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RHINOLOGY: NASAL OBSTRUCTION (JV NAYAK, SECTION EDITOR)

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Update on the Evaluation and Management of Nasal Valve Collapse

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Abstract

Purpose of Review This review covers the etiology, diagnosis, and management of nasal valve collapse (NVC). Particular attention is directed toward recent advances in office-based procedural treatment options.

Recent Findings While intervention for NVC has traditionally focused on graft and suture maneuvers performed via open functional septorhinoplasty, recent innovations include the use of radiofrequency energy and bioaborbable implants to strengthen the nasal valve and reduce dynamic collapse. Studies have demonstrated comparable long-term outcomes to conventional surgery in properly selected patients.

Summary Dynamic NVC is an important but often overlooked contributor to nasal obstruction. Innovative devices offer the option of in-office treatment without the costs and risks associated with general anesthesia in the operative setting. Along with the further development of new surgical techniques and office-based procedural device options, the validation of objective measures will be necessary to assess response to therapy and determine which interventions are most appropriate for individual patients.

Keywords Nasal valve collapse · Lateral nasal wall · Nasal valve stenosis · Lateral wall insufficiency · Radiofrequency · Bioabsorbable implant · Functional septorhinoplasty

Introduction

Nasal obstruction is a common patient symptom evaluated by otolaryngologists with a lengthy differential diagnosis [1•]. Chronic obstruction is associated with symptoms of nasal blockage, headache, fatigue, sleep difficulty, and reduced quality of life [2, 3]. Its etiology is often multifactorial with both anatomic (e.g., septal deviation) and physiologic (e.g., allergic rhinitis, chronic sinonasal inflammation) causes. While septal deviation and inferior turbinate hypertrophy receive much of the attention for anatomic obstruction, nasal valve collapse (NVC) is common yet oftenoverlooked—affecting up to 13% of the general population—and is particularly associated with difficultyin nasal inspiration, exercise intolerance, sleep disturbance, and decreased quality of life [4, 5•, 6]. Neglect of its contribution to a patient's clinical picture has been associated with surgical failure in the treatment of nasal obstruction [7].

Topical collection on *RHINOLOGY: Nasal Obstruction*

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Anatomy and Function of the Nasal Valve

As an important regulator of nasal airflow, the nasal valve may function to limit the amount of airflow to the nasal cavity's capacity for warming and humidifying inspired air [8]. The nasal valve is composed of the external nasal valve (ENV) and internal nasal valve (INV) (Fig. 1A). The ENV is defined by the cross-sectional area of the nasal ala located at the nasal vestibuleand is bounded by the caudal septum, medial crus of the lower lateral cartilage (LLC), alar rim, and nasal sillof the premaxilla [3, 9]. The INV is located approximately 1.5 cm posterior to the nasal orifice and is bound by the septum medially, caudal aspect of the upper lateral cartilage (ULC) superiorly, and head of the inferior turbinate laterally (Fig. 1B) [3, 10]. The INV should have a cross-sectional area of 55–60mm^2, and the angle between the ULC and the septum should be 10–15°. As the narrowest segment of the upper airway, the INV is associated with significant restriction of airflow at baseline, and its cross-sectional area can be further narrowed by a

