

Nasal Valve Surgery for Nasal Obstruction: A Systematic Review

Abstract

Nasal obstruction is a common presentation at rhinology clinics. Aetiologies can widely vary from inflammatory, mechanical obstructive to structural / anatomical causes of nasal obstruction.

Nasal valve collapse is a recognised cause of nasal path obstruction, whether presenting as the sole causative or as an addition to another obstructive aetiology. The identification of this cause of obstruction is essential in order to plan patients' management.

In this article we aim to describe the anatomy, physiology and pathophysiology of the nasal valve area. Then we highlight what the commonly found surgical methods of addressing this issue in literature, and the documented outcomes.

Keywords

Alar, Collapse, Graft, Rhinoplasty, Nasal valve.

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Introduction

Nasal obstruction is a common symptom seen in Rhinology clinics. The aetiology can range from physical obstruction (nasal polyps or sinonasal tumours), mucosal pathologies (rhinitis) to more structural problems such as septal deviation or nasal valve collapse. In a review of 500 patients, Elwany and Thabet found that nasal valve dysfunction has a role to play in 13% of patients complaining of nasal obstruction.¹

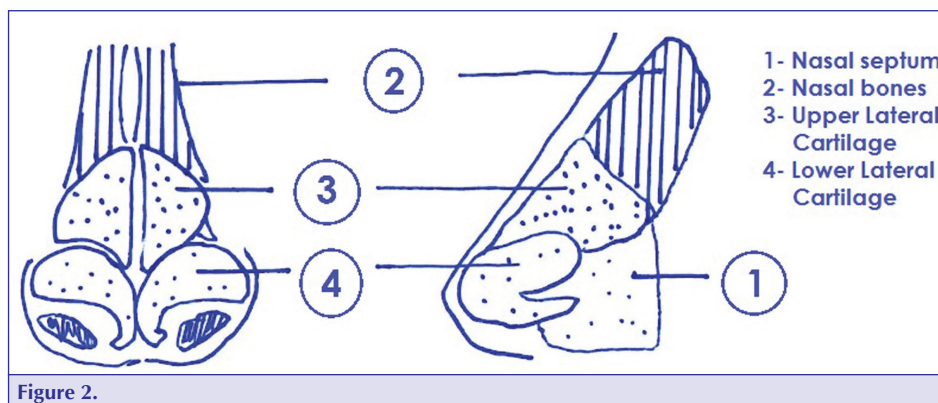
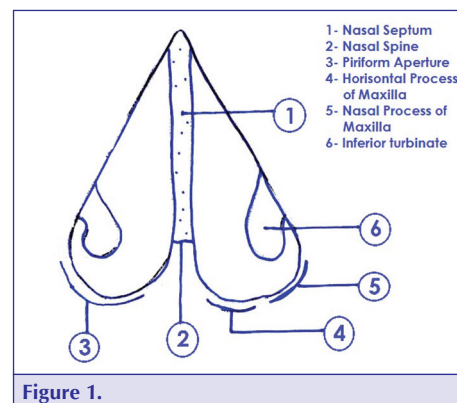
This systematic review focuses on nasal obstruction corresponding to the nasal valve, and summarises the choices of treatments available for nasal valve problems.

Anatomy

The term 'nasal valve' was first coined by Mink in 1903 to describe the slit-like opening of the junction between the upper lateral cartilages (ULC) and the lower lateral

cartilages (LLC).² It has great functional and aesthetic significance and has been the subject of numerous studies.³⁻⁵ It is customary to divide the nasal valve region into internal and external nasal valves.

The internal valve is defined as the angle between the caudal border of the upper lateral



cartilage (ULC) and dorsal septum, bounded laterally by anterior end of inferior turbinate and the remaining tissues surrounding the piriform aperture. An angle of less than 10-15° can cause nasal obstruction.⁶ The external valve is the entrance of the nares to the internal valve, and is composed of the alar rim, lower lateral cartilage (LLC), alar lobule, and nasal sill inferiorly.⁷ The complete function of the nasal valve remains uncertain, but it is widely accepted as a regulator of airflow and resistance as it is the most flexible and narrowest part of the nasal airway.⁸

Although semantically and anatomically separate, both internal and external nasal valves are usually involved in varying degrees in cases of excessive collapse during inspiration,⁹ either due to weakness of the structures and / or excessive negative airway pressure during inhalation.⁷

According to Poiseuille's law, airflow is proportional to the radius of the nasal passages, raised to the fourth power. Thus a small change in the angle of the valve will have a large effect on airflow and resistance of the nasal cavity. When air flows through a narrow space, it speeds up and creates an inward pressure owing to the Bernoulli principle. This will cause in-drawing of any weakened area, forming nasal valve collapse.⁶

The nasal valve composition includes the caudal aspect of both the ULC, with connections to the septum and piriform aperture, and the LLC, with attachment to the ULC by the scroll. The nasal alar support is composed of the lateral crura of the LLC with medial crura extension, ligamentous connections to the nasal septum and the attachment to the ULCs. Deficiencies of support of the anterior nose usually result from aging, trauma, or postoperatively from rhinoplasty procedures.¹⁰

Aetiology of nasal valve dysfunction

Factors involved in the narrowing and collapse of the nasal valve include congenital flaccidity, trauma, previous surgery and ageing.

