Intranasal Z-plasty for Internal Nasal Valve Collapse

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Objective: To describe the technique of intranasal Z-plasty and early results for this minimally invasive method to repair internal nasal valve collapse. Intranasal Z-plasty has been well described for nasal valve stenosis and cleft nasal deformities but poorly described for idiopathic nasal valve collapse, the most common indication for nasal valve surgery.

Design: A retrospective medical record review was performed for 12 patients undergoing intranasal Z-plasty for nasal valve collapse. Medical records were evaluated for age, sex, indication for surgery, prior surgical procedures, complications, results, and length of follow-up. A visual analog scale was used to rate nasal obstruction preoperatively and postoperatively.

Results: A total of 8 men and 4 women underwent surgery, and the procedure was bilateral in 10 of the 12 patients, for a total of 22 nasal valves. Eleven patients noted subjective improvement in airflow on both sides, with the remaining patient noting improvement on one side and no change in the opposite side. Mean follow-up was 16.8 months (range, 5-32 months). The mean preoperative nasal obstruction score was 7.2, and the mean postoperative nasal obstruction score was 3.3 (on a scale of 0 to 10, with 10 being total obstruction). No complications were reported, and no patients complained about postoperative nasal appearance.

Conclusion: Intranasal Z-plasty appears to be a safe, effective, and relatively noninvasive technique to repair internal nasal valve collapse.

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Although much has been written about the nasal valve, the region still lacks a uniform definition. The term nasal valve was first used by Mink, who referred to this as the region of intranasal narrowing within the nasal vestibule. More recently, the nasal valve region has been defined as a 3-dimensional structure bounded by the nasal septum medially, the lateral nasal wall to the bony point of the piriform aperture laterally, the caudal end of the upper lateral cartilage superiorly, the floor of the nose inferiorly, and the head of the inferior turbinate posteriorly. Many authors have further divided the nasal valves into internal and external valves. The external valve is composed primarily of the lateral crus of the lower lateral cartilage and is most commonly disturbed in aggressive alar cartilage reduction during rhinoplasty. The internal valve was described as the region from the junction point of the caudal part of the upper lateral cartilage with the septum to the bony point of the piriform aperture and the soft fibrofatty tissue in this region, and the angle between the septum and caudal border of the upper lateral cartilage in this area typically should be at least 10° to 15°.

The medical literature is replete with articles on surgery to correct the nasal valves. The most common surgical procedures are nasal septal reconstruction and inferior turbinate surgery, both of which contribute to the nasal valve region. Most procedures that specifically target the valve angle use rhinoplasty approaches, most commonly the open rhinoplasty approach. Spreaders, flaring sutures, titanium–expanded polytetrafluoroethylene butterfly grafts, orbital suspension sutures, lateral battens, lateral crus pull-up, alar expansion and reinforcement, and the lateral crural “flip flop” have all been described for nasal valve repair. However, all have their drawbacks, requiring prolonged healing times from the open rhinoplasty approach, separate donor sites for grafts, or the use of foreign bodies that entail the risk of infection or rejection and offer questionable longevity. The intranasal Z-plasty avoids many of these problems. The Z-plasty has been well described in both the otolaryngology and plastic surgery literature.
The procedure is performed with conscious sedation (usually intravenous) and local anesthesia. After intravenous or oral sedation is administered, local anesthesia is obtained by injecting lidocaine, 1%, with 1:100,000 epinephrine into the nasal valve region and anterior nasal cavity on both sides. The nasal cavity and face are then prepared with iodine solution, and sterile drapes are applied to the field. An intercartilaginous incision is then performed, with the incision made in the scroll region (ridge formed by the caudal border of the upper lateral cartilage overlapped by the lateral crus of the lower lateral cartilage) (Figure 1A). The Z-plasty incisions are then completed, and the soft tissue is elevated such that the anterior flaps are medially based and the posterior flaps are laterally based (Figure 1B). The caudal border of the upper lateral cartilage is then identified and removed to make room to mobilize the Z-plasty flaps (Figure 1C). The flaps are then interdigitated and sutured into position with 4-0 chromic sutures (Figure 1D). The apex of the anterior flap is technically difficult to suture into the posterior flap donor site. This is usually addressed by passing a 6-0 nylon suture through the apex of the flap and then passing it through the final destination (posterior flap donor site) and then externally, where it is passed through an external bolster composed of a dental roll. The suture is then passed back internally through the posterior flap donor site and then around a second dental roll bolster. The internal bolster is then packed snugly into the internal valve region, and the suture is tightened. If a contralateral procedure is indicated, the second side is addressed in an identical fashion. Bacitracin ointment is then applied to the bolsters and all suture lines, and the bolsters are left in place for 7 to 10 days. The patient is administered oral antistaphylococcal antibiotics (to prevent wound infections and toxic shock syndrome) and oral pain medications.

