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Management of Nasal Valve Dysfunction; H-Shaped cartilage Graft

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Abstract: Background: Diagnosing NV insufficiency is not always an easy task. The doctor's attention to the valve zone is caused by the unsatisfac¬tory result of the operation on the nasal septum and nasal con¬cha. Patient complaints about problems with nasal breathing require a mandatory examination of the vestibule of the nose without nasal mirror. The classic way to as¬sess NV dysfunction was proposed by Cottle. How¬ever, it to a greater extent demonstrates disturbances in the ar¬ea of INV than ENV. Treatment of nasal valve collapse is site-specific depending on the particular pathology leading to its manifestation. Treatment is typically aimed at either increasing the cross-sectional area of the valve for static obstructions (i.e., opening maneuvers) or supporting the lateral walls to prevent collapse for dynamic collapse (i.e., strengthening maneuvers). Treatment of the lateral wall is considered a distinct surgical entity from procedures to address the septum or turbinate. Surgical management may be necessary depending on the etiology of NVC, but promising advances have been made in minimally invasive office-based procedures as an alternative. Assessment of the efficacy of interventions can be subjective (e.g., visual analog scale (VAS), NOSE, SNOT-22) or objective (e.g., rhinomanometry, acoustic rhinometry), although more credence is given to subjective measures. Depending on a patient's anatomy and functional etiology for NVC, the traditional surgical interventions for nasal obstruction such as septoplasty and inferior turbinate reduction may resolve static NVC without the need to specifically address any lateral nasal wall collapse. Given that the INV is bound by the septum, ULC, and inferior turbinate, a septal deviation especially dorsally and inferior turbinate hypertrophy can easily narrow the nasal valve. The narrowed valve is then prone to higher airflow speeds due to Poiseuille's law and subsequent collapse due to the Bernoulli effect. Widening the static cross-sectional area of the valve may mitigate these forces and restore adequate valve competence. If the septal defection is particularly dorsal or caudal, involving the supporting strut, the crooked and obstructing septum may need to be addressed with an open septorhinoplasty approach, possibly with caudal septal repositioning or the addition of spreader grafts. In cases of septal loss and saddle nose deformity, due to trauma or otherwise, total extracorporeal septal reconstruction may be required. A longitudinal strip of cartilage 10 mm in length was then excised from the dorsal septum, thus creating a bed for the body of the H-shaped graft. The height of the strip was determined by the thickness of the body of the H grafte.

Keywords: Nasal Valve Dysfunction, -Shaped cartilage Graft

Introduction: Diagnosing NV insufficiency is not always an easy task. The doctor's attention to the valve zone is caused by the unsatisfactory result of the operation on the nasal septum and nasal concha. Patient complaints about problems with nasal breathing require a mandatory examination of the vestibule of the nose without nasal mirror. The classic way to assess NV dysfunction was proposed by Cottle. However, it to a greater extent demonstrates disturbances in the area of INV than ENV **(AlEnazi et al., 2023).**

An algorithm that has been demonstrated can be considered a more reliable and simple way. It includes an examination of the vestibule of the nose, a Cottle test, and a positive test using a cotton applicator **(Gilifanov et al., 2020).**

From a practical point of view, it is important to distinguish between static and dynamic collapse of NV. Static is characterized by anatomical narrowing of the lateral walls of the cartilaginous part of the external nose, dynamic, by their medial displacement on inspiration. Therefore, while assessing the ventilation function of the nose by the method of anterior active rhinomanometry, special attention should be paid to the indicators of the total volume flow and total resistance precisely on inspiration. Static collapse is often exacerbated by a dynamic component, and vice versa

