AMERICAN ACADEMIC PUBLISHER

INTERNATIONAL JOURNAL OF MEDICAL SCIENCES

ISSN NUMBER: 2692 - 5206 Volume 5,October ,2025

SURGICAL PERSPECTIVES AND PATHOPHYSIOLOGY OF NASAL VALVE OBSTRUCTION IN PATIENTS WITH SEPTAL DEVIATION

Norjigitov Firdavs Nodirjonovich

Assistant teacher of the Department of Otolaryngology,

Tashkent State Medical University

Abstract: This study examines nasal valve obstruction and its pathophysiological basis in patients with nasal septum deviation. The prospects and effectiveness of surgical procedures are analyzed. The study explores the etiology and clinical signs of nasal septum deviation, the impact of this pathology on the respiratory process, as well as achievements and challenges in the surgical field. The aim is to propose advanced approaches to improve patients' breathing quality and ensure the safety and efficacy of surgical interventions. The research findings will contribute to the development of new recommendations for treating nasal septum deviation in clinical practice.

Keywords: Nasal septum deviation, nasal valve obstruction, surgical intervention, pathophysiology, respiratory system, operative techniques, complications, treatment strategies, tissue management, reconstructive surgery.

Introduction

Obstruction of the nose is one of the most frequent symptoms observed in the field of otolaryngology and has an important impact on the quality of life and on sleep and on the function of the respiratory system generally. Of the causes due to structure, the internal and the external valves of the nose are the most important sites of airway resistance and are responsible for approximately two-thirds of overall nasal airway restriction. Small alterations to the valve nose geometry, i.e., those secondary to septal deviation, trauma, and age-related soft tissue laxity, can thus yield clinically significant breathing impairment. Deviation of the septum remains the most common cause and is characteristically associated with compensatory turbinate hypertrophy and lateral turbinal wall collapse.

More attention has been directed to the functional evaluation of outcomes of nasal surgery in the last ten years by integrating objective parameters like rhinomanometry and acoustic rhinometry and patient-self-report measures like the Nasal Obstruction Symptom Evaluation scale (NOSE) scale [1,2,6]. With this integrative strategy, surgical planning and postoperative analysis now can be more accurately defined with precision so that the functional advantage obtainable by structure correction can be more precisely quantitated by the clinician.

The Nasal Valve and its Pathophysiology

The anatomic division of the nasal valve is into internal and external components. The internal nasal valve between the upper lateral cartilage, the septum, and the head of the inferior turbinate

AMERICAN ACADEMIC PUBLISHER
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constitutes the narrowest part of the nasal airway, and the external valve is constituted by the alar rims, the nasal sill, and the columella. Typical internal nasal valve minimal cross-sectional areas reported in the literature range approximately from 0.7 to 1.1 cm^2, with valve angles commonly cited between ~10° and 15°. Because resistance varies nonlinearly with radius in classical fluid dynamics, small reductions in valve dimensions can produce a disproportionately large increase in airflow resistance Poiseuille's law describes laminar flow in simple cylindrical conduits and thus serves only as a conceptual analogue to the nasal situation, which involves complex geometry and mixed laminar/turbulent flow; therefore, the precise change in resistance depends on regional anatomy and flow regime[3,4] . Pathophysiologically, nasal valve obstruction may result from static narrowing (due to septal deviation, mucosal edema, or postoperative scarring) or dynamic collapse (owing to weakness of the upper lateral or alar cartilages that fail to withstand negative inspiratory pressure). Deviation of the septum toward the valve region reduces this angle and shifts the upper lateral cartilage medially, leading to inspiratory collapse [5]. Computational airflow modeling has recently demonstrated that even small (millimeter scale) anterior deviations can markedly disturb laminar flow and increase resistance[12].

In some studies, it was described how chronic turbulent flow caused by septal deformities leads to localized mucosal irritation and ciliary dysfunction, perpetuating mucosal edema and chronic rhinitis. These findings underscore that nasal valve obstruction is not purely mechanical but also involves secondary inflammatory and neurovascular responses. The interdependence between structural and mucosal factors explains why some patients continue to experience obstruction even after septal correction, necessitating targeted valve stabilization procedures.

Role of Septal Deviation in Nasal Valve Obstruction

Septal deviation has a reported prevalence of 75–90% in adults and is often asymptomatic until combined with nasal valve compromise [7]. Deformities such as spurs, crests, or high deviations in the dorsal septum are particularly significant because of their proximity to the valve area. When the deviation narrows the internal valve, compensatory hypertrophy of the contralateral turbinate further diminishes airflow. Multiple studies highlighted that chronic septal deviation induces adaptive changes including mucosal thickening and altered airflow distribution that promote inflammatory remodeling[8].