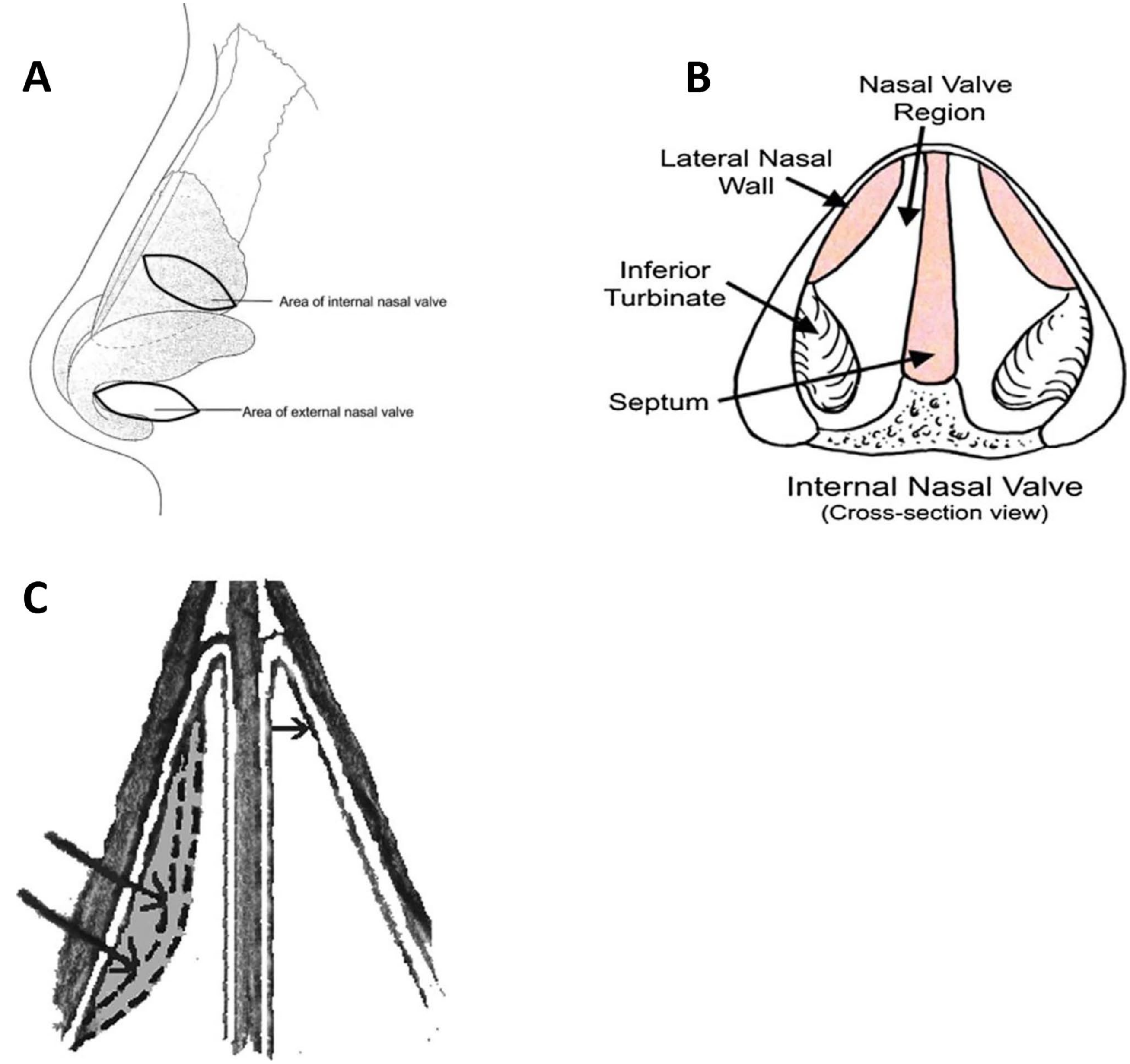

Fig. 1 **A** Location of nasal valves. (Reproduced and adapted from Spielmann et al. Laryngoscope 19 (2009):1281–1290, with permission from John Wiley and Sons) [11]. **B** Components of internal nasal valve. (Reproduced fromCannon et al. Otolaryngol Clin N Am 45 (2012):1033–1043, with permission from Elsevier) [59]. **C** Schematic illustration of the concept of dynamic nasal valve collapse. On the right nostril, the gray area represents the medial excursion of the upper lateral cartilage during inhalation because of the negative pressure created by Bernoulli forces, further narrowing the region of the internal nasal valve represented by the arrow in the left nostril. (Reproduced from Nuara et al. Laryngoscope 117 (2007):2100–2016, with permission from John Wiley and Sons) [47]

high septal deviation, deflection of the dorsal aspect of the caudal septum, or inferior turbinate hypertrophy [11].

