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Spreader graft to correct nasal valve stenosis with high septal deviation

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Abstract. *Spreader graft to correct nasal valve stenosis with high septal deviation. Objectives***:** Internal nasal valve stenosis can increase nasal airway resistance and cause nasal obstruction. This study investigated the relationship between different types of internal nasal valves and nasal obstruction, and the effect of spreader graft insertion on nasal obstruction among patients with stenosis of different types of internal nasal valves.
Methodology: Thirty-two patients (64 internal nasal valves) with symptoms of nasal obstruction were recruited consecutively from November 2012 to July 2016 at Taipei and Sijhih Cathay General Hospitals. The internal nasal valves were classified into six types according to endoscopic findings. The severity of nasal obstruction and effect of the modified Cottle maneuver were recorded using a visual analogue scale (VAS). Differences in the severity of nasal obstruction among patient with the different types of internal nasal valves were analyzed. The severity of nasal obstruction and effect of the modified Cottle maneuver were compared before and after spreader graft insertion.
Results: The most common type of internal nasal valve was high septal deviation (N=24, 39%), which also caused the most severe nasal obstruction (VAS score 6.42). The severity of nasal obstruction and effect of the modified Cottle maneuver decreased significantly after spreader graft insertion (average VAS scores decreased from 5.4 to 1.5 and 3 to 0.6, respectively).
Conclusions: In our Taiwanese patients with nasal obstruction caused by internal nasal valve stenosis, the most common type of internal nasal valve was high septal deviation. Spreader graft insertion improved nasal obstruction in patients with all types of internal nasal valves.

Introduction

Nasal obstruction (NO) is one of the most common complaints encountered in the otolaryngology department. The most common causes of NO include external nasal valve stenosis, internal nasal valve (INV) stenosis, septal deviation, and inferior turbinate hypertrophy. Nasal valve stenosis was first described by Dr. Mink in 1903.[1] The pressure inside the nose decreases during inspiration causing the weak lateral nasal wall to collapse. In contrast to nasal valve collapse, INV stenosis indicates structural narrowing that makes airflow inspiration and expiration difficult. The INV area is the narrowest part of the nasal airway. It is located superiorly from the angle of the upper lateral cartilage (ULC) and nasal septum, inferiorly from the floor of the piriform aperture, medially from the nasal septum, and laterally from the inferior turbinate head. Septal deviation, inferior turbinate hypertrophy, and an elevated nasal floor may all reduce the INV area. Before correcting INV stenosis, septoplasty and inferior turbinectomy should be considered, when indicated. The INV cross-sectional area ranges from around 55 to 64 mm^2, and is located approximately 1.5 cm posterior to the nostril.[2,3,4,5] Murat *et al*. classified INVs into six types: angle occupied by the septal body, sharp angle, blunt angle, concave caudal border, convex caudal border, and twisted caudal border.[6] No previous studies have discussed the relationship between different types of internal nasal valves

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and NO. Therefore, the aim of this study was to investigate whether the type of INV influences the severity of NO.

The INV angle is the triangular portion between the septum and caudal border of the ULC, and the angle is normally 10-15°.[4,7] The INV stenosis can be caused by collapse of the ULC and high septal deviation, and it can easily increase the resistance in the nasal airway and cause symptoms of NO. The modified Cottle maneuver (MCM) is used for the diagnosis of INV stenosis in patients with subjective complaints of NO. The MCM involves lateralizing the caudal border of the ULC using a probe or cotton swab. If the NO can be improved by the MCM, INV stenosis is suspected. In this study, we used the MCM for pre-operative evaluations of the effect of functional rhinoplasty with the aim of improving NO (Fig. 1).

Many methods are available to correct INV stenosis, including nostril stents, flaring sutures, and spreader, splay, butterfly, and batten grafts.[8-13] Spreader graft insertion (SGI) is widely used because of its high success rate. The goal of this study was to investigate the effect of SGI on NO among patients with different types of internal nasal valves, especially those with high septal deviation.

