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Management of Intractable Rhinitis: Posterior Nasal Neurectomy with or without Posterior Turbinectomy

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Abstract:

Intractable rhinitis, characterized by persistent nasal obstruction, rhinorrhea, sneezing, and congestion, remains a clinical challenge when conservative therapies fail. Conventional medical treatments, including intranasal corticosteroids, antihistamines, and decongestants, often provide only partial or temporary relief for patients with severe disease. Posterior nasal neurectomy (PNN) has emerged as a minimally invasive surgical approach targeting the posterior nasal nerve, which carries parasympathetic fibers responsible for excessive nasal secretions and congestion. By interrupting these neural pathways, PNN reduces hypersecretion and nasal obstruction while preserving the structural integrity of the nasal cavity. The addition of posterior turbinectomy, either partial or complete, is considered in select cases to further improve nasal airflow and reduce turbinate hypertrophy. However, the necessity and efficacy of combining turbinectomy with PNN remain subjects of debate, with studies reporting variable outcomes in symptom control, recurrence rates, and complications. Therefore, evaluating the effectiveness of posterior nasal neurectomy with or without posterior turbinectomy is essential for optimizing surgical management strategies for patients with intractable rhinitis.

Keywords: Intractable rhinitis, Posterior nasal neurectomy (PNN), Posterior turbinectomy, Chronic nasal obstruction, Nasal hypersecretion, Surgical management of rhinitis.

Introduction:

Posterior nasal nerve

- **Introduction**

Posterior nasal nerve (PNN) is a peripheral branch of the sphenopalatine ganglion. It enters the nasal cavity through a separate foramen, 4–5 mm below the sphenopalatine foramen. The posterior superior nasal nerves innervate the superior and middle turbinates, and the superior and middle meatus. Other parasympathetic nerve fibres of the nose branches off and joins the greater palatine nerve and enters the nasal cavity through the canaliculi in the perpendicular plate of the palatine bone as the posterior inferior nasal nerves. These nerves innervate the inferior turbinate and the inferior meatus **(1).**

Secretory motor fiber exits the pterygopalatine foramen in multiple branches, each of which is directed to a different target (eg, lacrimal gland and nasal mucosa). The branch originating from the pterygopalatine ganglion (PPG) is found to specifically innervate the nasal mucosa and has been called the posterior nasal nerve. Selective resection of this posterior nasal nerve removes the parasympathetic supply from the nasal cavity and provides the same benefits of vidian neurectomy, without having any of its complications **(2).**

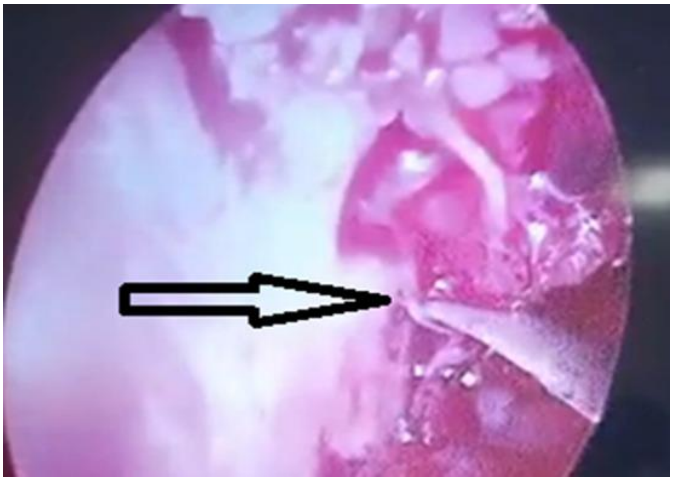

Figure 1. Branches of posterior nasal nerve to middle and inferior turbinate in sphenopalatine foramen sectioned using sickle knife **(3).**

❖ **Posterior Nasal Neurectomy (PNN)**

Posterior nasal neurectomy, first performed by Kikawada in 1997, has become an alternative to vidian neurectomy in Japan because it is safe, quick to perform, has less bleeding and almost no complications. However, this procedure has not been applied in Vietnam **(4).**

The PNN can be accessed through the middle meatus, making them amenable to minimally-invasive PNN-targeted procedures. Posterior nasal nerve neurolysis techniques such as radiofrequency ablation and cryotherapy thermal application methods have been used to disrupt the PNN in the posterior aspect of the middle meatus in the region of the sphenopalatine foramen **(5).**

Multicenter, patient-blinded, sham-controlled RCTs have been performed for radiofrequency ablation and cryoablation and have demonstrated clinical benefit for nasal symptoms. For both methods, validated quality of life surveys have demonstrated statistically significant improvement with treatment, with therapeutic effect **(6).**