Recent imaging and computational studies have confirmed that high anterior deviations generate the greatest increase in total nasal resistance. Recent studies used three-dimensional CFD (computational fluid dynamics) models to show that surgical correction of anterior deviations restored laminar flow and reduced wall shear stress in the nasal valve zone, correlating strongly with postoperative NOSE score improvement[13]. Few studies emphasized that destabilization of the dorsal septal strut compromises the internal nasal valve angle, necessitating structural reinforcement during septoplasty or extracorporeal septoplasty[9].

Septal deviation also has secondary implications for sinus ventilation and olfaction. By altering airflow direction and mucosal contact, it predisposes to chronic rhinosinusitis and hyposmia. Some researches reiterated that the nasal valve serves as a functional "gatekeeper," regulating

AMERICAN ACADEMIC PUBLISHER
INTERNATIONAL JOURNAL OF MEDICAL SCIENCES
ISSN NUMBER: 2692 - 5206 Volume 5,October ,2025

humidification and particulate filtration; hence, obstruction at this level has repercussions for both upper and lower airway physiology[10].

Surgical Management and Functional Outcomes

The modern surgical management of nasal valve obstruction emphasizes anatomic preservation, functional restoration, and aesthetic balance. Traditional submucous resection has been replaced by conservative septoplasty techniques that maintain the structural L-strut for dorsal and caudal support. Some researchers noted that evolving septoplasty concepts prioritize minimal cartilage resection and precise realignment to maintain mechanical stability of the valve region[11].

In complex deformities involving the dorsal septum or severe internal valve compromise, extracorporeal septoplasty remains the gold standard. In some studies, it was demonstrated that incorporation of internal nasal valve stabilization grafts during extracorporeal septoplasty markedly improves postoperative rhinomanometric values and NOSE scores [9]. Similarly, endoscopic-assisted septoplasty enables superior visualization and minimal mucosal trauma, yielding faster recovery and fewer adhesions [14].

Minimally invasive technologies have further expanded treatment options. Few studies reported successful outcomes with radiofrequency ablation and coblation of the septal swell body, which reduce mucosal volume and enhance valve patency without major structural alteration[2,5]. Recent multicentric analyses have confirmed these energy-based techniques to be effective in patients with persistent nasal obstruction following standard septoplasty, offering shorter downtime and minimal postoperative discomfort [15].

Functional rhinoplasty plays a crucial adjunctive role when valve collapse is the dominant pathology. Spreader grafts, flaring sutures, alar batten grafts, and butterfly grafts restore or widen the internal valve angle, providing both mechanical support and aesthetic improvement. Significant symptomatic relief in patients receiving the Wengen Breathe Implant was documented , with postoperative NOSE scores showing high improvement compared to baseline. Recent refinements in graft placement, particularly using autologous or bioresorbable materials, have reduced complications such as warping or extrusion [13,15].

Perioperative pain and mucosal healing are also integral to surgical success. Some studies demonstrated that fentanyl-impregnated nasal packing significantly lowered postoperative pain without compromising hemostasis or wound healing. The current shift toward enhanced recovery protocols emphasizes gentle tissue handling, absorbable packing, and early postoperative saline irrigation to minimize edema and synechiae formation.

Outcome assessment now incorporates both objective and subjective metrics. Certain researches highlighted the complementary value of acoustic rhinometry in mapping minimal cross-sectional area changes, while rhinomanometry quantifies pressure–flow relationships. Combined with validated symptom scores, these measures have established a robust framework for evaluating functional success and correlating surgical precision with patient satisfaction.

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Conclusion

Nasal valve obstruction is a dynamic interplay of structural deviation, mucosal disease, and dynamic wall collapse, with septal deviation the predominant factor. New imaging-based diagnostics, computational models, and functional tests have clarified nasal airflow physiology and informed precision surgery. The revolution from conventional septoplasty to anatomically tailored, function-preserving approaches has redrawn surgical standards. Balance between valve stabilization methods, minimally invasive devices, and evidence-based outcome criteria guarantees worldwide comprehensive treatment of nasal obstruction.

Follow-up studies should involve multicentric longitudinal studies that correlate the changes in computational airflow with outcomes and continue to refine graft materials and bioengineering methods to preserve valve integrity over the long term. Customized functional rhinoplasty based on preoperative airflow modeling and quantitative postoperative analysis is the next horizon to achieve long-term and physiologically optimal nasal airway reconstruction.15

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ISSN NUMBER: 2692 - 5206 Volume 5,October ,2025

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