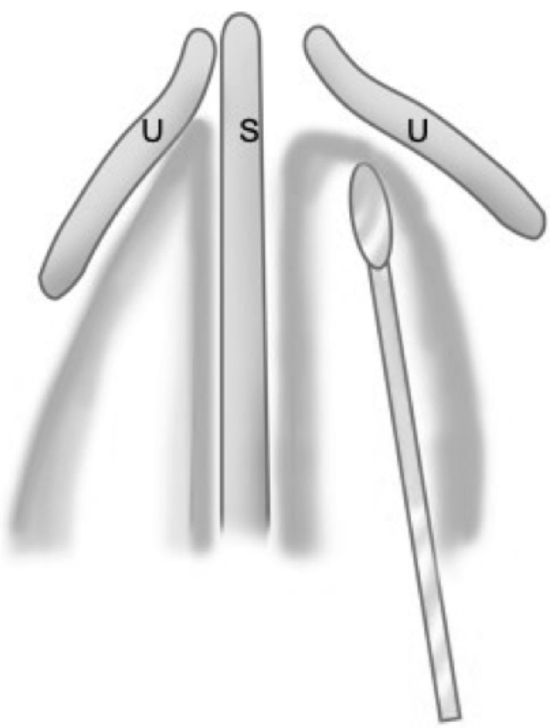

Figure 1
Modified Cottle Maneuver: The caudal border of the upper lateral cartilage is pushed laterally using a probe or cotton swab.
U: Caudal border of upper lateral cartilage; S: Septum

Materials and methods

This study was approved by the Institutional Review Board of Cathay General Hospital (IRB number: CGH-P106021). All consecutive adult patients with symptomatic INV stenosis selected for SGI from the Otorhinolaryngology Departments of Taipei and Sijhih Cathay General Hospitals from November 2012 to July 2016 were included in this study. Sixty-four INVs from 32 patients (23 men and 9 women) were analyzed (average age, 37 years; range: 20 to 70 years; Table 1). Bilateral INVs can be totally different types and the septum may deviate bilaterally; therefore, the INVs of both sides of each nose were recorded separately.

Table 1
Characteristics of the patients

Age (years)	Male	Female	Total	
20-30	10	1	11	
31-40	9	2	11	
41-50	2	3	5	32
51-60	1	2	3	
61-70	1	1	2	

The inclusion criteria were: (1) symptoms of NO caused by a narrow INV as assessed by nasal endoscopy and (2) positive MCM results. The exclusion criteria were: (1) nasal septal deviation other than high septum deviation that affected the INV; (2) history of rhinitis and an improvement in NO, assessed by a VAS, of more than 2 points after the application of nasal packing gauze soaked with epinephrine solution (1 mg/ml) at the common meatus; (3) history of rhinoplasty with grafts or suture techniques affecting the INV; and (4) those lost to follow-up within 2 months postoperatively.

All of the patients underwent nasal endoscopy to check the INV before surgery. A zero degree wide-angle endoscope with a diameter of 4 mm and length of 18 cm (HOPKINS® Telescopes, Karl Storz, Germany) was used. Based on the study by Murat *et al.*, we classified the INVs into six types according to the endoscopic findings and the INV angle between the septum and ULC as follows: high septal deviation (angle occupied by the septal body), sharp angle, blunt angle, concave caudal border, convex caudal border, and twisted caudal border.[5] All nasal endoscopic examinations were performed by Dr. Su-Yi Hsu. All patient information related to the INV was collected and analyzed.

The severity of NO was self-evaluated using a VAS from 0 to 10 points (0, no obstruction; 10, the most severe obstruction). The patients graded the NO using the VAS for one nostril at a time to distinguish the right INV and left INV. The MCM was performed using a cotton swab. The MCM makes it possible to confirm the diagnosis of INV stenosis with greater precision. We defined the "MCM effect" as the difference in VAS scores with and without the MCM to indicate the improvement in the NO after INV dilation. This was used to preoperatively predict the possible effect of SGI on INV stenosis. The MCM effect was evaluated both before and after SGI. We hypothesized that the MCM effect should be less pronounced after SGI than before. If the spreader graft was able to successfully widen the INV, the NO symptoms should be improved and there should not be much difference with and without the MCM.

For the functional rhinoplasty procedure, trans-columellar and marginal incisions were made and dissected to expose the lower lateral cartilage, ULC, and nasal bones. The septal cartilage was then exposed after developing bilateral septal mucoperichondrial flaps. When harvesting the septal cartilage for the spreader grafts, care was taken to preserve the L-strut 1-1.5 cm in width at the caudal and dorsal borders of the septum to support the framework of the nose. Septoplasty alone cannot correct INV stenosis, especially when it is caused by high septal deviation; thus, SGI was needed in these circumstances.

