Enlargement of Nasal Vault Diameter with Closed Septoturbinotomy

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Background: Septal deviation and inferior turbinate hypertrophy are important contributors to nasal airflow obstruction. In recent years, a closed septoturbinotomy, whereby a speculum is inserted into the nose and the blades are spread, has been shown to centralize the bony septum and outfracture the turbinates in most cases. It is a minimally invasive procedure that frequently corrects bony septal deviation and reduces enlarged inferior turbinates. However, the extent of vault enlargement by that method has not been quantified. The purpose of this study was to demonstrate and quantify the extent to which a closed septoturbinotomy enlarges the maximal diameter of the nasal vault.

Methods: Measurements and silicone molds of the nasal vault were obtained before and immediately after performing closed septoturbinotomy in nine human cadavers. Measurements were taken with standardized graduated rubber tubing. Molds were obtained with commercially available sealant.

Results: All cadaver noses demonstrated enlargement of maximal internal diameter of the obstructed side on both calibrated tubing and silicone mold measurements ($p < 0.05$). The mean postosteotomy-to-preosteotomy vault diameter ratio was 1.64 (range, 1.25 to 2.3) for the obstructed side and 1.16 (range, 1.0 to 1.4) for the unobstructed side. This 64 percent increase in radius permits a theoretical 7-fold increase in flow by Poiseuille's law.

Conclusions: Closed septoturbinotomy is a minimally invasive technique that enlarges the nasal vault in the overwhelming majority of cases. A clinical trial with rhinomanometry is needed to verify the extent of functional improvement. (*Plast. Reconstr. Surg.* 120: 753, 2007.)

A traditional septoplasty is an open procedure in that it requires elevation of the mucoperichondrium and mucoperiosteum to straighten and/or resect of parts of the cartilaginous and, if necessary, bony septum (perpendicular plate of the ethmoid). When indicated, inferior turbinectomy has also been shown to improve nasal airflow by reducing air resistance through the nasal vault,[1–4] although not all studies concur.[5,6] However, the above techniques are invasive, sometimes technically difficult to execute, and frequently (especially in the case of turbinectomies) associated with brisk nasal bleeding during surgery and occasional epistaxis following surgery (at the time of nasal pack removal).

To avoid the potential complications of open procedures to correct the bony septum and turbinate hypertrophy, the technique of closed septoturbinotomy was formally introduced in 1998.[7,8] It involves the insertion of a long- and wide-bladed nasal speculum along the nasal floor as far as the blades will pass. A careful, gradual spreading action fractures the deviated bony septum component toward the midline (centralizes it) and compresses, and usually fractures, the inferior turbinate (Fig. 1). There is no intent to fracture the cartilaginous septum, although that may occur. The procedure is therefore better characterized not simply as a closed septal osteotomy (as it was originally called), but as a closed septoturbinotomy. This septoturbino-

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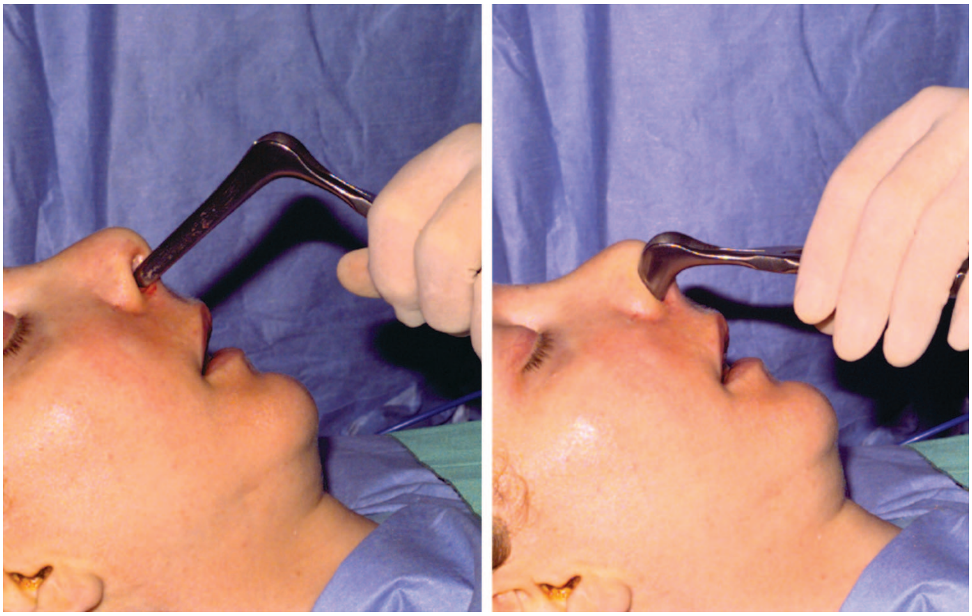

