

# Indications for Surgery in Refractory Rhinitis

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**Abstract** Medical treatment of chronic rhinitis is successful in a majority of patients, but there is a still large population of patients who fail medical therapy. Surgical treatment for patients with severe persistent allergic rhinitis is not a new solution, but recent advancements in technology and surgical technique have made surgery safer and more effective. There is no gold standard of treatment in patients with refractory rhinitis, and surgeons may select a variety of procedures and techniques based on a patient's anatomy, severity of disease, and comorbidities. Unfortunately, there are currently few large prospective, randomized controlled trials evaluating surgical treatments, and no study to date has compared immunotherapy to surgical intervention. Therefore, there is no hard and fast rule as to when to pursue surgical intervention after initial medical therapy has failed.

**Keywords** Inferior turbinate · Turbinoplasty · Vidian neurectomy · Allergic rhinitis · Surgery · Refractory rhinitis · Submucosal resection · Laser turbinoplasty · Microdebrider

## Introduction

Chronic rhinitis is one of the most common reasons for outpatient visits to primary care physicians, allergists, and otolaryngologists. Allergic rhinitis is by far the most common type of chronic rhinitis with vasomotor rhinitis, non-allergic rhinitis, and atrophic rhinitis being less common etiologies. Allergic rhinitis is one of the most common medical conditions in the world with an estimated 600 million people afflicted with the condition [1]. The main symptoms of

chronic rhinitis are nasal obstruction, rhinorrhea, and sneezing. Medical therapy consists of nasal saline rinses, oral antihistamines, intranasal steroids, intranasal antihistamines, leukotriene inhibitors, and immunotherapy. Surgical intervention is indicated if medical therapy fails to improve the patient's quality of life or if the treating physician feels surgical intervention may significantly improve quality of life beyond what medical therapy has been able to accomplish.

Nasal obstruction is the most common symptom that is refractory to medical therapy, and it is also the symptom most amenable to surgical intervention. Nasal obstruction is also the symptom that most correlates with patient quality of life over rhinorrhea and sneezing [2]. The vast majority of experience with surgical treatment of rhinitis lies with allergic rhinitis patients and the treatment of obstruction as a primary symptom. However, rhinorrhea may also be addressed surgically via neurectomy, but this technique is rarely performed and only used in the most severe and refractory cases of vasomotor rhinitis or in the most severe cases of allergic rhinitis. Surgical treatment for vasomotor rhinitis and atrophic rhinitis is more rare.

## Inferior Turbinate Reduction Surgery

The internal nasal valve is the key regulator of nasal airflow and is made up of the septum, the upper lateral cartilage, and the inferior turbinate. In the absence of nasal trauma, the inferior turbinate is the only structure that undergoes dynamic changes in size. Enlargement of the inferior turbinate is the main cause of nasal obstruction in patients with chronic allergic rhinitis. The size of the inferior turbinate is affected by both its underlying bony structure and the more variable soft tissue covering. The turbinates are lined by pseudostratified columnar epithelium and a submucosal lamina propria, which supports the epithelial layer. The submucosal layer is the layer responsible for the fluctuations in size of the inferior turbinate. The submucosa contains mucous glands, vasculature, goblet cells, parasympathetic nerve fibers, and inflammatory cells. Ig-E mediated inflammation leads to engorgement of the

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turbinate vasculature and thickening of the mucosal lining, especially the lamina propria [3]. Medical treatment of allergic rhinitis with topical nasal steroid sprays is directed at the mucosal lining of the inferior turbinate and results in decreased nasal resistance by reduction of the cross sectional area of the inferior turbinate. Likewise, the majority of surgical interventions for treating nasal obstruction in allergic rhinitis are directed at the inferior turbinate. A deviated septum is also capable of causing residual nasal obstruction in patients with chronic rhinitis after medical treatment, and septoplasty is often combined with the surgical treatment of the inferior turbinates. However, since obstruction from the septum is purely anatomic and structural, septoplasty is beyond the scope of this article. Table 1 lists significant papers discussed in this review and includes the major findings of each paper.

### Inferior Turbinate Reduction Surgery

The most aggressive technique to increase nasal patency is total resection of the inferior turbinate. However, total turbinectomy is rarely performed in the setting of allergic rhinitis because of the significant risk of debilitating postoperative atrophic rhinitis and empty nose syndrome. The most conservative technique is lateral outfracture of the inferior turbinate, which involves exerting lateral pressure on the turbinate until a fracture is felt or heard. Visualization of an improved nasal airway with a headlight or nasal endoscope is also helpful in quantifying the degree of improvement. This technique minimally disturbs the overlying mucosa and has the least chance of resulting in empty nose syndrome. Resulting increases in nasal patency appear to last at least 6 months after simple outfracture [4]. However, in most circumstances of severe allergic rhinitis, outfracture may not provide enough of a change in nasal cavity patency since this procedure in isolation does not change the inferior turbinate's soft tissue mass and only alters the turbinate's angle of attachment to the lateral wall. Additional, newer techniques focus on decreasing the inferior turbinate's soft tissue element with minimal disruption of the important mucosal surface.

### Classic Submucosal Resection

The original technique for submucosal resection involves an incision in the anterior head of the inferior turbinate, elevation of the overlying mucoperiosteum and resection of a significant portion of the underlying bone of the inferior turbinate. Portions of the inferolateral mucosa may be removed and the medial mucosa draped back over the exposed bone. By keeping the mucosa and submucosa intact, complications with ciliary mucus transport, synechia, and crusting from bony

exposure are minimized. Passali et al. compared the classic submucosal resection technique with other methods of turbinate reduction including total resection, cryosurgery, and laser surgery [5]. Over a 4-year period, the authors compared nasal patency, mucociliary clearance, IgA production, and complications. While total turbinectomy had the greatest increase in nasal patency, it caused poor mucociliary clearance and had the worst complications of hemorrhage. Submucosal resection had lower incidence of bleeding complications and better mucociliary clearance and IgA levels, although these findings did not reach statistical significance. When combined with lateral outfracture, there was no statistical difference between turbinate resection and the submucosal resection group with regards to rhinomanometry and acoustic rhinometry [5].