If the patient had previously undergone septo-plasty, conchal cartilage was a good alternative autologous material for the spreader grafts. Via a retro-auricular approach, cartilage of the concha cavum and concha cymba was harvested after carefully developing anterior and posterior cutaneoperichondrial flaps. The crus of helix and antihelix were kept intact to avoid auricular deformities. The septal or conchal cartilage was sculpted into two rectangular-shaped grafts for use as spreader grafts. The usual size of the spreader graft was approximately 7-8 mm in length, 4-5 mm in width, and 2-3 mm in thickness. The two spreader grafts were inserted between the ULC and septum. If the spreader grafts were made of conchal cartilage, the concave side was placed facing the septum. Using this method, the angle between the septum and ULC could be widened by the spreader graft (Fig. 2). Some of the patients also received other grafting for nose contour adjustments. All of the operations were performed by Dr. Su-Yi Hsu.

Two months after SGI, the self-evaluated VAS scores for the NO and MCM effect were recorded again. The results were compared with the data before SGI, and the effects of SGI on NO and the MCM were analyzed by t-test. The relationship between the type of INV and the severity of NO was evaluated using one-way analysis of variance (ANOVA). All of the analyses were performed using SPSS software.

Results

The nasal endoscopic examinations of the 32 patients (64 INVs) showed that the most common type of INV was high septal deviation (24 INVs, 39%). In correlation analysis between the type of INV and the VAS score for NO, the INV type causing the most severe NO was also high septal deviation (Table 2). In the one-way ANOVA of all

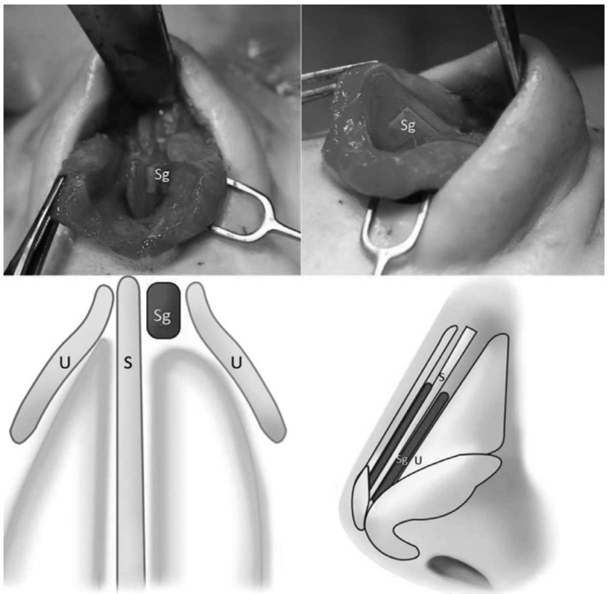

Figure 2
The angle between the septum and upper lateral cartilage could be widened by the spreader graft. The spreader graft was placed between the septum and upper lateral cartilage.
U: Caudal border of upper lateral cartilage; S: Septum; Sg: Spreader graft

Table 2
Analysis of INV type and the severity of NO caused by INV stenosis

INV Type	N (total 62)	NO VAS before SGI	NO VAS after SGI	Difference in the NO VAS before and after SGI	Score for MCM effect before SGI	Score for MCM effect after SGI	Difference in the MCM effect score before and after SGI
High Septal Deviation	24 (39%)	6.42	1.25	5.17	3.38	0.58	2.8
Sharp Angle	12 (19%)	6.17	1.75	4.42	3.75	0.67	3.08
Blunt Angle	6 (10%)	3.83	1.5	2.33	2.33	0.5	1.83
Concave Caudal Border	7 (11%)	2.57	0.43	2.14	2	0.29	1.71
Convex Caudal Border	8 (13%)	5.38	2.88	2.5	2.13	1	1.13
Twisted Caudal Border	5 (8%)	5	1.8	3.2	2.6	1.4	1.2

The most common type of INV was the high septal deviation, which was also the type causing the most severe NO. Patients with stenosis of all types of INVs had improved NO and MCM effect scores after SGI. The high septal deviation and sharp angle types were significantly corrected by SGI. NO: Nasal obstruction; INV: Internal nasal valve; MCM: Modified Cottle maneuver; SGI: Spreader graft insertion; VAS: Visual analogue scale. Data were recorded as the average VAS score.

Table 3
The VAS scores for NO and the MCM effect before and after SGI.

VAS	Before SGI	After SGI
NO	5.4	1.5 *
MCM Effect	3	0.6 *

The mean VAS scores for NO and the MCM effect were significantly lower after SGI, *$p < 0.05$. NO: Nasal obstruction; MCM: Modified Cottle maneuver; SGI: Spreader graft insertion; VAS: Visual analogue scale.