Twelve patients were identified over a 2-year period with nasal valve obstruction without stenosis. Ten patients had undergone prior surgical attempts to address nasal and sinus problems but had persistent subjective nasal obstruction believed to be secondary to internal nasal valve collapse. Two of these were believed to be iatrogenic. One patient had undergone a rhinoplasty 12 years before the Z-plasty and 2 separate revision rhinoplasties that were unable to relieve his subjective obstructive complaints. Another patient had undergone removal of basal cell carcinoma from the alar skin, and his postoperative obstruction was not improved with subsequent alar batten grafts. The remaining 10 cases were believed to be spontaneous, secondary to the patients' inherent nasal anatomy. Of these, 8 patients had undergone prior septoplasty and turbinooplasty, and 5 patients had undergone prior endoscopic sinus surgery, although none of these procedures improved their complaint of nasal obstruction.
The term nasal valve was first used by Mink⁴ to describe the narrowest portion of the anterior nasal cavity. The nomenclature for this area has been inconsistent, with some describing a single nasal valve region and others further dividing this into an internal nasal valve, defined as the angle between the nasal septum and the caudal border of the upper lateral cartilage, and the external nasal valve, which is located in the nasal vestibule and describes the lateral ala.¹⁰ Others have further divided this region into the cartilaginous vs bony valve segment¹⁷ or have divided the obstruction into fixed vs dynamic.

The nasal valve plays a crucial role in determining the airflow characteristics of the nasal airway. In addition to respiration, the airflow turbulence created in this region regulates temperature, humidification, and filtration of inspired air.¹⁸ The internal nasal valve cross-section is approximately 20 mm² to 40 mm² on each side, and this compose approximately half of the total airway resistance from the nose to the alveoli.¹⁹ The nasal valve region is located roughly 2 cm into the nasal cavity.²⁰ Numerous anatomic factors contribute to the nasal valve, including the nasal septum, upper lateral cartilages, bony pyriform aperture, inferior turbinates, and erectile tissue of the lateral nasal wall.²¹ The cartilaginous structures of the nasal vestibule combined with activity of the dilator naris and nasalis muscles contribute to airflow dynamics. Moreover, the internal nasal valve angle formed by the upper lateral cartilage connection to the nasal septum is of fixed dimensions. The flexibility of these structures allows the nasal valve to act as a Starling resistor, which can limit flow by collapsing when airflow is rapid, with partial collapse of the upper lateral cartilages occurring at a flow rate of approximately 30 L/min.²² The Poiseuille law states that flow through a tube is proportional to the product of pressure and the radius to the fourth power; thus, small changes in airway caliber can have dramatic effects on airflow through the nasal valves.

There are numerous causes of nasal valve obstruction. Mucosal causes such as allergic, occupational and vasomotor rhinitis are among the most common medical conditions, and septal deviation and hypertrophy of the head of the inferior turbinate are the most common causes requiring surgical intervention. These problems are commonly addressed before considering more complicated repairs of the nasal valves. Other causes include the cleft lip nasal deformity,¹⁵ abnormal anatomic configurations of the nasal valve,²³ aging with loss of cartilaginous support, nasal tip ptosis, paralysis of the nasal dilators, widening of the nasal swell body,¹⁷ narrowing of the bony pyriform aperture, and divergence of the medial crura.

Nasal valve obstruction may be iatrogenic as well. True stenosis of the internal nasal valve may occur after mucosal trauma to the internal nasal valve angle following septoplasty or septrhinoplasty, most commonly from endonasal approaches.²⁴ Separation of the upper lateral cartilage from the septum during these procedures may also disrupt middle nasal vault support with inward collapse of the upper lateral cartilages.²⁵ Cephalic trim of the lateral crura and resection of the scroll between the upper and lower lateral cartilages can lead to nasal valve collapse.²⁶ Aggressive lateral resection of the alar cartilage during rhinoplasty may lead to external nasal valve collapse with poor structural support of the lateral nasal wall. This may also occur after resection of skin neoplasms in the lateral alar region if adequate structural support is not reestablished.

Numerous procedures have been described to repair the nasal valve region. Sheen¹⁶ described the use of spreader grafts, which are fashioned from autologous cartilage and inserted between the upper lateral cartilage and the septum, thus widening the valve angle. Flaring sutures,⁷ butterfly grafts,²² lateral batten,²⁷ orbital suspension sutures,⁸ nasal bone outfurling,²⁸ lateral crus pull-up,¹⁰ alar expansion and reinforcement,¹¹ and lateral crural “flip flop”¹² have all been described. Z-plasty has been described for nasal vestibular stenosis¹⁴ and cleft nasal deformity.¹⁵ While the use of Z-plasty for narrowing rather than stenosis of the nasal valves is unique, other surgical flaps

### Table. Data Analysis for Patients Undergoing Intranasal Z-plasty

<table>
<thead>
<tr>
<th>Variable</th>
<th>No. of Patients</th>
<th>Mean (SD)</th>
<th>Median</th>
<th>Interquartile Range*</th>
</tr>
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<tr>
<td>Age, y</td>
<td>12</td>
<td>49.58 (14.07)</td>
<td>47.5</td>
<td>16</td>
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<tr>
<td>Follow-up, mo</td>
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<td>16.75 (9.10)</td>
<td>14.5</td>
<td>13</td>
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<tr>
<td>Postoperative score</td>
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<td>3.25 (1.36)</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Preoperative score</td>
<td>12</td>
<td>7.17 (1.03)</td>
<td>7</td>
<td>2</td>
</tr>
</tbody>
</table>

*Interquartile range: range between 25% quartile and 75% quartile.

