Similarly, ETDQ-7 scores were markedly elevated in the ET dysfunction group (20.07 ± 6.49 vs. 11.20 ± 6.50; p<0.001). The strong statistical significance, particularly for ETDQ-7, demonstrates a clear correlation between subjective symptom burden and objective ET dysfunction. Increased nasal obstruction severity appears directly associated with impaired middle ear ventilation.

Table 6: Distribution of Audiometry Findings (N = 120)

SN	Hearing Status	Frequency (n)	Percentage (%)
1	Normal	79	65.8
2	Mild to Moderate Conductive Hearing Loss	41	34.2
3	Severe Conductive Hearing Loss	0	0.0

Interpretation: Pure tone audiometry revealed normal hearing in 65.8% of patients. However, 34.2% demonstrated mild to moderate conductive hearing loss, while none had severe conductive deficits. The absence of severe hearing loss suggests that middle ear ventilation impairment associated with DNS may initially produce mild conductive deficits rather than advanced pathology. The proportion of patients with conductive hearing loss corresponds closely with the proportion showing abnormal tympanometric findings, reinforcing the relationship between Eustachian tube dysfunction and impaired sound transmission.

Table 7: Overall Prevalence of Eustachian tube dysfunction

ET Function Status	Frequency (n)	Percentage (%)
Normal	27	22.5
Dysfunction	93	77.5

Interpretation: Eustachian tube dysfunction was observed in 77.5% of patients with deviated nasal septum, while only 22.5% exhibited normal function. This high prevalence underscores the significant impact of nasal structural abnormalities on middle ear ventilation mechanisms. Given that the study excluded confounding conditions such as allergic rhinitis and chronic sinusitis, the observed dysfunction can be reasonably attributed to DNS itself. These findings strengthen the hypothesis that septal deviation is an independent risk factor for impaired Eustachian tube function.

Discussion

The present cross-sectional study was conducted to evaluate the correlation between deviated nasal septum (DNS) and middle ear ventilation dysfunction using objective tympanometric findings, Eustachian tube (ET) function tests, audiometry, and validated symptom scores including NOSE and ETDQ-7. The findings of this study demonstrate a high prevalence of Eustachian tube dysfunction (77.5%) among patients with DNS, a statistically significant association between the side of septal deviation and ipsilateral ET dysfunction (p = 0.001), and a strong relationship between symptom severity scores and objective ET impairment. These observations reinforce the concept that DNS is not merely a structural nasal deformity but may function as an independent anatomical factor influencing middle ear ventilation.

The demographic profile of the study population revealed a mean age of 33.82 ± 11.49 years, with the highest proportion of patients in the 18–30 year age group (46.7%) and a slight male predominance (53.3%). Comparable demographic trends have been reported in previous studies. Lee et al,[4] observed a mean age of 41.2 ± 17.1 years among 120 septoplasty patients, with 66.7% males. Similarly, Rathaur et al,[7] reported a mean age of 36 years and a male predominance of 60% in patients undergoing nasal obstruction surgery. The predominance of young adults in these studies suggests that symptomatic nasal obstruction and associated ET dysfunction are more frequently encountered in early and middle adulthood, likely due to greater awareness of nasal symptoms and occupational impact on quality of life.

One of the most striking findings of the present study is the high overall prevalence of ET dysfunction, observed in 77.5% of patients. This prevalence is considerably higher than the 29.2% preoperative ETD prevalence reported by Lee et al,[4] who assessed ETD using ETDQ-7 scoring in septoplasty candidates. The discrepancy may be attributed to methodological differences. While Lee et al. relied primarily on subjective ETDQ-7 criteria, the present study incorporated objective physiological ET function tests, including Valsalva, Toynbee, and Williams maneuvers, along with tympanometry. Objective testing may detect subclinical dysfunction that is not captured by symptom scoring alone. Furthermore, Son et al,[6] in their

systematic review and meta-analysis of septoplasty outcomes, reported that ET dysfunction was nearly twice as common on the narrowed side of septal deviation compared to the non-deviated side (OR 1.94; $p = 0.04$). They also demonstrated that ET dysfunction before septoplasty was approximately 4.46 times higher than after septoplasty ($p < 0.001$), emphasizing the strong association between structural nasal obstruction and ET impairment. These findings are consistent with the high prevalence observed in our study and support the concept that DNS significantly compromises ET function.

