Augmenting the nasal airway: Beyond septoplasty

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ABSTRACT

Background: Nasal airway obstruction is a common complaint of patients presenting to otolaryngology clinics and can be caused by a variety of anatomic factors. A number of advances in the surgical management of nasal airway obstruction have been made over the last century. The objective of this article is to provide descriptions of the surgical procedures used to augment specific anatomic deviations that lead to obstruction of the nasal airway.

Methods: The descriptions of surgical procedures were derived from a literature review as well as the empirical knowledge of the senior author. Preoperative considerations of nasal anatomy, the nasal airway, and the L-strut are detailed.

Results: Functional rhinoplasty techniques are reviewed including septoplasty, extracorporeal septoplasty, spreader grafts, batten grafts, alar rim grafts, and correction of caudal septal deviation.

Conclusion: The symptom, nasal obstruction, may arise from a number of different anatomic and physiological elements. The rhinoplasty surgeon must consider these contributing elements and manage accordingly, to achieve optimal results.

(NASAL OBSTRUCTION MAY ARISE FROM A NUMBER OF DIFFERENT ANATOMIC AND PHYSIOLOGICAL ELEMENTS. THE RHINOPLASTY SURGEON MUST CONSIDER THESE CONTRIBUTING ELEMENTS AND MANAGE ACCORDINGLY, TO ACHIEVE OPTIMAL RESULTS.)

ANATOMY OF THE NASAL AIRWAY

External Nasal Valve

The axially positioned nostrils guard the entrance to the bilateral nasal cavities. The nostrils are bordered laterally by the ala and medially by the columella. The nasal vestibule defines the area within the external nasal aperture. The soft tissue envelope and the medial footplates of the lower lateral cartilages (LLCs) support the most caudal portion of the columella.

The alar subunit is composed of the soft tissue envelope and the lateral crura of the LLCs. The skin of the ala and lower third of the nose is thick, relative to the upper nose, contains an abundance of sebaceous glands, and is intimately associated with the attached musculature.

The bony correlate for the posterior termination of the ENV is the pyriform aperture. The cartilaginous extent of the ENV ends at the scroll region joining the LLC and the upper lateral cartilage (ULC; Fig. 1).

Internal Nasal Valve

The INV is the point of greatest resistance in the nasal airway. The caudal inferior turbinate forms the inferolateral border of the INV. The ULC provides the lateral border of the INV as it continues superiorly toward the septum. At its junction with the nasal septum an angle of 10–15° is created. Medially, the INV is defined by the nasal septum and the valve is completed at the maxillary crest and floor of the nose.

Septum

The nasal septum is a midline structure that divides the nasal airway into two nasal cavities. It is firmly invested by mucoperichondrium, anteriorly, and mucoperiosteum, posterior and inferiorly. Its cartilaginous component, the quadrangular cartilage, forms its caudal-most extent, contributing to both the ENV and the INV. Additionally, the quadrangular cartilage defines the anterior nasal dorsum. Along the dorsum the LLCs are supported medially and are separated from the septum by fibrous attachments and its mucosal investment. At its most cephalic position the cartilage meets the paired nasal bones. At this junction, the “keystone” region of the nose, an area of stability essential to the support and structure of the nose, is located.

Inferiorly, the cartilaginous septum firmly rests on the maxillary crest and is bound by the decussating fibrous attachments at the junction of the perichondrium with the periosteum. The inferior septum is continued posteriorly by the vomer. Superior to the vomer, the septum approaches the nasal bones, the floor of the frontal sinus,
and the anterior skull base through the perpendicular plate of the
ethmoid.

The dynamic contribution of the septum to nasal airflow is the septal
body. This poorly understood vasoerectile structure has been localized to
the region anterior to the middle turbinate, above the nasal floor, and
caudally approaching the nasal valve region. The septal body invests an
observed thickening at the junction of the cartilaginous and bony sep-
tum. Furthermore, this region has a rich venous sinusoidal composi-
tion, thus, indicating a compliment to the nasal turbinates in regulat-
ing airflow.

Neurovascular Anatomy

The vascular contributions that are significant to rhinoplasty pri-
marily arise from the facial, sphenopalatine, and ophthalmic arteries.
The facial arteries provide blood supply to the caudal nasal septum
and nasal sidewall through the superior labial and the angular arter-
ies, respectively. The anterior ethmoid branch of the ophthalmic
artery contributes to the dorsal septum and the dorsal nasal tip
through dorsal nasal artery. The sphenopalatine artery contributes to
the septal blood supply through its posterior septal branches.

