Management of Nasal Valve Dysfunction

Dong-Yun Lee¹ · Tae-Bin Won²

¹ Department of Otorhinolaryngology-Head and Neck Surgery, Soonchunhyang University
College of Medicine, Seoul, Korea

² Department of Otorhinolaryngology-Head and Neck Surgery, Seoul National University
Hospital, Seoul, Korea

Corresponding Author: Tae-Bin Won

Department of Otorhinolaryngology-Head and Neck Surgery, Seoul National University
Hospital, 101, Daehak-ro, Jongro-gu, Seoul, Korea, 03080

Tel: +82-2-2224-2279

Fax: +82-2-482-2279

Email: binent@hanmail.net; bin2000@snu.ac.kr

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ORCID

Dong-Yun Lee  https://orcid.org/0009-0005-0458-0166

Tae-Bin Won  https://orcid.org/0000-0003-2266-3975

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Highlights

- Functional rhinoplasty enhances both appearance and breathing, specifically addressing issues related to nasal valve dysfunction.

- The nasal valve is a key factor in maintaining the nasal passage, influencing breathing and overall quality of life.

- Identifying the epicenter and mechanism of nasal valve dysfunction is crucial for selecting appropriate procedures.

- A thorough understanding enables surgeons to choose the best procedure for each patient, resulting in improved symptom relief and heightened aesthetic satisfaction.
Abstract

Nasal valve dysfunction can significantly affect nasal airflow and overall quality of life. This review provides a comprehensive overview of nasal valve dysfunction, including its mechanism, classification, and surgical management. Nasal valves are generally classified into internal and external valves, each of which plays a crucial role in regulating nasal airflow. Further subclassification of the external nasal valve into alar and rim valves, aids in specifying the site of obstruction and guiding surgical interventions. Dynamic nasal valve obstruction, often characterized by inspiratory nasal valve collapse, must be distinguished from static obstruction, which refers to nasal valve stenosis. Accurate identification of the site and mechanism of nasal valve dysfunction is essential for successful management. Various surgical procedures target specific components of the nasal valve and can effectively improve functional outcomes. Appropriate selection of procedures, individually or in combination, depends on the characteristics of nasal valve dysfunction, taking into consideration the individual characteristics of the external nose. Strict adherence to proper surgical techniques is crucial for optimizing treatment outcomes.

Keywords: Rhinoplasty, Nasal valve dysfunction, Internal nasal valve, External nasal valve, Surgical procedure
Introduction

Functional rhinoplasty encompasses various surgical procedures aimed at correcting nasal deformities that cause respiratory difficulties, with the goal of improving the appearance of the nose as well as respiratory functions.[1] Therefore, functional rhinoplasty includes surgeries aimed at addressing nasal valve issues, and patients with nasal obstruction due to nasal valve dysfunction are common candidates for functional rhinoplasty.[2]

First described by Mink in 1903, the triangular narrow space formed by the upper lateral cartilage, head of the inferior turbinate, and septum has been recognized as a key contributor to nasal obstruction.[3] The nasal valve is a critical component responsible for regulating airflow through the nose. Situated at the narrowest segment of the nasal cavity, it contributes to the highest airway resistance, serving as a key determinant of nasal physiology and exerting an impact on nasal obstruction and overall quality of life.[4] The significance of the nasal valve can be understood through the principles of fluid dynamics, particularly Poiseuille's law, which establishes the relationship between fluid flow, pressure, and radius. According to Poiseuille’s law, fluid flow is directly proportional to pressure and radius and inversely proportional to fluid viscosity and length.[5] Another principle that explains the nasal valve is Bernoulli's principle, which states that as air speed increases, the pressure decreases. According to this principle, when airflow passes quickly through the nasal valve, it causes a decrease in pressure, ultimately leading to an exacerbation of nasal obstruction.[6] Therefore, the nasal valve plays a vital role in nasal physiology and is closely associated with nasal obstruction, which can have a profound negative impact on an individual’s quality of life.