### Laser Turbinoplasty

Lasers may be used to direct energy at the inferior turbinate's submucosal layer leading to vaporization of excess tissue in a hemostatic fashion. Various lasers have been used to achieve turbinate reduction, each with a different depth of penetration and specific absorbing chromophore, including carbon dioxide (CO<sub>2</sub>), potassium-titanyl phosphate (KTP), neodymium-yttrium aluminum garnet (Nd:YAG), argon, holmium-yttrium aluminum garnet (Ho:YAG), and diode lasers. Several studies have investigated the efficacy of laser turbinoplasty in allergic rhinitis patients. Takeno et al. studied the effects of CO<sub>2</sub> laser turbinoplasty in a prospective cohort study, comparing 25 patients with perennial allergies to 26 patients with perennial and seasonal allergies based on positive skin and RAST testing [6]. They found improvements in nasal cavity volume as well as symptoms of sneezing and rhinorrhea. However, the increase in nasal cavity cross-sectional area was less pronounced after 4 months in the perennial allergy group compared to the perennial and seasonal allergy group (30.7 % increase vs. 61.7 % increase, though  $p < 0.01$  for both groups). Symptoms of sneezing and rhinorrhea were not as affected in those patients with perennial and seasonal allergy [6]. In a recent prospective cohort study using diode lasers, Caffier et al. found lasting improvements in objective and subjective measurements of nasal symptoms for up to 2 years after surgery in a study population of 20 seasonal allergy and 20 perennial allergy patients [7]. They measured rhinomanometry as well as symptom scores with regards to nasal obstruction, rhinorrhea, sneezing, and itching. Rhinomanometry at 150-Pa total nose inspiration revealed a significant mean ventilation increase from  $282 \pm 137$  cm<sup>3</sup>/s to  $496 \pm 40$  cm<sup>3</sup>/s after 1 year and to  $485 \pm 140$  cm<sup>3</sup>/s after 2 years ( $p < 0.0005$ ). Seventy percent of seasonal allergy patients and 60 percent of perennial allergy patients no longer took allergy medication 2 years post-surgery [7]. The diode laser has the inherent advantages of portability and relatively

**Table 1** List of significant articles

| Study (author, publication, date)                | Study population        | Study design                                                    | Sample size | Surgical intervention                | Comparator group                                | Measures                                                                              | Results, <i>P</i> -value                                                                                                                                                                                                                                                                                                                                |
|--------------------------------------------------|-------------------------|-----------------------------------------------------------------|-------------|--------------------------------------|-------------------------------------------------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Takeno et al. Ann Otol Rhinol Laryngol, 2003     | AR                      | Prospective cohort study                                        | 51          | Laser                                | Perennial vs. perennial and seasonal            | Acoustic rhinometry, symptom visual analog scale (VAS)                                | Cross-sectional area increased for both groups at 4 months but was significantly greater in seasonal group (30.7 % vs. 61.7 %, $p<0.05$ ); both populations had significant improvements in symptoms of nasal obstruction, sneezing, rhinorrhea ( $p<0.05$ ) but perennial had relatively greater change                                                |
| Cakli et al. Eur Arch Otorhinolaryngol, 2012     | NR                      | Prospective cohort study                                        | 62          | Laser                                | None                                            | Acoustic rhinometry, nasal obstruction VAS                                            | Cross-sectional area remained increased at 1 year ( $p<0.001$ ); mean visual analog scale scores reduced from 8.88 to 2.82 at 1 year ( $p<0.001$ )                                                                                                                                                                                                      |
| Sapci et al. Laryngoscope, 2003                  | AR and NR               | Prospective, randomized controlled clinical trial               | 45          | Laser, radiofrequency ablation (RFA) | Laser turbinoplasty vs. radiofrequency ablation | Symptom VAS, rhinomanometry, mucociliary transit time (MTT)                           | Symptoms decreased in both groups compared to control but no significant difference between surgical groups ( $p<0.01$ ); nasal resistance significantly decreased in both groups but no significant difference between surgical groups ( $p<0.01$ ); MTT increased only in the laser group ( $25.60\pm5.90$ minutes vs. $11.60\pm1.99$ min; $p<0.01$ ) |
| Powell et al. Laryngoscope, 2001                 | Obstructive sleep apnea | Prospective, randomized, double-blind, placebo-controlled trial | 22          | RFA                                  | RFA vs. placebo                                 | Nasal obstruction VAS                                                                 | Blinded examiner and patient did not demonstrate significant changes in nasal obstruction VAS; <i>demonstrates importance and need for blinding in these studies</i>                                                                                                                                                                                    |
| Safruddin et al. Eur Arch Otorhinolaryngol, 2013 | AR and NR               | Retrospective, observational cohort study                       | 142         | RFA                                  | None                                            | Patient questionnaire, VAS                                                            | 13.1 % of patients stopped nasal steroid use after surgery ( $p=0.019$ ), and 31.5 % of patients reduced their use a year after surgery                                                                                                                                                                                                                 |
| Lin, Arch Otolaryngol Head Neck Surg, 2010       | AR                      | Retrospective, observational cohort study                       | 101         | RFA                                  | None                                            | Symptom VAS                                                                           | Symptoms of nasal obstruction rhinorrhea, sneezing, itchy nose, and itchy eyes improved at both 6-month and 5-year time points (all $p<0.01$ )                                                                                                                                                                                                          |
| Gunhan et al. Eur Arch Otorhinolaryngol, 2011    | AR                      | Prospective, randomized controlled clinical trial               | 58          | RFA                                  | RFA vs. mometasone nasal spray                  | Rhinomanometry, symptom VAS, Rhinconjunctivitis Quality of Life Questionnaires (RQLQ) | Total nasal resistance only decreased in RFA group significantly ( $p=0.003$ ); nasal obstruction VAS score only decreased significantly in RFA group ( $p=0.032$ ); RQLQ                                                                                                                                                                               |

