Review Article

**Septoplasty alone is not suitable for most structural nasal obstructions**

Jin-Feng Liu a,*, Zhan-Feng Yan b, Zhi-Jin Zhang c, Ning-Yu Wang a

a Department of Otorhinolaryngology Head and Neck Surgery, Beijing Chaoyang Hospital, Capital Medical University, Beijing, 100020, China
b Department of Otorhinolaryngology, Dongzhimen Hospital, Beijing University of Chinese Medicine, Beijing, 100700, China
c The Third Clinical Medical School, Capital Medical University, Beijing, 100009, China

Received 4 January 2020; received in revised form 18 May 2020; accepted 20 May 2020
Available online 4 July 2020

**KEYWORDS**
Septoplasty; Nasal septum deviation; Structural nasal obstruction; Nasal ventilation expansion surgery; Nasal cavity

## Abstract

Septoplasty is widely used in the treatment of structural nasal obstructions, and it also has a good effect and a high degree of postoperative satisfaction. However, there are a large number of structures that demonstrate abnormalities related to structural nasal obstruction, including the external nose, maxilla, nasal cavity and paranasal sinus. Nasal septum deviation is only one sign of structural nasal obstruction and does not represent all possible structural abnormalities of the nasal cavity and its surrounding structures. Septoplasty is only performed to correct deviations of the nasal septum, which in many cases is obviously insufficient in restoring the symmetry of the nasal structure. Therefore, septoplasty alone is not suitable for the treatment of most structural nasal obstructions. Nasal ventilation expansion surgery, which typically covers more abnormal structural correction procedures than septoplasty, should be used when describing the treatment of structural nasal obstruction.

Copyright © 2020 Chinese Medical Association. Production and hosting by Elsevier B.V. on behalf of KeAi Communications Co., Ltd. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

* Corresponding author. Department of Otolaryngology Head and Neck Surgery, Beijing Chaoyang Hospital, Capital Medical University, No. 8, Gongti South Road, Chaoyang District, Beijing City, 100020, China.
E-mail address: sanming_1978@163.com (J.-F. Liu).
Peer review under responsibility of Chinese Medical Association.

https://doi.org/10.1016/j.wjorl.2020.05.007
2095-8811/© 2020 Chinese Medical Association. Production and hosting by Elsevier B.V. on behalf of KeAi Communications Co., Ltd. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).
Introduction

The nasal cavity performs important physiological functions, including warming, humidification, and filtering of the ventilated air, ciliary clearance, immunologic defence, and olfaction. Normal nasal structure and anatomical morphology play an important role in maintaining normal nasal function. Structural abnormalities of the nasal cavity and its surrounding structure can lead to changes in airflow dynamics and nasal resistance known as structural nasal obstruction, which affects the ventilation, temperature regulation and humidification functions of the nasal cavity.

Septoplasty is widely used in the treatment of structural nasal obstruction. A large number of studies have shown that septoplasty has a good effect. Van Egmond et al. performed a randomized controlled trial (RCT) in this field and showed that septoplasty is more effective than nonsurgical management for nasal obstruction in adults with a septal deviation. However, there is some scientific understanding that I would like to emphasize. According to an analysis of structural nasal obstruction and nasal structural abnormalities, both the nasal cavity and its surrounding structures (including bone and soft tissue) can be structurally abnormal, resulting in structural nasal obstruction; thus, nasal septum deviation is only one of a number of main structural abnormalities. Therefore, it is necessary to re categorize functional septoplasty. Currently, a more accurate surgical name is needed to better generalize surgical procedures used to treat structural nasal obstruction while reflecting the purpose of the operation. The definition of nasal ventilation expansion surgery (NVES) can cover additional abnormal structural correction procedures and would not be limited to septoplasty. NVES can be used to replace septoplasty when describing the treatment of structural nasal obstruction.