The first and second branches of the trigeminal nerve provide
sensation of temperature, pain, and changes in pressure (i.e., airflow).
The sensation of airflow is most profound at the skin-lined vestibule
where end-sensory mechanoreceptors serve to refine the tactile per-
ception. Alternatively, beyond the vestibule, the nasal mucosa has a
more primitive end-sensory arrangement, where no specialization of
the nerve endings or overlying epithelium exists, and arborization of
the nerve occurs terminally. Previous studies have shown that anes-
ethetizing the anterior nose results in a significant subjective sensation
of nasal obstruction when compared with anesthesia of the nasal mu-
cosa.

SURGICAL MANAGEMENT

Deviated Nasal Septum and Septoplasty

Deviation of the nasal septum is a common finding in patients
seeking attention for nasal obstruction and is commonly secondary to
three etiologies: congenital, traumatic, or iatrogenic. Previous epide-
miological studies have revealed that the finding of a straight septum
is present in only 42% of newborns and in adults, only 21%. Trauma
to the nose may result in a variety of bony and cartilaginous fractures
as well as dislocation of the cartilage off the maxillary crest. The
fractured cartilage may heal in a variety of orientations but often
results in anatomic deviation. Previous nasal surgeries may predis-
The standard approach to correction of cartilaginous septal deviation, first popularized by Killian and Freer, involves a submucous dissection of the quadrangular cartilage and removal of the deviation with preservation of mucoperichondrial flaps. Once the deviated segment of the septum has been exposed bilaterally it may be straightened through a variety of techniques. Conservatively, the deviated cartilage may be weakened on its concave side by cross-hatching with partial thickness incisions to relieve intracartilaginous tension. Alternatively, the deviation may be submucosally resected leaving a caudal-dorsal “L-strut” for support (Fig. 2).

**Caudal Septal Deviation**

The deviated caudal septum requires attention beyond the traditional septoplasty approach. These deviations are important on both the aesthetic and the functional levels. The caudal septum, if significantly deviated, may be noticeable on both frontal and lateral views of the face given its relationship to the lobule and columella. Furthermore, the septum contributes to both the ENV and the INV, and the caudal septum provides that contribution. Finally, the caudal septum provides essential structure to the nose and without an appropriate ~1-2 cm of caudal strut significant deformities such as saddle nose and tip ptosis may develop.

Correction of caudal septal deviation has been approached in a number of different ways, depending on the nature of the deformity. In the situation where the caudal septum has excessive vertical length and is positioned lateral to the anterior nasal spine, the swinging door technique, a technique first popularized by Metzenbaum, can be used. A complete transfixion incision may be necessary to raise bilateral mucoperichondrial flaps and expose the caudal septum from the anterior septal angle to the anterior nasal spine. Sharp incision may be...
necessary to maintain a continuous flap through the dense decussating fibers. The redundant cartilage is resected, leaving the caudal septum only attached superiorly. The now freed inferior portion of the caudal septum is anchored to the anterior nasal spine with sutures.

Pastorek\textsuperscript{15} proposed a modification of the swinging door technique. The deviated caudal septum may be transposed over the anterior nasal spine to the nasal cavity opposite the deviation without further resection of cartilage; this appropriately named “doorstop” technique, prevents the cartilage from returning to its original position. Sedwick \textit{et al.} found resolution of subjective nasal obstruction in 51/62 of his patients with caudal deviations treated with the aforementioned techniques.\textsuperscript{16}

Mild to moderate deviations may be dealt with in a manner similar to that previously described. Likewise, the deviated portion of the septum may be scored or morselized on the concave side to weaken the cartilage. The limitation of this technique is the propensity of the deviations to recur over time, this may be improved with the placement of Mustarde-type sutures through the deviation.\textsuperscript{17} Alternatively, batten grafting may be applied to the weakened caudal septum. These grafts are typically harvested from the posterior quadrangular cartilage or the perpendicular plate of the ethmoid. The batten grafts are then fashioned along the weakened cartilage to support and stabilize its corrected position. Extension of longer spreader grafts from the ULC onto the caudal septum may also be used to stabilize the cartilage. The main point of criticism of the use of the grafting techniques is the tendency of the overlapping grafts to widen the caudal septum and subsequently narrow the INV and ENV; thus, these grafts must be adequately thinned before securing to the septum.\textsuperscript{18}

Kridel\textsuperscript{19} popularized the tongue-in-groove technique for the management of caudal septal deviation. This technique requires the cephaloposterior advancement of the medial crura of the LLCs onto the caudal septum. The medial crura are then secured to the caudal septum providing enhanced stability and correction of the deviation. In Kridel \textit{et al.}’s series of 108 patients with caudal septal deviation good functional outcomes were noted.\textsuperscript{19} The main criticism of this technique, again, is widening of the columella.