**Table 1** (continued)

| Study (author, publication, date)            | Study population | Study design                                           | Sample size | Surgical intervention              | Comparator group                                                                        | Measures                                              | Results, <i>P</i> -value                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|----------------------------------------------|------------------|--------------------------------------------------------|-------------|------------------------------------|-----------------------------------------------------------------------------------------|-------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Di Rienzo Businco et al. Rhinology, 2010     | AR               | Prospective, non-randomized, controlled clinical trial | 220         | Coblation                          | Coblation and medical therapy vs. medical therapy alone; perennial vs. seasonal allergy | Symptom VAS, endoscopy score, rhinomanometry          | scores increased significantly in both groups but degree of change was higher in nasal symptoms in RFA group<br>VAS (nasal obstruction, itching, rhinorrhea, sneezing) improved in both groups ( $p<0.001$ ) but significant difference between coblation and control only in obstruction ( $p<0.001$ ); significant difference in endoscopy score ( $p<0.001$ ); only perennial allergy group had significant improvement in rhinomanometry over control ( $p<0.001$ ) |
| Cingi et al. Acta Otorhinolaryngol Ital 2010 | AR and NR        | Prospective cohort study                               | 268         | Microdebrider, RFA                 | Microdebrider vs. RFA                                                                   | Symptom score, rhinomanometry                         | Symptoms of nasal obstruction, headache, and hyposmia improved in both groups ( $p<0.05$ ) but improvement in nasal obstruction was better in microdebrider group ( $p<0.05$ ); rhinomanometry also better in microdebrider group ( $p<0.05$ )                                                                                                                                                                                                                          |
| Liu et al. Laryngoscope, 2009                | AR               | Prospective, randomized study                          | 120         | Microdebrider, RFA                 | Microdebrider vs. RFA                                                                   | Symptom VAS, rhinomanometry, saccharin transport time | Only microdebrider group maintained changes in VAS ( $p<0.0001$ ) and rhinomanometry ( $p<0.05$ ) after 3 years; both improved saccharin transport times up to 1 year ( $p<0.05$ ) but not after                                                                                                                                                                                                                                                                        |
| Lee et al. Eur Arch Otorhinolaryngol, 2011   | VR (75), AR (13) | Retrospective, observational study                     | 89          | Endoscopic vidian neurectomy (EVN) | None                                                                                    | Symptom VAS                                           | 91.7 % of patients were satisfied with results of surgery (VAS $\geq 6$ ); 23.8 % of patients had temporary dry eye (average 15 days)                                                                                                                                                                                                                                                                                                                                   |
| Su et al. Am J Rhinol Allergy, 2011          | AR               | Retrospective, observational study                     | 414         | EVN                                | None                                                                                    | Symptom VAS                                           | All symptoms (rhinorrhea, sneezing, eye itching, nose itching, nasal obstruction, and postnasal drip) had significant improvements in VAS ( $p<0.05$ ) with more dramatic changes in rhinorrhea, itching, and sneezing; temporary dry eye in 72.88 % (average 23 days)                                                                                                                                                                                                  |

**Table 1** (continued)

| Study (author, publication, date) | Study population | Study design                                 | Sample size | Surgical intervention     | Comparator group                                                                           | Measures          | Results, <i>P</i> -value                                                                                                                                                                                                                                                                |
|-----------------------------------|------------------|----------------------------------------------|-------------|---------------------------|--------------------------------------------------------------------------------------------|-------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Tan et al.                        | AR               | Prospective, non-randomized controlled study | 236         | EVN, partial turbinectomy | EVN (group 1) vs. partial turbinectomy/septoplasty (group 2) vs. medical therapy (group 3) | Symptom VAS; RQLQ | 64.7 % of group 1 categorized their symptoms as much improved at the end of the follow-up period, compared to 6.5 % of group 2, and 1.5 % of group 3; RQLQ and VAS scores for group 1 were significantly better than group 2 and control at each time point up to 3 years ( $p<0.001$ ) |

AR: Allergic rhinitis, NR: non-Allergic rhinitis, VR: vasomotor rhinitis

low cost. A Turkish group recently evaluated this technology in an outpatient clinic setting in a prospective cohort study of 62 non-allergic rhinitis patients (negative skin prick and normal IgE level), and they demonstrated significant improvements in objective measurements of nasal patency using acoustic rhinometry as well as improved symptom scores 1 year after surgery without any major complications or need for nasal packing. Cross-sectional measurements of the nasal cavity correlating to the position of the anterior and posterior inferior turbinate increased from 0.19 and 0.19 cm<sup>2</sup> to 0.28 and 0.26 cm<sup>2</sup>, respectively, at 1 year post-surgery ( $p<0.001$ ) [8]; 85.4 % of patients reported improved nasal breathing 1 year after the procedure, and the duration of each procedure only averaged 3 min per turbinate [8].

The drawback of laser turbinoplasty is the associated injury to the mucosal lining. Cassano et al. compared endoscopic submucosal resection to laser turbinoplasty with respect to nasal patency measured by rhinomanometry, mucociliary transport time, and cytology in a randomized, blinded prospective study of 150 patients with nasal obstruction [9]. The study population was a combination of allergic and non-allergic rhinitis patients; only 33 of the 150 patients had positive skin prick tests. On rhinomanometry, a significant decrease in nasal resistance was found at both the 1- and 3-month postoperative visits ( $p<0.01$ ) in both the laser and submucosal resection groups, and there were no significant differences in nasal resistance between the two intervention groups at either time point. They found that laser turbinoplasty impaired mucociliary clearance and resulted in an increase in altered ciliated cells in the mucosa ( $p<0.05$ ). In contrast, submucosal resection resulted in a reduction in goblet cells in the submucosa and maintained the ciliated epithelial layer ( $p<0.01$ ) [9]. In a prospective, randomized controlled clinical trial, Sapci et al. compared the effect of laser turbinoplasty versus radiofrequency ablation (RFA), a mucosal sparing technique, and found that both improved nasal obstruction but only laser therapy reduced mucociliary function [10]. Forty-five patients with nasal obstruction who failed nasal steroid therapy were randomly assigned to the laser turbinoplasty group, RFA group, or control group. Patients assigned to a surgical group had one inferior turbinate treated with either laser or RFA and the other inferior turbinate treated with partial turbinectomy. Patient symptoms were assessed using a visual analog scale, and at 12 weeks postoperative symptom scores for nasal obstruction decreased from moderate-severe to light-moderate in both groups ( $p<0.01$ ) with no significant difference between the two groups. Nasal resistance measured by rhinomanometry also significantly decreased ( $1.26\pm0.66$  Pa/(ccm/s) to  $0.40\pm0.01$  Pa/(ccm/s) in the laser group and  $1.38\pm0.99$  Pa/(ccm/s) to  $0.41\pm0.07$  Pa/(ccm/s) in the RFA group [10]. Mucociliary transport time (MTT) was measured using albumin labeled with technetium 99 m. Only in the laser-treated inferior turbinates was MTT significantly higher compared to the partial turbinectomy-treated turbinates in the same patient population

(25.60±5.90 min vs. 11.60±1.99 min;  $p<0.01$ ; MTT for the control group was 10.07 min [10].

