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Surgical Management of the Internal Nasal Valve: A Review of Surgical Approaches

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Abstract

Background Nasal valve collapse is relatively common with a lifetime prevalence of up to 13%. Etiologies include prior rhinoplasty, other surgical procedures, facial paralysis, congenital defects, trauma, and aging. Internal nasal valve collapse leads to impairment of nasal breathing, which significantly disturbs quality of life. Many approaches to increase the cross-sectional area of the internal nasal valve have been described.

Results The main categories reviewed in this article are cartilage grafting, implants, and suture suspension techniques. Cartilage grafting techniques include alar batten graft, butterfly graft, spreader graft, autospreader graft, and alar composite graft. The implant technique includes the titanium butterfly implant. The suspension techniques included are the transconjunctival approach, Mitek bone anchor, flaring suture, lateral pull-up, and piriform rim suspension. Surgeons must carefully consider functionality, cosmesis, and technical difficulty when selecting an approach.

Discussion We review indications, general approach, benefits, and considerations for a number of available techniques to help surgeons decide what approach might be best suited to the individual patient.

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Keywords Nasal valve · Internal valve · Collapsed valve · Stenosis

Introduction

Nasal valve collapse is estimated to occur in up to 13% of people [1]. Rhinoplasty is the most common cause of nasal valve collapse [2]. Additional causes include resection of neoplasms, facial paralysis, aging, trauma, and congenital defects. Nasal airflow is limited by the external and internal nasal valves [3–5]. The external nasal valve is comprised of the caudal border of the lower lateral cartilage, columella, and nasal floor [6]. The internal nasal valve is composed of the caudal margin of the upper lateral cartilage, the nasal septum, nasal floor, and anterior aspect of the inferior turbinate and their overlying mucosa [7–10]. The internal nasal valve typically sits at an angle of 10–15°, but the valve is dynamic, and an extensive range exists.

Nasal collapse can be identified on a directed physical examination using anterior rhinoscopy, the Cottle maneuver, or endoscopic examination. Commonly used options for the surgical widening of the nasal valve include cartilage grafting and suture suspension techniques [2, 11–13]. Surgical outcomes for nasal valve management may be measured using subjective and objective measurements. Subjective measurements include patient satisfaction and the Nasal Obstruction Symptoms Evaluation Scale

(NOSE). The NOSE is the most studied and validated form of subjective measurement [14]. Objective measurements include peak inspiratory flow rate and acoustic rhinometry. There is a debate in the literature regarding the use of imaging for evaluation of internal nasal valve collapse. In 2012, Moche et al. found that a radiographically measured valve area of <0.30 cm^2 on computed tomography (CT) scan was correlated with clinical narrowing with a sensitivity of 71.4% and specificity of 88.9% [15]. In 2014, Sedaghat et. al found that no significant correlation between physical examination findings and CT scan of the nasal valve and a 2010 clinical consensus statement determined that history and physical examination findings were the best tools for evaluation of nasal valve collapse [16, 17]. Studies have shown, however, that CT scans reformatted in the plane of the nasal valve are most accurate and reliable for evaluation of the nasal valve angle [18–20]. While there is not currently a consensus in the current literature on methods of reporting nasal valve repair outcomes, the reformatted CT scan is the most validated current method of radiographic evaluation.

As extensive controversy still exists over the best approach to fixing nasal valve collapse, we present a variety of techniques found in the current literature. This may help surgeons to compare their current operative approach to other methods to help guide operative decision making in the future.

Methods

To evaluate a variety of approaches to the management of the internal nasal valve, an in-depth literature review was performed using PubMed as the main electronic database. To identify current techniques used to approach the nasal valve, initial search items included nasal valve reconstruction and internal nasal valve (66 and 28 articles). A secondary review was performed on each identified technique using the following search items: alar batten graft, butterfly graft, titanium butterfly graft, spreader graft, spreader flap, autospreader graft, alar composite graft, nasal valve suspension, Mitek bone anchor suspension, flaring suture suspension, lateral pull up suspension, and piriform rim suture suspension. For each method, studies were selected to demonstrate the advantages and disadvantages of the method. The studies selected involved patients with a nasal valve collapse measured with a validated scoring system or radiographic evidence with all participants over the age of 18.