Management of Nasal Valve Collapse

Treatment of nasal valve collapse is site-specific depending on the particular pathology leading to its manifestation. Treatment is typically aimed at either increasing the cross-sectional area of the valve for static obstructions (i.e., opening maneuvers) or supporting the lateral walls to prevent collapse for dynamic collapse (i.e., strengthening maneuvers). Treatment of the lateral wall is considered a distinct surgical entity from procedures to address the septum or turbinate. Surgical management may be necessary depending on the etiology of NVC, but promising advances have been made in minimally invasive office-based procedures as an alternative. Assessment of the efficacy of interventions can be subjective (e.g., visual analog scale (VAS), NOSE, SNOT-22) or objective (e.g., rhinomanometry, acoustic rhinometry), although more credence is given to subjective measures **(Khanwalkar et al., 2021).**

Nonsurgical Interventions

Traditional nonsurgical options have been directed toward poor surgical candidates or those hesitant to pursue surgery. Nasal adhesive strips (e.g., Breathe-Rite strips) may strengthen the lateral wall and expand the valve outward to prevent collapse. External splinting can be used to support the lateral wall and INV. Internal dilators, such as nasal cones, can be temporarily placed within the anterior nasal airway to stent the INV and ENV. However, adherence to these interventions is limited, and they do not address potential underlying fixed anatomic issues (e.g., septal deviation, inferior turbinate hypertrophy) **(Deot et al., 2022).**

Management of Nasal Septum and Inferior Turbinate

Depending on a patient's anatomy and functional etiology for NVC, the traditional surgical interventions for nasal obstruction such as septoplasty and inferior turbinate reduction may

resolve static NVC without the need to specifically address any lateral nasal wall collapse. Given that the INV is bound by the septum, ULC, and inferior turbinate, a septal deviation especially dorsally and inferior turbinate hypertrophy can easily narrow the nasal valve. The narrowed valve is then prone to higher airflow speeds due to Poiseuille's law and subsequent collapse due to the Bernoulli effect. Widening the static cross-sectional area of the valve may mitigate these forces and restore adequate valve competence. If the septal defection is particularly dorsal or caudal, involving the supporting strut, the crooked and obstructing septum may need to be addressed with an open septorhinoplasty approach, possibly with caudal septal repositioning or the addition of spreader grafts. In cases of septal loss and saddle nose deformity, due to trauma or otherwise, total extracorporeal septal reconstruction may be required **(Lajdam et al., 2022).**

The inferior turbinate likewise may contribute to astatically, anatomically constricted narrowed nasal valve with subsequent collapse. No clear evidence has been established on an optimal surgical intervention for turbinate with regard to improvement in nasal valve function, with several options commonly utilized in practice (e.g., thermal ablation, radiofrequency ablation, ultrasound reduction, submucosal resection with or without bony removal) **(Moubayed et al., 2022).**

Functional Septorhinoplasty

The 2010 AAO-HNS consensus guidelines on NVC suggest that it should be surgically treated due to the futility of nasal corticosteroids in the treatment of this structural issue. Functional septorhinoplasty has traditionally been considered the treatment of choice and refers to a collection of surgical techniques to correct obstruction of the INV, ENV, or both. Both the static and dynamic components of NVC can be addressed by functional septorhinoplasty **(Justicz et al., 2020).**

Graft Techniques

A number of cartilage graft techniques performed through a functional septorhinoplasty approach have been identified to address NVC with substantial evidence to support their use. This is not an exhaustive list but rather introduces the most common maneuvers **(Garg et al., 2021).**

Spreader Graft

Spreader grafts are extremely versatile and considered a workhorse of surgical nasal valve repair. These linear strips of cartilage (1–2 mm in thickness, 3–6 mm in width, 10–15 mm in length) are harvested from the septum if performed with concurrent septoplasty or otherwise from the conchal cartilage. These grafts are placed in a submucosal subperichondrial pocket between the ULC and septum to widen the INV. It has been identified patients most likely to benefit from spreader grafts during primary rhinoplasty to prevent development of NVC. Those with dorsal septal deviations and valve narrowing may need placement of these grafts in addition to correction of the septal deviation. While the spreader grafts widen the nasal valve, they do not specifically address weakness of the lateral nasal wall, as compared to batten, butterfly, and lateral crural strut grafts **(Kapı et al., 2022).**