Nasal Valve Collapse

NVC may be either static or dynamic, the latter in which collapse of the alar rim or lateral nasal wall occurs with inspiration. While static obstruction is due to fixed, limited cross-sectional area of the nasal valve, dynamic obstruction occurs secondary to lateral wall insufficiency (LWI), i.e.,a lack of integrity of the lateral nasal wall that is susceptible to the Bernoulli effect (Fig. 1c) [12, 13]. This dynamic collapse may compromise the INV (zone 1), ENV (zone 2), or both [13]. Per Poiseuille'slaw, airflow through a lumen is proportional to r^4, and therefore, airflow accelerates as it passes the narrow region of the INV. This acceleration of airflow is associated with a drop in pressure as described by the Bernoulli principle, thereby leading to collapse of the valve and increased resistance—particularly if the sidewall cartilage lacks the strength and rigidity to maintain INV patency [8, 14]. The muscles that promote nasal valve patency—nasalis and dilator naris—can sometimes prevent collapse by directly impacting the ULCs and alar soft tissues. LWIis arguably a fundamentally different disease process from static airway obstructionbut is often neglected [14, 15, 16•]. As such, NVC may be due to an anatomically narrow valve that is predisposed to collapse because of the resulting negative inward pressures on it, or to particularly weak unilateral or bilateral sidewalls with insufficiency and incompetence of the supporting cartilages. Any structural or functional changes to the individual components of the valve—whether static or dynamic in nature—can impact airflow.

The etiology of NVC, whether fixed or dynamic, may be intrinsic, congenital, traumatic, or iatrogenic [17]. The most common cause is reportedly prior rhinoplasty [1•, 18]. Iatrogenic obstruction of the INV is typically due to over-resection of the ULCs or disruption of their attachment to the septum, excessive dorsum narrowing, or displacement of the nasal bones and their attachment to the ULCs. Involvement of the ENV is associated with aggressive narrowing of the nasal tip, over-resection of the LLC (particularly the lateral crura), displacement of weak alar cartilage, or stenosis of the ENV from fibrosis and scarring. Overly cephalic positioning of the LLCs during reductive rhinoplasty can lead to both ENV and INV stenosis, and lead to nasal obstruction. Facial nerve injury and paralysis may also lead to a nonfunctional dilator naris muscle with resulting collapse of a competent nasal valve. Aging itself is associated with weakness of the fibroareolar tissue of the nasal sidewall, also leading to valve collapse.

Evaluation of Nasal Valve Collapse

History

AAO-HNS clinical consensus guidelines support that NVC is a distinct clinical entity from other forms of nasal obstruction and is best evaluated with a thorough history and physical examination, as most objective measures are less clinically reliable [3]. Specific questions regarding nasal obstruction to elicit during history intake include presence and frequency of alternating left/right nasal obstruction, seasonal variation, history of prior surgery, history of trauma, and history of pharmacologic (e.g., fluticasone, oxymetazoline) and non-pharmacologic (e.g., Breathe-Rite strips or nasal cones) therapy and associated benefits, if any. Weak agreement in consensus guidelines suggests that a trial of Breathe-Rite strips may useful to confirm the diagnosis of NVC [3]. Endorsement of nasal obstruction with deep inspiration is a consistent finding in NVC. Validated survey instruments and patient-reported outcome measures (PROMs), such as the Nasal Obstruction Symptom Evaluation (NOSE) score, have been developed to standardize the subjective experience from patients and can also be used to evaluate response to therapy [19]. These instruments have been found to be more useful than any existing objective measures [3]. An improvement in NOSE exceeding 25–30 points has been suggested as a criterion for successful response to treatment [20].