### Radiofrequency Ablation and Coblation

Radiofrequency ablation (RFA) is a frequently used tool in the armamentarium of the otolaryngologist. When used in inferior turbinate surgery, a probe is introduced into the submucosa of the turbinate head, and low frequency energy is delivered to the tissues, causing thermal injury. The submucosal tissue damage eventually results in scarring and loss of tissue volume. A recent article by Kakarala et al. studied the histologic changes that occur over time after RFA of the inferior turbinate using a sheep model [11]. They compared multiple radiofrequency devices (two monopolar and one bipolar) to standard electrocautery over the course of 3 weeks and found that all of the devices caused epithelial disruption but that the radiofrequency devices had less permanent disruption than standard electrocautery. The mechanism of tissue reduction appeared to be destruction of submucosal glands and venous sinusoids, which were replaced over time with fibrosis [11].

Hytonen et al. reviewed 35 articles on intranasal applications of RFA [12]. Twenty-six articles were case series, nine were randomized controlled studies, and only one was double-blinded and placebo-controlled. Most articles reported subjective improvement in patient symptoms or subjective judgment of nasal patency such as visual endoscopy scores [12]. However, the only placebo-controlled trial demonstrated no statistically significant improvement in objective findings [13]. One of the advantages of RFA is that it can be performed in the clinic setting; many of the studies reviewed by Hytonen et al. demonstrated the safety of this technique and reported no major complications [12].

A recent study examining self-reported long-term results of patients who had undergone RFA of the inferior turbinates in an outpatient clinic setting under local anesthesia suggested the technique may decrease nasal steroid spray use and improve nasal obstructive symptoms [14•]. The study was relatively large with 142 patients and included only those patients who had treatment at least 1 year prior to the study (presumably allergic and non-allergic patients). Fifty-five percent of patients had overall improvement in overall nasal obstruction, with 61 % of patients having improvements in daytime symptoms and 52 % in nighttime symptoms; 13.1 % of patients stopped nasal steroid use after surgery ( $p=0.019$ ), and 31.5 % of patients reduced their use; 64 % of patients polled said they would recommend the procedure to another patient and would be willing to undergo treatment again. However, 36 % of patients answered negatively [14•]. A similar retrospective study that tracked patients with allergic rhinitis refractory to medical therapy over a longer period of 5 years also found significant improvements in subjective measures of nasal obstruction, rhinorrhea, sneezing, itchy nose, and itchy eyes

[15]. The study population included 101 patients with confirmed allergic rhinitis by RAST testing, and response rates were 77.3 % and 60.5 % at 6-month and 5-year time periods, respectively [15]. All symptoms were based on a standard 0 to 10 visual analog scale, and all symptoms (nasal obstruction rhinorrhea, sneezing, itchy nose, and itchy eyes) improved at both the 6-month and 5-year time points ( $p<0.01$ ). However, both of these studies lacked a control group and lacked objective measures of nasal patency.

A recent prospective, randomized controlled trial by Gunhan et al. of 58 patients with skin prick test-confirmed allergic rhinitis refractory to oral antihistamine compared treatment with intranasal steroid (mometasone furoate) and radiofrequency ablation [16•]. Anterior rhinomanometry, visual analog scale, and rhinoconjunctivitis quality of life questionnaires (RQLQ) were recorded at least 12 months post-treatment. Anterior rhinomanometry measurements only significantly improved in the RFA group [ $0.49\pm0.17$  to  $0.39\pm0.12$  Pa/cm(3)/s ( $p=0.42$ ), and from  $0.51\pm0.18$  to  $0.29\pm0.07$  Pa/cm(3)/s ( $p=0.003$ )]. Quality of life scores improved significantly in both groups, but perception of nasal congestion improved more in the RFA group measured by visual analog scale as did RQLQ scores in nasal symptoms and sleep domains [16•].

The Coblator radiofrequency device (Arthrocare Corp.) directs radiofrequency energy through a conductive medium of saline to create plasma, which disintegrates tissue on contact, dissolving the molecular bonds within the tissue. The advantage of coblation over conventional RFA is that coblation works at relatively low temperatures (40 to 70 °C), decreasing the potential for collateral thermal damage to the mucosa. A fairly large (220 patient) prospective non-randomized trial comparing coblation and medical therapy to medical therapy alone in patients with skin test-positive perennial and seasonal allergies found that patients who underwent coblation had significantly greater improvements in symptoms, endoscopy scores, and rhinomanometry measurements than those patients who only had continuation of nasal steroid and oral antihistamine therapy. Patients with perennial allergies seemed to derive the most benefit from combined surgical and medical treatment [17]. Coblation technology is also amenable to use in the outpatient clinic setting. Bhattacharyya et al. studied the safety and efficacy of this technology in an outpatient clinic setting in 26 consecutive patients and found statistically significant improvements in the overall score and specific nasal score in the Rhinosinusitis Symptom Inventory (RSI) at 3 and 6 months post-procedure ( $p<0.01$  for both time points) [18].