Current Techniques

Grafting methods involve the transposition of additional tissue as a method of re-shaping and fortifying the nasal structure. Suture suspension encompasses techniques for increasing nasal valve diameter through the use of sutures to add increased upward and/or outward mechanical forces on portions of the nasal canal. A list of techniques reviewed in this paper can be found in Table 1.

Grafting and Implant Techniques

Alar Batten Graft

The alar batten graft (Fig. 1a) is a cartilage graft typically harvested from the conchal cartilage. Using an endonasal approach, the graft is then placed submucosally at the point of maximal lateral wall collapse or supra-alar pinching and spans from the piriform aperture to the septal cartilage [21–23]. These grafts are limited to use in individuals with idiopathic or congenital causes of the collapse of the nasal sidewall, as these patients display the best outcome following batten grafting. Batten grafting is less effective in patients with critical stenosis of the external valve or a pinched middle vault [24]. In a review of 21 patients who underwent alar batten grafting for correction of internal valve collapse, all patients reported subjective improvement in their nasal airway at 3, 6, and 12-month follow-up. Six patients noted fullness in the scroll region [25]. Bewick et al evaluated 67 patients with 91% reporting an improvement of nasal blockage and 88% reporting quality of life improvement [26]. This technique uses one operative site with minimal cosmetic deformity. Alar batten grafts are typically not considered in cases of severe valvular collapse as a heartier graft is preferred. A common concern with the batten graft procedure is graft malpositioning, which can worsen sidewall collapse.

Table 1 Techniques reviewed for internal nasal valve repair

Techniques for internal nasal valve repair	
Cartilage graft and implant methods	*Suture suspension methods*
Alar batten graft	Transconjunctival approach
Butterfly graft	Mitek bone anchor
Titanium butterfly implant	Flaring suture
Spreader graft	Lateral pull-up
Autospreader graft	Piriform rim
Composite graft	

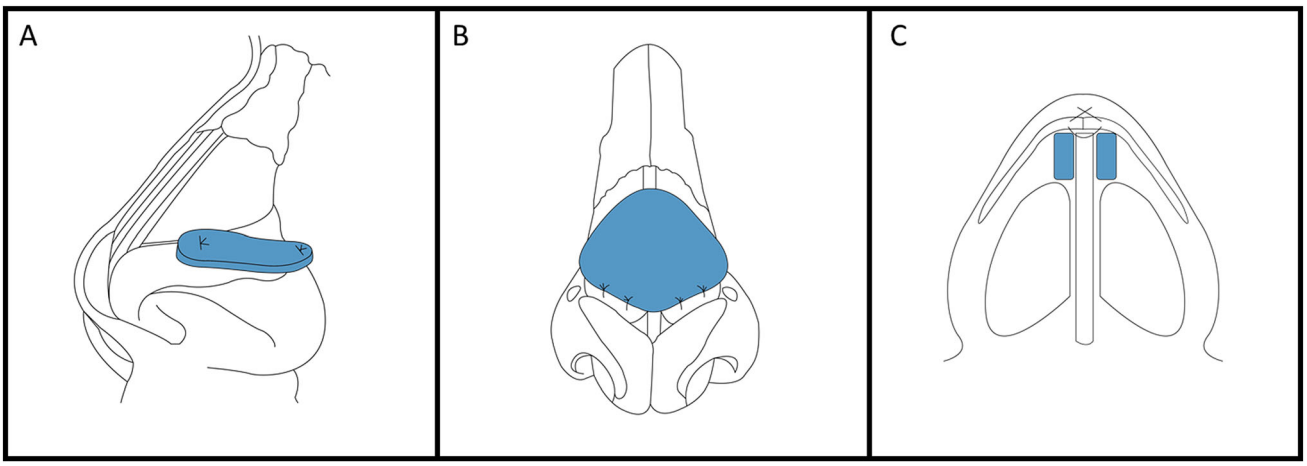

Fig. 1 Schematic diagrams of grafting techniques with graft represented in blue. **a** Alar batten graft. **b** Butterfly graft. **c** Spreader graft