Spreader Flap

This variation of the spreader graft uses the ULC, folded on itself, to provide extra support and widen the INV angle. They are used less frequently than spreader grafts because the ULCs are often thin with limited strength, thereby making the intervention less versatile. The only RCT for surgical maneuvers in the treatment of NVC evaluated the use of spreader faps, no difference was found in its use versus controls on either subjective VAS or objective acoustic rhinometry **(Naguib et al., 2020).**

Alar Batten Graft

These grafts were originally reported by Tardy and Toriumi in the 1990s. Their main role is in the setting of over-resection of the LLC and can be used to bolster the ENV, INV, or both. The graft is usually harvested from the septum or concha and is placed subcutaneously at the ULC and scroll region, often in conjunction with a spreader graft, to bolster the INV. By its placement superficial to the ULC, it is able to improve the ULC strength and resistance, as well as support otherwise flaccid LLCs and stabilize the lateral wall during dynamic inspiration. The graft extends into the soft tissue over the bony piriform apertures to provide lateral support to the ENV, but it does not have any medial support structure. The use of batten grafts has been associated with a decreased use of nasal corticosteroid sprays for congestion due to an improved airway **(Raposo et al., 2022).**

Lateral Crural Strut Graft

This graft helps to correct issues with the lateral crus and supra-alar groove given the LLC's major role in ENV dysfunction. The strut is placed into a pocket lateral to the piriform aperture in a more caudal orientation to provide underlay support. While caudally positioned LLCs can be addressed with these strut grafts alone, cephalically positioned LLCs often need formal repositioning with release of their lateral attachments in addition to strut graft placement. The lateral crural cephalic turn-in fap is a variation of this graft in which the cephalic portion of the lateral crura themselves are turned inward and sutured together to add support and prevent collapse. Both the strut and fap variations are associated with subjective improvement and improved mean nasal peak inspiratory flow, but without change in mean nasal airway resistance or minimum cross-sectional area **(Taha et al., 2023).**

Alar Rim Grafts

These cartilage grafts are placed in tunnels caudal to the border of the lateral crus of the LLC to prevent ENV collapse **(Kondo et al., 2020).**

Butterfly Graft

This graft, typically harvested from the conchal cartilage due to its natural curvature, is most often used in the revision rhinoplasty setting. The graft is placed at the junction of the ULC and LLC in the scroll region and over the septum. The graft mimics the ULCs to widen the nasal valve angle and support the sidewall. However, placement may lead to widening of the supra tip region and changes in nasal tip projection **(Sinkler et al., 2021).**

Upper Lateral Strut Graft

A cadaveric study assessed the use of strut grafts placed in a sub perichondrial pocket on the undersurface of the ULC extending over the piriform aperture and fixed to the dorsal septum and contralateral strut graft. A mean increase of 22% in INV cross-sectional area was noted on acoustic rhinometry **(Taha et al., 2023).**

Upper Lateral Splay Graft

The ULC splay graft was first described by Guyuron in 1998 and utilizes conchal cartilage placed over the septal dorsum and below each upper lateral cartilage to reconstruct the middle vault of the nose **(Kapı et al., 2022).**

Stairstep Graft

This method provides an alternative to the alar batten graft for dynamic ENV collapse. The 1.5-mm by 6–9-mm cartilage graft is placed via a trans vestibular approach to span the lateral 2/3 of the lateral crus and overlaps the piriform crest by 3–4 mm, with an inter positional graft secured to one end to increase the basal width. Eight of 8 patients reported improved nasal breathing at 3 months postoperatively without cosmetic concerns **(Khanwalkar et al., 2021).**

Alloplastic Implants

Alloplastic implants, such as polytetrafluoroethylene (PTFE), high-density porous polyethylene, and titanium, have been used to provide additional support to the lateral wall in lieu of autologous grafts, but their role has not been fully clarified. Furthermore, the implants may be associated with an increased risk of infection and extrusion due to rejection **(Jomah et al., 2024).**