Constriction of the internal valve is a common reason for nasal obstruction in patients who have undergone rhinoplasty.¹¹ Predisposing factors include full thickness mucocartilaginous transaction of each ULC from the septum, over-resection of the dorsal septum or ULC and mucosal scarring with synechia in the valve region.⁶ Reduction rhinoplasty intrinsically decreases the nasal airway area, with Grymer reporting a decrease of the internal valve cross-sectional area by 25% and the piriform aperture by 13%.¹⁰

Ageing also brings internal valve collapse as there is weakening of the muscular and fibrous support.⁹ Patients with internal valve collapse typically have a 'pinching' appearance or medial collapse of the supra alar region.⁷

External valve collapse is described as collapse of the nostril margin of the nose on moderate to deep inspiration.⁴ It is often seen in patients with narrow nostrils, a projecting tip and thin weak sidewalls, especially after over resection of the lateral crus of LLC.⁹ The commonest cause of alar rim collapse is previous surgery with over resection of the cephalic margin of the LLC.¹³ It also occurs in patients with weak, malpositioned or strangely-shaped lateral crura which are lying in a more cephalad position than usual.¹³ Just superior to the inferior turbinates, cephalad to the alar lobule, and posterior to the termination of the lateral crura,

is an area largely devoid of cartilage or bone, which Egan termed the supra-alar lateral wall.¹² Dynamic collapse is apt to occur here in proposed individuals. Troell also believed that patients with sleep-disordered breathing can generate large negative intrathoracic pressures that can be transmitted to the upper airway, causing a weakened nasal valve especially alar rim to collapse.¹⁴

Methodology

A multi-step search was carried out on EMBASE, MEDLINE and COCHRANE database, using the following search terms: "Alar collapse", "nasal valve collapse", "alar insufficiency", "nasal valve insufficiency", "alar incompetence", "nasal valve incompetence", "suturing", "cartilage graft" and "functional rhinoplasty". The results were limited to English language publications between 1980 and 2011.

The title and abstracts generated were independently screened to identify relevant articles. Case reports, editorials and letters were excluded. Full-length articles were then obtained, with only the ones that are relevant to the review included. Additional studies were identified by scanning the reference section of the individual studies.

Results

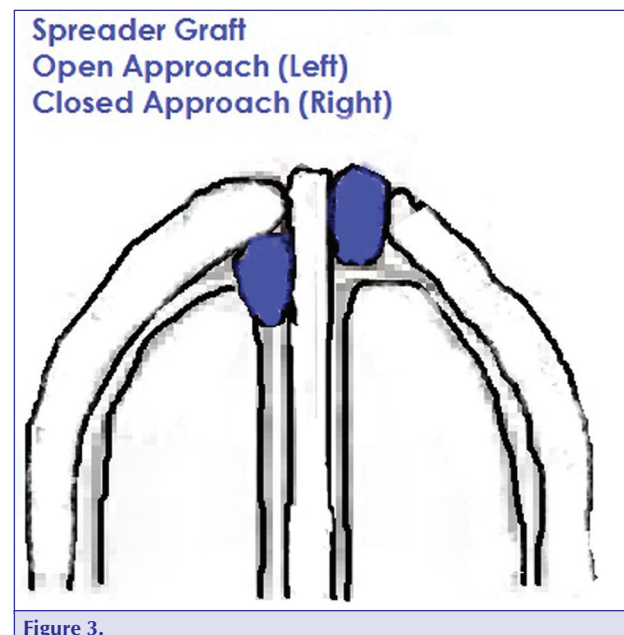
98 titles were generated, where 49 papers warranted full text review. 38 articles were included. Studies that used a combination of techniques but did not segregate the results accordingly were excluded.

Discussion

Methods using Cartilage Graft

1. Spreader Graft¹⁵⁻²⁰

Popularised by Sheen,²¹ grafts of 3-4cm length and 3-4mm width are placed between the nasal septum and the ULC after they are separated from each other, in order to lateralise the ULC and widen the nasal valve. Most studies used an external



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rhinoplasty approach, as it allows direct visualisation of the middle third of the nose. The grafts can be harvested from the posterior septum or concha area, and the ULC is separated from the septum in order for graft placement.

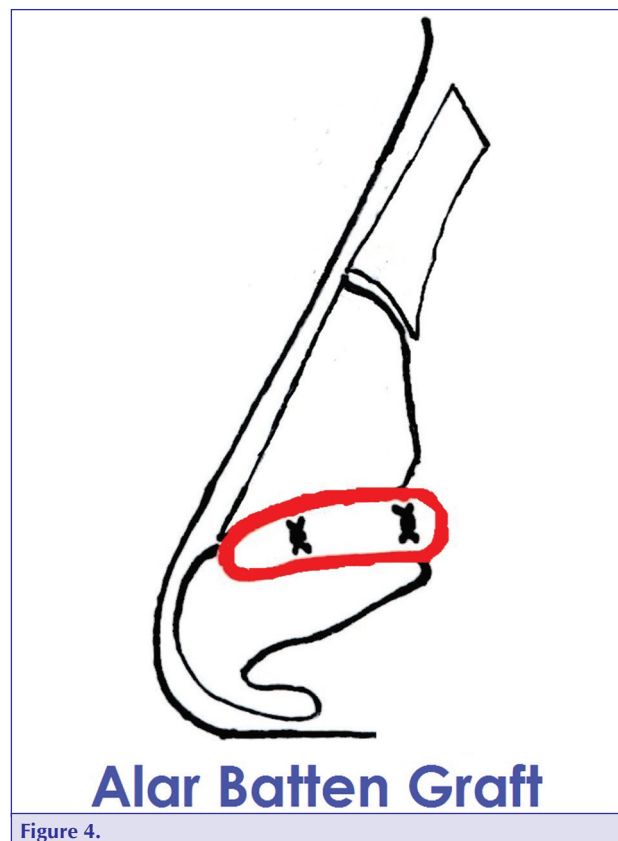
André and Islam both described a variation whereby an endonasal approach was being used and without detachment of ULC. André described placing the graft as high as possible in a subperichondrial plane.²² Islam cut out a window on the dorsal septum so as to house the spreader.²³

General agreement exists about the positive effect of spreader graft on nasal patency. Improvement rates in nasal patency range from 81% to 100% (see Table 1 for summary of results). Ingels went one step further, demonstrating that spreader grafts do not only improve nasal airway, but also widen the middle third of the nose by 6%. This was measured using Adobe Photoshop pre- and post-operatively. Reassuringly in their study of 15 patients, none of them noticed this widening.²⁰

Three studies reported on a combination of techniques: spreader and batten grafts,^{15,19} and spreader and flaring sutures.¹⁷ Schlosser and Park used spreader grafts, alar batten grafts and flaring sutures in different combinations and did not present their result separately, was therefore not included in this review. However their cadaveric study in the same paper demonstrated that the combination of spreader grafts and flaring suture has the greatest impact on cadaveric nasal airway when measured with acoustic rhinomanometry.²⁴