Nasal septum deviation is only one nasal anatomical abnormality that causes structural nasal obstruction

Nasal obstruction is the most common complaint in nasal clinics and seriously affects the quality of life of patients. Nasal obstruction may be acute or chronic, and can be caused by a variety of conditions, including rhinitis, chronic rhinosinusitis with or without nasal polyposis, medications, neoplasms and anatomical abnormalities. Patients with chronic nasal obstruction often have anatomical abnormalities of the nasal cavity and its surrounding structures. Nasal septum deviation (NSD) is the most common structural anomaly of the nasal cavity. However, some structural nasal obstruction patients may not present with deviation of the nasal septum. As a result of nasal development and nasal trauma, the structural changes in the nasal cavity and nasal sinuses can be very extensive. Abnormalities of the nasal valve are due to deformities of the external nasal cartilage bracket (Fig. 1 and Fig. 2), and a series of changes can occur in different parts of the nasal cavity structure, including the middle turbinate, inferior turbinate, nasal septum, anterior ethmoidal complex and uncinate process. Moreover, these structural changes may result in asymmetry between the sides of the nasal cavity, a decrease in total nasal ventilation, and, eventually, structural nasal obstruction. Hence, for patients complaining of nasal obstruction, all nasal structures that may contribute to the symptoms shown must be separately and carefully assessed to establish an appropriate treatment plan and thereby minimize the failure rate of surgery. Most of the time, NSD is one of a number of abnormal structures in structural nasal obstruction, not the only one. Rather than NSD, structural nasal obstruction should be considered the true disease in this case.

For patients with structural nasal obstruction, the objective evaluation of NSD is still difficult, especially because it is difficult to accurately determine the importance of NSD in the aetiology of the structural nasal obstruction. Anterior rhinoscopy and nasal endoscopy are considered the gold standards for the evaluation of NSD; however, these methods depend on the clinician’s experience. In addition, the examiner’s judgement of the precise location, deviation angle, and clinical impact on the patient of NSD can also be variable. Rhinomanometry and acoustic rhinometry have shown high sensitivity in assessing anterior NSD, whereas estimation of the deep septal deviations appear to be less accurate. Peak nasal inspiratory flowmetry (PNIF) has significant power to discriminate pathologic from healthy subjects. However, PNIF is unable to locate the narrowest point of the nasal obstruction. It is also influenced by collapsibility of the nasal valve. Andrews et al further demonstrated that PNIF does not correlate with the SNOT-22 disease-specific questionnaire. A national survey in the United Kingdom also showed that only 2% of respondents routinely used an objective assessment tool to evaluate nasal airflow/patency preoperatively. However, most patients with chronic nasal obstruction underwent clinical photography prior to undergoing surgery, because CT scans can provide a good means to understand the structural abnormalities of the nasal cavity and paranasal sinuses in patients with chronic nasal obstruction. Nevertheless, the angle of the NSD in the CT morphology was also unable to predict the severity of the nasal obstruction. This result once again shows the unparallel relationship between NSD and nasal obstruction. Therefore, we need to comprehensively evaluate nasal structural abnormalities in patients with nasal obstruction, not just those of the septal deviation.

Because the nasal structure varies greatly among different individuals, it is necessary to individually evaluate abnormal nasal structures on a per patient basis. However, for a particular patient, what structural changes are considered abnormal? Which structures need to be modified? At present, there is no exact indicator for making these judgments. The complexity of structural factors that underly nasal obstruction may also affect the formation of an international consensus on the treatment of NSD. The causes of nasal obstruction must be carefully analysed before a diagnosis of structural nasal obstruction can be made. Overall, the nasal structure needs to be evaluated on both sides in four aspects: (1) the external nasal morphology; (2) the nasal valve, nasal septum and nasal turbinate (including the superior, middle and inferior turbinate); (3) the anterior ethmoidal complex (including the agger nasi cells and ethmoidal bulla) and
Septoplasty is only one of the surgical components for the treatment of structural nasal obstruction