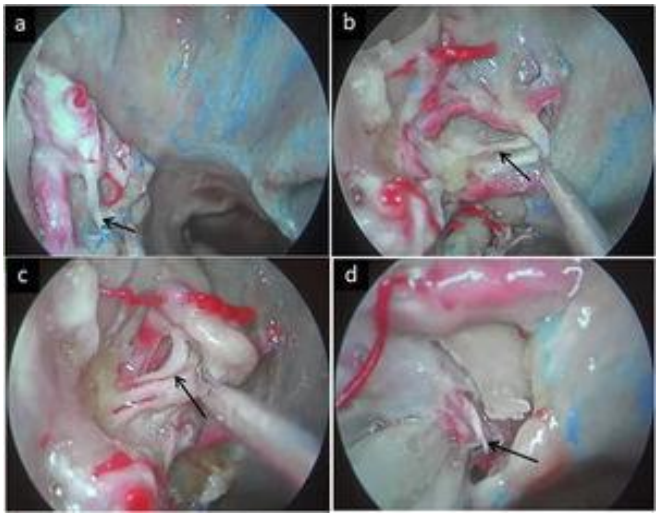

Figure 2. The posterior nasal nerve emerges from the sphenopalatine foramen and is distributed to the nasal mucosa following the branches of the sphenopalatine vessels. (a) The anteroinferior branch of the posterior nasal nerve toward the inferior turbinate. (b) The branch of the posterior nasal nerve toward the nasal septum. (c) The posterosuperior branch of the posterior nasal nerve toward the superior turbinate. (d) The pharyngeal nerve transmitted by the palatovaginal canal (PVC) **(7).**

Figure 3: Posterior nasal nerve dissection **(8).**

Effect of posterior nasal neurectomy on the suppression of allergic rhinitis:-

The posterior nasal nerve is the dominant source of the parasympathetic, sympathetic, and sensory fibers that innervate the nasal respiratory mucosa. Therefore, posterior nasal neurectomy (PNN) may induce denervation of the nasal mucosa and may relieve the nasal symptoms of AR. PNN can deplete nerve fibers, choline acetyltransferase, and neuropeptides in nasal respiratory mucosa. Therefore, PNN-induced nasal mucosal denervation should contribute to the suppression of the AR reaction **(9).**

However, for patients with allergic rhinitis refractory to medication therapy; surgical interventions such as endoscopic posterior nasal neurectomy (PNN) have been attempted. Endoscopic PNN, which involves the intranasal severing of the posterior nasal nerve, is a common surgical treatment for allergic rhinitis in Asia **(10).**

The posterior nasal nerve, which is a peripheral branch of the vidian nerve, innervates the nasal cavity via the pterygopalatine ganglion, which comprises parasympathetic and sympathetic vidian nerve fibers and sensory nerve fibers from the trigeminal nerve. Therefore, PNN is expected to suppress nasal hypersecretion by blocking autonomic vidian nerve fibers, similar to vidian neurectomy (VN), as well as hypersensitivity by simultaneously blocking sensory nerve fibers **(2).**

However, the effects of PNN on the suppression of sensitivity in the nasal mucosa remain controversial. Some previous reports have described the beneficial effects of PNN on rhinorrhea and sneezing, although other reports have failed to observe an effect of PNN on sneezing. The histological changes underlying the effects of PNN have not been elucidated because of the limitations of human studies and the lack of animal models **(11).**

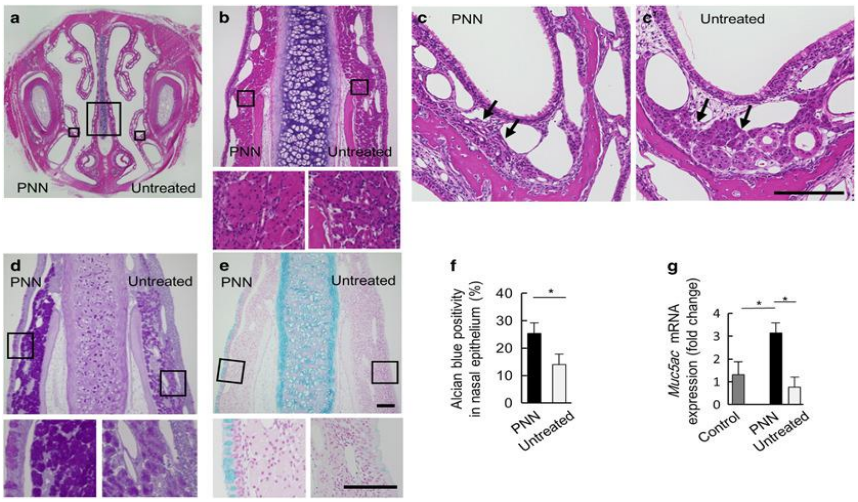

Figure 4. Histological changes in the nasal glands and goblet cells 2 weeks after the posterior nasal neurectomy (PNN). **(a)** Photomicrographs of representative coronal nasal cavity sections. **(b, d, e)** The magnified views of the septal mucosa indicated by the squares in **(a)**. **(c, c′)** The magnified views of the nasal glands in the lateral