2. Alar batten grafts^{5,7,13,19,25,28}

First described by Toriumi,²⁵ alar batten grafts are a workhorse technique in functional rhinoplasty for widening and strengthening the supra-alar lateral nasal wall. Typically of curved septal or auricular cartilage of 1.5-2cm in length by



4-6mm in width, it has proven to be a valid technique for the treatment of both internal and external valve collapse.^{4,7}

There are a myriad of techniques describe for placement of alar grafts. The approach ranges from rim or marginal

Table 1. Summary of studies using spreader grafts - Grouped as per techniques used

Study	Technique used	Approach	Outcome measures	Success rate	Complications rate
Zijker 1994	Spreader graft	Open	Nasal patency: Subjective assessed 10 point score	Nasal patency: 81% improved. Mean improvement 4.1 points	No major complications
Stal 2000	Absorbable spreader (Lactosorb)	Not specified	Nasal patency & aesthetic: subjective report, not specified	100% improved. No recurrence even though graft absorbed.	None
André 2004	Spreader graft (subperichondrial plane)	Endonasal	Nasal patency: Subjective assessed 4 pt scale	44% optimal, 44% improved	5.6% infection
Islam 2008	Spreader graft (window cut in dorsal septum)	Endonasal	NOSE. Nasal patency: Subjective assessed VAS. AR	NOSE improved by 11.07. VAS improved by 4.7. Both sig. AR: 91% improved MCA, sig.	None
Ingels 2008	Spreader	Open	Nasal patency & Aesthetic: Subjective assessed VAS. Adobe workshop photograph analysis of dorsal width.	Nasal patency: mean VAS increased by 3.4 points. Mean dorsal width increased by 6%. Not noticed subjectively	Not documented
Scutio 1999	Spreader graft & ULC suspension suture	Open	Nasal patency: Subjective assessed 10 point score	Nasal patency: 100% improved. Mean improvement 4.4 points	Not documented
Khosh 2004	Spreader, Batten or both	Either	Nasal patency & aesthetic: Subjective report, not specified.	Nasal patency: spreader 88% improved. Batten 100%. Both 93%.	4% synechia.
Faris 2005	Combined Spreader and Batten	Open	Nasal patency: Subjective assessed VAS. QOL: Subjective assessed VAS. Aesthetic: Subjective assessed 3point scale.	Patency: mean improvement 55mm. QOL: mean improvement 49mm.	8.7% - 1 graft reabsorption 1 graft migration

VAS = visual analogue scale. AR = acoustic rhinomanometry. NOSE= Nasal obstructive symptoms evaluation scale. MCA = minimum cross-sectional area.

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incisions, endonasal incision or external rhinoplasty approach. More recently Deroee et al described their 2mm stab incision in the alar-facial groove and blunt dissection to create a pocket. The incision could not be recognised by plastic surgeons rating digital photographs in 86% of patients when compared with the marginal incision.²⁷

The alar batten graft can be on-lay or under-lay in relation to the LLC, or in the alar fibro-fatty tissue caudal to the lateral crura. Some authors sutured the graft to the LLC; some left it tucked in its pocket (see summary in Table 2). In the underlay technique, care is taken to leave a strip of vestibular skin attached along the caudal border of the LLC.^{7, 26}

Most studies used either autologous septal or auricular cartilage as graft material. Auricular cartilage can be a more superior choice as it provides better contour due to its curvature.^{5,7,19} The graft is bevelled at the edges, and at least one side of the perichondrium is retained to minimise absorption.^{5,7,19} André et al. in their series of 27 patients found no difference in outcome concerning graft material or approach used.²⁶

Placement of graft is at the supra-alar collapse near caudal margin of ULC for internal valve collapse, and caudal to lateral crura in external valve collapse. For the on-lay method, the main concern is aesthetic change to the nose; for the under-lay

method, this may simply push the internal aspect of the lateral nasal wall inward.¹²

Collectively the studies showed 65% to 96% of improvement in their subjective nasal patency score. Anterior active rhinomanometry improved by 341,⁷ and significant improvement in NOSE score.²⁷ Faris et al used a combination of spread and batten grafts, and showed there was significant subjective improvement of nasal patency and QOL when compared to their preoperative VAS scores. Of their patients, 96% claimed to not notice any post op change in the appearance of their nose.¹⁹ In Kalan's study, patients' scoring on post-operative cosmesis outcome was found to be higher than those of the surgeons'.¹³

In 2011, Khalil et al.⁵⁰ described their technique of using alar batten grafts. Alar battens were placed to overlap the junction of the ULC & LLC (scroll area). They fashioned small insertion pocket superficial to the ULC and overlying the upper half of the LLC. The batten is initially pushed cephalically to sit in the upper segment of the pocket lateral to the ULC, and then is 'massaged' externally downwards to overlap the upper rim of the LLC too.

They assessed outcomes using two separate cohorts using a global outcome of improvement reported by the patients and the direct post operative observations of the clinician. In their first cohort (immediate and intermediate follow-up) 98 % of patients had either complete or partial relief of their symptoms (88% and