Although septoplasties have been performed for thousands of years (first recorded in the Ebers Papyrus, 3500 BC, Egypt). The septoplasty for chronic nasal obstruction is still an important part of endoscopic sinus surgery. Because most patients with nasal obstruction without tumour and inflammation are accompanied with deviation of the nasal septum, septoplasty alone can also achieve a high degree of postoperative satisfaction. However, some patients still suffer from persistent obstruction after their primary septoplasty. Williams et al showed that persistent nasal obstruction may be seen in patients with a narrow, high arched hard palate despite prior nasal surgical intervention. Currently, there is still a knowledge gap in this field of surgery. The literature also suggests that septoplasty is only one of the surgical components for the treatment of structural nasal obstruction; the surgery should also correct the other structural factors hindering nasal ventilation as much as possible and restore the structural symmetry of the bilateral nasal cavity beyond what can be achieved with septoplasty. Therefore,
nasal cavity: intranasal structures (turbinate and nasal structures affecting the physical volume or width of the nasal obstruction while reflecting the purpose of the generalise the surgical procedures used to treat structural malformities of the nasal valve as well. Therefore, there is a need for a more accurate name that could better manage the surgical procedures used in the management of structural nasal obstructions because this condition can be commonly caused by structural abnormalities of the nasal valve as well. Therefore, there is a need for a more accurate name that could better generalize the surgical procedures used to treat structural nasal obstruction while reflecting the purpose of the operation. The surgical implications of NVES can include all structures affecting the physical volume or width of the nasal cavity: intranasal structures (turbinate and nasal septum) and structures surrounding the nasal cavity (nasus externus, nasal valve, nasal pyriform aperture, anterior ethmoidal complex and maxillary sinus, etc., Fig. 3). Hence, we suggest that NVES should be used instead of septoplasty in the treatment of structural nasal obstruction.

In patients with chronic nasal obstruction, because the nasal structure varies greatly among different individuals, it is necessary to individually evaluate the abnormal nasal structure according to different patients. When a patient has many structural abnormalities at the same time, how can the structure of surgical intervention be chosen? At present, the surgical procedures used are still based on the clinical experience of the doctor. Therefore, the understanding of the pathological changes of the remaining nasal cavity morphology apart from NSD in patients with nasal obstruction is helpful for us to develop a surgical plan and determine the surgical components before the operation.

Structural remodelling of the nasal cavity after septum deviation may be the cause of structural nasal obstruction

It is undeniable that deviation of the nasal septum is the most important cause of structural nasal obstruction. However, in many cases, the occurrence of NSD is not consistent with the time of nasal obstruction. Most patients with nasal obstruction have progressive aggravation. This suggests that as a result of deviation of the nasal septum, the nasal cavity has experienced a long adaptive process (compensation), and NSD may be the driving factor for the remodelling of other nasal structures. We think that other structures of the nasal cavity have the ability to adjust or compensate adaptively as a result of NSD. This adaptive structural adjustment of the nasal cavity and paranasal sinuses is called plasticity in the present review. The plasticity of the nasal structure is the key to its compensation for certain structural changes in the nasal cavity. Remodelling of the nasal cavity and paranasal sinuses refers to the structural changes that occur as a result of their plasticity. The purpose of the natural remodelling of the nasal cavity and paranasal sinus is to improve the nasal ventilation function, and if the structural remodelling of the nasal cavity finally allows respiratory function, this compensation does not result in disease and is considered successful (Fig. 1). This may be why the incidence of NSD is as high as 80% in people without nasal obstruction. If this compensation ultimately leads to a deterioration of the nasal ventilation function, however, failed compensation occurs and leads to structural nasal obstruction, which is a reasonable explanation for the time difference between the occurrence of NSD and the occurrence of nasal obstruction in patients.

