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 empiric 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.

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Nasal obstruction is one of the most common complaints of patients presenting to otolaryngology clinics. A number of different anatomic factors may contribute to the subjective sensation of decreased nasal airflow. Septoplasty is frequently performed on patients with anatomic changes of the nasal septum that impinge on the nose's function as an airway. Although this procedure will produce improvement in nasal function in a majority of patients with simple deviation, augmentation of the nasal valves must also be considered.

The salient nasal anatomy of the nasal septum, internal nasal valve (INV), and external nasal valve (ENV) is reviewed in regard to their contributions to the nasal airway. The common surgical approaches to address the problems of nasal valve stenosis, nasal valve collapse, and other anatomic distortions of the nasal airway are described.

PREOPERATIVE NASAL EVALUATION

The nasal airway serves as the primary conduit for inspired air to reach the lower respiratory tract. The effects of ecogeographical evolution has produced significant individual variation in the size and shape of the human nose.¹ Thus, the anatomic contribution to the complaint of nasal obstruction must be elucidated before embarking on surgical repair.

Historical information that must be ascertained includes prior surgeries, trauma, allergic, and sinus symptoms. Furthermore, subjective questionnaires such as the Nasal Obstruction Symptom Evaluation² should be used to characterize the patient's complaint. Preoperative assessment should include anterior rhinoscopy to find septal deviation, nasal endoscopy to rule out polypoid, Cottle maneuvers and external dilators to define dynamical valve collapse, and trials of decongestants to determine the contribution of mucosal congestion. Care must be taken to rule out previously undiagnosed congenital abnormalities such as choanal atresia/stenosis or pyriform aperture stenosis. Objective testing such as rhinomanometry and acoustic rhinometry may be performed to provide a numerical stratification of the patient's complaints and have been shown to predict postoperative patient satisfaction.³ Based on these assessments the clinician may develop a surgical plan individualized to the patient's anatomic disposition.

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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 inferiolateral 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 ULCs 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,

Figure 1. This series of pictures represents the nasal keystone area (solid black circle), internal nasal valve (dashed black oval), and external nasal valve (dashed white oval).

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.⁴ The septal body invests an observed thickening at the junction of the cartilaginous and bony septum. Furthermore, this region has a rich venous sinusoidal composition, thus, indicating a compliment to the nasal turbinates in regulating airflow.⁵

Neurovascular Anatomy

The vascular contributions that are significant to rhinoplasty primarily 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 arteries, 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 perception.⁶ 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.⁷ Previous studies have shown that anesthetizing the anterior nose results in a significant subjective sensation of nasal obstruction when compared with anesthesia of the nasal mucosa.⁸

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 epidemiological studies have revealed that the finding of a straight septum is present in only 42% of newborns and in adults, only 21%.⁹ Trauma

Figure 2. The “L-strut” is depicted here in a sagittal orientation. The importance of preserving of at least 1cm of cartilage both caudally and dorsally is demonstrated here. The strut maintains the articulation cephalically at the keystone, and caudally at the anterior nasal spine, while providing support along the dorsum, and at the nasal tip.

to the nose may result in a variety of bony and cartilaginous fractures as well as dislocation of the cartilage off the maxillary crest.¹⁰ The fractured cartilage may heal in a variety of orientations but often results in anatomic deviation. Previous nasal surgeries may predis-

Figure 3. (Upper left) During extracorporeal septoplasty the quadrangular cartilage is resected en bloc. (Upper right) The PDS™ Flexible Plate (Ethicon Inc., Somerville, NJ) is fashioned into the desired reconstructed septum. (Lower left) Septal remnants are positioned onto the plate to achieve a straightened profile along its caudal and dorsal sides. (Lower right) The reconstructed septum is secured to the maxillary crest and nasal dorsum.

Figure 4. Spreader grafts are depicted here in lateral, frontal and in cross-sectional views. The functional contribution of these grafts to the INV is best demonstrated on the cross-sectional view.

pose the septum to deviation through asymmetrical external forces and scar formation during healing.¹¹

The standard approach to correction of cartilaginous septal deviation, first popularized by Killian¹² and Freer,¹³ 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 esthetic 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,¹⁴ 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.