### Microdebrider

Microdebrider-assisted turbinoplasty involves making a stab incision in the anterior turbinate, and a pocket is elevated

around the turbinate bone. The microdebrider is then inserted into the turbinate, cutting and sucking away the submucosal tissue in a controlled and precise manner. Chen et al. in a randomized clinical trial compared microdebrider-assisted turbinoplasty to traditional submucosal resection in a group of 160 perennial allergy patients and determined that microdebrider-assisted turbinoplasty had equal improvements in objective and subjective measures including rhinomanometry, visual analog scales, mucociliary transport, and subjective complaints [19]. The effects were maintained for the 3 years that patients were enrolled in the study in both groups [19]. Unlike the laser or radiofrequency ablation, the microdebrider does not have a hemostatic effect, and there is the potential as in traditional submucosal resection for bleeding. In a large prospective study of 268 patients comparing microdebrider-assisted turbinoplasty and radiofrequency ablation in patients with nasal obstruction (presumed allergic and non-allergic rhinitis), Cingi et al. showed that patient satisfaction and rhinomanometric measurements were significantly better in the microdebrider group [20]. However, the rate of minor bleeding was increased in the microdebrider group (7 patients vs. 2 patients) though this finding was not found to be statistically significant. The patients who bled after microdebrider-assisted turbinoplasty did require packing with a hemostatic agent [20]. Microdebrider-assisted turbinate reduction has been shown to have equal or greater success compared to diode laser [21], radiofrequency ablation [22], and coblation turbinoplasty [23]. A large prospective randomized trial comparing microdebrider-assisted turbinoplasty and RFA demonstrated that microdebrider-assisted turbinoplasty has longer lasting effects when compared with radiofrequency ablation using a number of measures [22]. Liu et al. studied a total of 120 patients with perennial allergies over a 3-year interval and found that while both techniques improved symptom scores, anterior rhinomanometry scores, and saccharin transit times up to 2 years post-procedure, only those patients who underwent microdebrider-assisted turbinoplasty maintained these improvements to 3 years post-procedure. On a standard 0 to 10 visual analog scoring, 3-year post-nasal obstruction was reduced from  $8.68 \pm 1.05$  to  $1.55 \pm 0.81$ , sneezing from  $6.15 \pm 1.02$  to  $1.88 \pm 1.06$ , rhinorrhea from  $6.97 \pm 0.96$  to  $1.68 \pm 0.99$ , and snoring from  $6.70 \pm 1.06$  to  $1.77 \pm 0.83$ . The RFA group had returned to baseline symptom score levels. Likewise, mean nasal resistance continued to be reduced by half after 3 years ( $0.32 \pm 0.08$  Pa/ml/s to  $0.16 \pm 0.04$  Pa/ml/s) in patients who had microdebrider-assisted surgery, while the RFA group returned to baseline nasal resistance [22]. In a similar randomized prospective clinical trial comparing of microdebrider and coblation turbinoplasty in patients with nasal obstruction (presuming both allergic and non-allergic rhinitis), Lee et al. found that both techniques yielded improvements in nasal patency at 2, 6, and 12 months using acoustic rhinometry to measure cross-sectional area.

However, the microdebrider group showed significantly better patency compared to the coblation group at 2 and 12 months [23].

### Summary of Inferior Turbinate Surgery

Numerous techniques and technologies exist for reducing the volume of the inferior turbinates, and there is no clear consensus on which is the best method. Microdebrider, coblation, and RFA are mucosal sparing, and all have been shown to be effective at reducing turbinate volume and patient symptoms of obstruction for upwards of 6 months [24, 25]. Each technique offers distinct advantages and disadvantages. RFA and coblation technology is portable and hemostatic, allowing it to be a safe technique for use on patients in the clinical setting under local anesthesia. However, with both techniques there is still transfer of heat energy to the surface, causing epithelial damage and potential for mucociliary disturbance. Microdebrider-assisted turbinoplasty has been shown in several studies to be superior to RFA and coblation in terms of extent and length of its efficacy. However, there is more potential for bleeding when compared to the therapies that deliver heat energy to the tissue.

### Vidian Neurectomy

The work of Malcomson over half a century ago demonstrated that overactive parasympathetic input resulted in vasomotor rhinitis [26]. Subsequently, clinical data published by Golding-Wood spurred the development of surgical procedures to address intractable vasomotor rhinitis resistant to conservative measures. Initial surgical attempts focused on section of the greater superficial petrosal nerve, but the attendant risk of facial palsy was unacceptably high. In 1961, Golding-Wood introduced the transantral vidian neurectomy [27]. This approach required resection of the anterior and posterior walls of the maxillary sinus, placing the internal maxillary artery, maxillary nerve, superior alveolar nerve, and sphenopalatine ganglion at risk. Other approaches were proposed the decade following Golding-Wood's report, including transeptal and transpalatal approaches. The multitude of approaches proposed suggest that none offered an entirely satisfactory outcome, likely due to the difficulties in nerve identification without magnification, risk of significant complications including palatal fistulas and damage to vision, and troublesome bleeding within a small surgical field often filled with a considerable amount of fat within the pterygopalatine fossa that may obscure important structures. As a result, vidian neurectomy fell out of favor for several decades. In the 1980s, Krajina advocated a transnasal approach with the use of an operating microscope and diathermy [28]. While this was a

less invasive procedure with a lower complication rate, concerns persisted regarding the ability to precisely treat the vidian nerve in this manner. The introduction of endoscopes and endoscopic techniques in the 1980s revolutionized the management of diseases of the paranasal sinuses by allowing markedly improved visualization and the ability to perform precise dissection. Kamel and Zaher first reported an endoscopic approach to vidian neurectomy in 1991 [29], and several other authors have subsequently reported their refinements of the endoscopic approach. Endoscopic vidian neurectomy (EVN) offers the advantages of precise identification of the vidian nerve and canal largely due to improved visualization.

The vidian nerve is formed by the junction of the greater petrosal and deep petrosal nerves just anterior to the foramen lacerum. The vidian nerve is housed within the vidian canal, which courses along the floor of the sphenoid sinus anteriorly to connect to the pterygopalatine fossa. This canal is 10–18 mm in length, with a funnel that widens as it enters the posterior wall of the pterygopalatine fossa. The parasympathetic fibers synapse at the sphenopalatine ganglion and form three branches that innervate the nasal mucosa, lacrimal gland, and palate.

