Functional Compromise in the Middle Vault in the Management of Revision Rhinoplasty

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Abstract

As rhinoplasty procedures become more common, the need for revision surgeries increases as well. Unlike primary rhinoplasties, revision rhinoplasties can be more challenging because of anatomic differences from initial surgery, a lack of available cartilage, tissue remodeling responses, and other complications. As such, surgeons should be prepared to address revision rhinoplasty patients differently from primary rhinoplasty patients. Here, the authors describe a generalizable approach to revision functional rhinoplasty patients and detail some of the surgical techniques that can be employed to achieve optimal outcomes, with particular attention paid to procedures that can be used in the middle vault.

Keywords
► rhinoplasty
► revision
► nasal surgery
► nasal valve collapse
► nasal obstruction

While the nose is often thought of as the organ of olfaction, we know the functions of the nose are far more diverse and essential to life. A nose that functions well enhances the transit and quality of air that reaches the lungs and thereby allows for optimal gas exchange at the alveolar level. Airflow, humidification, filtration, and warming of inspired air round out the essential nasal functions. To perform such sophisticated and important functions, the anatomy of the nose is intricately developed, and nasal physiology is quite complex. As surgeons we are able to control and enhance the supportive nasal anatomy, and in that way we are able to at least preserve, and at times improve, the capacity of the nose to perform its physiological tasks.

Rhinoplasty is a surgical procedure that may affect both the internal and external nose, may alter the nasal shape, and may be performed for functional or cosmetic reasons. Functional rhinoplasty aims to improve breathing and olfaction by altering the intricate nasal anatomy to improve airflow without intentionally changing the overall external shape of the nose; such procedures include repair of nasal valve stenosis and deviated septum repair, including at times caudal and dorsal septal deviations which may unintentionally alter the nasal shape.¹,² Functional reconstructive rhinoplasty, which may intentionally alter the external shape of the nose, may be undertaken to repair cleft lip or other congenital nasal deformities, and to repair traumatic or neoplastic nasal deformities—in such cases, intentional changes are made to the shape of the nose to restore form and improve function and patient quality of life. Cosmetic (aesthetic) rhinoplasty alters the appearance of the nose based on a patient desire and surgeon’s decision to intentionally and electively change the appearance of the nose, and often includes maneuvers to alter the shape of the nasal tip, reduce the dorsal hump, or straighten a crooked nose. As rhinoplasty procedures become increasingly popular, so does the need for revision procedures; rates of revision can be common for both cosmetic and functional procedures, with reports of up to 15.7%.³–⁵ Unfortunately, revision rhinoplasties may become increasingly challenging with each additional intervention, and the ideal situation would be to limit revision rates. Scar tissue, weakened cartilage, bone, and skin support, and reduced blood supply all contribute to the challenges associated with revision rhinoplasty. Perfect structure and function should be our goal in every single rhinoplasty, but we know well that this goal is elusive and revision rhinoplasty is a reality for a small segment of every surgeon’s patient base. Moreover, all surgeons should recognize the importance of preoperative counseling and understand a patient’s expectations. Ensuring that patients understand perfect nasal function...
may not be achievable is paramount to achieving satisfactory outcomes. Selecting patients with high levels of psychosocial function may help to prevent postoperative complications. Several studies have shown high rates of depression in rhinoplasty patients. As such, it may be impossible to achieve the outcomes desired in these patients due to pre-existing psychiatric comorbidities. Many patients may have body dysmorphic disorder, and will never be satisfied with any bodily changes.

Common Causes of Revision Rhinoplasty

It is important to recognize the reasons that patients opt for revision nasal surgery, and the complaints that prompt it. In a study of 150 patients who underwent revision rhinoplasty in a busy New Hampshire practice, Constantian found that the two most common reasons were the introduction of a new deformity (41%) or a failure to correct an original deformity (33%). Other reasons included the “perceived loss of personal, familial, or ethnic characteristics” (15%), a desire to improve upon an already acceptable result (10%), and new/unrelieved airway obstruction (1%). Chauhan et al found that the most common causes for revision rhinoplasty were crooked nose (38%), nasal airway obstruction (36%), bulbous tip (33%), and nose too large (25%). A study by Lee et al found that the most common causes for revision rhinoplasty included nasal obstruction (65%), dorsal asymmetry (33%), nostril asymmetry (18%), and tip asymmetry (14%). Looking at specific etiologies for nasal obstruction in revision rhinoplasty, a study by Goudakos et al found that most causes of revision rhinoplasty for nasal airway obstruction included septal deviation or nasal valve dysfunction (91.3%).