Pastorek¹⁵ 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 *et al.* found resolution of subjective nasal obstruction in 51/62 of his patients with caudal deviations treated with the aforementioned techniques.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.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 secured 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.¹⁸

Kridel¹⁹ 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 *et al.*'s series of 108 patients with caudal septal deviation good functional outcomes were noted.¹⁹ The main criticism of this technique, again, is widening of the columella.

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,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 replantation. Subperichondrial dissection was performed to expose the cartilaginous and bony septum. The ULCs are sharply incised extramucosally from their junction with the dorsal septum and dissected laterally. The dorsal septum is then freed from the aforementioned “keystone” area where there is essential attachment of the dorsal septal cartilage to the nasal bones and perpendicular plate of the ethmoid. An inferiorly based osteotomy may be necessary to separate the caudal septum from the anterior nasal spine and maxillary crest.

Once the septum has been freed from its bony attachments, it is removed and its structure is examined. The reconstructed septum must contain straight sections caudally and through the dorsum to recreate the L-strut (Fig. 2). This may be achieved by rotation of the septal specimen to reorient a straight posterior septum or by weakening deviated cartilage through scoring techniques previously described.

Most²¹ has described a modification of this technique that preserves the dorsal septum at the keystone area, which minimizes the destabilization of the nose and irregularities of the dorsum. The current authors prefer to maintain a 1.5- to 2-cm keel of intact dorsal septal cartilages attached to the nasal bones and ethmoid plate to aid in repositioning of the reconstructed cartilaginous septum.

Figure 5. Alar batten grafts are secured in an underlay fashion. The grafts extend toward the pyriform aperture, beyond the lateral crus, for enhanced stability.

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^{18,20} (Fig. 3). Boenisch,^{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.^{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 patient.²⁰

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 septorhinoplasty. 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°.

The common surgical management of this situation is accomplished through the use of spreader grafts, first described by Sheen.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.

Figure 6. 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.

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,²⁷ 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.²⁸ 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, Gassner²⁹ 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.*³⁰ 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.³¹ Toriumi noted that cephalic orientation of the lateral crus will decrease the support of the ala during inspiration and allow for collapse.³² 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 crura of the LLC to improve the strength of the cartilage. The indications for their use are weak or deformed lateral crura. 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, Toriumi³² 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).³¹ Using these techniques in 80 patients, Cervelli *et al.* described a 90% functional postoperative score of excellent.^{21,33}

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.³⁴ Common indications include alar retraction, dynamic collapse of the ala during inspiration,

or alar contour deformity. The grafts are fashioned from quadrangular or costal cartilage, and suggested dimensions are a 2-to 3-mm width and 15- to 25-mm length.³⁵ 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.³⁶ 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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REFERENCES