The palatovaginal canal is formed by the application of the sphenoid process of the palatine bone to the vaginal process of the sphenoid bone, and it transmits the pharyngeal nerve as it travels from the pterygopalatine ganglion to the pharyngeal orifice of the auditory tube [30]. The palatovaginal canal is located just inferomedial to the vidian canal; the pharyngeal nerve can potentially be mistaken for the vidian nerve without adequate surgical exposure, resulting in a suboptimal result from EVN.

Computed tomography (CT) of the paranasal sinuses should be routinely obtained in patients being evaluated for sinonasal surgery, including EVN. Yazar et al. reported that the vidian canal was embedded inside the sphenoid corpus in 36 % of cases, partially protruded in 54 % of cases, and connected to the bone with a stalk inside the sinus in 10 % of cases [31]. Lee et al. classified the vidian canal into three types based on CT findings: vidian canal completely within the sphenoid sinus (type 1), vidian canal on the floor of the sphenoid sinus or partially protruding into the sphenoid sinus (type 2), and vidian canal completely embedded in the sphenoid corpus (type 3) [32].

The operative setup for EVN is identical to that of endoscopic sinus surgery. Surgery may be offered as a unilateral or a bilateral procedure, with the bilateral procedure offering the benefit of a single procedure but increasing the potential risk of bilateral complications such as dry eye symptoms. Intraoperative image guidance using the preoperative CT scan is very useful to confirm identification of the vidian canal. A wide sphenoidotomy is performed to allow visualization of the bony landmarks within the sphenoid sinus. In patients with

type 1 and type 2 vidian canals (where the vidian canal is accessible as it courses through the sphenoid sinus), the paper-thin wall of the vidian canal is fractured and the nerve severed with a curved instrument or laser fiber.

In cases of a type 3 vidian canal completely encased within the confines of the sphenoid bone, the vidian nerve can be identified as it enters the posterior aspect of the pterygopalatine fossa. Following sphenoidotomy, the sphenoid process of the palatine bone is removed to uncover the medial portion of the pterygopalatine fossa. The periosteum is incised, the fat of the pterygopalatine fossa is exposed and the vidian nerve is dissected out of the fat and clearly visualized, and the nerve is severed and cauterized. Alternatively, a retrograde approach including a wide maxillary antrostomy, identification of the sphenopalatine foramen, and dissection posteriorly toward the posterior wall of the pterygopalatine fossa may be performed to identify the vidian nerve.

Eye dryness is the most common complication following EVN, affecting 12–30 % of patients. This is primarily due to the loss of postganglionic secretomotor fibers innervating the lacrimal gland. Transient cheek and palate numbness, nasal crusting and nasal dryness are potential adverse effects after endoscopic vidian neurectomy. Bleeding from the sphenopalatine artery may result in postoperative epistaxis, but adequate hemostasis is usually obtained at the time of surgery.

Outcomes following endoscopic vidian neurectomy are favorable for properly selected patients. Robinson and Wormald [33] reported their early experience with 9 patients who underwent 14 EVNs. They noted significant improvements in rhinorrhea and nasal obstruction, but no significant changes in sneezing or postnasal drip over an average follow-up of 2 years. In their series, 35 % of patients complained of mild occasional eye dryness, with one patient requiring intermittent ongoing treatment.

Lee et al. [32] reported the outcomes of 178 EVNs performed on 89 patients with intractable rhinorrhea. Seventy-five patients had vasomotor rhinitis, and 14 patients had allergic rhinitis. These patients were followed for an average of 1.5 years after surgery. Over 90 % of their patients were satisfied with the surgical results, with two patients undergoing revision surgery due to relapse of symptoms. The incidence of postoperative dry eyes was 23 % in this series.

Su et al. [34] reported the outcomes of 414 EVNs performed on a total of 317 patients with refractory allergic rhinitis. The approach was clinically successful in 90.3 % of the entire cohort. The short-term surgical outcomes of 163 patients who underwent a total of 236 EVNs with at least 6 months of follow-up were analyzed (average of 23 months). Immediate cessation of sneezing and rhinorrhea occurred uniformly with significant improvement in rhinorrhea, itching, sneezing, obstruction, and postnasal drip based on a visual analogy scale. Three recurrences (1.27 %) were

detected during the 1-2 years of follow-up. Dry eyes were reported in a total of 172 surgical sides (72.9 %), but only 6 sides had persistent symptoms for >6 months requiring eye drops (2.5 %). Palatal numbness occurred in 7 of 236 sides (2.97 %) and resolved within an average of 13 days.

Tan et al. [35•] reported their series of 236 patients with moderate to severe persistent allergic rhinitis who were offered one of three treatments: (1) bilateral EVN ( $n=93$ , 186 sides), (2) partial inferior turbinectomy  $\pm$  septoplasty ( $n=51$ ), and conservative medical therapy consisting of nasal steroid sprays and oral antihistamines ( $n=92$ ). One hundred ninety-nine patients were followed for more than 3 years (including 85 patients who underwent bilateral EVN). Rhinoconjunctivitis Quality of Life Questionnaire (RQLQ) and visual analog scale (VAS) scores were significantly lower at 6 months, 1 year, and 3 years after undergoing bilateral EVN or septoplasty  $\pm$  partial inferior turbinectomy, with the greatest improvement noted in those undergoing EVN. RQLQ and VAS scores for patients undergoing conservative therapy were unchanged over the follow-up period. Subjectively, 64.7 % of patients undergoing EVN categorized their symptoms as much improved at the end of the follow-up period, compared to 6.5 % of patients undergoing septoplasty and/or turbinectomy, and 1.5 % of patients treated conservatively. Overall, RQLQ and VAS scores were significantly better than the septoplasty  $\pm$  partial inferior turbinectomy group and the control group at every time point up to 3 years ( $p<0.001$ ).