The nasal valve is commonly classified as the internal or external nasal valve. The internal nasal valve is positioned approximately 1.5 cm from the nostril and is delimited by the nasal septum medially, caudal aspect of the upper lateral cartilage laterally, and inferior turbinate inferiorly.[7-9] Typically, the angle of the internal nasal valve ranges from 10° to 20°, reflecting
its anatomical characteristics.[10] In contrast, the external nasal valve is often referred to as the entrance to the nose. It is bounded by the columella and medial footplate medially, the alar rim laterally, and the posterior aspect of the internal nasal valve.[11]

It is important to consider the racial variations in nasal valve anatomy.[12] Previous studies have demonstrated notable differences in the angles of the nasal valves between Asians and Caucasians: the angle of the internal nasal valve is approximately 22.0° in Asians and 15.5° in Caucasians, indicating that these angles are larger in Asians than in Caucasians.[10] Additionally, Asians generally have thicker skin, which helps prevent the collapse of the lateral nasal wall.[13, 14] Consequently, Asians may experience relatively fewer nasal valve problems than Caucasians. These anatomical differences have significant implications in the selection of appropriate surgical procedures for addressing nasal valve dysfunction.

Globally, various surgical procedures have been employed to treat nasal valve dysfunction. The selection of an appropriate surgical procedure for nasal valve dysfunction depends on identifying the causes of nasal obstruction, distinguishing between static and dynamic obstructions, and accurately pinpointing the anatomical site of nasal valve dysfunction. Furthermore, surgical procedures may affect a patient’s esthetic appearance. Therefore, it is essential to assess concurrent nasal deformities and consider the potential esthetic changes associated with each surgical procedure to select the most suitable procedure for the patient. This review provides a comprehensive overview of the management of nasal valve dysfunction, with emphasis on the appropriate selection of common surgical techniques.

**Mechanism and evaluation of nasal valve dysfunction**

In patients with nasal valve dysfunction, it is important not only to identify the area of nasal valve dysfunction but also to distinguish the mechanism of obstruction. Dynamic obstruction typically manifests as nasal valve collapse and occurs during inspiration. This is caused by the
collapse of more flexible airway segments owing to the pressure mismatch between the extranasal and intranasal air.[15] The main objective in a patient with dynamic obstruction is to reinforce the flexible or weak airway segment. By contrast, static obstruction refers to nasal valve stenosis that leads to diminished patency. This can narrow the nasal airway and restrict airflow (Figure 1). The treatment for these patients involves opening and widening the narrowed airway. Therefore, distinguishing dynamic from static obstructions is essential for appropriate treatment planning. Static and dynamic obstructions often coexist in some patients, posing additional challenges for corrective intervention.

To manage nasal valve dysfunction accurately, it is essential to determine the epicenter of collapse and identify any concomitant nasal deformity. This can be achieved through a comprehensive nasal airway examination, including anterior rhinoscopy, endoscopy, computed tomography (CT), and nasal airway maneuvers. Anterior rhinoscopy and endoscopy enable direct visualization of the nasal valve region, aiding in the identification of collapse and deformities. CT scans can provide additional information about the nasal airway posterior to the stenotic nasal passage. The Cottle’s maneuver is performed by gently pulling the cheek adjacent to the nose laterally. A positive test, indicating improved airflow, suggests nasal valve dysfunction.[16] Care should be taken not to over-lateralize the cheek, which could lead to a false-positive result. This maneuver generally improves both the internal and external nasal valves. Therefore, while a positive result is indicative of a nasal valve problem, it does not precisely pinpoint the epicenter of the collapse. In the modified Cottle’s maneuver, a small curette is inserted into the nasal passage with gentle support from different areas of the nasal valve, seeking subjective improvement in nasal breathing and identifying the site of collapse or stenosis. (Figure 2). These maneuvers provide valuable information for clinicians to diagnose and plan appropriate interventions for patients with nasal airway issues. Additionally, subjective tests, such as the nasal obstruction symptom evaluation and visual analog scale, as well as
objective tests, such as peak inspiratory flow rate and acoustic rhinometry, can provide valuable insights into a nasal obstruction.[17-21]