Physical Examination

Physical examination involves close inspection of the nose both at rest and with inspiration prior to the use of topical decongestants. Anterior rhinoscopy should be performed to assess the septum and inferior turbinates, both of which can contribute to narrowing of the nasal valve. Presence of external valve stenosis should be evaluated. Weak cartilage with visible inspiratory collapse of a flaccid sidewall of the alar lobule may be noted with dynamic obstruction and LWI. To further assess for dysfunction of the ENV, examination should directed toward assessment of thin skin, a deep supra-alar groove, a parenthesis deformity of the nasal tip, narrow and/or elongated nostrils with over-projection of the tip, shortened medial crura with a widened columella, caudal septal deviation with contralateral collapse, and cephalic position of the lateral crura leading to loss of lateral cartilage support [4]. During examination, topical decongestant spray can be applied. If patient symptoms improve to a tolerable level, consideration may be given to medical therapy(e.g., nasal corticosteroids) or procedures directed toward turbinate hypertrophy rather than the lateral sidewall.

The Cottle maneuver, in which the cheek skin lateral to the nasal sidewall is pulledlaterally, is a non-specific finding for INV dysfunction as nearly all individuals will have improved nasal breathing with this action. The modified Cottle maneuver, in which a thin instrument (e.g., wire loop curette or cotton tip applicator) is used to intranasally support the weakened cartilage segment and stent the lateral crus while a patient breathes normally, may more specifically indicate the presence of functionally significant NVC and LWI if the maneuver alleviates symptoms of dynamic nasal obstruction (Fig. 2) [21••].

While nasal endoscopy is not mandatory per guidelines from the AAO-HNS, anterior rhinoscopy alone may miss several important findings, and the addition of endoscopy may identify additional areas of pathology that require surgical intervention; in one study, this was found to be the case in 28 of 96 patients [3, 22]. A grading system based on the degree of INV collapse noted on endoscopy has been validated for clinical use, in which grade 1 indicates < 33% reduced distance from lateral wall to septum

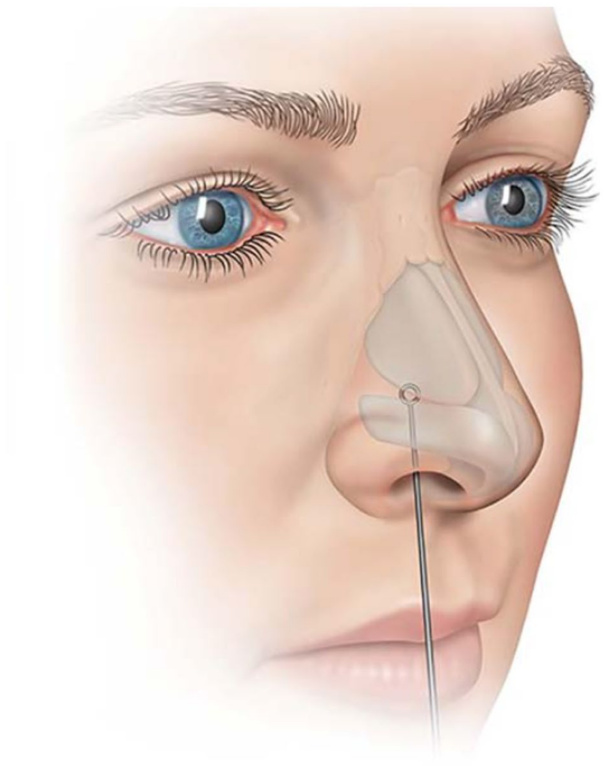

Fig. 2 Modified Cottle maneuver. This is performed by gently supporting the lateral wall cartilage internally on each side of the nose while the patient is asked to inspire in a normal fashion. (Reproduced fromStolovitzky et al. A Prospective Study for Treatment of Nasal Valve Collapse Due to Lateral Wall Insufficiency: Outcomes Using a Bioabsorbable Implant, *Laryngoscope* 128 (2018):2483–2489, with permission) [60]

during inspiration, grade 2 indicates 33–66%, and grade 3 indicates > 66% [23].