SGI on INV stenosis. The INV type with the highest score for the MCM effect was the sharp angle type, followed by high septal deviation (Table 2).

Among the 64 INVs in our study, 59 (92%) had improved NO after SGI. There was a significant difference between the VAS score for NO before and after SGI (VAS 5.4 and 1.5, respectively, $p < 0.05$; Tables 2 and 3). Overall, five INVs (in four patients) had a higher VAS score for NO after surgery, and only one of these INVs was the high septal deviation type. The success rate of SGI in the high septal deviation type was 96%, and the NO improved from a preoperative VAS score of 6.42 to 1.25 after SGI (Table 2).

Table 4
One-way ANOVA between patients with high septal deviation and the other INV types

High Septal Deviation	Difference in NO VAS	P value	Difference in improvement of NO VAS before and after SGI	P value
Sharp Angle	0.3	1.0	0.8	0.9
Blunt Angle	2.6	0.2	2.8	0.3
Concave Caudal Border	3.8	0.009	3.0	0.1
Convex Caudal Border	1.0	0.9	2.7	0.2
Twisted Caudal Border	1.4	0.9	1.9	0.7

In this table, we compared the results between high septal deviation and the other five internal nasal valve types to investigate whether there were any significant differences. The only significant difference was when comparing the NO score before surgery between the high septal deviation and concave caudal border types. NO: Nasal obstruction; SGI: Spreader graft insertion; VAS: Visual analogue scale. Data were recorded as the average VAS score.

INV types, a significant difference in the NO score was only found between the high septal deviation and concave caudal border types (6.4 vs. 2.6, p = 0.09; Table 4). The MCM effect was used for preoperative evaluations and to predict the effect of

To further evaluate differences in improvements in NO after SGI between the high septal deviation and other types of INVs, we used one-way ANOVA. No significant differences were found between patients with high septal deviation and all other types of INVs for the improvements in NO after SGI (Table 4). We also recorded the MCM effect before and after SGI to assess whether the spreader graft successfully widened the INV. If the SGI widened the INV successfully, the NO symptoms should have been improved, and the difference between the VAS scores with and without the MCM should have decreased. The results showed that the MCM effect significantly declined after SGI (Table 3), meaning that INV stenosis caused less severe NO after surgery, even in patients with high septal deviation (Table 2). No scarring complications (notching, hyperpigmentation, or hypertrophic scarring) or nose deformities were noted after surgery.

Discussion

The most common type of INV among our patients in Taiwan was high septal deviation, as found in the studies by Murat *et al*. and Arslan *et al*. from Turkey and Delank *et al*. from Germany.[6,14,15] In addition, the high septal deviation type caused the most severe NO with a VAS score of 6.42 before surgery. In the one-way ANOVA of NO severity for all INV types, a significant difference was only found between the high septal deviation and concave caudal border types (Table 4). Although patients with high septal deviation had the highest VAS score for NO, there was no significant difference between all groups. Further studies with more cases are needed to verify which type of INV is associated with the most severe NO.

The MCM effect was recorded before surgery to predict the effect of SGI, and patients with the sharp angle type of INV had the highest score. This may be because the sharp angle type is mainly caused by collapse of the caudal border of the ULC, and the MCM can widen the INV by pushing the ULC laterally (Table 1). The effect of the MCM on high septal deviation is unclear since a deviated septum cannot be moved medially with cotton swabs. According to our results, patients with high septal deviation had high scores when rating the MCM effect (average 3.38) that were similar to the scores from patients with the sharp angle type (average 3.75). These results suggest that SGI can effectively dilate high septal deviation.

Among our 64 INVs, SGI significantly improved NO with a success rate of 92% (59 INVs; Table 3). All types of INV stenosis were effectively corrected by SGI, as indicated by an improvement in the average VAS score for NO from 5.4 to 1.5. The success rate of SGI for high septal deviation was 96% (23 INVs) with an improvement in VAS score for NO from 6.42 to 1.25. Only one of these INVs had a slightly worse VAS score for NO after SGI (VAS 4 to 6). The improvements in NO after SGI were shown by the average differences in the postoperative VAS scores for NO of 5.17 and 4.42 for patients with the high septal deviation and sharp angle types, respectively (Table 2). When dealing with clinical complaints of NO caused by INV stenosis with a high septal deviation or sharp angle, we strongly recommend SGI as an effective treatment.