**Classification of nasal valve dysfunction**

The nasal valve is commonly classified into the internal and external valve. The internal nasal valve, referred to as the narrowest part of the nose, is formed by the junction between the upper and lower lateral cartilages, known as the scroll area.[22] This area consists of vertical and longitudinal ligaments, and the cartilage has tight and interconnected relationships with the overlying skin and the superficial musculoaponeurotic system.[23] In addition, the scroll area, along with the connections of the medial crus of the lower lateral cartilage to the caudal septum and upper lateral cartilage, plays a significant role in providing support to the nasal tip (Figure 3).[24]

Although the definitions and anatomical borders of the internal nasal valve are well established, confusion exists regarding the external nasal valve area, which has been characterized as the area under the lower lateral cartilage or sometimes as the area closer to the nostrils.[11, 25, 26] In this review, to provide a clearer anatomical boundary of the external nasal valve and the related surgical procedures, we further classified the external nasal valve into the alar and rim valves (Figure 4). The alar valve is the proximal (inner) region of the external nasal valve and is typically associated with the alar groove. It is bordered medially by the caudal septum and laterally by the alar cartilage and soft tissues. Therefore, alar valve dysfunction can be further classified based on the problems associated with the caudal septum, alar cartilage, or lateral soft tissue. If the caudal septum is deviated, septoplasty is needed to correct the alar valve problem.[27-29] If a recurving alar cartilage causes alar valve dysfunction (Figure 5), surgical techniques directed to address the alar cartilage, such as lateral crura strut...
graft or lateral crura flip-flop, can be used. An alar batten graft spanning the soft tissue lateral wall can be used when the lateral soft tissue is the primary cause of alar valve dysfunction. The rim valve is the distal (outer) region of the external nasal valve. The rim valve is composed of the columella, medial footplates of the lower lateral cartilage, alar rim, and nostril sill. Therefore, in patients with rim valve dysfunction, interventions such as columeloplasty, alar rim graft, and alar rim vestibuloplasty can be performed based on the epicenter of collapse.

Management of nasal valve dysfunction according to the epicenter of dysfunction

Understanding the distinct regions of the nasal valve is essential for the evaluation and selection of adequate surgical techniques. Table 1 shows the common surgical procedures used for managing nasal valve dysfunction based on the epicenter of the dysfunction.

Surgical procedures for internal nasal valve dysfunction

Spreader graft

The spreader graft is a standard surgical technique for middle vault reconstruction in cases of internal nasal valve dysfunction.[30] Initially introduced in 1984, this procedure effectively restores the internal nasal valve, enhances nasal dorsal esthetic lines, and provides support for correcting a deviated dorsal septum.[31] It can be performed using either an endonasal or open rhinoplasty approach. Typically, the cartilage harvested from the septum is shaped into a rectangular graft and inserted into a submucoperichondrial pocket between the upper lateral cartilage and dorsal septum (Figure 6). Alloplastic alternatives have also been reported.[32, 33] The spreader graft is often combined with other techniques to optimize outcomes. A study described significant improvements in both objective and subjective assessments of internal
nasal valve function, in both static and dynamic conditions, following the spreader graft.[34] Another study revealed that nasal airway resistance decreased in 52.9% of patients who underwent the spreader graft.[35]

The spreader flap technique, similar to the spreader graft, has yielded comparable outcomes.[36] This technique involves the inward folding of the upper lateral cartilage to function as a “graft,” occupying the same anatomical space as conventional spreader grafts.[15, 37] This modified technique offers comparable benefits, such as reducing a widened dorsum, especially when the upper lateral cartilage is thinner than the spreader graft.[38] A clinical trial comparing spreader grafts and spreader flaps demonstrated no significant differences in nasal obstruction, cosmetic satisfaction, or minimal cross-sectional area changes between the two procedures.[39]