Additional Studies

Auxiliary studies to produce objective data may be helpful, but their role has not been fully clarified. Acoustic rhinometry measures the cross-sectional area of the nasal valve and can be used to evaluate for static obstructive narrowing or stenosis [11]. Anterior rhinomanometry can be used to measure airway resistance and theoretically may provide information about dynamic valve collapse. Peak inspiratory airflow can be used to evaluate changes in nasal conductance. However, more emphasis has been placed on the value of subjective measures, as the correlation with the currently available objective measures has been questioned [24].

There is currently no major role for CT or MRI in the workup on NVC in the absence of other concerning symptoms [3].

Management

Treatment of NVC is site-specific depending on the particular pathology leading to its manifestation [1•]. Treatment is typically aimed at either increasing the cross-sectional area of the valvefor static obstructions (i.e., opening maneuvers) orsupporting the lateral walls to prevent collapse for dynamic collapse (i.e., strengthening maneuvers) [11]. Treatment of the lateral wall is considered a distinct surgical entity from procedures to address the septum or turbinates [3]. 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 [25].

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 [26]. However, adherence to these interventions is limited, and they do not address potential underlying fixed anatomic issues (e.g., septal deviation, inferior turbinate hypertrophy). In cases of valve narrowing due to inferior turbinate hypertrophy associated with rhinitis, intranasal corticosteroids or antihistamines may be helpful, but otherwise have limited to no role in cases of isolated LWI.

Some studies have identified a potential role for biofeedback training utilizing a home exercise regimen of specific movements, with or without the addition of transcutaneous or intranasal electrical stimulation of the nasal muscles (i.e., dilator naris) [27].

Management of Nasal Septum and Inferior Turbinates

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 addressany lateral nasal wall collapse [3]. 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 (Fig. 1C). Widening the static cross-sectionalarea of the valve may mitigate these forces and restore adequate valve competence.If the septal deflection 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 (see below). In cases of septal loss and saddle nose deformity, due to trauma or otherwise, total extracorporeal septal reconstruction may be required.

The inferior turbinates 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 turbinates 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).

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 [3]. 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 [28•]. Both the static and dynamic components of NVC can be addressed by functional septorhinoplasty [29].

Despite improved understanding of the pathophysiology of NVC, nearly all studies on the benefits of surgicaltreatment with functional septorhinoplasty and associated graft and suture maneuvers have produced level IV evidence. Surgical research is prone to selection and allocation bias, and there has been a notable dearth of RCTs [11, 25]. Study results are clouded by a lack of controls and multiple procedures being performed simultaneously—often in combination with septoplasty and turbinate reduction [12]. Nevertheless, despite the heterogeneity of their component studies and lack of RCTs, systematic reviews and meta-analyses have demonstrated the case for functional septorhinoplasty to improve NOSE scores in those with LWI by an average of 42–50 points [15, 30].

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 [31]. This is not an exhaustive list but rather introduces the most common maneuvers.

Spreader Graft

Spreader grafts are extremely versatile and considered a workhorse of surgical nasal valve repair [32, 33]. 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 a concurrent septoplasty or otherwisefrom the conchal cartilage. These grafts are placed in a submucosal subperichondrial pocket between the ULC and septum to widen the INV. Boccieri et al. identified patients most likely to benefit from spreader grafts during primary rhinoplasty to prevent development of NVC [34]. 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 (see below).

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 flaps, and of note,no difference was found in its use versus controls on either subjective VAS or objective acoustic rhinometry [35].

Alar Batten Graft

These grafts were originally reported by Tardy and Toriumi in the 1990s [36, 37]. 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.