\textbf{Extracorporeal Septoplasty}

More severe deviations or loss of significant portions of the septum necessitate reconstruction through extracorporeal septoplasty. The execution of this procedure requires en bloc removal of the residual cartilaginous and bony septum for extracorporeal reshaping, followed by reinsertion in a straightened dorsal and caudal septal configuration. Gubish,\textsuperscript{20} who performed the procedure >2000 times, found the open approach superior to the endonasal approach for the improved visualization it provided for dissection and re plantation. Subperichondrial dissection was performed to expose the cartilaginous and bony septum. The ULCs are sharply incised extramucosally improving visualization it provided for dissection and replantation. In Kridel \textit{et al.}’s series of 108 patients with caudal septal deviation good functional outcomes were noted.\textsuperscript{19} The main criticism of this technique, again, is widening of the columella.

In circumstances where only weakened or crooked cartilage segments remain the septal plate may be supported with grafts from the bony septum, auricular or costal cartilage grafts. Alternatively, a polydioxanone, PDS Flexible Plate (Ethicon, Inc., Somerville, NJ) may be used to augment reconstructed septum\textsuperscript{19,20}(Fig. 3). Boenisch,\textsuperscript{22,23} in a series of 369 extracorporeal septoplasty patients, in which the PDS foil was used, reported no short- or long-term complications such as rejection, infection, or necrosis.

Moreover, residual cartilage fragments are often sutured along the reconstructed dorsal septum, as spreader grafts, to widen the INV at the ULC. The reconstructed septal plate is then secured in place to the columella/medial crura, ULC, keystone area, and maxillary crest with nonresorbable sutures.\textsuperscript{18,20,24,25} In 404 patients undergoing extracorporeal septoplasty, Gubish found that 96\% of his patients reported improvement in their nasal breathing. The most common postoperative complaint was irregularity of the dorsum, seen in 8\% of patients.\textsuperscript{20}

\textbf{Surgical Management of the INV}

Obstruction of nasal airflow through the INV is usually a result of changes in its major components: the dorsal septum, the ULC, or the caudal inferior turbinate. There are a variety of procedures available to manage obstruction caused by inferior turbinate hypertrophy and they are beyond the scope of this article. Obstruction at the level of the INV caused by dorsal septal deviation is typically resolved through the procedures previously described such as submucosal resection, as well as extracorporeal septoplasty. Once these two key areas are properly addressed, the contribution of the ULC may become the focus of the surgeon.

Weakness or absence of the ULC typically arises in the patient who has previously undergone septrhinoplasty. An obvious sign of insufficiency of the ULC is the inverted-V deformity where the caudal end of the nasal bones is visible and creates a discontinuity with the middle nasal vault. This defect is created when resection of the broad dorsal septum allows the ULC to collapse medially, thus narrowing the middle nasal vault and INV to less than its normal 10–15\(^\circ\).

The common surgical management of this situation is accomplished through the use of spreader grafts, first described by Sheen.\textsuperscript{26} The spreader grafts are matchstick-shaped pieces of autologous cartilage typically harvested from septal or costal cartilage. They will sit in an extramucosal pocket between the caudal septum and ULC and are secured in place with nonresorbable sutures (Fig. 4). These grafts serve to broaden the dorsal septum and widen the angle between the septum and ULC, thus enlarging the INV.
A second procedure for dealing with weakened or deficient ULC, which are causing dynamic inspiratory collapse, is the splay or butterfly graft. In this procedure, described by Clark and Cook, cartilage grafting material is typically harvested from conchal cartilage. The graft is placed over the septal dorsum with its V-orientation facing caudally. The graft is secured to the lateral wings of the ULC. The resulting splay created by the inherent strength of the cartilage serves to stabilize the ULC from collapsing during inspiration. To prevent pollybeak deformity during this procedure, the graft must be adequately thinned or the dorsal septum reduced to maintain a smooth dorsal line on profile. Similarly, flaring sutures use the same principle as butterfly graft. Sutures are secured to the lateral/caudal ULC, pass over the dorsal septum, and are secured to the contralateral ULC. With tightening along the midline a flaring effect is created. Care must be taken to avoid the risk of a “cheese-wire” effect and loosening.