Table 2. Summary of techniques used in Alar Batten studies

Study	Approach	Onlay / Underlay	Sutured / Tucked in	Outcome measures	Success rate	Complication Rate
Toriumi 1997	Either	Caudal to LLC, extend to piriform aperture	Tucked in	Nasal patency: subjective assessed 5 point scale	Patency: 98% improved, mean 2.5 points	2.2% - intranasal scarring
Kalan 2001	Open approach	Underlay. Graft extended to lateral of piriform aperture	Sutured to LLC	Nasal patency: subjective VAS 10 point scale. Aesthetic: VAS 10 point scale.	Patency: 82% improved. Aesthetic: pt's scale score higher than surgeon's	Not documented
Becker 2003	Marginal incision	Caudal to LLC.	Tucked in	Nasal patency: Subjective reporting. Not specified.	96% improved	Not documented
Faris 2006	Open approach. Combined batten & spreader. Submucosal pocket cephalic to caudal of ULC	Overlay	Sutured to septum	Nasal patency: Subjective assessed VAS. QOL: Subjective assessed VAS. Aesthetic: Subjective assessed 3 point scale.	Patency: mean improvement 55mm. QOL: mean improvement 49mm.	8.7% - 1 graft re-absorption 1 graft migration
André 2006	Either. If endonasal - rim / marginal incision	Underlay. Graft extend to beyond piriform aperture	Sutured to lateral crura	Nasal patency: Subjective rating 4 point scale.	65% optimal or improved breathing. 2% worse	None
Cervelli 2009	Open approach	Underlay, caudal to LLC	Sutured to lateral crura	Nasal patency: subjective rating 5 pt scale. RMM. Aesthetic: Photo rating by pt and surgeon.	Patency: improved by 2.5 points. RMM improved by 341.	3.75% hypertrophic scar. 15% oedematous tip, settled down. 1.25% graft migration. 1.25% skin necrosis
Deroee 2011	Alar-facial stab	Pocket in alar fibrofatty area	Tucked in	ROE. NOSE. Aesthetic: Photos rated by surgeon	ROE & NOSE: sig improvement. Aesthetic: 80%-86% of pts has scar that surgeon can't identified.	None
Khalil 2011	Endonasal - intercartilaginous	Onlay	Tucked in	Nasal patency: subjective reporting, objective assessment	Patency: 88% resolution, 10% modest improvement	8% temporary facial swelling, 6% fullness of side wall, 2% extrusion

RMM = Active anterior rhinomanometry. ROE=Rhinoplasty outcome evaluation instrument. NOSE= Nasal obstruction symptoms evaluation.



10% respectively). A further cohort (to assess long term outcomes) showed improvement in 94% of patients' symptomatology (56% complete and 38% partial).⁵⁰

From their point of view the advantages of their technique are:⁵⁰

1. Quick and easy to master without significant complications.
2. Performed through an endonasal approach without visible scars.
3. Positioning the graft in the scroll area minimises cosmetic deformity.
4. Suitable for the treatment of either / both external / internal valve alar collapse.

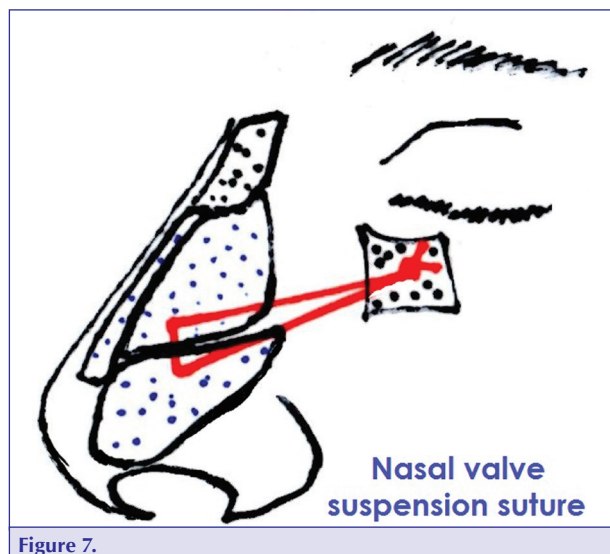
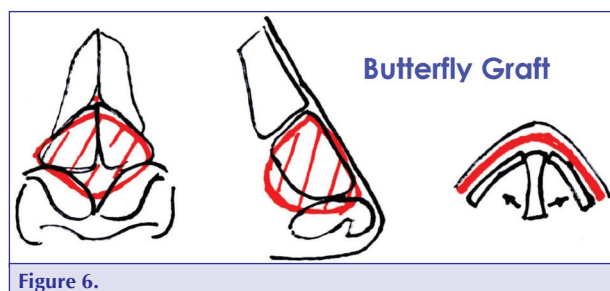
3. Alar rim reconstruction graft^{14,29}

Similar to the alar batten, the alar rim graft is placed closer to and parallel to the rim rather than the lateral crura. Troell et al. believed that standard alar batten does little to support the nasal rim, and inserted their graft by a vestibule incision at the junction of the nares and nasal lobule.¹⁴ Their study revealed a 95% reported improvement of nasal patency, compared to 75% in the alar batten graft group.

Boahene uses a smaller strip of cartilage, 15-25mm long by 2-3mm wide, and a marginal incision to insert the cartilage into the alar rim.²⁹ Their study only reported photographic outcome.

4. Butterfly graft³⁰⁻³²

The butterfly graft over the nasal dorsum has been used in both secondary and primary rhinoplasty for internal valve collapse. Cartilage of approximately 1x2cm in size is usually



harvested from the auricular concha. The graft is inserted into a sub-SMAS plane either via endonasal or open approach. The caudal end of the graft is sutured to the caudal end of ULC.

Three studies showed improved breathing in 80% to 100% of patients. In addition, Ackam et al showed 65% patients had improved or stopped snoring. However, 12-19% were dissatisfied with the cosmetic outcome of their nose,^{31,32} leading to Friedman cautioning about adequate preoperative explanation and managing patients' expectations, as maintaining an aesthetic dorsum with a butterfly graft does possess a technical learning curve. Their advice is to bevel the edges of the graft, and to place crushed cartilage over the graft and dorsum to maintain its smoothness.³² Eight to nineteen percent of patients are also unhappy about the outcome of the ear.

With increased experience, the conchal butterfly graft can be both functionally and cosmetically outstanding, but care should be taken to emphasise on the potential aesthetic change of the nose and ear.

Methods using Suturing

Most suturing methods aim to enlarge the narrowed valve area, with the exception of Mendelsohn's alar expansion suture, which claimed to both enlarge and strengthen the lateral wall if used concomitantly with a cartilage graft. Park's flaring suture was used in conjunction with spreader graft placement.³³

1. Nasal valve suspension suture^{9,34-37}

Paniello pioneered the nasal valve suspension suture in 1996, whereby the ULCs were suspended by placement of a permanent suture at the site of collapse and traction laterally

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Table 3. Summary of studies using Nasal Valve Suspension Sutures.