nasal wall indicated by the squares in (a). The black arrows indicate the nasal glands in the lateral nasal wall. **(a–c)** Hematoxylin and eosin staining. **(d)** Periodic acid–Schiff staining. **(e)** Alcian blue staining.

The magnified views of the areas indicated by the squares in the upper panels **(b, d, e)** are shown in the lower panels. Scale bar, 100 μm. **(f)** Quantitative analysis of Alcian blue-positive areas in the nasal epithelium. The data are shown as the mean±s.e.m. (n=4). * P<0.05 (unpaired two-tailed Student t-test). **(g)** Mucin 5ac (*Muc5ac*) mRNA expression in the nasal respiratory mucosa **(12).**

Posterior nasal nerve neurectomy (PNNN) is an effective method to control symptoms of hyper-responsiveness rhinitis by blocking both parasympathetic and trigeminal innervations to nasal mucosal tissue, without injuring lacrimal vagal fibers. The reported surgical procedures for PNNN, all were selective resection of posterior nasal nerve branches, causing a residue of a few branches of the nerve. As a result, patients either do not achieve the best improvement of symptoms, or relapse and experience long-time failure after PNNN **(13).**

Furthermore, exclusive of innervation from the posterior nasal nerve via the sphenopalatine foramen, Bleier, et al found nasal mucosal tissues were also innervated by accessory posterior nasal nerve, which traversing through the palatine bone perpendicular plate into nasal cavity. In theory, blocking more autonomic and sensory innervations to nasal mucosal tissue should improve the AR symptom managements **(14).**

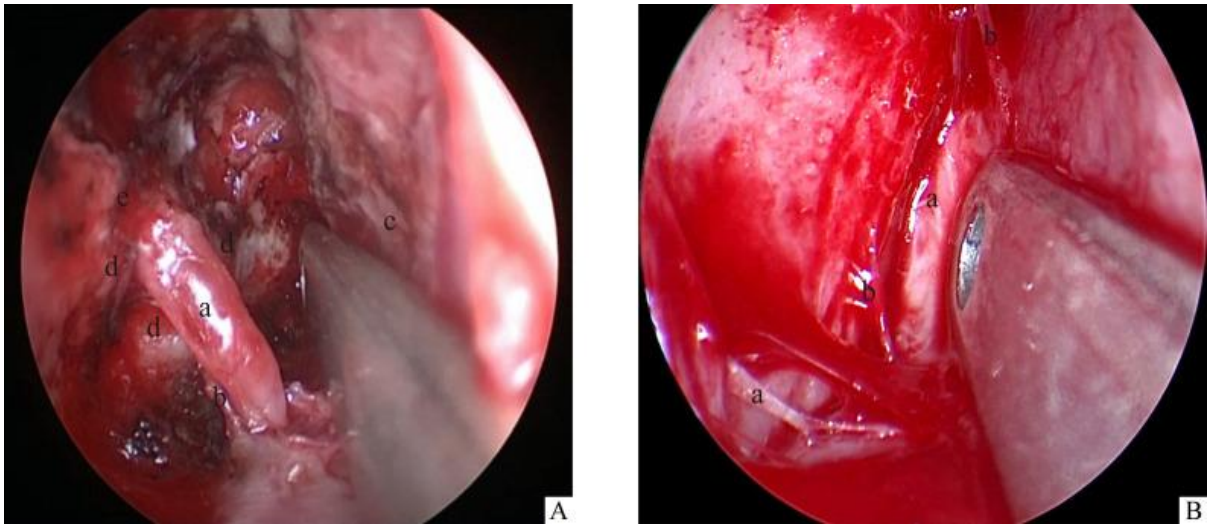

Figure 5. Screenshots during the mPNNN-aPNNN in the right nasal cavity: A: Except the sphenopalatine artery preserved, all other soft tissues in the neurovascular bundle, including the nerve trunks and fascicles of posterior nasal nerve and the branches of the vessels, were resected at the sphenopalatine foramen. a: Sphenopalatine artery; b: Severed end of a branch of the posteriornasal nerve; c: Mucoperiosteal flap; d: Bare bone around the the sphenopalatine foramen; e: Location where the ethmoidal crest has been removed. B: Accessor posterior nasal nerve perforated through the palatine bone perpendicular plate. a: Branch of accessory posterior nasal nerve; b: Branch of accessory posterior nasal nerve and assoppanied vessel. mPNNN-aPNNN: Modified PNNN-accessory posterior nasal nerve neurectomy; PNNN: Posterior nasal nerve neurectomy **(15).**