Lateral Crural Strut Graft

This graft helps to correct issues with the lateral crusand 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 flap 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 flap 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 [38].

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 [39].

Butterfly Graft

This graft, typically harvested from the conchal cartilage due to its natural curvature, is most often used in the revision rhinoplasty setting [40]. 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 supratip region and changes in nasal tip projection [41].

Upper Lateral Strut Graft

A cadaveric study assessed the use of strut grafts placed in a subperichondrial pocket on the undersurface of the ULC extending over the piriform aperture and fixed to the dorsal septum and contralateral strut graft [42]. A mean increase of 22% in INV cross-sectional area was noted on acoustic rhinometry.

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 [43].

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 transvestibular approach to span the lateral 2/3 of the lateral crus and overlaps the piriform crest by 3–4 mm, with an interpositional graft secured to one end to increase the basal width [44]. Eight of 8 patients reported improved nasal breathing at 3 months postoperatively without cosmetic concerns.

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 [45]. Furthermore, the implants may be associated with an increased risk of infection and extrusion due to rejection [46].

Other Surgical Maneuvers

For a patient who has suffered traumatic displacement of nasal bones with disruption of the fibrous attachments to the ULC, medial osteotomies may be required.

Stenosis of the nostrils—by definition involving the ENV—may require division or resection of the scar followed byintramural support with either skin grafts or composite grafts(e.g., conchal bowl). Nasal stenting may be required to maintain patency of the corrected nasal airway and prevent re-stenosis.

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 [47]. Data on additive effects of sutures over graft techniques are lacking.

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 [48].

Suspension Suture

Paniello introduced nasal valve suspension in 1996 [49]. 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 [11]. This technique can be very effective but may add unwanted fullness to the nasofacial groove.

Newer Innovations

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.

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 seach 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. An RCT comparing RFITT ($n=7$) to BAST ($n=6$) with VAS found similar immediate postoperative results while long-term results favored RFITT [50••]. Physician assessment of valve function also favored RFITT.

The VivAer Stylus (Aerin Medical) is a newly commercially available device using bipolar temperature-controlled RF at 60 °C and a console setting of 4 W (Fig. 3). The tip is positioned into the mucosa overlying the lower edge of the ULC and used on 3 non-overlapping areas of the lateral wall of the nasal valve for 18 sat each site. The underlying submucosal collagen and elastin fibers provide scaffolding for the mucosa and dictate its firmness and elasticity. RF-induced heating is thought to improve nasal valve patency either by tissue tightening and contraction through immediate effects on existing collagen accompanied by induction of new collagen production, or alternatively by temporarily softening the alar cartilage itself to allow remodeling before regaining its elasticity in a new anatomic conformation [51•, 52].

Six-month outcomes among 50 patients with at least severe or extreme obstruction at baseline on the NOSE instrument showed an average decrease of 69% at 6 months after treatment with VivAer [51•]. The mean improvement in NOSE scores of 53.5 compares well with the improvement of 42–50 suggested by meta-analyses of surgical septorhinoplasty [15]. Of 39 patients who agreed