Fig. 1. Technique of closed septoturbinotomy. (*Left*) A medium-sized speculum is inserted just beyond the nostril rim, with care being exercised to avoid tearing the vestibular mucosa. (*Right*) The blades are spread. Usually, a crunching sound is heard as the bony septum centralizes and the turbinate infractures.

tomy maneuver is then used on the unobstructed side in addition to the obstructed side, to ensure a midline septum. In this manner, the technique may be likened to the effect of a "reverse nutcracker," which compresses outwardly toward the septum and turbinates. Care must be taken to insert the speculum beyond the nostril rim so as to avoiding tearing the rim skin when expanding the speculum.

In the original study, the technique improved the bony vault volume ratio of the obstructed to unobstructed sides in 82 percent of 32 patients examined.[7,8] That study was limited in that quantitative nasal vault measurements were not taken. Airways were graded on the basis of physical examination findings. If the bony septum appeared to divide the nasal vault into two equal compartments (a 50:50 compartment ratio), the posterior airway was considered to be excellent, whereas if the vault was divided into an approximately 70:30 ratio, the posterior airway was considered poor. The nasal vaults were examined before and after performance of the maneuver. No specific attention was directed toward turbinate outfracturing. However, turbinates were witnessed to be reduced in size postoperatively. It was unclear whether this was attributable to an associated fracture or whether this might have represented compensatory reduction as a function of improved bony compartment ratios. Because the estimates of bony compartment ratios were, by definition, qualitative, only indirect conclusions could be drawn regarding the cross-sectional dimensions of the nasal vault. Therefore, the current study was designed to demonstrate a reproducible enlargement of the nasal vault diameter in a cadaver model.

MATERIALS AND METHODS

Nine human cadavers with obstructive nasal anatomy were obtained from a medical school anatomy dissection laboratory. Five male and four female cadavers were studied. Two techniques were used to evaluate the nasal vault size.

Vault sizes were measured as follows. The first technique involved the instillation of a quick-drying, commercially available silicone caulking sealant (DAP, Inc., Baltimore, Md.) in each naris to obtain a model of the interior of each nasal cavity (Figs. 2 and 3). The models were allowed to dry for 24 hours and then easily extracted from the cadaver nasal vaults. Comparison of the vault models with human skulls showed that significant detail of the internal nasal architecture (e.g., turbinate shape and size, septal deviation) was preserved. The models were then sectioned and the location of their maximal diameters was noted.