Butterfly Grafts

The butterfly graft (Fig. 1b) is a cartilage graft taken from the conchal cartilage of the ear. The graft is positioned superficial to the anterior septal angle and caudal edge of the upper lateral cartilage [27, 28]. The graft provides an outward force to widen the nasal airway; leading to an increased internal valve angle and area. A study of 82 patients found that 83.3% of patients reported "excellent" improvement in nasal breathing and 70.9% found improvement in fatigue due to difficulty breathing following butterfly grafting for nasal suspension [27]. A commonly reported disadvantage of the technique includes poor cosmetic outcomes due to the bulky graft causing fullness over the dorsum [29, 30]. However, the 2009 study found that 88% of patients reported satisfaction with the cosmetic outcome of butterfly grafting [29]. Additionally, modifications have been made to create a longer and thinner graft to reduce cosmetic defects [31–33].

Titanium Butterfly Implant

Popularized by A'Wengen in 2006, the titanium implant functions to maintain the patency of the valve during inspiration [34]. The implant has a dumbbell-like shape with a narrow midpoint. The narrow midpoint of the graft minimizes the dorsal fullness postoperatively, while the robust lateral sidewall creates a larger area to distribute for force on the nasal sidewall [35]. The implant is positioned with the midpoint superior to the nasal tip with the lateral limbs extending to the point of maximal valvular collapse. The implant can be placed using intranasal or transcutaneous approaches. A study of 32 patients showed an increase in peak nasal inspiratory flow 6 weeks and 6 months postoperatively showing an increase in nasal patency and improvement of quality of life of the patient [36]. Limitations of this approach include the possibility of infection or rejection of the implant, mild increase in nasal width, and nasal tip bossa formation [35]. The implant has an added benefit of the ability to reshape the implant if cosmetic deformity persists and may have a better cosmetic outcome compared to a cartilage butterfly graft due to a lower profile [37].

Spreader Graft

The spreader graft (Fig. 1c) is typically harvested from the septal or costal cartilage. This graft may be placed between the anterior septum and anterior lateral cartilage in the mid-vault region. Therefore, the graft increases the angle and areas of the internal nasal valve by displacing the upper lateral cartilage [26, 38–40]. This technique addresses static causes of nasal collapse and is most beneficial when addressing significant causes of mid-vault nasal collapse [41]. The 2009 study described for butterfly grafting also investigated the spreader graft, which found that the spreader graft had a reported 90% "excellent" improvement in nasal breathing with a 60% improvement in fatigue from difficulty breathing [29]. A 2015 study investigated 87 patients undergoing spreader graft and found that nasal airway resistance decreased in 46 patients (52.9%) following the spreader graft technique. Studies found no significant difference in airflow improvement between the spreader graft and the flaring suture technique or the autospreader technique [42, 43]. The spreader graft can be placed by either a trans-nasal or open rhinoplasty approach. An open approach offers an easier visualization for placement and securing of the graft. With the trans-nasal approach, placement of the spreader graft can be technically difficult and can lead to a widened nasal column.

Spreader Flap (Autospreader Graft)

The autospreader graft, or spreader flap, is a modification of the classic spreader graft. The autospreader technique utilizes an infolding of the upper lateral cartilage to serve as the "graft" and occupies the same space that a traditional spreader graft would as shown in Fig. 1c [27, 44, 45]. The technique has similar applications and benefits as the traditional spreader graft, with an added benefit of eliminating a cartilage graft. The S technique also allows for the preservation of the nasal mucosa. The modified technique may also reduce the cosmetic widened dorsum as the upper lateral cartilage is commonly thinner than a typical spreader graft [27]. A 2007 study investigated 25 autospreader grafts with follow-up time between 11 and 19-months. Twenty-one of these cases were conducted with an open approach, and four were conducted with a closed, transnasal approach. Of these 25, 22 cases were classified as satisfactory both intra- and postoperatively, yielding a surgical success rate of 88%. The only complication reported was an aesthetically narrow middle vault that did not cause airway obstruction [42].