Suture Techniques

Several suture techniques have been identified to mitigate the lateral wall collapse associated with NVC. However, they have been reported to potentially lose suspension over time with associated loss of patient satisfaction. Data on additive effects of sutures over graft techniques are lacking **(San Nicoló et al., 2020).**

Flaring Sutures

This nonabsorbable suture is placed in a horizontal mattress fashion through the caudal and lateral border of the ULC, across the nasal dorsum, and then through the contralateral ULC, thereby widening the nasal valve angle **(Kim et al., 2021).**

Suspension Suture

Paniello introduced nasal valve suspension in 1996. Typically placed and secured via a transconjunctival incision, this suture suspends the lateral border of the ULC to a fixed point on the ipsilateral medial infraorbital rim, thereby widening the angle of the INV. Numerous modifications have been made over the years, with some incorporating a bone anchor suspension technique (BAST) system that secures the suture to the bony orbital rim. This technique can be very effective but may add unwanted fullness to the nasofacial groove **(Khanwalkar et al., 2021).**

Given the risk of complications associated with these adjunctive open surgical procedures, the potential for unwanted cosmetic changes, and the costs of operating facilities and general

anesthesia, attention has been directed toward the development of novel minimally invasive alternatives to address NVC **(Jones et al., 2022).**

Radiofrequency-Induced Thermotherapy (RFITT)

Radiofrequency (RF) technology, which has been used with some success for turbinate reductions, has now been studied for its effects on nasal valve repair, and in particular dynamic LWI. In the described technique, the probe is placed into a soft tissue pocket lateral to the lateral crus of the LLC in the direction of the piriform aperture. Three separate sites are ablated for 10 searches to create scar tissue and increase tone to reduce lateral wall collapse. Physiologically, the tissue is ablated by heat desiccation and frictional energy, creating finely controlled necrotic lesions to induce scar formation. The resulting tissue contraction leads to reduced volume, and ultimately, the scar is resorbed while increased tone remains **(Kang et al., 2024).**

Latera Implant

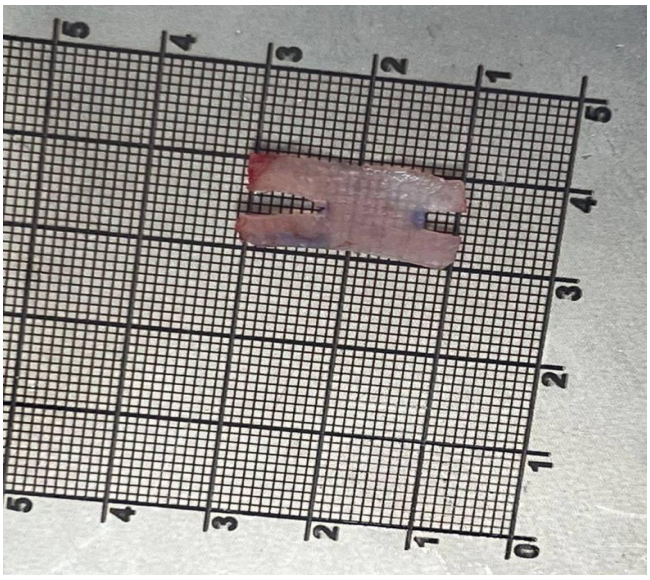
For those who would like to avoid the potential risks of soft tissue manipulation, another minimally invasive in-office treatment has been developed to bolster and stabilize the lateral nasal sidewall with a bioabsorbable implant. Unlike other alloplastic implants that have been used in lieu of autologous cartilage, the Latera implant (Stryker Corporation) is made from an absorbable 70:30 copolymer of poly(l-lactide) and poly(d-lactide). The copolymer is shaped into a ribbed, semi-rigid cylindrical structure with an apical forked end and is introduced percutaneously via an endonasal delivery tool starting in the vestibular skin. Once deployed, the proximal end of the implant is positioned above the alar crease and the distal forked end over the ipsilateral nasal bone or frontal process of the maxilla. The implant is laid over or through the LLC and ULC, potentially helping with dysfunction of both the INV and ENV. The implant resorbs over 18 months, leaving a fibrous capsule that continues providing support even after its dissolution, with histologic analyses demonstrating that structural support remains from mature collagenized fibrous tissue at least 24 months post-procedure **(Kim et al., 2020).**

Endoscopic-Assisted Internal Nasal Valve Reconstruction Using H-Shaped cartilage Graft.