Authors	Technique used	Approach	Outcome measures	Success rate	Complication Rate
Panieollo 1996	Nasal valve suspension sutures	Endonasal. Transconjunctival.	Nasal patency: Subjective assessed 10 point scale. RMM. AR. Photographic analysis	Nasal patency: 100% ↑. RMM 83%. AR 33%. Increased MCA. Photographs: 50% widening	No major complication
Lee 2001	Nasal valve suspension sutures – modified. Double permanent suture used. infraorbital retaining suture	Infraorbital incision. No nasal incision.	Nasal patency: Subjective rating- 3 point scale. Photographic document.	100% improved. 78% feels satisfied.	11% minor asymmetry of eye
Friedman 2004	Nasal valve suspension sutures. Bone anchored system	Endonasal incision. Infraorbital incision.	Nasal patency: Subjective reported, not specified. AR in 52 patients SNOT-20 in 52 patients	Nasal patency: 91.7% improved. 8.3% no improvement. AR: 94% improved MCA. SNOT: 84% improvement of scores. Mean post op scores sig lower.	6.7% Complications – persistent pain, intranasal granuloma, infraorbital abscess.
Nuara 2007	Nasal valve suspension suture.	Infraorbital incision. No nasal incision.	Nasal patency: Subjective reported, not specified.	Nasal patency: 82% improved, where 71% reported complete resolution at 1 week.	24% infection. 35% loss of suspension at 6-22 months
Andre 2008	Nasal valve suspension	Infraorbital incision. No nasal incision.	Nasal Patency: Subjective scoring 1-10	79% subjective improvement. (Average 2-3 points). Improvement reduced with time.	25% comp's: tenderness, swelling, infection.

AR= acoustic rhinomanometry. RMM= Active anterior rhinomanometry. MCA = Minimum cross-sectional area. SNOT = Sinu-nasal Outcome Test.

anchoring to the maxillary periosteum. Friedman introduced the modification where a Mitek self-retaining screw is used as an anchor. Lee used a double suspension suture and anchored to a permanent stay suture infraorbitally. André did not use a stay suture, anchoring the suspension suture directly onto periosteum of inferior orbital rim. Friedman's 2004 paper was included in this review but not his 2003,³⁸ as this consisted only a description of his method.

Subjective symptoms were improved in 71% to 100% of patients. However Nuara noted that long-term satisfaction decreased to less than half of patients when followed up for more than a year. André similarly reported modest improvement that lasted for a short period of time, and a relatively high complication rate. Twenty-five percent of their patients experienced inflammation, swelling or pain under the eye,

leading them to conclude that the nasal valve suspension suture is not recommended as a first line treatment for valve insufficiency.

2. Flaring suture³³

The flaring suture is placed through the caudal aspect of the ULC in a vertical fashion, and then passed on the contralateral side in a similar fashion. The caudal end of the ULC is typically hidden under the scroll, and the lateral crura will have to be retracted inferiorly for sufficient exposure. Tightening of the mattress suture across the dorsum will result in the ULC "flaring" laterally, increasing the angle of the internal nasal valve.

Park used the flaring suture in conjunction with spreader grafts, via an open approach. All patients in his series reported breathing improvement.

Table 4. Summary of studies using other suture techniques

Authors	Technique used	Approach	Outcome measures	Success rate	Complication Rate
Park 1998	Flaring suture (in conjunction with spreader graft)	Open	Nasal patency: Subjective reported, not specified.	100% improved nasal patency.	Not documented.
Ozturan 2002	Horizontal mattress suture to bend ULC	Open	Endoscopic angle measure Aesthetic: Patient assessed VAS, Surgeon assessed VAS	Valve angle: ↑ by 16.2° Aesthetic: No difference in cosmetic outcome between patient and surgeon	11.2% synechia
Mendelshohn 2006	Lateral expansion suture	Open	Nasal patency: Subjective assessed 10 point scale. Aesthetic: Subjective assessed 3 point scale.	Nasal patency: 94% improvement (significant). Aesthetic: 56% better, 44% no change	None
Dutton 2008	Intranasal Z-plasty	Endonasal incision	Nasal patency: Subjective assessed 10 point scale.	Nasal patency: Mean improvement of post operative score of 3.92 (significant) Aesthetic: no complaint	None
Rizvi 2011	Concealed lateralising suture	Endonasal incision. Lateral nasal wall incision.	Nasal patency: Subjective assessed, not specified	Nasal patency: 89.9% improvement	10.1% failure – suture unravelled, cut through, infection.

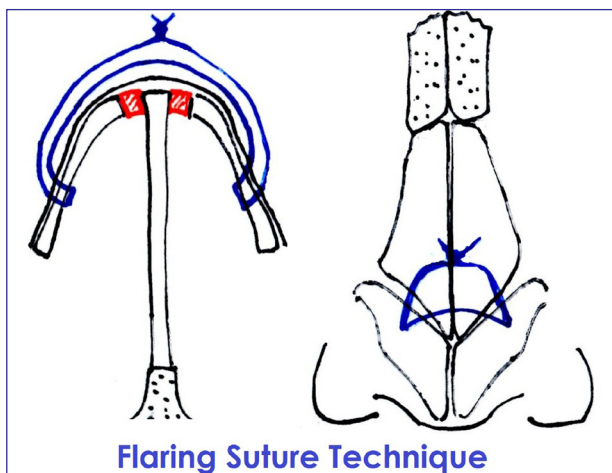


Figure 8.

3. Lateral Mattress Bending suture⁶

Using 5-0 polypropylene, Ozturan devised a horizontal mattress suture on each ULC without entering the mucoperichondrium. The tightened mattress suture causes the ULC to convert into a convex shape, thus increasing the internal valve angle.

Using pre and post op endoscopic photos to measure the internal valve angle, they showed there was statistically significant increase from $9.1 \pm 4.2^\circ$ to $25.3^\circ \pm 3.8^\circ$. 11% of patients had synechia, and no patients required revision surgery.

4. Alar expansion suture³⁹

Using an external rhinoplasty approach, the alar expansion suture passes through the lateral crus of LLC into the nasal vestibule, loops back through the mucosa and lateral crus, then passes over the septum to undergo the same manoeuvre on the opposite side. Tying of this suture gently opens up the lateral crura and nasal valve. If the lateral crus buckles, the suture is removed and reinforcement batten implants are placed on each side before re-suturing again.

Ninety-four percent of patients experienced good improvement in their airway, and the improvement is statistically significant. No complications were reported. Mendelsohn claims to address both the problems of expanding



Figure 10.