The surgical procedures for PNNN can be divided into 3 approaches: The first is selective resection of the posterior nasal nerve branches at the sphenopalatine foramen without resecting the sphenopalatine artery.

This approach is very difficult to keep a clear surgical field because of bleeding from the branches of sphenopalatine artery and veins, and a few branches of posterior nasal nerve remain. For example, Takahara, et al only resected the anteroinferior branch toward the inferior turbinate and poterosuperior branch toward the middle meatus **(16).**

The second approach resects the neurovascular bundle, which might cause serious intraoperative or postoperative nasal bleeding. The third is resection of peripheral branches in the inferior turbinate, in which hypersecretion from the posterior part of the middle turbinate could not reduced. In addition, the 3 methods do

not have resect the accessory posterior nasal nerve. The symptoms relapse and long-time failure after the surgery of PNNN might be due to the postoperative functional compensation of the remained posterior nasal nerve and accessory nerves **(17).**

The clear surgical field during mPNNN-aPNNN procedure helps to achieve resection of the trunks and branches of posterior nasal nerve at the sphenopalatine foramen and remove the accessory posterior nasal nerve at the palatine bone perpendicular plate. Thus, more nasal mucosal autonomic and sensory fibers could be denervated than those in other approaches of PNNN, leading to a more effective outcome. First of all, the mucosal stimulated parasympathetic state and the efferent function of autonomic nerves should subside after blocking the autonomic innervations in AR patients **(18).**

Surgical Procedure

Under general endotracheal anesthesia, transnasal posterior nasal nerve resection was performed on both sides. After topical nasal decongestion with 0.1% xylometazoline hydrochloride (Otrivin®, Novartis, Nyon, Switzerland) and submucosal infiltration with 2% lidocaine and 1:100,000 epinephrine (AstraZeneca, Cambridge, UK) a one centimeter vertical incision was made with a No. 15 scalpel blade (Feather®, Japan) behind the uncinate process inferiorly and posteriorly. The mucosa was undermined to look for the ethmoidal crest.

To find the pterygopalatine bundle more easily, using a 2 mm Kerrison Rongeur Punch (Karl Storz, Tuttlingen, Germany) to open the ethmoidal crest and see the full view of the bundle. After exposing the bundle, we looked for and isolated the posterior nerve away from the pterygopalatine artery. In order to resect the nerve, a 5 mm curved blade Sickle Knife **(19).**

The main purpose of posterior nasal neurectomy is to disrupt the imbalance between the parasympathetic and sympathetic innervation of the nasal cavity and reduce the nasal secretions. As a result, this surgery may help to reduce nasal obstruction as well as nasal discharge and postnasal discharge **(20).**

Posterior Nasal Nerve Neurectomy for the Patients of Allergic Rhinitis:-

Resection of the posterior nasal nerve is especially effective for severe rhinorrhoea because the interruption of parasympathetic nerve fibres suppresses nasal secretion. As it contains afferent sensory fiber supplying the posterior half of the mucosa in the nasal cavity, sneezing can be reduced, thus making this procedure superior to Vidian neurectomy **(2).**

The posterior nasal nerve emerges from the SPF and is distributed to the inferior turbinate mucosa following the branches of the sphenopalatine vessels. Innervation of the parasympathetic component increases the secretomotor function, and innervation of the sensory component regulates the sensitivity of the nasal mucosa. By resection of the posterior nasal nerve at this point, it can expect modifying the hyperreactivity of the neural network that augments the allergic reaction. In addition, this technique causes partial denervation of the middle turbinate and septum submucosal glands based on anatomical innervation **(21).**

The results confirm the desired efficacy of over 90% of cases for a follow-up period of 6 months to 2 years reported by Kikawada particularly in reducing nasal symptoms of rhinitis such as nasal discharge, nasal congestion, sneezing and post-nasal discharge significantly. Kikawada also reported more than 80% efficacy in 94 patients after 2 years of surgery which are similar these findings **(22).**

Ogawa et al. found out that PNN in allergic rhinitis patients significantly reduce levels of IL-5, eotaxin protein in nasal secretions. They also observed reduction of infiltrated immuno-component cells in the subepithelial mucous layer, which are major sources of cytokine release **(23).**

Mori et al., Kobayashi et al. also reported similar patient benefits following posterior nasal neurectomy. They concluded that selective resection of peripheral branches of the posterior nerve could reduce allergic symptoms. Kawamura et al. (2000), in their study of PNN with harmonic scalpel among 20 patients, observed subjective improvement in nasal obstruction, sneezing and nasal discharge in 100%, 90 and 75% patients respectively.