Alar Composite Graft

Konig first described the alar composite graft for nasal reconstruction in 1902 [46]. This technique has since been used for a variety of nasal repairs including nasal valve repair and valvular insufficiency. This technique involves the transposition of a skin and cartilage graft for the repair of an alar defect [46–49]. This technique has been described using tissue sourced from a variety of locations, including the lower conchal cartilage, the inner arm, supraclavicular area, and the earlobe [15, 48, 49]. Bottini et. al. found in 2007 that of 15 patients receiving a composite graft for injuries including nasal valve collapse, respiratory symptoms improved in all cases. Only three cases demonstrated an adverse aesthetic result [47]. Rao and Touriumi recommended this method as a reliable option for correction of nasal defect due to tissue injury, particularly when large defects are noted [50]. This procedure is most useful for internal nasal valve collapse in the setting of full- or partial-thickness injury to the ala; however, it is limited in the setting of nasal valve collapse without tissue injury.

Suspension Techniques

Transconjunctival Approach to Nasal Valve Suspension

This technique was the first developed for nasal valve suspension by Paniello in 1996 [51]. His initial method used a transconjunctival incision to access the orbital rim. An intranasal incision is made to pass the sutures from the nose to the transconjunctival incision, and the sutures are affixed to the orbital rim. The initial study included 12 men who underwent unilateral nasal valve correction. All patients reported subjective improvement in their symptoms. Rhinomanometry illustrated reduced nasal resistance in 10 of the 12 patients. Six patients also experienced an increased cross-sectional area of the internal nasal valve. The operation resulted in a cosmetic sequela of widening of the mid-third of the nose in half of the patients. This method requires extensive time to expose the bone through the transconjunctival incision to drill the hole and requires significant healing time [51–53]. The unilateral transconjunctival approach resulted in slight asymmetry, and the patients with bilateral repairs resulted in mixed results [54]. Complications of the transconjunctival approach include entropion and ectropion [27].

Mitek Bone Anchor Suspension Technique

The Mitek Bone Anchor approach (Fig. 2a) represents a modification of Paniello's original technique. The Mitek anchor is placed in the inferior orbital rim by a transconjunctival incision. An additional incision is made through the mucosal layer midway between the two endpoints chosen for suspension, allowing the suture to be buried in the mucosa. This modification was made due to the development of granulation material forming in the original incision described by Paniello [21, 55]. Second, a cutting needle was used to pass the suture instead of a tapered needle. These modifications were tested in a 2004 retrospective study of 188 patients with an added prospective study of 52 patients. 91.7% of patients reported a subjective improvement with the remaining reporting no improvement at a 6-month follow-up [51]. The overall complication rate was 6.7%. Short-term complications included persistent pain at the orbital suspension site, intranasal granulomas, abscess formation, and persistent granulation at infraorbital site [55]. Long-term complications included the relaxation of sutures and subsequent loss of nasal support.

Flaring Sutures

The flaring suture (Fig. 2b) is a horizontal mattress suture that transverses the upper lateral cartilage to the nasal dorsum [56, 57]. When the suture is tightened, the upper lateral cartilage flares outwards to increase the angle and area of the internal nasal valve [27]. This technique addresses static and dynamic causes of nasal collapse. The advantages of this technique include the elimination of a cartilage graft and technical ease of the procedure. This technique is commonly seen as a temporary solution, as the