**Flaring suture**

The upper lateral cartilage flaring suture technique can also be used to address internal nasal valve dysfunction. This procedure involves the placement of horizontal mattress sutures on both the upper lateral cartilage using the dorsal septum as a fulcrum to widen the angle and cross-sectional area of the internal nasal valve (Figure 7). An onlay graft is often placed on the dorsum to avoid the cheesecutting effect. One of the advantages of the flaring suture technique is its simplicity as it does not require the use or additional grafts. However, this procedure can lead to the widening of the nasal dorsum potentially altering the appearance of the nose.[40] A comparative study between patients who underwent the spreader graft and flaring suture procedures demonstrated improvements in nasal resistance in both groups, yielding similar
The flaring suture technique is typically performed in conjunction with other surgical procedures, such as the spreader grafts potentially enhancing surgical outcomes.[41]

Butterfly graft

The butterfly graft, initially introduced by Hage in 1964, offers simultaneous improvement of the internal nasal and alar valves.[42] The conchal cartilage is commonly utilized for butterfly grafts owing to its elasticity and natural curved surfaces.[43] The harvested conchal cartilage is shaped into a butterfly-like configuration and positioned on the superficial aspect of the upper lateral cartilage and cephalic edge of the lower lateral cartilage (Figure 8).[44] This procedure effectively increases the angle of the internal nasal valve and reinforces the upper lateral cartilage by overall lifting, including the caudal margin of the upper lateral cartilage. The butterfly graft, is particularly beneficial when addressing accompanying deformities such as supratip depression or saddle nose deformity.[15] The literature highlights the positive outcomes of the butterfly graft in terms of both functional improvement of the internal nasal valve and cosmetic enhancement. Clark et al. reported high rates of nasal airway improvement (97%) and cosmetic improvement (86%) in patients who underwent the butterfly graft.[44] Additionally, a long-term study involving 500 patients over 15 years demonstrated nasal obstruction improvement in 87% of cases and cosmetic improvement in 53% of cases following the butterfly graft.[45]

Surgical procedures for alar valve dysfunction

Alar batten graft
The alar batten graft enhances support for the alar valve, especially the soft tissue in its lateral wall. A piece of cartilage graft, with sufficient size and strength is positioned mostly on the soft tissue lateral wall of the alar valve. The term non-anatomical location is emphasized to stress its location which is not above the lateral crus of the alar cartilage, but rather in the soft tissue lateral wall, extending into the pyriform aperture (Figure 9). Care must be taken to bevel the edges to avoid excessive bulging in the lateral walls. The primary objective of the alar batten graft is to address the collapse of the alar valve; however, it can also correct internal nasal valve collapse by placing the caudal portion of the cartilage graft on the cephalic portion of the lateral crus.[46] Sufyan et al. demonstrated that nasal obstruction significantly improved, and the use of nasal sprays was reduced in patients who underwent the alar batten graft.[47] Similarly, a study involving 67 patients who underwent the alar batten graft reported that 91% of patients experienced improved nasal congestion and 88% reported an improved quality of life following the procedure.[48]

**Lateral crura flip-flop**

This procedure aims to correct the concavity and restore proper support to the alar valve. The lateral crura flip-flop technique can be used when the collapse of the alar valve is attributed to recurvature, which is the paradoxical concavity of the lateral crura. To manage the alar valve collapse, the deformed segment of the lateral crura is removed while preserving the vestibular mucosa. The excised cartilage is then flipped over such that the concavity faces inward. Subsequently, the excised cartilage is sutured to the remaining lower lateral cartilage to ensure secure fixation (Figure 10). The lateral crura flip-flop technique offers the advantage of avoiding additional cartilage harvesting. However, it is important to ensure that the cartilage to
be flipped has sufficient strength for support. If this is the case, alternative options such as lateral crura strut grafts or onlay grafts to strengthen the lateral cartilages can be considered.[49]