Looking for and understanding these common complaints, and establishing realistic goals for the patient, are imperative as we try to attain good outcomes during revision rhinoplasty. Since achieving a perfect nose, and even understanding what that means to each individual patient and surgeon, is an elusive goal that is especially difficult to achieve in revision surgeries, as it is possible that patients who require revision surgeries are already disadvantaged due to a variety of issues such as unrealistic expectations, poor prior experience, unclear about their goals or needs, and technical surgical challenges. Revision surgeries are complex because there is thick scar tissue, collapsed or altered cartilage and bone, variant anatomies that need to be explored, and less predictable healing of the skin soft tissue envelopes on the newly structured skeleton.

Surgical Techniques in Revision Rhinoplasty

Numerous surgical techniques may be used to address some of the more common causes of revision rhinoplasty, and we will explore some of these here. We note the ubiquitous use of autologous cartilage, which is the gold standard for revision rhinoplasty when grafting is needed. Additionally, external rhinoplasty approaches have been cited to be more frequently chosen over endonasal procedures, as reported by Vuyk et al. However, we would add that the choice of the approach to take depends on the specific needs of the patient, preferences of the surgeon, and agreed upon goals set by the preoperative discussions—in many situations an endonasal approach may be used to achieve the agreed upon goals set by the patient and surgeon, and this fact should not be overlooked.

Nasal valve collapse continues to be recognized with increasing frequency as one of the main contributors to nasal airway obstruction, and nasal valve collapse is a common complication following primary rhinoplasty. The nasal valve can collapse at either the internal nasal valve, external nasal valve, or both, and treatments differ depending on the location. The internal nasal valve has a smaller diameter, and is therefore the primary regulator of airflow and the culprit in many pathologies and can be corrected during primary of revision surgery. Spielmann et al covered all the different surgical techniques that have been used for nasal valve collapse, and found that generally the most commonly utilized and successful procedures had been spreader grafts, butterfly grafts, alar batten grafts, and nasal valve suspension or flaring sutures. Here, we will review common surgical techniques used in revision rhinoplasty with a focus on techniques to address nasal valve collapse. Some examples of the most commonly used grafts and their positioning in the nose are shown in Fig. 1.

As we discuss the different techniques, we highlight the various indications for which they have been used. Recognize that different surgeons will have differing perceptions of what the underlying anatomical problems are and different preferences regarding how they want to manage them. This is not a “cookie-cutter” operation and our goal is not to impose certain techniques on others but simply to demonstrate some of the commonly available techniques. We also note that while the majority of these techniques focus on function, appearance must often be considered and we as surgeons must educate the patients that improvements in both form and function can be realistically achieved, though at times with difficulty.

Spreader Grafts

Spreader grafts (Fig. 2) can be used to address internal nasal valve collapse in revision rhinoplasty, and have been shown to be successful for revision rhinoplasties. Septal cartilage is the best source for spreader graft donor material, but conchal cartilage grafts have also been shown to be successful as spreader grafts, along with rib cartilage, injectable biomaterials, or even absorbable plates. Just because all of these different materials have been noted to be useful in the literature, a surgeon should use their best judgment to decide which materials are safest and serve the best interests of the patient over the long term. The purpose of the spreader graft is to widen the apex of the internal nasal valve and increase the valve angle between the dorsal septum and upper lateral cartilage, which has been determined to ideally be 10 to 15 degrees. The spreader grafts are placed along the dorsal aspect of the septum and are secured to the septum, and then to the upper lateral cartilages on either sides of the nose with a 5 to 0 polydioxanone suture. Spreader grafts are particularly useful for treating upper lateral cartilage subluxation or collapse, although onlay grafts may be occasionally used.
Spreader Flaps
Spreader flaps or “turn-in flaps” or “auto-spreader grafts” may also be used as an alternative to formal spreader grafts in the event that autologous cartilage is not available and there is excessive and redundant dorsal upper lateral cartilage available to turn-in on itself as a spreader. The use of the spreader flap, or autospreader, entails using existing upper lateral cartilage that is not removed during hump reduction, releasing the lateral cartilage from the septum, and rolling it onto itself to create a flap that is folded over and then secured to the septum, serving an equivalent purpose as the spreader graft. Despite their value to revision rhinoplasty, there is controversy over the value of the spreader graft in maintaining patency in the nose. The main advantage is to be able to avoid harvesting and grafting cartilage, and can take less time, but requires a humpectomy so is particularly suitable for specific cases. The flap has also shown to add a “spring action” that can be used to widen the valve angle. A randomized control trial comparing spreader flaps as an alternative to spreader grafting was performed by Saedi et al, which demonstrated no difference in nasal obstruction and cosmetic satisfaction between the two groups. Given the particular indications above, there are certainly situations that call for the flap over the graft, but the differences between the two in other cases should continue to be investigated.