In the situation where reduction of the bony and cartilaginous dorsum leaves an open middle vault, Gassner describes a dorsal onlay graft that simultaneously reconstructs the INV. In this procedure a posterior septal graft is harvested between 8 and 9 mm wide, with length variable depending on the amount of dorsum to be reconstructed. The dorsal septum must be reduced along its length to receive the graft and maintain a continuous dorsal profile. The graft fits horizontally within the middle vault and is secured to the septum and ULC with sutures. The ULCs are sutured to the undersurface of the onlay graft, thus laterally rotating the graft and maintaining a wider, more natural, septal-ULC angle. Similarly, the modified Skoog dorsal reduction proposed by Hall et al. resects an en bloc dorsal graft that is reshaped extracorporeally, replanted, and secured to the ULC and septum. These two procedures provide functional reconstruction of the middle vault and INV while concurrently addressing irregularities of the dorsal profile.

**Surgical Management of the ENV**

Unlike obstruction at the level of the INV, obstruction of the ENV and intervalve area tend not to be related to previous nasal surgery. Weakness and instability of the ENV is often a byproduct of normal anatomic development and aging. These patients will present with nasal morphology such as narrow nostrils, recurvature of the lateral crus of the LLC, overprojected tip, and weak sidewalls that predispose the patient to obstruction. Toriumi noted that cephalic orientation of the lateral crus will decrease the support of the ala during inspiration and allow for collapse. Based on these preoperative findings, augmentation of the support of the lateral crura and ala are the primary interventions to correct ENV dysfunction.

Lateral crural strut grafts are cartilaginous grafts that are sutured along the lateral crus of the LLC to improve the strength of the cartilage. The indications for their use are weak or deformed lateral crus. They typically will extend laterally out over the pyriform aperture for enhanced support. They are secured either over (subcutaneous) or under (submucosal) the length of the lateral crus by nonresorbable suture. In some cases, they may be used to completely replace a deficient or missing lateral crus of the LLC.

Alar batten grafts have been the staple of augmentation of the ENV. They are autologous cartilage grafts typically taken from septal or conchal cartilage. Depending on the point of maximal collapse on preoperative dynamic testing, the batten grafts may be placed at different points along the nasal sidewall. Weakness may be seen at the level of the lateral crus, the intervalve area, or at the caudal end of the ULC. The batten grafts are placed in subcutaneous or submucosal pockets that are tailored to the exact dimensions of the graft, and the dissection is carried laterally toward the pyriform aperture. If precise pockets are created, the grafts may be simply placed and do not require suturing. In his review, Toriumi noted that subcutaneous grafts may add fullness to the supraalar region but was acceptable by his patients. Alternatively, Kenyon advocated a submucosal positioning of the graft for cosmesis as well as the empiric mechanical advantage of an underlay graft in improving the support and stability of the ala (Fig. 5). Using these techniques in 80 patients, Cervelli et al. described a 90% functional postoperative score of excellent.

Finally, alar rim grafts are an additional measure are used during rhinoplasty to augment the ENV. They are often used as adjuncts to the previously mentioned surgical techniques. Common indications include alar retraction, dynamic collapse of the ala during inspiration, and alar rim grafts are depicted here in lateral, frontal, and basal views. They are inserted through the marginal incisions and improve the strength and stability of the ala.
or alar contour deformity. The grafts are fashioned from quadrangular or cartilage, and suggested dimensions are a 2-to 3-mm width and 15- to 25-mm length. They are placed within a pocket created along the alar margin. If the pocket is formed to the correct dimension, they may be simply placed and the incision closed (Fig. 6). The tip of the rim graft is thinned to prevent contour deformity in the area of the soft tissue triangle. Alternatively, a resorbable stitch may be placed around the graft to prevent migration.

CONCLUSION

Nasal obstruction is a common complaint and will present in a number of anatomic variations. Performing submucous resection septoplasty in patients with concomitant nasal valve obstruction will often result in dissatisfied patients who are now without the convenient abundance of autologous quadrangular cartilage. The use and indications for open versus endonasal approaches must be thoroughly reviewed preoperatively so that the operation undertaken is appropriate for the intended outcomes. It is imperative that the rhinological surgeon considers the multiple contributing elements that lead to anatomic obstruction and is knowledgeable of the complete armamentarium of techniques used to functionally improve the nasal airway.

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