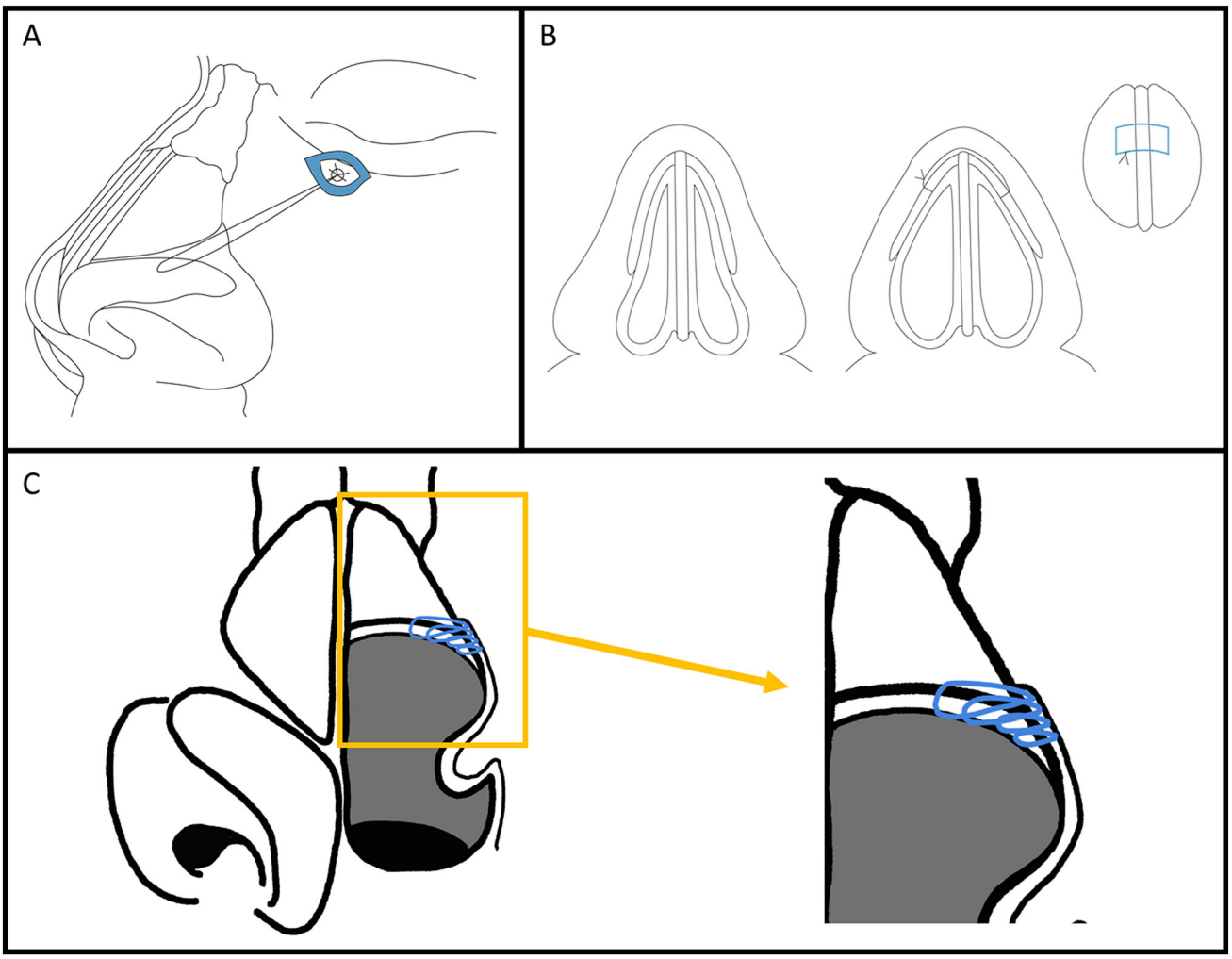

Fig. 2 Schematic diagrams of suspension techniques. **a** Mitek anchor suspension with bone anchor placement shown in blue. **b** Flaring suture with suture pattern demonstrated to blue. **c** Piriform rim suspension with suture shown in blue

suture can relax over time. The 2015 study comparing the spreader graft to the flaring suture found that 63.2% (84/133) of patients showed improvement in airflow following the flaring suture technique [42].

Lateral Pull-Up Technique

In this technique, the lateral crus of the nasal cartilage is suspended by a stitch tunneled in the subperiosteal plane of the bony pyramid of the nose within the piriform aperture. The stitch is then attached to a drill hole created approximately 5 mm from the caudal border of the piriform aperture [58]. A 2006 study of 7 patients found that all 7 patients experienced improved nasal breathing following the lateral pull-up technique [58]. No rhinomanometry was reported. Edema and ecchymosis at the site of the piriform aperture were noted, but no major complications were reported. The cosmetic changes were minimal, with slight upward rotation of the nasal tip and an upward movement of the caudal border of the nostril [58].