Butterfly Grafts
Butterfly grafts are typically performed with conchal cartilage and are placed in a symmetric “V” shape on top of the nasal dorsum to increase the spread of the nostrils.
of the upper lateral cartilages and dorsal septum to serve as an internal “breathe right” strip in the nose. Clark and Cook showed that butterfly grafts were successful at improving function in revision rhinoplasty by strengthening and widening the nasal sidewall at the internal nasal valve. Modifications to the butterfly graft exist to decrease its visibility, where the shape is changed to decrease its width and increase its length (~3.5 cm in length and 0.9 cm in width). A longer graft means that it can reach the pyriform aperture, and is less visible. A modified suturing technique can be used, which is a horizontal mattress suture over the center of the graft, as opposed to two sutures at the lateral edge of the ULCs. The graft is less visible the more caudally placed it is. Loyo et al found that these modifications were successful in improving nasal breathing with acceptable cosmetic satisfaction, where casual observers and health care providers are unable to identify the graft placement.

**Suspension or Flaring Stitch**

Nasal valve flaring stitch is a horizontal mattress suture placed between the upper lateral cartilages on either side of the nose that is tied down over the dorsal septum and which acts as a fulcrum to widen the internal valve angle and nasal sidewall. The cephalic border of the lower lateral cartilages can also be suspended to the lower border of the orbital maxillary periosteum for the same purpose, as in the suspension suture technique. Neither of these techniques requires grafting, may be less invasive, and may be used as an adjunct to any of the other techniques.

**Alar Batten Grafts, Lateral Crural Strut Grafts, Alar Rim Grafts**

Alar batten grafts are versatile and may be used to support the sidewall at a variety of different locations. They may be placed on top of existing and weak cartilages at the point of greatest sidewall collapse, and may therefore be used to correct problems of both internal and external valve collapse along the nasal sidewall. They are extremely effective in revision rhinoplasty as they may be placed in regions of previously removed lower lateral cartilages to replace the missing structural support. Alar batten grafts are traditionally done with autologous septal cartilage, but they may also be made of ear cartilage or rib cartilage grafts. In addition to the functional support they provide, alar batten grafts may help to prevent and correct alar retraction, notching, and pinching, which can all result from prior primary rhinoplasty. Lateral crural strut grafts, like alar batten grafts, are placed along the sidewall to correct sidewall weakness and collapse. While alar batten grafts are placed along the superficial surface of the sidewall cartilages, lateral crural strut grafts are placed deep to the cartilage they are meant to support. In addition to structural support, they tend to flatten and straighten the overlying cartilage that they sit under, most commonly the lateral crura of the lower lateral cartilage. In this fashion they provide structural support and at the same time create changes to the form of the lateral crura. Alar rim grafts may be used to correct alar flare, alar margin collapse, mild alar retraction, and to support the external nasal valve. These grafts may be useful in cases of cephalic malposition of the lower lateral cartilage, as they provide structural cartilage graft material in regions devoid of cartilaginous support. It is a frequently used technique in revision rhinoplasty to support the external nasal valve and improve the nasal base. The aforementioned techniques may be used to strengthen the internal and external nasal valve, and may be placed via an intercartilaginous, marginal, or external incision with septal, auricular, or rib grafts.