They reported no surgical complications. Cassano et al. attributes the reduction in sneezing and nasal pruritis following posterior nasal nerve transection to the resection of posterior inferior nasal nerve fibres **(24).**

❖ **Posterior Turbinectomy**

Turbinectomy is a partial or complete resection of the inferior turbinate with or without the guidance of an endoscope. The microdebrider instrument is often used in this procedure in order to remove some of the soft tissue component, and the debrider can be used even in the more complex cases of bony hypertrophy **(25).**

The exposed raw mucosal edges and bone from this procedure may lead to nasal crusting with need for postoperative debridement. The mucosal edges may continue to bleed despite electrocautery control and nasal packing may be needed for hemostasis. Some evidence exists that turbinectomy may lead to a high incidence of empty nose syndrome. However, the evidence is conflicting, and results seem to be quite operator dependent **(26).**

- **Resectioning Procedures**

Resection and surgical reduction of the inferior turbinates are techniques that date back to the early nineteenth century. Total turbinectomy (full turbinate separated directly at the base of the lateral nasal wall) and partial turbinectomy (mucosal lamina and bones resected in the front third of the turbinate) are not, to date, widely used due to the obvious disadvantages that can be applied meeting. There is a highly inappropriate success rate that can vary between 0% and 89% **(27).**

Turbinectomy is not compatible with the primary goal of preserving nasal function; some patients suffered from atrophic rhinitis and secondary ozaena with symptoms of nasal dryness, crusting, bleeding, pain, and headache. Talmon et al., performed, over 6 years, 357 total inferior bilateral turbinectomies in patients with chronic nasal obstruction: 351 patients (98.3%) underwent the procedure without any significant complication, six patients (1.7%) experienced postoperative bleeding that required emergency surgery. Huizing and de Groot referred to a total turbinectomy as a “nasal crime”: they, therefore, suggest never to remove more than half of the inferior turbinate **(28).**

When traditional therapy fails to reduce AR symptoms, inferior turbinate reduction (ITR) is one of the simplest procedures made for the surgical treatment of nasal blocking. A series of techniques concerning reducing turbinates are currently feasible as cryosurgery, electrocautery, laser turbinectomy, partial or total turbinectomy, and Vidian’s neurectomy give different results. Due to direct manipulation of the mucous membrane during surgery, adverse accidents such as bleeding, pain, crusting, smell change, dry nose, and synechia can happen **(29).**

Eosinophils, mast cells, and other immune cells play a critical role in allergic rhinitis: surgical treatment help prevent eosinophil and immune cell-mediated allergic diseases. Mladina et al. in 78 patients treated with turbinate surgery found improvements in 90% of cases of post-operative cytologic findings both in allergic and non-allergic subjects. Moreover, Cassano et al. stated symptoms’ reduction in 51.4% of allergic rhinitis.

In contrast, the authors found improvements in 42.8% with non-allergic rhinitis with eosinophils (NARES) and 64.3% of mast cells with eosinophils (NARESMA). The primary goals of turbinal surgery, according to the clinical practice guidelines (2015), are based on observational studies, with a preponderance of benefit over damage, evaluating **(30):**

❖ Quality of life (QoL) and nasal breathing improvement.

❖ Symptomatic gain achieved through various mechanisms: exuberant mucous tissue reduction determines a reduction of the contact points for the allergens present in the inhaled air.

❖ Reduction in the use of drugs with better patient compliance.

❖ Preservation of the nasal mucosa using techniques that maintain mucociliary activity unchanged.