- Churchill SE, Shackelford LL, Georgi JN, and Black MT. Morphological variation and airflow dynamics in the human nose. *Am J Hum Biol* 16:625–638, 2004.
- Stewart MG, Witsell DL, Smith TL, et al. Development and validation of the Nasal Obstruction Symptom Evaluation (NOSE) scale. *Otolaryngol Head Neck Surg* 130:157–163, 2004.
- Pirila T, and Tikanto J. Acoustic rhinometry and rhinomanometry in the preoperative screening of septal surgery patients. *Am J Rhinol Allergy* 23:605–609, 2009.
- Cole P. The four components of the nasal valve. *Am J Rhinol* 17:107–110, 2003.
- Costa DJ, Sanford T, Janney C, et al. Radiographic and anatomic characterization of the nasal septal swell body. *Arch Otolaryngol Head Neck Surg* 136:1107–1110, 2010.
- Wrobel BB, and Leopold DA. Olfactory and sensory attributes of the nose. *Otolaryngol Clin North Am* 38:1163–1170, 2005.
- Cauna N, Hinderer KH, and Wentges RT. Sensory receptor organs of the human nasal respiratory mucosa. *Am J Anat* 124:187–209, 1969.
- Jones AS, Wight RG, Crosher R, and Durham LH. Nasal sensation of airflow following blockade of the nasal trigeminal afferents. *Clin Otolaryngol Allied Sci* 14:285–289, 1989.
- Gray LP. Deviated nasal septum. Incidence and etiology. *Ann Otol Rhinol Laryngol Suppl* 87:3–20, 1978.
- Lee M, Inman J, Callahan S, and Ducic Y. Fracture patterns of the nasal septum. *Otolaryngol Head Neck Surg* 143:784–788, 2010.
- Yeo NK, and Jang YJ. Rhinoplasty to correct nasal deformities in postseptoplasty patients. *Am J Rhinol Allergy* 23:540–545, 2009.
- Killian G. Die submuköse Fensterresektion der Nasenscheidewand. *Arch Laryngol Rhinol (Berl)* 16:326, 1904.
- Freer O. The correction of deflections of the nasal septum with minimum of traumatism. *JAMA* 38:636–692, 1902.
- Metzenbaum M. Replacement of the lower end of the dislocated septal cartilage vs. submucous resection of the dislocated end of the septal cartilage. *Arch Otolaryngol* 1929:282–292.
- Pastorek NJ, and Becker DG. Treating the caudal septal deflection. *Arch Facial Plast Surg* 2:217–220, 2000.
- Sedwick JD, Lopez AB, Gajewski BJ, and Simons RL. Caudal septoplasty for treatment of septal deviation: Aesthetic and functional correction of the nasal base. *Arch Facial Plast Surg* 7:158–162, 2005.
- Ellis MS. Suture technique for caudal septal deviations. *Laryngoscope* 90:1510–1512, 1980.
- Haack J, and Papel ID. Caudal septal deviation. *Otolaryngol Clin North Am* 42:427–436, 2009.
- Kridel RW, Scott BA, and Foda HM. The tongue-in-groove technique in septorhinoplasty. A 10-year experience. *Arch Facial Plast Surg* 1:246–256, 1999.
- Gubisch W. Twenty-five years experience with extracorporeal septoplasty. *Facial Plast Surg* 22:230–239, 2006.
- Most SP. Anterior septal reconstruction: Outcomes after a modified extracorporeal septoplasty technique. *Arch Facial Plast Surg* 8:202–207, 2006.
- Boenisch M, and Nolst Trenite GJ. Reconstruction of the nasal septum using polydioxanone plate. *Arch Facial Plast Surg* 12:4–10, 2010.
- Boenisch M, and Nolst Trenite GJ. Reconstructive septal surgery. *Facial Plast Surg* 22:249–254, 2006.
- Heppert W, and Gubisch W. Septal surgery in rhinoplasty. *Facial Plast Surg* 27:167–178, 2011.
- Gubisch W. Extracorporeal septoplasty for the markedly deviated septum. *Arch Facial Plast Surg* 7:218–226, 2005.
- Sheen JH. Spreader graft: A method of reconstructing the roof of the middle nasal vault following rhinoplasty. *Plast Reconstr Surg* 73:230–239, 1984.
- Clark JM, and Cook TA. The “butterfly” graft in functional secondary rhinoplasty. *Laryngoscope* 112:1917–1925, 2002.
- Park SS. The flaring suture to augment the repair of the dysfunctional nasal valve. *Plast Reconstr Surg* 101:1120–1122, 1998.
- Gassner HG, Friedman O, Sherris DA, and Kern EB. An alternative method of middle vault reconstruction. *Arch Facial Plast Surg* 8:432–435, 2006.
- Hall JA, Peters MD, and Hilger PA. Modification of the Skoog dorsal reduction for preservation of the middle nasal vault. *Arch Facial Plast Surg* 6:105–110, 2004.
- Ballert JA, and Park SS. Functional considerations in revision rhinoplasty. *Facial Plast Surg* 24:348–357, 2008.
- Toriumi DM, Josen J, Weinberger M, and Tardy ME Jr. Use of alar batten grafts for correction of nasal valve collapse. *Arch Otolaryngol Head Neck Surg* 123:802–808, 1997.
- Cervelli V, Spallone D, Bottini JD, et al. Alar batten cartilage graft: Treatment of internal and external nasal valve collapse. *Aesthetic Plast Surg* 33:625–634, 2009.
- Apaydin F. Nasal valve surgery. *Facial Plast Surg* 27:179–191, 2011.
- Boahene KD, and Hilger PA. Alar rim grafting in rhinoplasty: Indications, technique, and outcomes. *Arch Facial Plast Surg* 11:285–289, 2009.
- Phillips PS, Stow N, Timperley DG, et al. Functional and cosmetic outcomes of external approach septoplasty. *Am J Rhinol Allergy* 25:351–357, 2011. □