Furthermore, the plasticity of the nasal cavity and paranasal sinuses may be related to their developmental stage. Deviation of the nasal septum can occur at different stages of development, and the remodelling changes of other structures of the nasal cavity may also differ. On the whole, the remodelling of the nasal cavity and paranasal sinus can be divided into bone structure remodelling and mucous membrane remodelling. We speculate that the remodelling of the osseous structure mainly occurs during the development of the nasal cavity and paranasal sinuses, while mucous remodelling can occur at any time in life (Fig. 4). Due to airflow changes, compensatory hypertrophy of the nasal mucosa on the concave side is often found. Furthermore, there may be greater lymphocytic infiltration and squamous metaplasia in the lateral wall mucosa on the concave side than on the convex side, which may be evidence of mucosal remodelling. Based on the inference of the structural remodelling of the nasal cavity and paranasal sinus, the septoplasty alone cannot completely restore the symmetry of the nasal cavity between the two sides, and the remodelling structure should

Fig. 3 The range of nasal ventilation expansion surgeries (NVESs) and the relationship of NVES with septoplasty. NVES covers most of the surgical aspects of structural nasal obstruction, and septoplasty is only one part of NVES. FESS: functional endoscopic sinus surgery; MS: maxillary sinus; ES: ethmoidal sinus.
be carefully identified and treated at the same time during septoplasty.

Finally, we would like to stress once again that structural nasal obstruction should be an independent disease that may be related to the structural remodelling of the nasal cavity and paranasal sinuses. All structures involved in nasal remodelling or resulting in structural asymmetry should form the focus of the NVES. However, according to the degree of structural abnormality, the components of the surgery should be individualized. Septoplasty alone is not suitable for the treatment of most structural nasal obstructions because it cannot completely reflect the connotation and purpose of surgery.

Fund program

The general work was supported by the Capital Medical University Student Research Innovation Project, China (No. XSKY2020158).

Declaration of Competing Interest

The authors have no relevant competing interests to declare in relation to this manuscript.