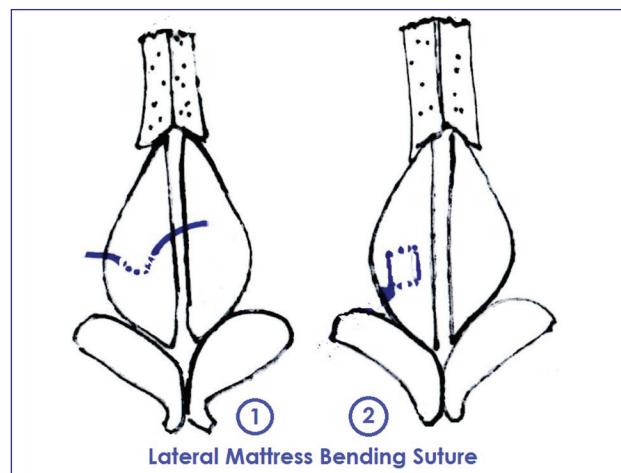


Figure 9.

the cross-sectional area and the issue of dynamic collapse by having a combination method of suturing plus grafting.

5. Z-plasty⁴⁰

Dutton described a Z-plasty based on an intercartilaginous incision as the central incision of the Z. Elevating the vestibule skin and transposing the anterior and posterior triangular flaps, this aims to increase the area of the valve region. They found improvement of mean post-operative scoring, which is significant.⁴⁰ This technique is minimally invasive, no foreign body as valve suspension, but conceptually and technically can be challenging and require experience to master

6. Concealed Lateralising Suture Technique^{41,42}

This is a variation of the nasal valve suspension suture. Rizvi and Gauthier improvised this technique to making a stab incision over the nasal bone laterally, anterior and inferior to the medial canthus. An endonasal intercartilaginous incision is also made. A 3/0 prolene suture is passed from the external incision under the SMAS layer, piercing the ULC, before looping back lateral to the ULC and emerging externally again inferior to the medial canthus.

They reported 10 year results in their later paper.⁴² The reported complete satisfaction rate was 89.9% with the improvement in their nasal airway. A 10.1% failure rate was due to the suture cutting through the ULC, unravelling, or to an infection.

Methods Involving Excision or Transposition

1. The J-flap⁴³

O'Halloran believes it is the loosening of the fibroareolar tissue lateral to the nasal valve that causes the prolapse of the lateral

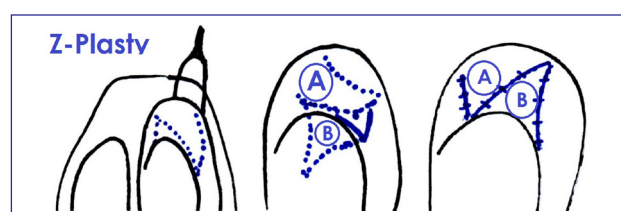
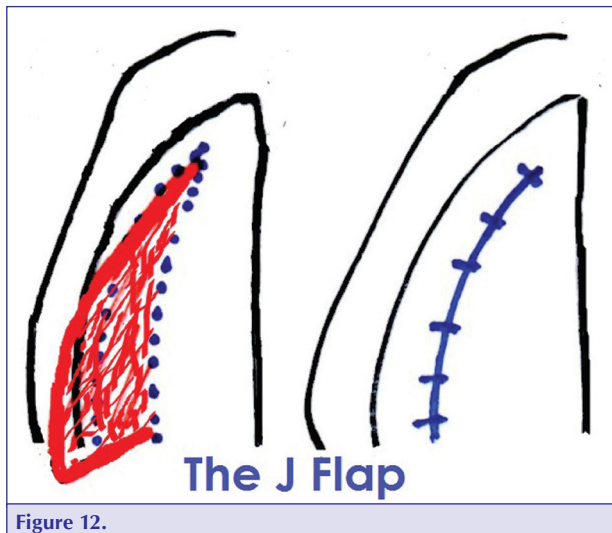


Figure 11.



crus into the airway and the secondary narrowing of the nasal valve angle. The J-flap is designed to tighten the lateral nasal wall by excising a portion of the mucosa and cartilage at the caudal margin of the protruding lateral crus. Symptoms improvement was reported in 89% of patients, with no complications noted.

2. Excising ULC caudal edge

Using an incision at the caudal edge of ULC, dissection was carried out on the supra and infraperichondrial plane. The ULC was exposed and a 2-3mm strip was excised off its caudal edge. Kantas et al. explained that this technique resulted in strengthening of the ULC by postoperative scars which functioned to pull open the nasal valve edge.⁴⁴ Their results showed 65.1% of patient reporting improved nasal patency, with statistically significant increase in nasal flow in active anterior rhinomanometry.

3. Transposition⁴⁵

Armengot et al. proposed transposing the inferior edge of ULC from under the lateral crura to over and sutured in place.

Methods using Injections

Nyte reported his injection technique using calcium hydroxylapatite⁴⁶ and hyaluronic acid⁴⁷ to simulate the effect of spreader graft. The injections are performed under local anaesthetic and direct vision, in a submucoperichondrial and / or submucosal plane. The 3 points of injection proposed were:

- 1-2mm from apex of internal valve on caudal medial surface of ULC
- 3-4mm from apex of internal valve on caudal medial surface of ULC
- 2-3mm cephalic to the internal valve apex on the superior aspect of the medial ULC

The ULC becomes supported with the injection material, and lateralises away from the septum, creating a wider internal valve angle. He reported on 27 and 5 patients in each series. The outcome measures were not specified, but all patients reported subjective improvement in nasal patency.

Methods using Implants

Ramakrishnan et al. used prefashioned porous polyethylene implants as alar batten grafts, and pre-soaked the implants in

antibiotics.⁴⁸ Turegan et al. fashioned a thin sheet of porous polyethylene into a saddle shape akin a conchal butterfly graft to correct dorsal deformity and internal valve collapse.⁴⁹ Both groups demonstrated complete improvement in nasal patency as reported by patients; however 21% experienced extrusion and 17% infection in the former study.