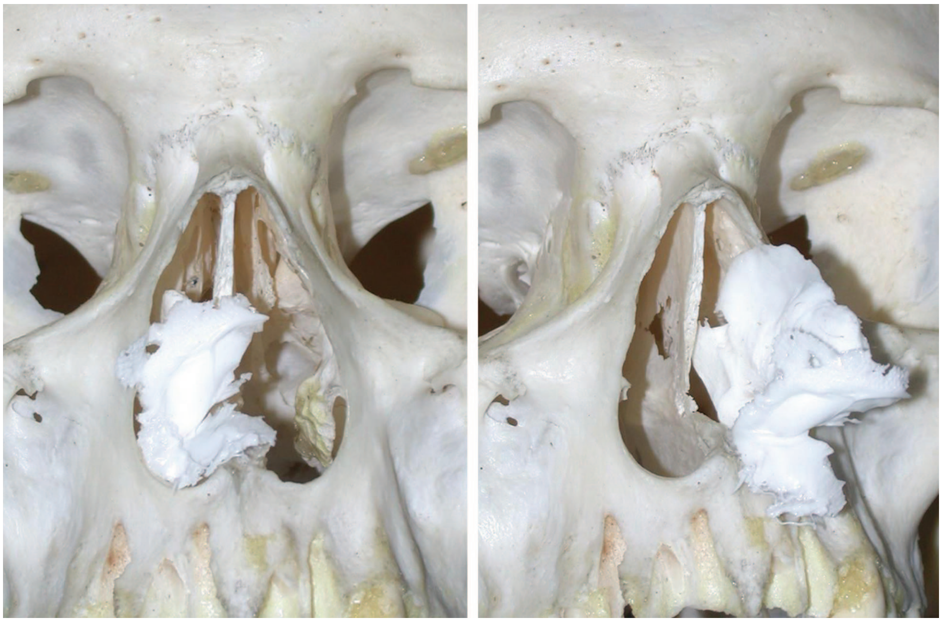

Fig. 2. Cadaver nasal cast models and anatomical detail. These nasal vault casts show good detail of septal and turbinate architecture. (*Left*) Coronal view; (*right*) oblique view.

Fig. 3. Preprocedural and postprocedural nasal vault models. Representative models of the left and right nasal vaults obtained before and after closed septoturbinotomy in a cadaver. To the left in each figure is the preprocedural model; to the right is the postprocedural model. (*Left*) Models of the left vault; (*right*) models of the right vault.

In the second technique (performed 2 to 3 days after the molds were removed), graduated, transparent, semifirm, rubber tubing was inserted along the nasal floor to the posterior nasal vault in each naris until resistance to easy passage was encountered. The graduated tubing used was manufactured in nonmetric increments of 1/16 inch. Larger diameter tubing was inserted in increasing increments of 1/16 inch. The largest diameter tube accommodated comfortably by a given nasal hemivault was defined as the maximal nasal vault diameter on that side.

The septoturbinotomy procedure was performed by placing a medium large nasal speculum in the obstructed side and manually spreading the blades. Usually, a crunching sound was heard. Care was taken not to overly spread the blades or do it under pressure beyond that which would be used on an actual patient. To be certain that the dilation on the obstructed side was not overdone or did not cause impingement of the bony septum on the contralateral side, the speculum was then put in the contralateral side and the blades were spread with minimal pressure. After the septo-

Table 1. Preprocedure and Postprocedure Nasal Vault Measurements in Cadaver Noses (in inches)

			Preprocedure		Postprocedure		Postprocedure-to-Preprocedure Diameter Ratio	
Cadaver	Sex	Deviation	Right	Left	Right	Left	Right	Left
6391	M	Left	4/16	3/16	5/16	7/16	1.25	2.33
6281	F	Left	4/16	4/16	5/16	6/16	1.25	1.5
6396	M	Right	5/16	5/16	8/16	7/16	1.6	1.4
6126	F	Left	5/16	4/16	4/16	6/16	0.8	1.5
6225	M	Right	4/16	4/16	6/16	4/16	1.5	1.0
6130	F	Right	4/16	4/16	7/16	5/16	1.75	1.25
6293	M	Left	3/16	3/16	4/16	5/16	1.33	1.67
6394	F	Left	4/16	3/16	4/16	5/16	1.0	1.67
6286	M	Right	4/16	3/16	5/16	3/16	1.25	1.0

turbinotomy was performed, it was invariably noticed that the closed speculum passed more easily on both sides after the dilation than before the dilation. Measurements and models were taken immediately after the closed septoturbinotomy. Digital photographs of the preosteotomy and postosteotomy models were obtained.

RESULTS

There were five left- and four right-sided deviations (Table 1). Closed septoturbinotomy was shown to enlarge the maximal internal nasal diameter in all nine patients. The median diameters before septoturbinotomy (as measured with the graduated tubing) were 4/16 inch for the right side (range, 3/16 to 5/16 inch) and 4/16 inch (range, 3/16 to 5/16 inch) for the left. Median diameters after septoturbinotomy by the graduated tubing method were 5/16 inch for the right (range, 4/16 to 8/16 inch) and 5/16 inch for the left (range, 4/16 to 7/16 inch). Maximal nasal diameter on the previously obstructed side was increased by a mean of 64 percent and a median of 60 percent (mean postprocedure-to-preprocedure diameter ratio, 1.64; median postprocedure-to-preprocedure diameter ratio, 1.6; $p < 0.001$ on two-tailed *t* test). The ratios of enlargement ranged from 1.25 to 2.33. In addition, because the closed septoturbinotomy was applied bilaterally to ensure medialization of the septum, the nonobstructed side was enlarged by an average of 14 percent (mean postprocedure-to-preprocedure diameter ratio, 1.14; range, 0.8 to 1.4), with a median enlargement of 25 percent (median postprocedure-to-preprocedure diameter ratio, 1.25), but this increase was not statistically significant ($p = 0.095$; two-tailed *t* test).