**Lateral crura strut graft**

The lateral crura strut graft is an effective procedure for addressing alar valve collapse resulting from lateral crura deformity. The procedure involves creating a space between the vestibular mucosa and lateral crura, followed by the insertion of an autologous graft. The graft is then sutured to the lateral crura to provide reinforcement and lateralization, thereby supporting the alar valve (Figure 11). During the procedure, it is crucial to ensure that the inserted cartilage remains positioned below the native cartilage to avoid external visibility.[46] In cases where the lateral crura are unsuitable for reconstruction, they can be resected and replaced using septal, conchal and or rib cartilages. Care must be taken to bevel the edges and place the lateral end in a pocket that maintains symmetry and adequate angulation of the lateral crus.

**Surgical procedures for rim valve dysfunction**

**Columelloplasty**

A wide columella can lead to nasal obstruction owing to the narrowing of the rim valve. The columelloplasty is a useful procedure in such cases. A columellar incision is made along the caudal border of the medial crus, followed by resection of the soft tissue. In instances where there is a wide flaring or bulky medial footplate, judicious resection and approximation can be adjunctively performed (Figure 12). In a study involving 35 patients who underwent the
columelloplasty, favorable cosmetic outcomes were reported, along with improved breathing and no complications. They reported a slightly better outcome when both the soft tissues and medial footplate were excised compared to excising only the soft tissue.[50]

**Alar rim graft**

The alar rim graft is an effective procedure for addressing rim valve collapse by increasing the support of the alar rim and improving the esthetic curve between the nasal tip and nasal ala.[51] Cartilage grafts are carefully carved into a long, thin shape and inserted along the inner aspect of the alar margin in the subcutaneous pocket (Figure 13). The alar rim graft is typically performed through the marginal incision method; however, the alar facial stab method can also be used.[52] In a study that investigated the outcome of alar rim grafts performed in 31 patients, alar rim grafts supported the external natural valve and improved natural base harmony.[53] Another study on alar rim grafts reported that patients who underwent the procedure showed good results in the improvement of alar retraction.[54]

**Alar rim vestibuloplasty**

The alar rim vestibuloplasty is performed in cases of stenosis of the rim valve. The operative technique will vary according to the deformity and typically involves the concurrent use of skin and cartilage grafts.[55] Stenosis of the rim valve can occur due to congenital factors, infections, burn injuries, nasogastric tube placement, and iatrogenic causes.[55, 56] The alar rim vestibuloplasty involves the sequential steps of scar lysis, rim support using a cartilage graft, skin grafting to address defects, and adjunctive placement of a silastic sheet for graft support (Figure 14). In patients with rim valve stenosis, the alar rim vestibuloplasty is a reasonable
option for improving nasal airflow and yields favorable functional and esthetic outcomes with minimal complications.[57]

Nasal valve surgery and its impact on the external appearance of the nose

Nasal valve surgery can affect the external appearance of the nose. However, in most patients, nasal esthetics is improved following surgery, and it is essential to provide preoperative explanations to patients regarding the potential changes in the external appearance of the nose. While addressing internal nasal valve dysfunction, the spreader graft may slightly widen the middle dorsum. The alar batten graft requires careful beveling of the cartilage to reduce the risk of sidewall bulging. As previously mentioned, the butterfly graft may be ideal for patients with mild supratip depression because it can induce supratip fullness or pollybeak deformity in patients with a normal appearance. The lateral crura flip-flop technique may improve lower-third esthetics by smoothing the prominent alar grooves. When applied, the alar rim graft can resolve mild retraction by causing caudal movement of the alar rim. Collectively, it is important to evaluate the preexisting nasal esthetics of the patient when planning nasal valve surgery and carefully select the appropriate procedure accordingly.

Conclusion

The nasal valve plays an important role in maintaining the nasal passage, with significant implications on nasal breathing and overall quality of life. Nasal valve dysfunction should be suspected in patients complaining of nasal obstruction.