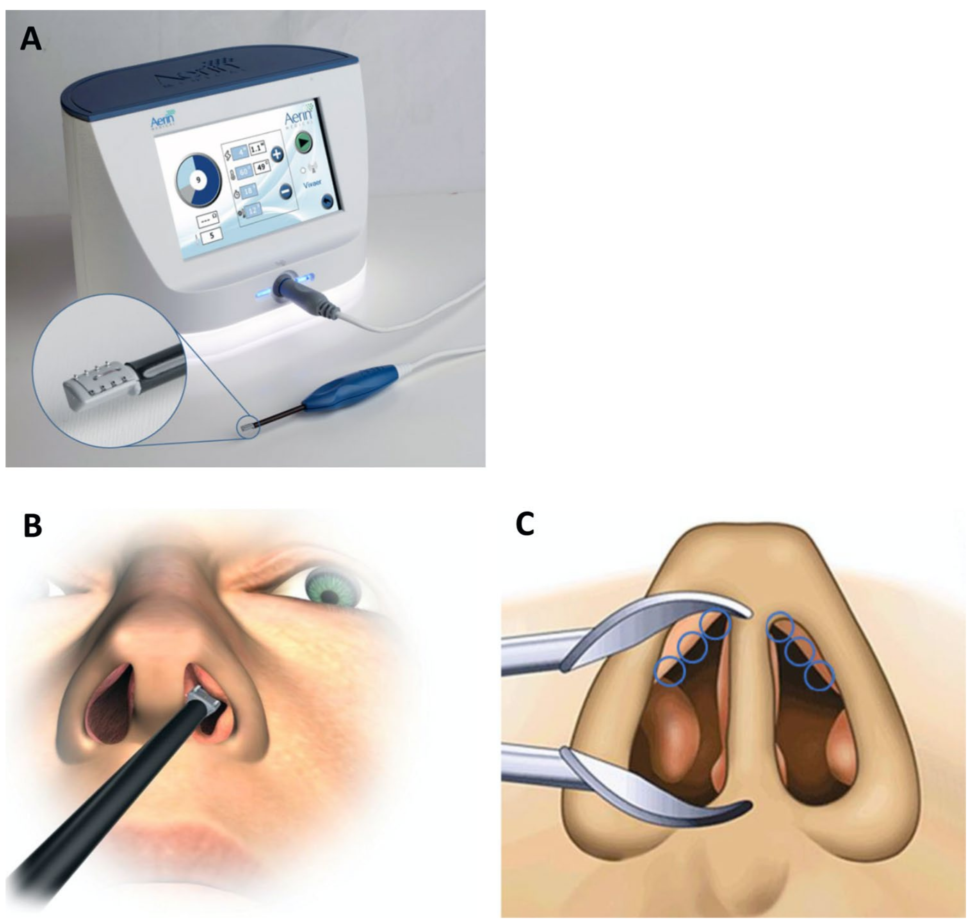

Fig. 3 **A** The Aerin Medical generator and VivAer stylus with magnified view of stylus tip. (Reproduced from Jacobowitz et al. Laryngoscope Investigative Otolaryngology 4 (2019):211–217, with permission) [51•]. **B** Placement of the stylus against the lateral nasal wall/nasal valve region. (Reproduced from Ephrat et al. International Forum of Allergy & Rhinology 11 (2021):755–865, with permission) [52]. **C** Nasal valve treatment areas. Treatment applied with the stylus tip positioned onto the mucosa overlying the caudal (lower) edge of the upper lateral cartilage bilaterally in 3 nonoverlapping zones, marked by circles in the figure. (Reproduced from Ephrat et al. International Forum of Allergy & Rhinology 11 (2021):755–865, with permission) [52]