An example of correction of septal deviation and obstructing inferior turbinates is illustrated in Figure 4, which demonstrates preprocedural and postprocedural configurations of the nasal septum and inferior turbinate in an embalmed cadaver. The silicone compound fills the caudal two-thirds of the vault and obtains a satisfactory cast in the area of the inferior turbinates. Examination of the casts indicated that in every case the location of diameter change was confined primarily to the inferior turbinate level, that the bony turbinate did indeed end up closer to the maxillary wall, that the width of the turbinate was reduced, and that the gap between the turbinate and maxillary wall was reduced.

DISCUSSION

We wish to make it clear at the outset that this experimental design in cadavers does not allow mucosal factors, and especially the dynamism of the nasal sidewall, to be factored into the conclusions. It is, of course, uncertain whether the dramatic effect on nasal diameter witnessed in the cadaver would be entirely reproducible in a living patient's nose. Cadaveric mucosal tissue and bone may not exhibit the same compliance characteristics as living tissue. We are grateful to one of the reviewers for pointing that out. However, there is an unmistakable change in the bony anatomy of the vault as a result of fracturing the bony septum and turbinates. The purpose of this study was to quantify these changes and thereby illustrate the dramatic extent of bony change observed when septoturbinotomy is performed.

The technique enlarged the obstructed nasal cavity in every cadaver examined in this study, as measured both by the standardized graduated rubber tubing measurements and by the models. The results of this study indicate as much as a 64 percent increase in the maximal diameter of obstructed nasal vaults, which would permit a theoretical 7-fold increase in laminar airflow by Poi-

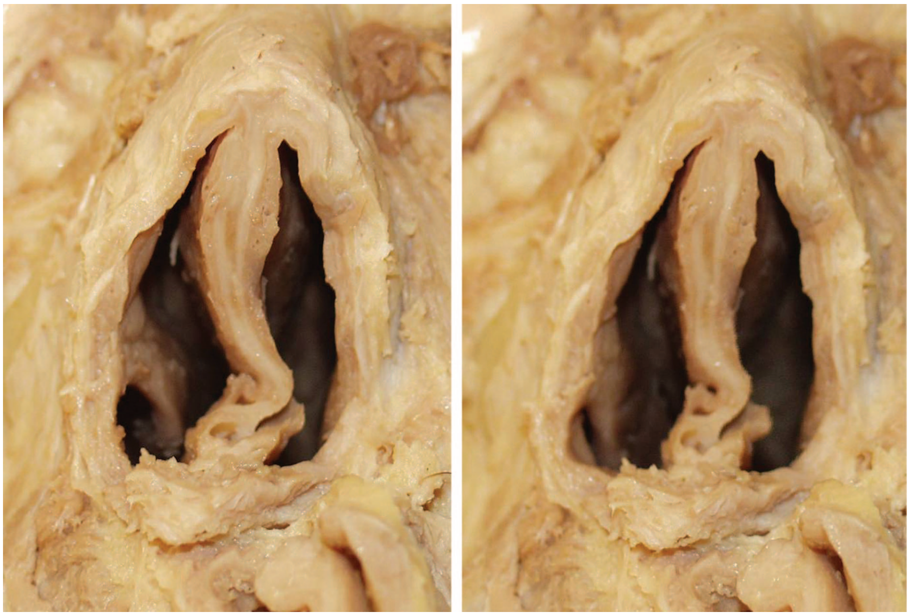

Fig. 4. Effect of closed septoturbinotomy on septal deviation in a cadaver nose. (*Left*) Cadaveric septal deviation and obstructing turbinate before closed septoturbinotomy. (*Right*) Improved cadaveric septal deviation and turbinate obstruction after closed septoturbinotomy. Note the position of the inferior turbinate, which no longer projects prominently into the nasal vault.

seuille's law. However, that flow increase may only be in one cross-section of the nasal vault. One cannot expect an overall increase in airflow of that magnitude unless the entire length of the vault was increased 7-fold.