Tympanometric evaluation in the present study revealed that 34.2% of patients exhibited abnormal middle ear pressure patterns, with 24.2% demonstrating Type B curves suggestive of middle ear effusion and 10% showing Type C curves indicative of negative middle ear pressure. This proportion closely parallels findings reported by Rathaur et al,[5] who observed preoperative Type C tympanograms in 35% of ears and Type B curves in 3.3% of cases. They reported statistically significant postoperative improvement in tympanometric values following nasal obstruction surgery ($p < 0.05$), highlighting the reversible nature of ET dysfunction when nasal airflow is restored.

A particularly important finding in the present study is the statistically significant association between the side of septal deviation and the side of ET dysfunction ($\chi^2 = 16.727$; $p = 0.001$). Patients with left-sided DNS predominantly exhibited left-sided ET dysfunction (47.1%), whereas right-sided DNS was significantly associated with right-sided dysfunction (48%). This laterality correlation strongly supports a localized mechanical and aerodynamic effect rather than a generalized inflammatory mechanism. Lee et al,[4] similarly reported that ETD prevalence was significantly higher on the convex (narrowed) side of septal deviation (28.3% vs. 15.8%; $p < 0.05$), particularly in unilateral ETD cases. Son et al. [6] further demonstrated that ET dysfunction was nearly twice as common on the deviated side compared to the contralateral side. These findings collectively strengthen the hypothesis that altered nasal airflow dynamics and localized pressure gradients in the nasopharynx directly influence ipsilateral ET patency.

The present study also demonstrated a significant correlation between symptom severity and objective ET dysfunction. Patients with ET dysfunction had significantly higher NOSE scores ($p = 0.012$), indicating greater nasal obstruction severity, and markedly elevated ETDQ-7 scores ($p < 0.001$), reflecting increased ET-related symptom burden. Lee et al,[6] reported that septoplasty resulted in significant postoperative improvement in ETDQ-7 scores, particularly in patients with preoperative positive ETD, with greater improvement observed on the convex side (66.7% vs. 33.3%). Awan et al,[7] in their systematic review and meta-analysis, concluded that nasal surgery produces consistent and significant improvement in ETDQ-7 scores, tympanometric findings, and overall ET function outcomes. The concordance between subjective symptom burden and objective ET dysfunction observed in our study aligns closely with these findings and suggests that validated symptom scoring tools can effectively reflect physiological impairment.

Audiometric assessment in the present study revealed that 34.2% of patients had mild to moderate conductive hearing loss, while none exhibited severe conductive deficits. Notably, the proportion of patients with conductive hearing loss corresponded closely to the proportion with abnormal tympanometric findings (34.2%), reinforcing the link between ET dysfunction, negative middle ear pressure, and impaired sound transmission. Rathaur et al,[5] similarly observed improvement in middle ear pressure and ET function following nasal obstruction surgery, leading to improved hearing outcomes.

Radiological evidence further supports the long-term consequences of persistent ET dysfunction secondary to DNS. Sistani et al,[8] evaluated CT scans of 150 patients with septal deviation and demonstrated a significant relationship between septal deviation severity and chronic otitis media ($p < 0.05$).

The pathophysiological mechanisms underlying the association between DNS and ET dysfunction are multifactorial. Altered nasal airflow due to septal deviation increases nasal airway resistance and generates negative pressure gradients within the nasopharynx. Turbulent airflow may lead to mucosal irritation and edema around the pharyngeal opening of the ET, narrowing the lumen and impairing active opening during swallowing or Valsalva maneuver. Awan et al,[7] described the “unified airway” theory, wherein nasal airflow disturbances influence ET function through shared mucosal and autonomic mechanisms. The strong ipsilateral correlation observed in the present study further supports a localized aerodynamic effect rather than systemic inflammation alone.