The scar tissue that develops inside the submucosal layer leads to damage of both to the vascularization and the glandular structures, preventing their regrowth through fibrosis with the reduction of the amount of specific IgE

present on the nasal mucosa and of eosinophils. Mucosa's preservation that remains perfectly functioning allows, after the ITH procedure, both the maintenance of enough air space to support air's humidification and purification and the maintenance of airways physiological resistance **(31).**

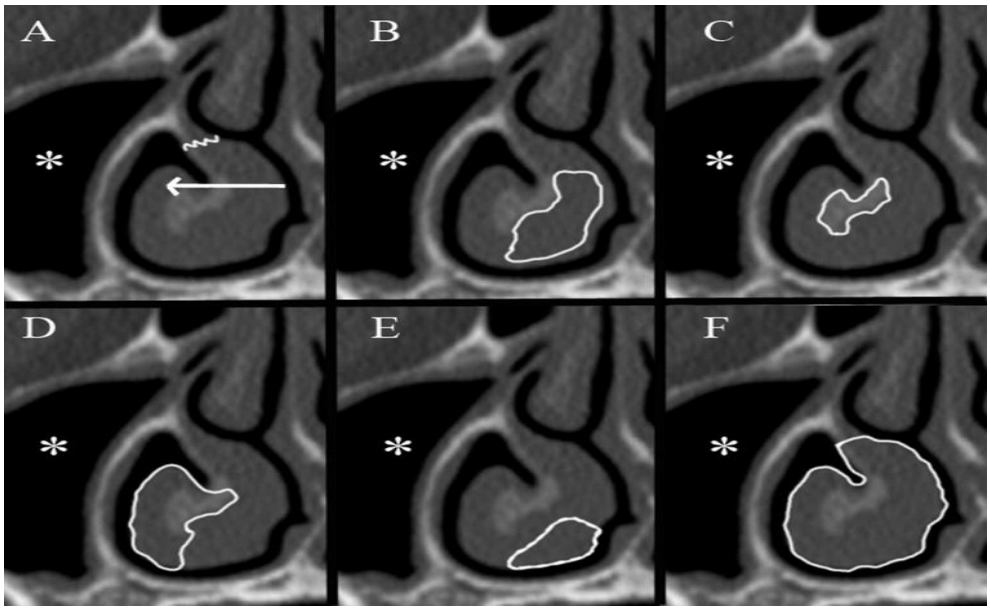

Figure 6. Surgical techniques for inferior turbinate reduction differ in the amount and type of tissue resected. The maxillary sinus is labeled with an asterisk for orientation purposes, and the tissue typically removed for each technique is demarcated. (A) Lateralization of the inferior turbinate with outfracture. (B) Submucosal soft tissue reduction (ie, submucosal electrocautery, radiofrequency coblation, and microdebrider). (C) Resection of the inferior turbinate bone. (D) Resection of the inferior turbinate bone and lateral mucosa. (E) Partial mucosal and soft tissue resection or ablation (ie, laser turbinectomy). (F) Total turbinectomy **(32).**

- **Effects of Surgical Treatment (posterior Turbinectomy) for Allergic Rhinitis:**

Surgical treatment is an option to control severe nasal symptoms and to improve QOL in AR patients refractory to medical management. inferior turbinate **(IT)** is a primary target of allergic effects. Therefore, IT reduction is a main stream of surgical options for AR, although its efficacy for AR symptoms is still controversial. Among numerous techniques for IT reduction , submucosal bony resection is a traditional procedure and its long-term efficacy for maintenance of nasal airflow is known **(29, 33).**

Another merit of submucosal bony resection is the preservation of the surface mucosa, which contributes to the maintenance of ciliary function. To reduce the risk for atrophic rhinitis, which is one complication after submucosal bony resection, partial resection of IT bones is performed. Posterior nasal neurectomy is a modified surgical technique of vidian neurectomy, which decreases hypersecretion and hypersensitivity. Based on this, a combination of submucosal resection of IT bones and posterior nasal neurectomy has been used for AR patients refractory to medical management **(34).**

- **Long-term Outcomes of Turbinate Surgery in Patients With Allergic Rhinitis:**

Treatment of AR comprises allergen avoidance, pharmacotherapy, immunotherapy, and combination therapy, according to the severity of symptoms. Sometimes, if medical treatment fails to relieve nasal obstruction because of hypertrophy of the inferior turbinate, surgical reduction can be performed to control allergic symptoms **(35).**

Hypertrophy of the inferior turbinate has long been established as the main cause of nasal congestion because it can reduce nasal airflow. Mucosal hypertrophy also underlies many of the specific and interrelated factors that contribute to nasal congestion, as well as other symptoms. For this reason, if patients with AR with hypertrophy of the inferior turbinate have undergone failed medical therapy, physicians may consider turbinate surgery **(36).**

Generally, nasal obstruction is the symptom that is most refractory to medical management in patients with AR; it can also be the most troublesome. Although surgery cannot eliminate the inflammatory origins of AR, improving nasal patency could reduce the edematous mucosa and alleviate allergic symptoms, such as nasal obstruction and rhinorrhea.