Other limitations of this study include the inability of the models and tubing measurements to fully characterize the upper portions of the nasal vault, which contribute to nasal airflow. The viscosity of the sealant prevented it from fully coating the nasopharynx or the level of the superior concha. The models provided good information on the anatomical detail of the lower two-thirds of the nasal cavity, with the greatest detail at the level of the inferior turbinate. The utility of intranasal cavity modeling with graduated cylindrical inserts has been previously demonstrated.[9]

Constantian and Clardy[10] rightly pointed out that the septum and turbinates may not be the most significant causes of nasal airway obstruction. However, they do play a significant role. Courtiss and Goldwyn[3] described the effects of turbinate surgery on airflow using Poiseuille's law[11]:

$$Flow = Constant \times Radius^4 / Length$$

By increasing the radius of the nasal cavity, resistance to airflow decreases with the fourth power of the radius, with a concomitant enormous improvement in nasal flow rate. Techniques that enlarge the cross-sectional dimensions of the nasal vault include open or closed septoplasty (which results in an absolute increase in the transverse dimension of the obstructed vault) and turbinectomy (which removes a space-occupying mass that reduces the open cross-sectional area). The turbinate procedures include subtotal or total turbinectomy, mucosal cautery, submucous resection, and turbinate fracture.[12–19] In a large series, Rohrich et al.[12] advocate submucous resection as an important adjunct to rhinoplasty. Mabry[13] popularized a partial turbinectomy technique, but recommended that the surgeon perform the most conservative surgical approach to the turbinates that consistently provides a good airway in that surgeon's hands. Similarly, Chang and Reis[14] emphasized the importance of using simple techniques that preserve function with low complication rates. As simple and as obvious as these techniques and recommendations appear, reported results are often varied and controversial. Thomas et al.[5] showed no significant nasal airway improvement with posterior amputation of the turbinate with outfracture. Nunez and Bradley[15] similarly did not observe reduced nasal congestion when turbinate resection was added to septoplasty, compared with septoplasty alone. Ho et al. observed early improvements in nasal obstruction with septoplasty and turbinectomy but diminished benefit over time.[16] Some data support lateral outfracture in combination with submucous decongestion as the most effective approach to the hypertrophied turbinate while acknowledging the greater technical requirements for proper execution.[17] However, outfracturing the turbinates without resection has been even more controversial than actual excision of the turbinates. It has been disappointing to some.[18] Warwick-Brown and Marks[6] compared diathermy with or without outfracture, partial turbinectomy, and direct linear cautery and found equivalent early success rates with these procedures, and equivalent rates of decline in patient satisfaction over time.

Techniques of "blind" septal and turbinate fracture have long been among the techniques used by plastic surgeons.[7,8] It has been simple to learn and safe. As an adjunct to rhinoplasty in the modestly deviated septum with or without turbinate hypertrophy, it can accomplish significant improvement in a matter of a minute. In the original description of this procedure, most of cases showed clinically enlarged nasal vaults. No significant complications were reported in that series. Since that clinical article was presented, the technique itself has changed slightly. One of the senior authors uses a medium length speculum (R.P.G.) so that the instrument can be inserted completely into the nasal cavity. When the blades are spread, they will not fracture the skin of the nostril, which may occur otherwise. The other senior author (M.A.L.) uses a 6- or 8-inch Peon clamp to dilate the nasal vault and uses a 26- or 28-French Rusch tube sutured across the membranous septum to provide additional internal buttressing to the septum and turbinates for approximately 1 week. Clearly, little is lost by attempting the closed septoturbinotomy in a patient with airway obstruction involving the posterior septum and turbinates. If it fails to show a significant improvement, an open approach is performed.

There are contraindications for the procedure. A persistent drawback of the technique is that it is not well suited to correct a markedly thick bony septum. Also, heavy vomerine bones are less likely to fracture in a controlled fashion using closed techniques. Patients with profound, externally visible dorsal deviation or large, thick vomerine ridges are probably better served with open techniques that permit more control over cartilaginous stresses and bony resistance. It is also possible to inadvertently fracture the cartilaginous septum, which would be a problem if the cartilaginous septum is to be used as donor material. Long-term data on the efficacy of the technique in patients must be sought. Future studies must focus on rhinomanometric measurements in patients undergoing cosmetic rhinoplasty, in whom closed septoturbinotomy is the sole technique used for correction of mild deviations and obstructive symptoms.