Nasal valve dysfunction is one of the frequent causes of chronic nasal obstruction in adults, which accounts for approximately 13% of the cases undergoing nasal surgery. Aging, trauma, prior rhinoplasty, and septal anomalies all lead to nasal valvular dysfunction both statically and dynamically **(Sunnychan et al., 2023).**

H-Shaped cartilage Graft

A graft was harvested from the septal cartilage. The graft dimensions were approximately 20 mm in length and 10 mm in width, wider at its caudal end. Two rectangular pieces of cartilage were dissected from the caudal and cranial ends of the template, giving the graft an H shape. The graft now had a central body and two arms at the cranial and caudal ends each. Caudal arms are 3 to 4 mm and cranial arms are 6 to 7 mm in length, connected with approximately 10 mm of body



Figure(A) H-shaped cartilage with caudal arms (3mm), cranial arms (7mm) and connection (10mm).of the body

. The gap dissected between the arms was tailored according to the thickness of the dorsal septal cartilage. A longitudinal strip of cartilage 10 mm in length was then excised from the dorsal septum, thus creating a bed for the body of the H-shaped graft. The height of the strip was determined by the thickness of the body of the H graft **(Tastan et al., 2011).**

The cephalic arms of the H graft were gently inserted into these subperichondral pockets in the intact septal perichondrium area. These pockets help to fix the cephalic arms of the graft. The body of the graft was then placed in the previously prepared bed to rest on the dorsal septum but under ULC. The skin of the nose was redraped and examined for contour deformities and the continuity of the dorsal nasal lines.

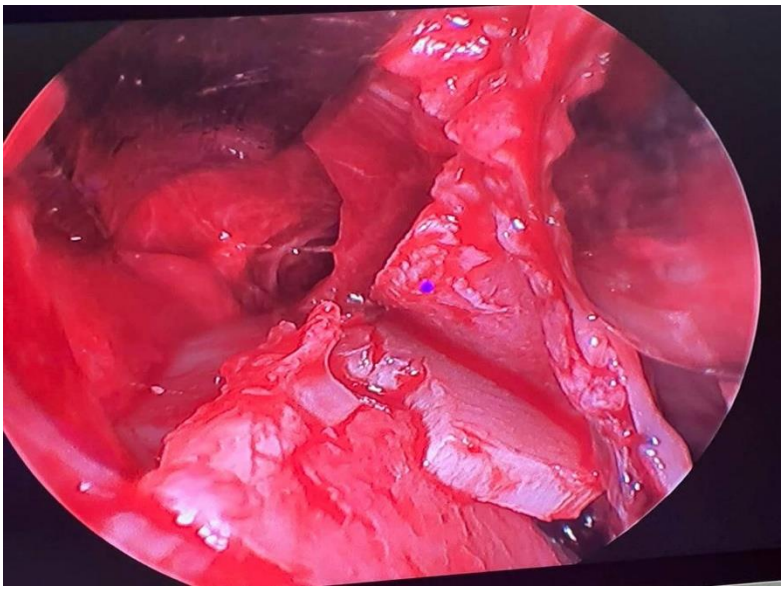


Figure (B): *H-shaped cartilage after placed between ULC and Septum.*

After ensuring the width and shape of the graft, the graft was placed to its bed, and caudal arms of the graft were fixed to the caudal septum with 5/0 polydioxanone suturing. Then, the internal nasal valve region was inspected to ensure the maintenance of sufficient airway passage. The fine-tuning of the lateralization of ULC may be done by placing the ULC to H graft sutures to a more medial or lateral position. The sutures were placed at points where the desired level of lateralization that was ideal for both contour and function could be achieved **(Ji et al., 2022).**