Conclusion

Nasal valve insufficiency is a common cause of nasal airway obstruction, and can be a multidimensional problem. In some patients, a reduced cross-sectional area or an acute valve angle of less than 10° is the main cause. In others, it is the weak nasal sidewall causing their symptoms. Many techniques have been devised to correct the functional and cosmetic aspects of this problem, as summarised above. The aim of these techniques was to broaden the internal valve, and re-establish the stiffness of the lateral nasal wall, in an attempt to improve airflow at this area.

A thorough preoperative assessment is important to determine the cause of the nasal obstruction; this should include the static and dynamic structures. Septal deviation and nasal polyps aside, the angle of the internal valve and the state of the lateral nasal wall during dynamic inspiration should be assessed. Most authors from this review used the Cottle's manoeuvre to assess alar obstruction, however there is concern that this can be non-specific as it enhances breathing even when nasal obstruction is a consequence of septum deviation or turbinate enlargement.¹⁵ Many also suggested tenting of the valve area internally with either a cotton-tip applicator or an ear curette, to more reliably determine the exact site of the obstruction. There is global emphasis on the importance of a detailed history of nasal symptoms and previous nasal surgery / trauma, Nasal medication and atopic state (including results of objective tests).⁵⁰ Ideally, Patients who were considered for surgery should have had already optimum medical therapy to their nasal symptoms without a satisfactory relief.⁵⁰

The main aims of surgery to the nasal valves are threefold:⁴⁵

1. Increasing the septo-lateral angle if it was diminished
2. Stabilizing the free edge of the ULC to avoid its collapse
3. Strengthening the ULC and alar cartilages and increase resistance to negative pressure during inhalation.

The key in treating nasal valve obstruction is in the correct pre-operative diagnosis. Apart from differentiating between external and internal valve narrowing, it is also paramount to decide whether the valvular insufficiency arose from a static or dynamic cause. This will serve to guide treatment plan, as to whether a widening or strengthening solution is needed.

Most of the techniques above work only to solve one problem. Spreader grafts widen the middle nasal vault and aid in repositioning the ULCs, but fail to support the lateral nasal walls. Alar batten grafts provide support to the lateral nasal walls; they do not widen the middle vault. Butterfly grafts are useful for relieving obstruction of the middle nasal vault, but the technique frequently requires an open approach and conchal cartilage harvesting, carrying a risk of cosmetic dissatisfaction. Upper lateral suspension procedure is technically demanding and requires special equipment and infra orbital incision. Some suture techniques (flare suture, lateral expansion suture) claimed to be able to both widen

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and support the nasal valve. However it is possible that a combination of techniques may be necessary in some cases.

The last consideration is the approach used, and the pre-operative counselling of patients. Many techniques had favoured an open approach, as it provides good access to the cartilage framework, but this leaves an external scar. Cartilage

grafts used may also produce cosmetic alterations. Patients will need proper and detail explanation and counselling if unexpected post-operative disappointment is to be avoided.

Declaration of competing interests

Nothing to declare.