The clinical implications of these findings are significant. Routine nasal evaluation should be considered in patients presenting with unexplained ET dysfunction or mild conductive hearing loss. Early identification and correction of septal deviation may prevent progression to chronic otitis media, mastoid changes, and long-term auditory impairment. The significant association between symptom severity scores and objective dysfunction suggests that validated tools such as NOSE and ETDQ-7 may aid in screening and monitoring patients.

The high prevalence of Eustachian tube dysfunction (77.5%) observed in the present study is supported by existing evidence demonstrating that nasal septal deviation can independently impair middle ear ventilation. Previous studies have shown that nasal obstruction alters pressure dynamics within the nasopharynx, thereby affecting Eustachian tube opening and function.[9] This aligns with our findings where a large proportion of patients exhibited ET dysfunction despite exclusion of inflammatory conditions.

Kaya et al. reported that patients with deviated nasal septum show significant improvement in Eustachian tube function and middle ear pressure following septoplasty, suggesting a direct mechanical relationship between nasal obstruction and ET dysfunction.[10] This is comparable to our results, where abnormal tympanometric findings were observed in 34.2% of patients, indicating compromised middle ear ventilation.

Furthermore, studies on ET pathophysiology have emphasized that increased nasal resistance and altered airflow patterns can impair the active opening mechanism of the Eustachian tube, leading to negative middle ear pressure and effusion.[11] This supports our observation of a strong correlation between NOSE scores and ET dysfunction, indicating that severity of nasal

obstruction directly influences middle ear physiology.

Additional evidence suggests that nasal pathologies, including septal deviation, can lead to functional obstruction at the pharyngeal opening of the Eustachian tube due to mucosal edema and pressure imbalance.[12] This mechanism is consistent with our finding of a significant association between DNS laterality and ipsilateral ET dysfunction.

Moreover, the importance of objective assessment of ET function using tympanometry and physiological tests has been emphasized in recent literature, as symptom-based evaluation alone may not accurately reflect functional impairment.[13] This validates our study design, which incorporated both subjective (NOSE, ETDQ-7) and objective (tympanometry, functional tests) parameters.

The present study is strengthened by its use of objective ET function testing, tympanometry, and statistical analysis demonstrating laterality correlation. However, its cross-sectional design limits causal inference, and postoperative follow-up was not performed to assess reversibility. Future longitudinal studies evaluating pre- and postoperative ET function in this cohort would provide stronger causal evidence.

In conclusion, the present study demonstrates a statistically significant association between deviated nasal septum and Eustachian tube dysfunction, with strong ipsilateral correlation and significant association with symptom severity and conductive hearing changes. These findings are consistent with recent systematic reviews and meta-analyses , supporting DNS as an independent anatomical risk factor for impaired middle ear ventilation and highlighting the importance of comprehensive nasal assessment in otological practice.

Conclusion

A high proportion of patients (77.5%) exhibited Eustachian tube (ET) dysfunction on functional testing, indicating that septal deviation has a substantial impact on ET patency. Tympanometric abnormalities (Type B and Type C curves) were observed in 34.2% of patients, reflecting impaired middle ear pressure regulation. Additionally, 34.2% of cases showed mild to moderate conductive hearing loss on audiometric evaluation, further supporting the functional consequences of ET compromise.

A statistically significant correlation was found between the laterality of DNS and the side of ET dysfunction ($\chi^2 = 16.727$; $p = 0.001$), highlighting an ipsilateral anatomical relationship. Patients with ET dysfunction had significantly higher NOSE and ETDQ-7 scores compared to those with normal ET function , establishing that increased severity of nasal obstruction is directly associated with greater middle ear ventilation impairment.

The findings suggest that DNS contributes to ET dysfunction through mechanical obstruction, altered nasal airflow dynamics, and subsequent negative middle ear pressure changes. Persistent dysfunction may predispose patients to tympanic membrane retraction, middle ear effusion, and conductive hearing deficits.

Overall, DNS should be recognized not only as a cause of nasal obstruction but also as a potential contributing factor to middle ear pathology. Comprehensive evaluation of patients with septal deviation should include assessment of ET function and hearing status.

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Conflicts of interest

There are no conflicts of interest.

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