The endoscopic approach has become the preferred method of access to various sinonasal procedures. The endoscope allows not only magnification but also illumination of difficult-to-reach areas. While there are many options in dealing with a narrowed nasal valve, the most widely performed surgical procedure is the spreader graft. The approach for its placement is either trans nasally or through the external open rhinoplasty technique. While both are successful, the open technique provides better visualization, more precise grafting, and more accurate suture fixation when compared to the trans nasal. For these reasons, it has become the preferred approach **(AlEnazi et al., 2023).**

At the caudal portion, lateralization of the ULCs on the graft could easily be adjusted to achieve the desired effect without excessive caudal widening. Also, the possible widening effect of the graft at the supra tip region is somewhat compensated by previous scroll resection, which is the curvature located between the caudal upper lateral cartilage and the cephalic lateral crura. Scroll resection, curving of the graft after fixation, and most important the restoration of dorsal aesthetic lines achieve cosmetically satisfactory results **(AlEnazi et al., 2023).**

Apart from the functional and aesthetic advantages, using an H-shaped graft not only improved the stability but also offered technical ease to the surgeon. Inserting the cephalic portion of the graft into the tight-fitting sub perichondral tunnel eliminated the possibility of graft rotation without the necessity of placing sutures to a challenging zone. Caudal extensions could easily be sutured together and interlocked to the septum. Thus, the graft was designed in H pattern just to lie firmly on the cartilage septum, with the cephalic portion beneath the cephalic part of ULC and the nasal bone and the caudal limbs secured to each other. The H graft, extending from the rhinion to the nasal tip (by differing graft width at various points), allows cosmetically pleasing reconstruction of the dorsum and restores dorsal aesthetic lines. On the other hand, this technique requires a straight in bloc graft and a straight dorsal septum. Any curvatures or irregularities of the dorsal septum and the septal cartilage graft should be addressed and corrected before the placement of the graft that may prolong the operative period. The procedure also requires a meticulous surgical technique **(Jones et al., 2022).**

References:

Abdelwahab, M. A., Neves, C. A., Patel, P. N., & Most, S. P. (2020). Impact of dorsal preservation rhinoplasty versus dorsal hump resection on the internal nasal valve: a quantitative radiological study. Aesthetic Plastic Surgery, 44, 879-887.

Aladag, I., Songu, M., Aslan, H., Imre, A., & Pinar, E. (2019). Internal nasal valve expanding graft for middle vault reconstruction. Journal of Craniofacial Surgery, 30(3), 860-862.

AlEnazi, A., Alshathri, A. H., Alshathri, A. H., Algazlan, A., Alkudsi, N., Assiri, H., & Alarfaj, A. (2023). Assessment and Diagnostic Methods of Internal Nasal Valve: Systematic Review and Meta Analysis. JPRAS Open.

Das, A., & Spiegel, J. H. (2020). Evaluation of validity and specificity of the Cottle maneuver in diagnosis of nasal valve collapse. Plastic and reconstructive surgery, 146(2), 277-280.

Deot, N., Obayemi, A., & Davila, R. O. (2022). Non-Surgical Devices for Nasal Obstruction. Facial Plastic Surgery, 38(04), 359-363.

Elwany, S., & Askar, M. (2023). Rhinology review. Springer Nature.

Erdoğan, M. M., & Levent, U. Ğ. U. R. (2023). Changes in nasolabial angle may alter nasal valve morphology and airflow: a computational fluid dynamics study. Journal of Health Sciences and Medicine, 6(2), 500-505.

Friedman, O., & Wang, K. (2023). Nasal Physiology and Pathophysiology and Their Relationship with Surgery: The Nasal Valves. In Nasal Physiology and Pathophysiology of Nasal Disorders (pp. 255-268). Cham: Springer International Publishing.

Gagnieur, P., Fieux, M., Louis, B., Béquignon, E., Bartier, S., & Vertu-Ciolino, D. (2022). Objective diagnosis of internal nasal valve collapse by four-phase rhinomanometry. Laryngoscope investigative otolaryngology, 7(2), 388-394.