No significant difference was found in the one-way ANOVA of improvements in the severity of NO after SGI for all INV types (Table 4). The significant improvements in NO after SGI in all groups suggest SGI effectively corrects INV stenosis and improves nasal breathing in most cases, including patients with the high septal deviation type. However, the lack of significant differences in the improvements in NO severity among the groups suggests that further studies with more cases are needed to clarify which type of INV may be most effectively corrected by SGI.

The MCM effect was also used to evaluate the treatment effect of SGI on INV stenosis postoperatively. A decreased score for the MCM effect after SGI would mean that the INV stenosis had been corrected by surgery. In this study, the MCM effect score was significantly decreased after SGI (mean VAS 3 to 0.6, $p < 0.05$). The MCM effect score for patients with high septal deviation INVs significantly decreased from 3.38 before SGI to 0.58 after. This may suggest that SGI can improve NO even if it is caused by high septal deviation.

Many kinds of treatment are available for INV stenosis. Self-holding dilators made of wire or rubber were first introduced in 1967.[8] These devices have to be worn in the nostril at night to keep the nasal valve open during sleep. Due to the inconvenience and poor compliance, nostril dilator devices are no longer used. Park *et al*. proposed the flaring suture technique between the bilateral ULC and across the dorsal part of the septum, with the stitches sutured at the medial edge of the bilateral ULC to create tension at the midline.[9] This suture may rotate the ULC externally, however, widening of the nasal dorsum is inevitable. A more aggressive suture technique, a lateral suspension suture, was described by Paniello *et al*. in 1996. This suture involves stitches going through the collapsed ULC that are tied at the orbital rim to suspend the stenotic nasal valve.[16]

Releasing the tension of the caudal ULC may play a role in widening the INV angle.[17] Robert *et al*. proposed a minimally invasive method to release the caudal border of the ULC and widen the INV angle by making an incision anteriorly to the caudal ULC and dissecting the fibrous tissue attached under the ULC. Subsequently, 1 to 2 mm of the fibrous tissue is resected to release the tension of the ULC and widen the INV angle.[17,18]

Cartilage grafting has been widely used since the 1990s. The alar batten graft is placed at the subcutaneous pocket close to the caudal margin of the ULC,[13] and the splay graft is inserted over the dorsum of the septum and below the bilateral ULC to widen the vault of the nose.[11] The butterfly graft is modified from the splay graft, and is placed superficially to the ULC and inserted deeply into the cephalic edge of the lower lateral cartilage.[12]

The spreader graft was first described by Dr. Sheen in 1984 to prevent the collapse of the caudal of ULC after dorsal hump reduction. Patients with "short nose syndrome", involving a short nasal bone, long and weak ULC, and thin skin, are also candidates for SGI.[10] Many experienced surgeons use SGI to correct INV stenosis, and improvements in NO have been reported in most cases.[19] Park *et al*. suggested that the flaring suture combined with a spreader graft may be more effective to widen the INV angle. If a patient needs elongation of the nasal tip, the spreader graft is also a good method to stabilize the septal extension graft.[20] Endoscope-assisted SGI was first proposed by Dr. Andre in 2004. The endonasal SGI can also achieve good results, with a reported success rate of 97%. However, it may be difficult for a novice surgeon to develop the correct pocket for graft placement.[21] Hussein *et al*. proposed an autospreader graft to widen the INV angle made from the medial portion of the ULC. An autospreader graft can be inverted downward to widen the INV, and it can be created in a short time without harvesting cartilage from other sites. In addition, it can be more stable when applied in the space between the septum and ULC. Moreover, Seyed *et al*. reported that an autospreader flap can yield outcomes equivalent to a spreader graft.[22,23]

In the current study, SGI significantly improved NO in all of the patients regardless of the type of INV, especially in those with high septal deviation and sharp angle types. There are several limitations to this study. The sample size was relatively small, and more data are needed to verify the effect of SGI on the different types of INVs. The amenability of SGI for stenosis of the different types of INVs also needs to be further evaluated in future studies to provide more specific recommendations to clinical surgeons. In addition, computed tomography may be a more objective tool to measure the INV angle and prevent observer bias. David *et al*. suggested that nasal base view computed tomography can accurately measure the INV angle.[24]

Conclusions

High septal deviation was the most common type of INV and caused the most severe NO in our Taiwanese patients with NO caused by INV stenosis. High septal deviation had a good response to the MCM and could be widened by SGI with good functional results. SGI improved NO in patients with stenosis of all types of INVs, especially in the those with high septal deviation and sharp angle INVs.

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