Turbinate surgery relieves allergic symptoms in patients with medically refractory AR, and various surgical methods for turbinate surgery have been introduced **(37, 38).**

Figure 7: Intraoperative endoscopic view showing the branches of the posterior nasal nerve emerging from the SPF. (a) Resection of the anteroinferior branch toward the inferior turbinate. (b) Resection of the posterosuperior branch toward the middle meatus. (c) The SPA is well preserved after nerve resection (arrow). EC = ethmoidal crest **(16).**

References:

1. Bloom, J.D., Antunes, M.B. and Becker, D.G. (2011) 'Anatomy, physiology, and general concepts in nasal reconstruction', Facial Plastic Surgery Clinics, 19(1), pp. 1–11.
2. Kobayashi, T. et al. (2012) 'Resection of peripheral branches of the posterior nasal nerve compared to conventional posterior neurectomy in severe allergic rhinitis', Auris Nasus Larynx, 39(6), pp. 593–596.
3. Joshi, S. V et al. (2022) 'Posterior nasal nerve resection–a novel and effective way to surgically treat refractory allergic and vasomotor rhinitis', Indian Journal of Otolaryngology and Head & Neck Surgery, 74(Suppl 2), pp. 1556–1561.
4. Kikawada, T. (2007) 'Endoscopic posterior nasal neurectomy: an alternative to vidian neurectomy', Operative Techniques in Otolaryngology-Head and Neck Surgery, 18(4), pp. 297–301.
5. Ehmer, D. et al. (2022) 'Long-term outcomes following temperature-controlled radiofrequency neurolysis for the treatment of chronic rhinitis', Allergy & Rhinology, 13, p. 21526575221096044.
6. Gerka Stuyt, J.A. et al. (2021) 'Evaluation of in-office cryoablation of posterior nasal nerves for the treatment of rhinitis', Allergy & Rhinology, 12, p. 2152656720988565.
7. Hua , H. et al. (2022) 'The long-term outcomes of posterior nasal neurectomy with or without pharyngeal neurectomy in patients with allergic rhinitis: a randomized controlled trial', Brazilian Journal of Otorhinolaryngology, 88(Suppl 1), pp. 147–155.
8. Elsayed, A. E. A., Mostafa, S. Y., Ibrahim, H. A., Elsawy, M. F., & Elsayed, A. F. (2024). Comparison Between the Effect of Turbinoplasty With and Without Posterior Nasal Nerve Neuroectomy in Patients of Allergic Rhinitis Not Responding to Medical Treatment. International Journal of Medical Arts, 6(4), 4329–4337.
9. Wang, L., Chen, M. and Xu, M. (2020) 'Effect of posterior nasal neurectomy on the suppression of allergic rhinitis', American journal of otolaryngology, 41(3), p. 102410.
10. Okubo, K. et al. (2014) 'Japanese guideline for allergic rhinitis 2014', Allergology International, 63(3), pp. 357–375.
11. Halderman, A. and Sindwani, R. (2015) 'Surgical management of vasomotor rhinitis: a systematic review', American journal of rhinology & allergy, 29(2), pp. 128–134.