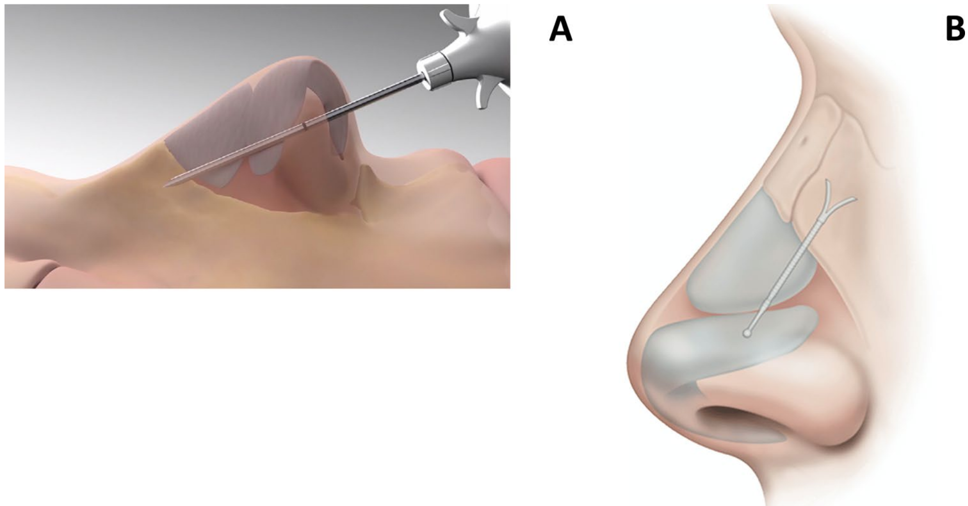

Fig. 4 **A** Latera implant delivery device. **B** Latera implant shown in proper position supporting the lateral nasal wall/nasal valve. The distal tip with prongs rests atop the frontal process of the maxilla, and the main body of the implant is placed lateral to both the ULC and LLC. (Reproduced from Sanan et al. Facial Plast Surg Clin N Am 27 (2019):367–371, with permission from Elsevier) [54]

to be followed to 24 months, 36 continued to demonstrate durable improvement [52]. All five components of the NOSE scale remained improved at each follow-up interval, and patients indicated generally favorable outcomes regarding quality of life, in particular sleep measures. Over 60% indicated reduced use of oral medications and nasal sprays, and over 80% reported decreased use of external nasal tape strips. Despite the study's limitations, including lack of randomization to a control group, these early results hold promise.

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, theLatera implant (Stryker Corporation) is made from an absorbable 70:30 copolymer of poly(L-lactide) and poly(D-lactide) [53]. 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 (Fig. 4). 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 [54, 55•].

Individual studies and a meta-analysis have demonstrated that placement of the implant is associated with improvement in subjective symptoms of nasal obstruction with reduced NOSE scores as well as improved endoscopic scores reported by physicians up to 24 months post-procedure, with improvements in NOSE at least comparable to septorhinoplasty [29, 30, 53, 56••, 57••]. An individual RCT comparing the implant to sham placement found significant improvement in NOSE in both groups at 3 months, but with clinically greater effectiveness in NOSE and VAS with the implant arm [21••]. Risks are minimal overall, with the most common being implant extrusion (6%), postoperative site pain (1.8%), foreign body sensation (2.3%), localized swelling (1.8%), and mucosal infection (1.4%) [56••]. In one study, all adverse events had resolved by 6 months [29]. Aside from the strong safety and efficacy profile, the major advantage of this intervention is that it can be performed in the office, potentially in combination with turbinate RF ablation to further widen the nasal valve [29]. The intervention has the potential for reduced postop recovery time and reduced costs associated with anesthesia and facility fees.

Nasal Valve Lift

This novel approach utilizes placement of polylactic acid threads at the lateral nasal wall and valves, presumably increasing the body's production of collagen and promoting fibrosis thereby strengthening local tissue. The threads are placed in a sub-SMAS layer over the later wall and ENV under local anesthesia. Patients enrolled in a study provided positive feedback regarding subjective symptoms, but no objective measures were assessed [58].

Conclusion

While significant advances have been made to both diagnose and manage NVC in recent years, much work remains to be done. Along with the introduction of new techniques and devices, the development of validated objective measures to assess patency of the nasal valve and improvement in NVC will help assess response to therapy and determine which interventions are most appropriate for individual patients. Given the variety of etiologies that lead to NVC, it is important to determine the underlying cause so that targeted therapy with the highest chance of success can be offered. Future studies of surgical technique should aim to use more homogenous patient cohorts, isolated single techniques, and randomization to produce better data, although such studies are difficult to design. Additional devices and procedural therapeutics may expand the breadth of office-based options, but individual patients should be carefully evaluated to select the most appropriate treatment plan with the fewest risks.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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•• Of major importance

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