Twenty-six of 85 patients (30.6 %) who underwent bilateral EVN experienced temporary dry eye symptoms that resolved within 1 month after treatment with eye drops. Seven patients (8.2 %) reported that they had no tears while crying. Palate

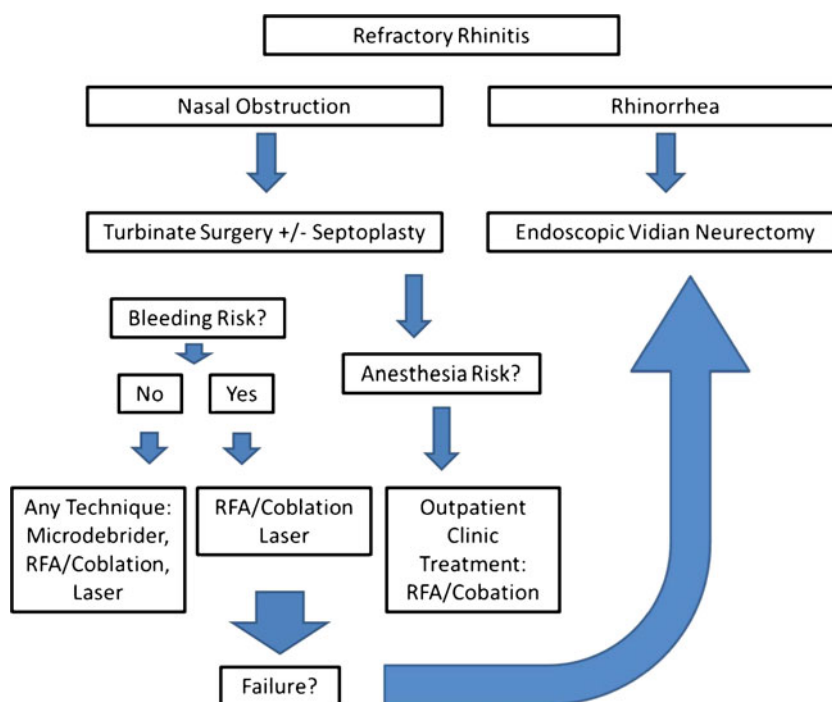
numbness occurred in eight patients (9.4 %) and resolved within the first postoperative year with no special treatment. Thirteen patients (15.3 %) had mild nasal dryness.

In summary, EVN is a highly effective option for treatment of recalcitrant vasomotor or allergic rhinitis. A thorough discussion of risks including dry eye symptoms and cheek and palate numbness should be included in the process of informed consent. More recent efforts by Bleier et al. [36] to elucidate the intricacies of autonomic innervation to the nasal mucosa have identified the presence of individual rami, termed accessory posterolateral nerves, that project from the pterygopalatine fossa directly into the nasal cavity and contain approximately equal numbers of sympathetic and parasympathetic fibers. These efforts hold potential for the development of highly selective, lacrimal sparing procedures for the management of intractable rhinitis.

## Conclusions

Surgical therapy for chronic rhinitis is indicated when medical therapy is unable to provide the patient with adequate symptom relief. Nasal obstruction is the symptom that is most commonly refractory to medical treatment, and surgical treatment usually involves volume reduction of the inferior turbinate. This can be accomplished with a number of techniques, and no single procedure has emerged as the gold standard. Each has its own advantages and disadvantages, but certainly the newer techniques of radiofrequency ablation, coblation, and microdebrider provide a theoretical advantage of maintaining the integrity of the mucosa. Unrelenting rhinorrhea

**Fig. 1** Flow chart of treatment options in patients with severe refractory rhinitis



may also negatively affect the chronic rhinitis patient's quality of life, and endoscopic vidian neurectomy is a viable option for this population. Though a much less frequently utilized technique than inferior turbinate reduction, EVN has been proven to be safe and effective in patients whose rhinorrhea is a primary and severe symptom. Recent studies have also implied that experienced endoscopic surgeons should consider its use in those patients with severe persistent allergic rhinitis who fail septoplasty and turbinate reduction. Figure 1 depicts a proposed flow chart of treatment options for the surgeon to consider in this patient population.

### Compliance with Ethics Guidelines

**Conflict of Interest** Arthur W. Wu and Jonathan Y. Ting declare that they have no conflict of interest.

**Human and Animal Rights and Informed Consent** This article does not contain any studies with human or animal subjects performed by any of the authors.

### References

Papers of particular interest, published recently, have been highlighted as:

- Of importance
- Of major importance

1. Nathan RA, Meltzer EO, Derebery J, et al. The prevalence of nasal symptoms attributed to allergies in the United States: findings from the burden of rhinitis in an America survey. *Allergy Asthma Proc.* 2008;29:600–8.
2. Bousquet PJ, Demoly P, Devillier P, et al. Impact of allergic rhinitis symptoms on quality of life in primary care. *Int Arch Allergy Immunol.* 2013;160:393–400.
3. Berger S, Gass S, Ophir D. The histopathology of the hypertrophic inferior turbinate. *Arch Otolaryngol Head Neck Surg.* 2006;132:588–94.
4. Aksoy F, Yildirim YS, Veyseller B, et al. Midterm outcomes of outfracture of the inferior turbinate. *Otolaryngol Head Neck Surg.* 2010;143(4):579–84.
5. Passali D, Lauriello M, Anselmi M, et al. Treatment of hypertrophy of the inferior turbinate: long-term results in 382 patients randomly assigned to therapy. *Ann Otol Rhinol Laryngol.* 1999;108(6):569–75.
6. Takeno S, Osada R, Ishino T, Yajin K. Laser surgery of the inferior turbinate for allergic rhinitis with seasonal exacerbation: an acoustic rhinometry study. *Ann Otol Rhinol Laryngol.* 2003;112:455–60.
7. Caffier PP, Scherer H, Neumann K, Luck S, Enzmann H, Haisch A. Diode laser treatment in therapy-resistant allergic rhinitis: impact on nasal obstruction and associated symptoms. *Lasers Med Sci.* 2011;26:57–67.
8. Cakli H, Cingi C, Guven E, Gurbuz MK, Kaya E. Diode laser treatment of hypertrophic inferior turbinates and evaluation of the results with acoustic rhinometry. *Eur Arch Otorhinolaryngol.* 2012;269:2511–7.
9. Cassano M, Granieri C, Del Giudice AM, Mora F, et al. Restoration of nasal cytology after endoscopic turbinoplasty versus laser-assisted turbinoplasty. *Am J Rhinol Allergy.* 2010;24:310–4.
10. Sapci T, Sahin B, Karavus A, Akbulut UG. Comparison of the effects of radiofrequency tissue ablation, CO2 laser ablation, and partial turbinectomy applications on nasal mucociliary functions. *Laryngoscope.* 2003;113:514–9.
11. Kakarala K, Faquin WC, Cunningham MJ. Radiofrequency volumetric tissue reduction of the inferior turbinate in a sheep model. *Laryngoscope.* 2012;122:724–9.
12. Hytonen ML, Back LJ, Malmivaara AV, et al. Radiofrequency thermal ablation for patients with nasal symptoms: a systematic review of effectiveness and complications. *Eur Arch Otorhinolaryngol.* 2009;266(8):1257–66.
13. Powell NB, Zonato AI, Weaver EM, et al. Radiofrequency treatment of turbinate hypertrophy in subjects using continuous positive airway pressure: a randomized, double-blind, placebo-controlled clinical pilot trial. *Laryngoscope.* 2001;111:1783–90.
14. Safiruddin F, Vroegop AV, Ravesloot MJ, de Vries N. Long-term self-reported treatment effects and experience of radiofrequency-induced thermotherapy of the inferior turbinates performed under local anesthesia: a retrospective analysis. *Eur Arch Otorhinolaryngol.* 2013;270:1849–53. *This article provides long-term questionnaire-based data on the effectiveness of radiofrequency inferior turbinate surgery.*
15. Lin HC, Lin PW, Friedman M, Chang HW, et al. Long-term results of radiofrequency turbinoplasty for allergic rhinitis refractory to medical therapy. *Arch Otolaryngol Head Neck Surg.* 2010;136:892–5.
16. Gunhan K, Unlu H, Yuceturk AV, Songu M. Intranasal steroids or radiofrequency turbinoplasty in persistent allergic rhinitis: effects on quality of life and objective parameters. *Eur Arch Otorhinolaryngol.* 2011;268:845–50. *This prospective randomized study compared conservative medical therapy to radiofrequency turbinoplasty and found that only RFA turbinate surgery improved nasal patency on objective measurements though both treatments improved quality of life significantly.*
17. Di Rienzo Businco L, Di Rienzo Businco A, Lauriello M. Comparative study on the effectiveness of Coblation-assisted turbinoplasty in allergic rhinitis. *Rhinology.* 2010;48:174–8.
18. Bhattacharyya N, Kepnes LJ. Clinical effectiveness of coblation inferior turbinate reduction. *Otolaryngol Head Neck Surg.* 2003;129:365–71.
19. Chen YL, Tan CT, Huang HM. Long-term efficacy of microdebrider-assisted inferior turbinoplasty with lateralization for hypertrophic inferior turbinates in patients with perennial allergic rhinitis. *Laryngoscope.* 2008;118:1270–4.
20. Cingi C, Ure B, Cakli H, Ozudogru E. Microdebrider-assisted versus radiofrequency-assisted inferior turbinoplasty: a prospective study with objective and subjective outcome measures. *Acta Otorhinolaryngol Ital.* 2010;30:138–43.
21. Kassab AN, Rifaat M, Madian Y. Comparative study of management of inferior turbinate hypertrophy using turbinoplasty assisted by microdebrider or 980 nm diode laser. *J Laryngol Otol.* 2012;126:1231–7.
22. Liu CM, Tan CD, Lee FP, Lin KN, Huang HM. Microdebrider-assisted versus radiofrequency-assisted inferior tubinoplasty. *Laryngoscope.* 2009;119:414–8.
23. Lee JY, Lee JD. Comparative study on the long-term effectiveness between coblation and microdebrider-assisted partial turbinoplasty. *Laryngoscope.* 2006;116:729–34.
24. Bhandarkar ND, Smith T. Outcomes of surgery for inferior turbinate hypertrophy. *Curr Opin Otolaryngol Head Neck Surg.* 2010;18:49–53.
25. Chhabra N, Houser SM. Surgical options for the allergic rhinitis patient. *Curr Opin Otolaryngol Head Neck Surg.* 2012;20:199–204.
26. Malcomson KG. The vasomotor activities of the nasal mucous membrane. *J Laryngol Otol.* 1959;73:733.
27. Golding-Wood PH. Observations on petrosal and vidian neurectomy in chronic vasomotor rhinitis. *J Laryngol Otol.* 1961;75:232.

28. Krajina Z. Critical review of Vidian neurectomy. *Rhinology*. 1989;27(4):271–6.
29. Kamel R, Zaher S. Endoscopic transnasal vidian neurectomy. *Laryngoscope*. 1991;101:316–9.
30. Wentges RT. Surgical anatomy of the pterygopalatine fossa. *J Laryngol Otol*. 1975;89:35–45.
31. Yazar F, Cankal F, Haholu A, et al. CT evaluation of the vidian canal localization. *Clin Anat*. 2007;20:751–4.
32. Lee JC, Hsu CH, Kao CH, Lin YS. Endoscopic transsphenoidal vidian neurectomy. *Eur Arch Otorhinolaryngol*. 2011;268:851–6.
33. Robinson SR, Wormald PJ. Endoscopic vidian neurectomy. *Am J Rhinol*. 2006;20:197–202.
34. Su W, Liu S, Chiu F, Lee C. Antegrade transsphenoidal vidian neurectomy: short-term surgical outcome analysis. *Am J Rhinol Allergy*. 2011;25(6):217–20.
35. Tan G, Ma Y, Li H, Wang J. Long-term Results of Bilateral Endoscopic Vidian Neurectomy in the Management of Moderate to Severe Persistent Allergic Rhinitis. *Arch Otolaryngol Head Neck Surg*. 2012;138(5):492–7. *This article is a large prospective non-randomized trial comparing continued medical therapy, septoplasty with turbinoplasty, and endoscopic vidian neurectomy in patients with severe persistent allergic rhinitis. While those patients who underwent septoplasty and turbinate surgery had significant improvements in quality of life and visual analog scale assessment of their symptoms, the endoscopic vidian neurectomy group had significantly better scores at all time points..*
36. Bleier BS, Feldman R, Sadow PM, Wu AW, Ting J, Metson R. The accessory posterolateral nerve: an immunohistological analysis. *Am J Rhinol Allergy*. 2012;26(4):271–3.