References

1. Elwany S, Thabet H. Obstruction of the nasal valve. *J Laryngol Otol* 1996;**100**:221-24.
2. Lee J, Constantinides M. Trends in functional rhinoplasty 2008. Current Opinion in *Otolaryngology & Head and Neck Surgery* 2009;**17**(4):295-301.
3. Tardy M, Garner E. Inspiratory nasal obstruction secondary to alar and nasal valve collapse: technique for repair using autologous cartilage. *Otolaryngol Head Neck Surg* 1990;**1**:215-18.
4. Constantine M. The incompetent external nasal valve: pathophysiology and treatment in primary and secondary rhinoplasty. *Plast Reconstr Surg* 1994;**93**:919-31.
5. Becker D, Becker S. Treatment of nasal obstruction from nasal valve collapse with alar batten grafts. *J Long Term Eff Med Implants* 2003;**13**(3):259-69.
6. Ozturan O, Miman MC, Kizilay A. Bending of the Upper Lateral Cartilages for Nasal Valve Collapse. *Archives of Facial Plastic Surgery* 2002;**4**(4):258-61.
7. Cervelli V, Spallone D, Davide Bottini J, Silvi E, Ventile P, Curcio B, et al. Alar Batten Cartilage Graft: Treatment of Internal and External Nasal Valve Collapse. *Aesth Plast Surg* 2009;**33**(4):625-34.
8. Apaydin F. Nasal valve surgery. *Facial Plastic Surgery* 2011;**27**(2):179-91.
9. André RF, Vuyk HD. Nasal valve surgery; our experience with the valve suspension technique. *Rhinology* 2008;**46**(1):66-69.
10. Grymer L. Reduction rhinoplasty and nasal patency: change in the cross-sectional area of the nose evaluated by acoustic rhinometry. *Laryngoscope* 1995;**105**:429-31.
11. Kasperbauer J, BE K. Nasal valve physiology: implications in nasal surgery. *Otolaryngol Clin North Am* 1987;**20**:699-719.
12. Egan K, Kim D. A Novel Intranasal STent for Functional Rhinoplasty and Nostril Stenosis. *Laryngoscope* 2005;**115**:903-09.
13. Kalan A, Kenyon G, Seemungal T. Treatment of external nasal valve (alar rim) collapse with an alar strut *The Journal of Laryngology and Otology* 2001;**115**:788-91.
14. Troell R, Powell N, Riley R, Li K. Evaluation of a new procedure for nasal alar rim and valve collapse: Nasal alar rim reconstruction. *Otolaryngol Head Neck Surg* 2000;**122**(2):204-11.
15. Khosh M, Jen A, Honrado C, Pearlman S. Nasal valve reconstruction - experience in 53 consecutive patients. *Arch Facial Plast Surg* 2004;**6**:167-71.
16. Zijlker T, Quaendvlieg P. Lateral augmentation of the middle third of the nose with autologous cartilage in nasal valve insufficiency. *Rhinology* 1994;**32**(1):34-41.
17. Scutio S, Bernardeschi D. Upper lateral cartilage suspension over dorsal grafts: a treatment for internal nasal valve dynamic incompetence. *Facial Plastic Surgery* 1999;**15**:309-16.
18. Stal S, Hollier L. The use of resorbable spacers for nasal spreader grafts. *Plast Reconstr Surg* 2000;**106**:922-28.
19. Faris C, Koury E, Kothari P, Frosh A. Functional rhinoplasty with batten and spreader grafts for correction of internal nasal valve incompetence. *Rhinology* 2006;**44**:114-17.
20. Ingels KJAO, Orhan KS, van Heerbeek N. The Effect of Spreader Grafts on Nasal Dorsal Width in Patients With Nasal Valve Insufficiency. *Archives of Facial Plastic Surgery* 2008;**10**(5):354-56.
21. Sheen J. Spreader graft: A method of reconstructing the roof of the middle nasal vault following rhinoplasty. *Plast Reconstr Surg* 1984;**73**:230.
22. André RF, Paun SH, Vuyk HD. Endonasal Spreader Graft Placement as Treatment for Internal Nasal Valve Insufficiency. *Archives of Facial Plastic Surgery* 2004;**6**(1):36-40.
23. Islam A, Arslan N, Felek S, Celik H, Demirci M, Oguz H. Reconstruction of the INternal Nasal Valve: Modified Splay Graft technique with Endonasal Approach. *Laryngoscope* 2008;**118**:1739-43.
24. Schlosser RJ, Park SS. Surgery for the Dysfunctional Nasal Valve. *Archives of Facial Plastic Surgery* 1999;**1**(2):105-10.
25. Toriumi D, Josen J, Winberger M, Tardy MJ. Use of alar batten grafts for correction of nasal valve collapse. *Arch Otolaryngol Head Neck Surg* 1997;**123**:802-08.
26. André RF, D'Souza A, Kunst H, Vuyk HD. Sub-alar batten grafts as treatment for nasal valve incompetence; description of technique and functional evaluation. *Rhinology* 2006;**44**:118-22.
27. Deroee A, Younes A, Friedman O. External nasal valve collapse repair: The limited alar-facial stab approach. *Laryngoscope* 2011;**121**:474-79.
28. Khalil H, Foxton C, Mitchell-Innes A. Septoplasty with alar batten for the treatment of alar collapse: how we do it. *Clinical Otolaryngology* 2011;In print.
29. Boahene K, Hilger PA. Alar rim grafting in rhinoplasty. *Arch Facial Plast Surg* 2009;**11**(5):285-89.
30. Clark J, Cook TA. The 'butterfly' graft in functional secondary rhinoplasty. *Laryngoscope* 2002;**2002**(112):1917-25.
31. Akcam T, Friedman O, Cook TA. The Effect on Snoring of Structural Nasal Valve Dilatation With a Butterfly Graft. *Arch Otolaryngol Head Neck Surg* 2004;**130**(11):1313-18.
32. Friedman O, Cook TA. Conchal cartilage butterfly graft in primary functional rhinoplasty. *Laryngoscope* 2009;**119**:255-161.
33. Park S. The flaring suture to augment the repair of the dysfunctional nasal valve. *Plast Reconstr Surg* 1998;**101**:1120-22.
34. Paniello R. Nasal valve suspension. An effective treatment for nasal valve collapse. *Arch Otolaryngol Head Neck Surg* 1996;**122**:1342-46.
35. Nuara M, Mobley S. Nasal valve suspension revisited. *Laryngoscope* 2007;**117**(12):2100-6.
36. Lee DS, Glasgold AI. Correction of Nasal Valve Stenosis With Lateral Suture Suspension. *Archives of Facial Plastic Surgery* 2001;**3**(4):237-40.
37. Most SP. Analysis of Outcomes After Functional Rhinoplasty Using a Disease-Specific Quality-of-Life Instrument. *Archives of Facial Plastic Surgery* 2006;**8**(5):306-09.
38. Friedman M, Ibrahim H, Syed Z. Nasal Valve suspension: an improved, simplified technique for nasal valve collapse. *Laryngoscope* 2003;**113**:381-85.
39. Mendelsohn MS, Golchin K. Alar Expansion and Reinforcement. *Archives of Facial Plastic Surgery* 2006;**8**(5):293-99.
40. Dutton JM, Neidich MJ. Intranasal Z-plasty for Internal Nasal Valve Collapse. *Archives of Facial Plastic Surgery* 2008;**10**(3):164-68.
41. Rizvi S, Gauthier M. How I Do It: Lateralizing the collapsed nasal valve. *Laryngoscope* 2003;**113**:2052-54.
42. Rizvi S, Gauthier M. Lateralising the collapsed nasal valves simplified: 10-Year Survey of a Simple Concealed Suture Technique. *Laryngoscope* 2011;**121**:558-61.
43. O'Halloran L. The lateral crural J-flap repair of nasal valve collapse. *Otolaryngology - Head and Neck Surgery* 2003;**128**(5):640-9.
44. Kantas I, Balatsouras D, Vafiadis M, Apostolidou M, Korres S, Danielidis V. Management of inner nasal valve insufficiency. *Journal of Otolaryngology-Head & Neck Surgery* 2008;**37**(2):212-18.
45. Armengot M, Zapater C, JRA B. Upper lateral cartilage transposition in the surgical management of nasal valve incompetence. *Rhinology* 2003;**41**:107-12.
46. Nyte C. Spreader graft Injection with calcium hydroxylapatite: A non surgical technique for internal nasal valve collapse. *Laryngoscope* 2006;**116**:1291-92.
47. Nyte C. Hyaluronic acid spreader graft injection for internal nasal valve collapse. *Ear, Nose & Throat Journal* 2007;**86**(5):272.
48. Ramakrishnan J, Danner C, Yee S. The use of porous polyethylene implants to correct nasal valve collapse. *Otolaryngol Head Neck Surg* 2007;**136**:357-61.
49. Turegun M, Acarturk T, Ozturk S, Sengezer M. Aesthetic and functional restoration using dorsal saddle shaped medpor implant in secondary rhinoplasty. *Ann Plast Surg* 2008;**60**(6):600-03.
50. Khalil, H.S., Foxton, C.R. & Mitchell-Innes, A.M. Septoplasty with alar batten for the treatment of alar collapse: how we do it. *Clinical Otolaryngology* 36, 575-587.