References

1. Han DM, Zhang L. Nasal cavity ventilation expansion techniques. Acta Otolaryngol. 2011;131:1244–1248.
2. Yuan XP, Guo QR, Geng CL, Liu Y, Wang M, Xing ZM. Subjective and objective evaluation and correlation analysis of pre- and post- operation in patients with structural nasal obstruction. Zhonghua Er Bi Yan Hou Tou Jing Wai Ke Za Zhi. 2016;51:902–908.
3. van Egmond MMHT, Rovers MM, AHJ T, van Neerbeek N. Septoplasty for nasal obstruction due to a deviated nasal septum in adults: a systematic review. Rhinology. 2018;56:195–208.
4. van Egmond MMHT, Rovers MM, Hannink G, CTM H, van Heerbeek N. Septoplasty with or without concurrent turbinate surgery versus non-surgical management for nasal obstruction in adults with a deviated septum: a pragmatic, randomised controlled trial. Lancet. 2019;394:314–321.
5. Unadkat S, Pendolino AL, Joshi A, et al. A national survey of functional septorhinoplasty surgery performed in the United Kingdom: a clinician end-user questionnaire to assess current practice and help inform future practice. Eur Arch Otorhinolaryngol. 2020;277:475–482.
6. Esmaili A, Acharya A. Clinical assessment, diagnosis and management of nasal obstruction. Aust Fam Physician. 2017;46:499–503.
7. Kumar L, Belalddarov BP, Bannur H. Influence of deviated nasal septum on nasal epithelium: an analysis. Head Neck Pathol. 2017;11:501–505.
8. Whyte A, Boedinghaus R. Imaging of adult nasal obstruction. Clin Radiol. 2019 Sep 9. S0009-9260(19) 30372-1. https://doi.org/10.1016/j.crad.2019.07.027 [Online ahead of print].
9. Ural A, Kansiz A, İnanlı HM, İmamoğlu M. Association of inferior turbinate enlargement, concha bullosa and nasal valve collapse with the convexity of septal deviation. Acta Otolaryngol. 2010;130:271–274.
10. Lund VJ, Stammberger H, Fokkens WJ, et al. European position paper on the anatomical terminology of the internal nose and paranasal sinuses. Rhinol Suppl. 2014;24:1–34.
11. Jinfeng L, Jinsheng D, Xiaohui W, Yanjun W, Ningyu W. The pneumatization and adjacent structure of the posterior superior maxillary sinus and its effect on nasal cavity morphology. Med Sci Monit. 2017;23:4166–4174.
12. Williams R, Patel V, Chen YF, et al. The upper airway nasal complex: structural contribution to persistent nasal obstruction. Otolaryngol Head Neck Surg. 2019;161:171–177.
13. Andrews PJ, Choudhury N, Takahr A, Poirrier AL, Jacques T, Randhawa PS. The need for an objective measure in septorhinoplasty surgery: are we any closer to finding an answer? Clin Otolaryngol. 2015;40:698–703.
14. Janovic N, Janovic A, Milicic B, Djuric M. Is computed tomography imaging of deviated nasal septum justified for obstruction confirmation. Ear Nose Throat J. 2019, 145561319871533.
15. Rimmer J, Hollings P, Lund VJ, et al. European position paper on diagnostic tools in rhinology. Rhinology. 2019;57:1–41.
16. Sommer F, Hoffmann TK. Septoplasty-a surgical or political challenge. Lancet. 2019;394:276–278.
17. Villwock JA, Koppersmith RB. Diagnostic algorithm for evaluating nasal airway obstruction. Otolaryngol Clin North Am. 2018;51:867–872.
18. Demir D, Asil K, Güven M, Ü Erkorkmaz. Does septoplasty change the dimensions of compensatory hypertrophy of the middle turbinate. J Laryngol Otol. 2016;130:554–559.
19. Schuman TA, Senior BA. Treatment paradigm for nasal airway obstruction. Otolaryngol Clin North Am. 2018;51:873–882.
20. Most SP, Rudy SF. Septoplasty: basic and advanced techniques. Facial Plast Surg Clin North Am. 2017;25:161–169.
21. Becker SS, Dobratz EJ, Stowell N, Barker D, Park SS. Revision septoplasty: review of sources of persistent nasal obstruction. Am J Rhinol. 2008;22:440–444.
22. Park CY, Hong JH, Lee JH, et al. Clinical effect of surgical correction for nasal pathology on the treatment of obstructive sleep apnea syndrome. PLoS One. 2014;9, e98765.
23. Teichgraeber JF, Gruber RP, Tanna N. Surgical management of nasal airway obstruction. Clin Plast Surg. 2016;43:41–46.
24. Teitelbaum JI, Barrett DM. Nasal airway obstruction structure and function. JAMA Otolaryngol Head Neck Surg. 2020.
25. Liu J, Liu Q, Wang N. Posterior ethmoid cell expansion towards the inferolateral region of the sphenoid sinus: a computed tomography study. Surg Radiol Anat. 2019;41:1011–1018.
26. Liu J, Dai J, Wen X, Wang Y, Zhang Y, Wang N. Imaging and anatomical features of ethmomaxillary sinus and its
differentiation from surrounding air cells. Surg Radiol Anat. 2018;40:207–215.

27. Demir D, Asil K, Güven M, Kayabaşoğlu G, Yılmaz MS. Assessment of the correlation between nasal septal deviation and compensatory hypertrophy of the middle turbinate. Eur Arch Otorhinolaryngol. 2015;272:2847–2851.

28. Koo SK, Kim JD, Moon JS, Jung SH, Lee SH. The incidence of concha bullosa, unusual anatomic variation and its relationship to nasal septal deviation: a retrospective radiologic study. Auris Nasus Larynx. 2017;44:561–570.

29. Liu JG, Wang MQ, Zhu XH, Liu YH, Cai JY. Microvascular remodeling of nasal mucosa in allergic rhinitis induced by an allergen in Sprague-Dawley rats. Genet Mol Res. 2015;14:11624–11630.

30. Kamani T, Yılmaz T, Sürcü S, Bajin MD, Günaydın RO, Kuşçu O. Histopathological changes in nasal mucosa with nasal septum deviation. Eur Arch Otorhinolaryngol. 2014;271:2969–2974.