12. Nishijima, H., Kondo, K., Toma-Hirano, M., Iwasaki, S., Kikuta, S., Fujimoto, C., Ueha, R., Kagoya, R., & Yamasoba, T. (2016). Denervation of nasal mucosa induced by posterior nasal neurectomy suppresses nasal secretion, not hypersensitivity, in an allergic rhinitis rat model. Lab Invest, 96(9), 981-993.
13. Makihara, S. et al. (2021) 'Underwater posterior nasal neurectomy compared to resection of peripheral branches of posterior nerve in severe allergic rhinitis', Acta Oto-Laryngologica, 141(8), pp. 780–785.
14. Bleier, B.S. and Schlosser, R.J. (2011) 'Endoscopic anatomy of the postganglionic pterygopalatine innervation of the posterolateral nasal mucosa', in International forum of allergy & rhinology. Wiley Online Library, pp. 113–117.
15. Yunfangzi, G.U. et al. (2023) 'Effects of modified posterior nasal nerve neurectomy combined with accessory posterior nasal nerve neurectomy on controlling intractable allergic rhinitis', Journal of Central South University Medical Sciences, 48(3), p. 404.
16. Takahara, D., Takeno, S., Hamamoto, T., Ishino, T., & Hirakawa, K. (2017). Management of intractable nasal hyperreactivity by selective resection of posterior nasal nerve branches. International Journal of Otolaryngology, 2017(1), 1907862.
17. Jean, E.E. et al. (2022) 'Neuroimmune regulatory networks of the airway mucosa in allergic inflammatory disease', Journal of leukocyte biology, 111(1), pp. 209–221.
18. Voisin, T., Bouvier, A. and Chiu, I.M. (2017) 'Neuro-immune interactions in allergic diseases: novel targets for therapeutics', International Immunology, 29(6), pp. 247–261.
19. Kimihiro, O. et al. (2017) 'Japanese guideline for allergic rhinitis 2017', Allergology International, 66(2), pp. 205–219.
20. Kanaya, T. and Kohno, N. (2017) 'Endoscopic Posterior Nasal Neurectomy with Continuous-Suction Irrigation Method', J Otolaryngol Res, 1(1), p. 113.
21. Eren, E. et al. (2015) 'A new method of identifying the posterior inferior nasal nerve: implications for posterior nasal neurectomy', Journal of Craniofacial Surgery, 26(3), pp. 930–932.
22. Trivedi, B. et al. (2022) 'Is posterior nasal nerve neurectomy really a ray of hope for the patients of allergic rhinitis', Indian Journal of Otolaryngology and Head & Neck Surgery, 74(Suppl 3), pp. 4713–4717.
23. Ogawa, T. et al. (2007) 'Submucous turbinectomy combined with posterior nasal neurectomy in the management of severe allergic rhinitis: clinical outcomes and local cytokine changes', Auris Nasus Larynx, 34(3), pp. 319–326.
24. Cassano, M. et al. (2012) 'Cytologic alterations in nasal mucosa after sphenopalatine artery ligation in patients with vasomotor rhinitis', American Journal of Rhinology & Allergy, 26(1), pp. 49–54.
25. Ozcan, K.M. et al. (2008) 'Microdebrider for reduction of inferior turbinate: evaluation of effectiveness by computed tomography.', Journal of Otolaryngology--Head & Neck Surgery, 37(4).
26. Chhabra, N. and Houser, S.M. (2009) 'The diagnosis and management of empty nose syndrome', Otolaryngologic Clinics of North America, 42(2), pp. 311–330.
27. Scheithauer, M.O. (2010) 'Surgery of the turbinates and "empty nose" syndrome', GMS current topics in otorhinolaryngology, head and neck surgery, 9.
28. Maniaci, A. et al. (2021) 'Surgical treatment for the refractory allergic rhinitis: state of the art', Allergies, 1(1), pp. 48–62.
29. Seidman, M.D. et al. (2015) 'Clinical practice guideline: allergic rhinitis', Otolaryngology–Head and Neck Surgery, 152(1_suppl), pp. S1–S43.
30. Cassano, M. et al. (2013) 'The role of nasal cytology in the management of inferior turbinate hypertrophy', International Journal of Immunopathology and Pharmacology, 26(1), pp. 207–215.
31. Wise, S.K. et al. (2023) 'International consensus statement on allergy and rhinology: Allergic rhinitis - 2023', International forum of allergy & rhinology, 13(4), pp. 293–859. Available at: https://doi.org/10.1002/ALR.23090.
32. Jourdy, D. (2014) 'Inferior turbinate reduction', Operative Techniques in Otolaryngology-Head and Neck Surgery, 25(2), pp. 160–170.
33. Chhabra, N. and Houser, S.M. (2014) 'Surgery for allergic rhinitis', in International forum of allergy & rhinology. Wiley Online Library, pp. S79–S83.

34. Nakagawa, T., Ogino-Nishimura, E. and Hiroshiba, S. (2022) 'Effects of Surgical Treatment for Allergic Rhinitis on Sleep and Mental Health in Adolescents', Surgeries, 3(1), pp. 20–27.
35. Bousquet, J. et al. (2020) 'Next-generation Allergic Rhinitis and Its Impact on Asthma (ARIA) guidelines for allergic rhinitis based on Grading of Recommendations Assessment, Development and Evaluation (GRADE) and real-world evidence', Journal of Allergy and Clinical Immunology, 145(1), pp. 70–80.
36. Ye, T. and Zhou, B. (2015) 'Update on surgical management of adult inferior turbinate hypertrophy', Current opinion in otolaryngology & head and neck surgery, 23(1), pp. 29–33.
37. Harju, T. et al. (2018) 'A prospective, randomized, placebo-controlled study of inferior turbinate surgery', The Laryngoscope, 128(9), pp. 1997–2003.
38. Gillman, G.S. et al. (2019) 'A prospective study of outcomes of septoplasty with turbinate reductions in patients with allergic rhinitis', Otolaryngology–Head and Neck Surgery, 160(6), pp. 1118–1123.