Piriform Rim Suture Suspension

One of the newer techniques is referred to as the piriform rim suture suspension (Fig. 2c), where a trans-nasal approach is used via a 5 mm incision made above the piriform rim and continued toward the upper lateral nasal cartilage and caudally toward the inferior turbinate. 5–7 drill holes are made in the piriform bone and suture is passed through the drill holes into the upper lateral nasal cartilage and back to the drill holes, where they are eventually affixed. This allows for multiple points of contact which applies a superolateral force to the upper lateral cartilage, as well as additional points of support should one suture fail. Additional benefits of the technique include its minimally invasive nature, minimal impact on cosmesis,

and the ability to perform the technique under general anesthesia [59].

The authors have attempted the piriform rim suture technique on a series of 21 patients. Intraoperative imaging from the procedures may be found in Fig. 3. Thirteen (62%) were male, and eight (38%) were female. Eighteen (86%) of patients had bilateral procedures. The average preoperative NOSE score was 17 (SD =2). At 1-month follow-up, the average NOSE score was 7 (SD = 2.8). At 6-month follow-up, the average NOSE score was 5 (SD = 2.5). The mean percent change was 59% and 70% at 1 and 6 months, respectively (p <0.03; CI = (6.45–7.6); (4.54–6.25). All patients healed without sequelae. One patient reported significant worsening after 6 months. No patients experienced suture failures or neuralgias.

The piriform rim suture suspension technique is the author's treatment of choice when the angle of the internal valve is less than 15°. The advantages of the technique include its simplicity, minimally invasive nature, and multiple points of contact between bone and cartilage. Due to the minimally invasive nature, distortion of the external nose is minimal. Unfortunately, this technique is limited to patients without major nasal deformities, as it does not provide enough flexibility to be used in those situations.

Discussion

The internal valve was recognized by Mink in 1903 as the flow-limiting segment of the nasal airway [60]. When evaluating a patient with a collapse internal valve, the relevant anatomy needs to be understood. Both the piriform aperture and the cartilaginous vestibule contribute to nasal airflow resistance, with the piriform aperture providing the major contribution [61]. The internal and external valves of the nose are structurally maintained by the alar cartilages