**Alternative Techniques**

In revision rhinoplasty where there is an absence of cartilaginous raw materials, alternative techniques may be helpful to improve the nasal airway. Radiofrequency has been utilized for lateral wall collapse. Seren described this technique as a fast, effective, and safe alternative, where low-energy radiofrequency is applied submucosally through a probe and results in tissue fibrosis and retraction. Weissman and Most demonstrated the effectiveness in a trial of 13 patients, finding that this technique could significantly reduce nasal obstruction. Another alternative technique, especially in cases of inadequate cartilage support and very weak, long, and floppy upper lateral cartilages, is the M-plasty technique. In this technique, a small intercartilaginous incision is made, and a variable amount of the distal upper lateral cartilage is resected. This effectively shortens the length of the middle third and widens the internal nasal valve area, thereby improving nasal airflow.

**Revision Septoplasty**

Revision septoplasty is frequently performed to address nasal valve collapse or ongoing septal deviation after septrhinoplasty, and particular attention should be paid to addressing the cartilaginous versus bony septum. In particular, many caudal septal deviations are encountered in revision rhinoplasty, and without proper correction of these deformities, the nasal valve will remain compromised. Patients with failed prior septoplasty often resort to subsequent nasal valve surgery. Gillman et al found that revision septoplasty was highly effective in improving nasal obstruction in patients with persistent septal deviation despite prior septoplasty. Techniques for septal reconstruction are widely performed and discussed extensively in the literature and as such are not covered here.

**Tip Revision**

Tip revisions are commonly needed in revision rhinoplasty for aesthetic purposes, but they may also be required at times of functional purposes. Shield grafts, trimming of the lateral crura, and columellar struts (Fig. 4) may help to prevent ptosis of the nasal tip and represent some of the more commonly employed techniques for tip revisions. A shield graft is a piece of cartilage placed along the infratiflop lobule portion of the nasal tip that helps to define and project the nose. It may also be used to provide structural support to alar replacement grafts or to existing weak lateral crura in a manner similar to a gusset plate on a bridge construct. A columellar strut graft is placed in the columella to support...
the nasal tip and prevent ptosis. Loyo and Wang consider tip revision the most complex portion of revision rhinoplasty, and columellar struts, tongue-in-groove, or caudal septal extension grafts play integral roles in providing tip support for long term form and function.

Injectable Biomaterials in Revision Rhinoplasty
Surgeons should consider minimally invasive mechanisms for restoring the nose after rhinoplasty to prevent secondary surgery if possible, especially if only small cosmetic changes are desired. Injectable biomaterials, which include hyaluronic acid and calcium hydroxyapatite, are commonly used for small aesthetic corrections in the nose. Moreover, injectables only temporarily fix deformity but do not achieve permanent changes, as injectables eventually resorb and lose their ability to provide structural support. As reported by many, significant vascular complications, including embolization and blindness, continue to be a major problem caused by the use of injectables when they encounter local blood vessels. As such, surgeons should be wary of their use and assess every patient on a case-by-case basis, while being knowledgeable about the various fillers, indications, and proper injection techniques.

Conclusions
The above techniques highlight just a few tools that are available to surgeons as they address complications that are frequently causes of revision rhinoplasty. Our hope is to merely highlight some common techniques and mention their indications. In addition, many of the techniques described in the extensive body of literature that has been published for primary rhinoplasty may also be applied to revision rhinoplasty. We note the important caveats to secondary rhinoplasty, which are the formation of scar tissue, the lack of autologous cartilage, in addition to tissue quality and anatomical changes that may complicate the operation.

We also note that our role as physicians encompasses not only surgically performing revision rhinoplasties, but also managing the patient pre- and postoperatively. Managing patient expectations in all operations is absolutely essential, but in rhinoplasty and revision rhinoplasty this becomes a major issue. Establishing excellent patient rapport, understanding the motivations of the patient for surgery, and determining whether the patient's hopes and goals for the surgical outcome are attainable. Achieving success in our surgical task requires that we develop the ability to diagnose and assess nasal problems, master the tools to diagnose including anterior rhinoscopy and endoscopy, understand how to use photoanalysis, understand the underlying cartilaginous support structures that underlie the nasal topography, predict the amount of cartilage needed to revise the nose, and finally master the technical skills and variety of techniques that might be needed to achieve the desired result. Quality-of-life measurements are imperative for preoperative and postoperative assessments. Many surgeons use objective measurements of nasal airflow including rhinomanometry, acoustic rhinometry, imaging studies, and rhinoresiliography. All of these tools should be within a surgeon's disposal and utilized when deemed necessary.

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