Our review focuses on the common procedures available for addressing nasal valve issues. Additionally, we have discussed the mechanism of nasal valve dysfunction, as well as the
classification of the nasal valve. When choosing surgical procedures, it is important to have a comprehensive understanding of the nasal anatomy and underlying mechanisms involved. Identifying the specific epicenter of nasal valve dysfunction and assessing concurrent nasal deformities are also essential. A comprehensive understanding will enable surgeons to choose the most appropriate procedure for each patient, leading to improved symptom relief and increased esthetic satisfaction.
References


Figure legends

Figure 1. Dynamic obstruction and static obstruction of the external nasal valve. (A), (B) Dynamic obstruction during inhalation; (C) static obstruction of left nasal valve.

Figure 2. Diagnostic maneuver of nasal valve dysfunction. (A) Cottle’s maneuver; (B) modified Cottle’s test.

Figure 3. Anatomic landmarks of the internal nasal valve. (A) Illustration of the right internal nasal valve; (B) endoscopic view of the right internal nasal valve; (C) endoscopic view of the denuded internal nasal valve after mucosa removal. S: septum, ULC: upper lateral cartilage, T: inferior turbinate.

Figure 4. Schematic diagrams of the nasal valve. 1: Internal nasal valve, 2: alar valve, and 3: rim valve.

Figure 5. Recurvature of the alar cartilage. Recurvature of the alar cartilage causes static obstruction in the nasal valve, which hinders the airflow.

Figure 6. Spreader graft. The cartilage graft is inserted into a pocket between the upper lateral cartilage and dorsal septum to restores the internal nasal valve. (A) Before and (B) after bilateral spreader grafts.

Figure 7. Flaring suture together with an onlay graft. Horizontal mattress sutures on both the upper lateral cartilage are performed on top of an onlay graft placed above the dorsum.

Figure 8. Butterfly graft. The cartilage graft is positioned at the junction of the upper and lower lateral cartilage improving both internal nasal valve and alar valve dysfunction. (A) Before and (B) after the butterfly graft.

Figure 9. Design of the alar batten graft. A cartilage graft is placed in a non-anatomical position, mostly on the soft tissue lateral wall.
Figure 10. Lateral crura flip-flop. (A) Deformed lateral crura; (B) excision of the deformed segment of cartilage; (C) flipping over of the excised cartilage; (D) suturing the excised cartilage to the lower lateral cartilage.

Figure 11. Lateral crura strut graft. (A) Curled lateral crura; (B) creating a space between the vestibular mucosa and the lateral crura; (C) insertion of the cartilage graft.

Figure 12. Columelloplasty. (A) Wide columellar base; (B) medial footplate and soft tissue resection; (C) after columelloplasty.

Figure 13. Alar rim graft. (A) Creating subcutaneous pockets on the inner aspect of the alar cartilage; (B) insertion of the cartilage graft; (C) suture after the alar rim graft.

Figure 14. Alar rim vestibuloplasty. (A) Left rim valve stenosis; (B) scar lysis; (C) cartilage graft for rim support; (D) harvest of a skin graft from the retroauricular area; (E) after a skin graft; (F) silastic sheet bolstering; (G) after the alar rim vestibuloplasty.
Table 1. Common surgical procedures based on the classification of nasal valve dysfunction.

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<th>Features</th>
<th>Aesthetic Impact</th>
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<td>Strips of cartilage graft between ULC and dorsal septum</td>
<td>Opens internal valve</td>
<td>Correct deviated dorsal septum</td>
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<td>Flaring suture</td>
<td>Horizontal mattress sutures between the ULC</td>
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<td>Lateral crura strut graft</td>
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<td>Alar rim graft</td>
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<td>Alar rim vestibuloplasty</td>
<td>Scar lysis, cartilage graft, skin graft</td>
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ULC, upper lateral cartilage.
Figure 3.

(A) UL S T

(B) UL C S

(C) UL Scroll area

Figure 4.
Figure 7.

Figure 8.

(A)  (B)
Figure 9.

Figure 10.
Figure 14.