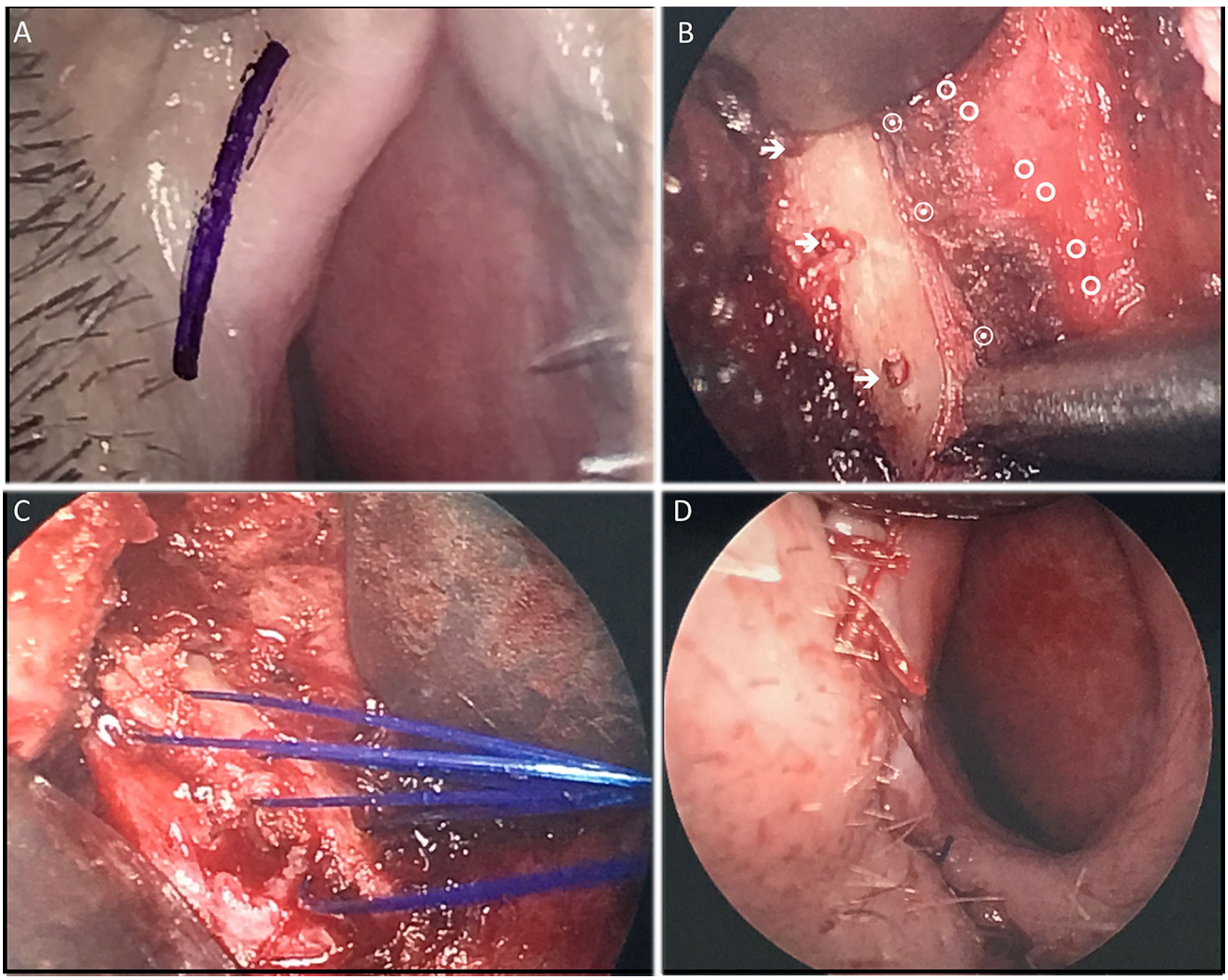

Fig. 3 Intraoperative pictures from piriform rim suspension technique. **a** Location of incision. **b** Location of drill holes in piriform rim. **c** Sutures through drill holes. **d** Incision site after closure

Table 2 Comparison of techniques

Method	Type	Indication	Advantages	Disadvantages
Alar batten graft	Conchal cartilage graft	Idiopathic or congenital collapse of the nasal sidewall	One operative site Minimal cosmetic deformity	Less effective with critical stenosis of external valve or pinched middle vault Graft mispositioning can worsen collapse
Butterfly graft	Conchal cartilage graft	Static and dynamic causes of collapse	Relative ease of operation	Poor cosmetic outcome due to graft size
Titanium butterfly implant	Titanium implant	Similar to butterfly graft, but is a longer and thinner graft	Minimal cosmetic deformity Can be adjusted after implantation	Rejection of the implant Bossa formation Increase in appearance of nasal width
Spreader graft	Septal or costal cartilage graft	Static causes of collapse	Best for mid-vault causes of nasal collapse	Graft placement is technically difficult Widened nasal column Requires multiple operative sites
Autospreader graft	Infolding of upper lateral cartilage	Static causes of collapse (same as the spreader graft)	Elimination of cartilage graft Reduction of widened nasal column	Aesthetically narrow middle vault Operative difficulty
Composite graft	Full- or Partial-thickness tissue graft	Tissue injury to the ala	Repair of tissue damage, including when limited vascular supply	Not advantageous in patients without direct tissue injury
Transconjunctival approach	Suspension	Static and dynamic causes of collapse	Elimination of graft	Cosmetic widening and asymmetry Long operative time Formation of granulation tissue at incision site
Mitek Bone Anchor	Suspension	Static and dynamic causes of collapse	Elimination of graft Minimize formation of granulation tissue	Relaxation of sutures over time
Flaring suture	Suspension	Static and dynamic causes of collapse	Elimination of graft Technical ease	Relaxation of sutures over time
Lateral Pull-Up	Suspension	Static and dynamic causes of collapse	Elimination of graft	One suture which can fail or relax over time
Piriform Rim	Suspension	Static and dynamic causes of collapse Angle of the internal valve is less that 15 degrees	Elimination of graft Minimal cosmetic deformity Minimally invasive Multiple points of contact	Cannot be used on patients with major nasal deformities

and the nasalis dilator and alar dilator muscles are innervated by the facial nerve [62, 63]. The nasalis muscle has two portions, the transverse and alar portions. The alar portion of the nasalis muscle inserts into the lower lateral nasal cartilage. The alar portion of the nasalis and the alar dilator muscle are responsible for increasing the caliber of the nasal vestibule. Based on Bernoulli's principle, as airspeed increases, the pressure falls leading to external valve collapse [1, 64, 65]. This collapse is worsened when the nasal valve is weakened. The surgical techniques outlined in this review manipulate the various anatomic landmarks in order to correct for nasal valve collapse (Table 1).