Garg, L. N., Singh, N. K., Kappagantu, K. M., & Yadav, A. (2021). Spreader graft placement: an effective procedure for alleviation of internal nasal valve collapse. Journal of Oral and Maxillofacial Surgery, 79(10), 2134-2142.

Gassner, H. G., Friedman, O., Sherris, D. A., & Kern, E. B. (2006). An alternative method of middle vault reconstruction. Archives of Facial Plastic Surgery.

Georgolios, A., Cooper, D. J., & Tham, T. (2023). Diagnosis and Management of Common Presentations of Posttraumatic Nasal

Janovic, N., Janovic, A., Milicic, B., & Djuric, M. (2022). Relationship between nasal septum morphology and nasal obstruction symptom severity: computed tomography study. Brazilian Journal of Otorhinolaryngology, 88, 663-668.

Ji, K. S. Y., & Krane, N. A. (2022). Surgical treatment of dynamic nasal collapse. Facial Plastic Surgery, 38(04), 339-346.

Jomah, M., Smith, O., Villemure-Poliquin, N., & Cunningham, H. (2024). Use of alloplastic implants for correction of deviated nasal septum: Systematic review and meta-analysis. American Journal of Otolaryngology, 104240.

Jones, E. A., & Sivam, S. (2022). Minimally invasive nasal valve treatment. Facial Plastic Surgery, 38(04), 353-358.

Nigro, C. E. N., de Aguiar Nigro, J. F., Mion, O., & Mello Jr, J. F. (2009). Nasal valve: anatomy and physiology. Brazilian journal of otorhinolaryngology, 75(2), 305-310.

Raposo, A., Lajara, J., Guillén, A., & García-Purriños, F. (2022). Modified alar batten grafts for treatment in nasal valve dysfunction: Our experience. Auris Nasus Larynx, 49(3), 396-400.

Sakarya, E. U., Kar, M., & Bafaqeeh, S. A. (2020). Surgical anatomy of the external and internal nose. All Around the Nose: Basic Science, Diseases and Surgical Management, 39-47.

San Nicoló, M., Berghaus, A., Jacobi, C., Kisser, U., Haack, M., & Flatz, W. (2020). The nasal valve: new insights on the static and dynamic NV with MR-imaging. European Archives of Oto-Rhino-Laryngology, 277, 463-467.

Sheen, J. H., & Rees, T. D. (1984). Spreader graft: a method of reconstructing the roof of the middle nasal vault following rhinoplasty. Plastic and reconstructive surgery, 73(2), 238-239.
Shelke, S. S., & Kulkarni, S. V. (2020). Study of Correlation between Endoscopic Assessment and Radiological Evaluation in Chronic Nasal Obstruction. MVP Journal of Medical Sciences, 90-97.
Sidle, D. M., Stolovitzky, P., O'Malley, E. M., Ow, R. A., Nachlas, N. E., & Silvers, S. (2021). Bioabsorbable implant for treatment of nasal valve collapse with or without concomitant procedures. Facial Plastic Surgery, 37(05), 673-680.
Sinkler, M. A., Wehrle, C. J., Elphingstone, J. W., Magidson, E., Ritter, E. F., & Brown, J. J. (2021). Surgical management of the internal nasal valve: a review of surgical approaches. Aesthetic Plastic Surgery, 45, 1127-1136.
Staibano, P., & Bonaparte, J. P. (2020). The relationship between the Ottawa Valve Collapse Scale (OVCS) and clinical outcomes in septoplasty patients. Journal of Otolaryngology-Head & Neck Surgery, 49(1), 14.
Stewart, M. G., Witsell, D. L., Smith, T. L., Weaver, E. M., Yueh, B., & Hannley, M. T. (2004). Development and validation of the Nasal Obstruction Symptom Evaluation (NOSE) scale. Otolaryngology—Head and Neck Surgery, 130(2), 157-163.