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have been described for this indication. Schulte et al\textsuperscript{39} and Kasperbauer et al\textsuperscript{30} described the intranasal M-plasty, which in many ways is similar to the Z-plasty with the location of the primary incision and the removal of the caudal border of the upper lateral cartilages, but the Z-plasty uses triangular flaps to further alter and lateraleze the scroll region. The removal of the caudal upper lateral cartilage is somewhat counterintuitive with both procedures but is necessary to normalize the valve angles and, in the case of the Z-plasty, to mobilize the flaps. Flap mobilization also creates mild cephalic rotation of the nostrils, which further improves nasal airflow, although this is not severe enough to cause significant cosmetic deformity as demonstrated in this series of patients. The intranasal lateral crural J-flap has been described, but it involves a much more extensive closed rhinoplasty dissection than the intranasal Z-plasty.\textsuperscript{31}

The Z-plasty is conceptually a novel technique to repair nasal valve collapse when compared with existing techniques. It is known that this technique successfully repairs internal nasal valve obstruction, since it has been successfully used for nasal valve stenosis and the cleft nasal deformity for many years.\textsuperscript{14,15} However, its use for the indication of noncleft collapse rather than stenosis is unique. It is postulated that the procedure essentially widens the valve angle and creates a subtle tip rotation, both of which are known to improve nasal airflow, particularly in the geriatric patient. While the widening of the valve angle was clinically obvious to the surgeons in all cases and evidenced in Figure 2, this was not specifically measured in this study and should be evaluated in follow-up studies. It is widely accepted that the normal internal nasal valve angle should be 10° to 15° and that widening this angle in patients with internal nasal valve obstruction improves their airway. It is also widely accepted that rotation of a ptotic nasal tip may improve nasal airflow, especially in a geriatric population, and that removal of a cephalic strip of alar cartilage in the scroll region, or in this case removal of the adjacent caudal border of the upper lateral cartilage, creates a cartilaginous void in the scroll region and allows for rotation of the tip. Both of these effects appear to occur with this procedure, and it is hypothesized that these are the mechanisms for improvement in nasal airflow in these patients. Moreover, the internal nasal valve can conceptually be considered similar to a contracture, and the use of the Z-plasty to relieve contracture has been widely accepted in the field of facial plastic and reconstructive surgery.

This case series included 12 consecutive patients who underwent 22 nasal valve repairs with Z-plasty for nasal valve obstruction due to abnormal anatomic configurations, rather than other indications that have been previously described such as stenosis or cleft nasal deformity. The patients showed a statistically significant subjective improvement in their nasal valve obstruction based on a visual analog scale, and nasal endoscopy by the operating surgeon revealed subjective widening of the valve angle in all cases (Figure 2). No complications were reported, and although the procedure can cause slight widening of the nostrils and mild cephalic nasal tip rotation (factors that tend to improve nasal airflow), the changes were subtle, and none of the patients complained of the postoperative appearance of their nose. The mean follow-up in these patients was approximately 1.5 years. While these results appear impressive, the statistics were based on subjective rather than objective findings. Objective studies such as rhinomanometry or acoustic rhinometry may have complemented the patients’ observations, but these studies were not used routinely in our practice at the time this series of patients underwent their surgical procedures.

While the numerous aforementioned procedures have been described to correct nasal valve obstruction, the intranasal Z-plasty offers a number of advantages. First and foremost, the procedure is minimally invasive. It does not require an open rhinoplasty with extended healing times as with spreader graft placement and does not require tissue grafting. The procedure is performed entirely intranasally, and the tissue dissection is significantly less than even that with a closed-tip rhinoplasty. While the suture suspension technique\textsuperscript{8} also requires less dissection, that procedure relies on a foreign body for valve suspension and may theoretically be less permanent because the suture fixation to the soft tissues may considerably relax with time. Similarly, the titanium-expanded polytetrafluoroethylene butterfly implant also

Figure 2. Preoperative (A) and immediate postoperative (B) appearance for a patient undergoing a right nasal valve repair with intranasal Z-plasty.
subjects the patients to the risks of permanent foreign body implantation. The Z-plasty is relatively quick and painless, since the procedure may even be performed with local anesthesia with or without oral sedation. Perhaps the only drawback is the learning curve because the procedure can be conceptually and technically challenging and require experience to master.

In conclusion, numerous surgical procedures have been described to improve nasal valve collapse. The intranasal Z-plasty appears to offer a minimally invasive technique to improve nasal airflow due to internal nasal valve collapse, with less reliance on extensive tissue dissection, grafting, and foreign bodies compared with other techniques. The procedure appears to significantly improve patients’ subjective nasal airflow complaints with a negligible complication rate and minimal if any effect on the external appearance of the nose. Further objective studies such as rhinomanometry or acoustic rhinometry and objective measurement of the internal valve angles appear warranted to further evaluate this procedure.

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REFERENCES