This review article covers the use of grafts, implants, and suspension techniques to address the management of a collapsed nasal valve. In general, cartilage grafting techniques are relatively permanent. Limitations to the cartilage graft typically include the necessitation of multiple operative sites, and grafts may not be sufficient when the collapse involves the entire caudal aspect of the junction between the upper lateral cartilage and lower lateral cartilage [54]. Suture suspensions are relatively less invasive and simpler, but concerns have been raised with durability and in situations with large lateral nasal collapse. The advantages and disadvantages of each surgical method can be found in Table 2. Non-surgical methods include topical nasal strips, cones, and sponges.

Grafting techniques represent a broad category of valve repair characterized by insertion or transposition of

material into various areas of the nose. Alar batten and butterfly grafting techniques are advantageous due to relative ease of operation, although the alar batten graft is less effective for mid-vault deformities and the butterfly graft has been associated with poorer cosmetic outcomes [24, 29, 30]. The titanium butterfly implant represents an option to improve cosmesis due to adjustment after implantation, although graft rejection can limit the overall effectiveness [37]. The spreader graft represents a useful option for the correction of mid-vault collapse [41]. While the comparison of techniques is limited by available data, the alar batten and the autospreader graft had the best subjective improvements among grafting techniques, with 88% of patients reporting postoperative satisfaction, respectively [26, 42]. This was followed by the butterfly graft, which demonstrated 83% postoperative satisfaction [27]. The authors recommend choosing a procedure primarily based on the specific nasal defect, as rigorous direct comparisons have not been performed to date.

Nasal suspension techniques are generally less invasive than grafting techniques and do not require tissue transposition. All sutures suspension techniques are effective for both static and dynamic valve collapse, which represents another benefit to these approaches. The transconjunctival approach has been reported to have cosmetic widening and nasal asymmetry, as well as granuloma formation at the operative site [51–54]. The Mitek bone anchor and flaring suture have no reported granuloma sequelae but have had reported relaxation or failure of suture, which leads to an eventual partial or total failure of the operation [42, 55]. This leads the authors to recommend the piriform rim suture suspension method, which uses a multitude of drill holes and sutures to create multiple points of contact to distribute the force across the piriform bone. This technique is, however, limited to patients with relatively minor nasal deformities and a nasal valve angle $<15°$. Postoperative NOSE scores demonstrated improvement in 70% of patients receiving the piriform rim suspension method in the author's case series. Outcome comparisons of suture suspension techniques are again limited by a lack of available data; however, studies have shown a 91% postoperative satisfaction rate with the Mitek bone anchor technique compared to 63% with the flaring suture [42, 51]. Unfortunately, no large studies have investigated satisfaction following other suture suspension techniques.

Summary

Each method for surgical correction of the collapsed internal nasal valve has various indications. Surgical treatment options include cartilage grafting, implants, and suture suspension. Grafting methods discussed include alar batten, butterfly, spreader, autospreader, and composite. Implants include the titanium butterfly implant. Suspension techniques include transconjunctival approach, flaring sutures, Mitek bone anchor, lateral pull up, and piriform rim suture suspension.

Generally, suture suspension methods avoid transposition of tissue and therefore reduce intra-operative time. Additionally, suture suspension methods have a favorable cosmetic outcome with less manipulation of tissue. Local anesthesia can be used for some suture suspension methods.

There are a multitude of available procedural options for surgical correction of the internal nasal valve. At present, patients should be carefully evaluated for the most appropriate technique based on specific pathology and presentation.

Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflicts of interest to disclose.

Ethics Approval This article does not contain any studies with human participants or animals performed by any of the authors.

Informed Consent For this type of study, informed consent is not required.

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