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DISCLOSURES

Ronald P. Gruber, M.D., makes instruments for Integra. All royalties go to the Plastic Surgery Educational Foundation. None of the other authors has a financial interest in any of the products, devices, or drugs mentioned in this article.

REFERENCES

1. Courtiss, E. H. Diagnosis and treatment of nasal airway obstruction due to inferior turbinate hypertrophy. *Clin. Plast. Surg.* 15: 11, 1988.
2. Courtiss, E. H., and Goldwyn, R. M. Resection of inferior turbinates: A 10-year follow-up. *Plast. Reconstr. Surg.* 86: 152, 1990.
3. Courtiss, E. H., and Goldwyn, R. M. The effects of nasal surgery on airflow. *Plast. Reconstr. Surg.* 72: 9, 1983.
4. Courtiss, E. H., and Goldwyn, R. M. Resection of inferior turbinates: A 10-year follow-up. *Plast. Reconstr. Surg.* 86: 152, 1990.
5. Thomas, P. L., John, D. G., and Carlin, W. V. The effect of inferior turbinate outfracture on nasal resistance to airflow in vasomotor rhinitis assessed by rhinomanometry. *J. Laryngol. Otol.* 102: 144, 1988.
6. Warwick-Brown, N. P., and Marks, N. J. Turbinate surgery: How effective is it? A long-term assessment. *O.R.L. J. Otorhinolaryngol. Relat. Spec.* 49: 314, 1987.
7. Gruber, R., and Lesavoy, M. Closed septal osteotomy. *Ann. Plast. Surg.* 40: 283, 1998.
8. Gruber, R., and Lesavoy, M. Simple technique to correct the bony septum. *Plast. Reconstr. Surg.* 102: 244, 1998.
9. Buenting, J. E., Dalston, R. M., Smith, T. L., and Drake, A. F. Artifacts associated with acoustic rhinometric assessment of infants and young children: A model study. *J. Appl. Physiol.* 77: 2558, 1994.
10. Constantian, M. B., and Clardy, R. B. The relative importance of septal and nasal valvular surgery in correcting airway obstruction in primary and secondary rhinoplasty. *Plast. Reconstr. Surg.* 98: 38, 1996.
11. Courtiss, E. H., Gargan, T. J., and Courtiss, G. B. Nasal physiology. *Ann. Plast. Surg.* 13: 214, 1984.
12. Rohrich, R. J., Krueger, J. K., Adams, W. P., Jr., and Marple, B. F. Rationale for submucous resection of hypertrophied

inferior turbinates in rhinoplasty: An evolution. *Plast. Reconstr. Surg.* 108: 536, 2001.
13. Mabry, R. L. Surgery of the inferior turbinates: How much and when? *Otolaryngol. Head Neck Surg.* 92: 571, 1984.
14. Chang, C. W., and Ries, W. R. Surgical treatment of the inferior turbinate: New techniques. *Curr. Opin. Otolaryngol. Head Neck Surg.* 12: 53, 2004.
15. Nunez, D. A., and Bradley, P. J. A randomised clinical trial of turbinectomy for compensatory turbinate hypertrophy in patients with anterior septal deviations. *Clin. Otolaryngol.* 25: 495, 2000.
16. Ho, W. K., Yuen, A. P., Tang, K. C., Wei, W. I., and Lam, P. K. Time course in the relief of nasal blockage after septal and turbinate surgery: A prospective study. *Arch. Otolaryngol. Head Neck Surg.* 130: 324, 2004.
17. Passali, D., Lauriello, M., De Filippi, A., and Bellussi, L. *Comparative study of most recent surgical techniques for the treatment of the hypertrophy of inferior turbinates (in Italian). Acta Otorhinolaryngol. Ital.* 15: 219, 1995.
18. Martinez, S. A., Nissen, A. J., Stock, C. R., and Tesmer, T. Nasal turbinate resection for relief of nasal obstruction. *Laryngoscope* 93: 871, 1983.
19. Jackson, L. E., and Koch, R. J. Controversies in the management of inferior turbinate hypertrophy: A comprehensive review. *Plast. Reconstr. Surg.* 103: 300, 1999.