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Two types of vidian neurectomy show efficacy in treating allergic rhinitis and vasomotor rhinitis

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This study aimed to evaluate the efficacies of endoscopic vidian neurectomy (VN) and highly selective vidian neurectomy (HSVN) for the treatment of allergic rhinitis (AR) and vasomotor rhinitis (VMR). All AR and VMR patients were divided into two groups, Group VN and Group HSVN. The efficacy evaluation methods were visual analog scale (VAS), rhinoconjunctivitis quality of life questionnaire (RQLQ), and medication score. The efficacy evaluations were used to assess patient rhinitis symptoms, quality of life and drug usage. The time points of follow-up period were preoperative, 3 months, 6 months, 1 year, 2 years, and 3 years post operation. By analyzing pre- and postoperative VAS, medication score and RQLQ score, the results showed that rhinitis symptoms and quality of life in both VN and HSVN groups were significantly improved at 3 years, and the rate of improvement decreased gradually with time. Post operation, there were no significant differences in VAS and medication scores between the VN and HSVN groups. With respect to RQLQ, postoperative 2 years and 3 years improvements in sleep disorders, non-nasal symptoms and eye symptoms were significantly greater in the HSVN group than in the VN group. Improvements in rhinitis symptoms and quality of life in AR and VMR were sustained by VN and HSVN until 3 years post operation, with greater quality of life improvements in the HSVN group.

Keywords Allergic rhinitis, Vasomotor rhinitis, Vidian neurectomy, Highly selective vidian neurectomy, Quality of life

Allergic rhinitis (AR) is a chronic inflammatory disease of the nasal mucosa mediated by immunoglobulin E (IgE) after exposure to allergens[1,2]. Vasomotor rhinitis (VMR) is often associated with autonomic nervous system dysfunction. The pathophysiology of VMR is unclear and is generally classified as "idiopathic" rhinitis[3]. The symptoms of AR and VMR are similar, including sneezing, rhinorrhea, nasal itching, nasal congestion, and eye itching. According to statistics, the prevalence of AR in the United States is 19.9%. Meanwhile, the prevalence of AR in major Chinese cities increased from 11.1% in 2005 to 17.6% in 2011[4]. Vasomotor rhinitis is the most common type of non-allergic rhinitis, and foreign epidemiological data show that it accounts for at least two-thirds of all non-allergic rhinitis[5].

At present, the main clinical therapeutics of AR and VMR include avoiding allergen exposure, medication therapies, immunotherapy, and surgical treatment. Most allergens cannot be avoided in daily life[6]. Medication therapies for AR and VMR include nasal hormones, oral antihistamines, and nasal antihistamines, and so on. These medication therapies are considered effective for short term alleviation of AR and VMR symptoms[7]. Only a small number of patients who are allergic to dust mites and wormwood can choose this treatment[8–10]. VMR patients do not have a choice of immunotherapy. Allergic Rhinitis and its Impact on Asthma guidelines – 2016 revision (ARIA2016) recommended support patients, their caregivers, and health care providers in choosing the optimal treatment[11]. For moderate-to-severe AR and VMR where the above treatment methods are not applicable or have poor results, surgical treatment can be chosen[12]. AR and VMR surgical interventions may be of two types, that is, inferior turbinate reduction and nasal septum correction to improve nasal ventilation function[13,14], as well as vidian neurectomy (VN) to reduce nasal hyperresponsiveness[12,15–17]. The first type mainly improves nasal congestion, but the long-term effect is not ideal. The second type surgery can comprehensively improve various symptoms of AR and VMR with relatively longer therapeutic effects. Studies have also shown that VN is more effective in controlling and relieving clinical symptoms of AR and VMR[18,19]. Highly selective vidian neurectomy (HSVN) is a subtype of VN. VN has a higher incidence of secondary complications such as dry eye and hard palate paraesthesia, but HSVN has a shorter duration of postoperative effect[15].

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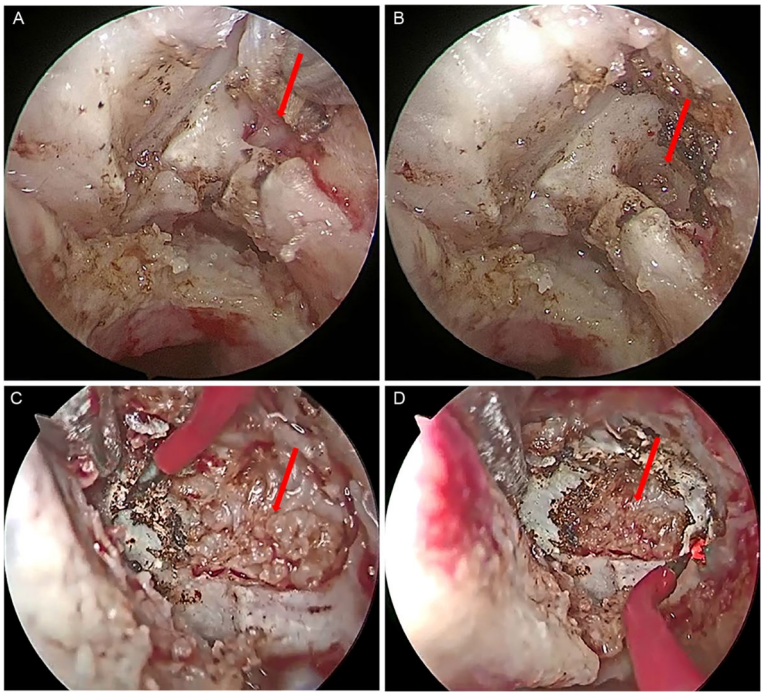

Fig. 1. Surgical diagram of VN and HSVN. (a) Vidian nerve, red arrow pointed to vidian nerve. (b) Vidian nerve tube opening, red arrow pointed to vidian nerve tube. (c) Severed sphenopalatine artery, red arrow pointed to sphenopalatine artery. (d) Severed peripheral sphenopalatine artery nerve, red arrow pointed to sphenopalatine artery. VN, vidian neurectomy; HSVN, highly selective vidian neurectomy.

	VN($n=85$)	HSVN($n=40$)	*p*-value
Age(years)	46.8	36.5	0.066
AR	54	23	0.518
VR	31	17	
Female	21	20	0.005
Male	64	20	
Left	46	-	-
Right	39	-	-
Eosinophil ratio(%)	5.48	4.95	0.589
Eosinophils number(10^9)	0.35	0.56	0.186
VAS-Overall	8.72	9.31	0.082
Medication score	2.62	2.54	0.761
RQLQ-Overall	88.51	89.52	0.789

Table 1. General characteristics of patients.

There are a few studies comparing the two VN surgical methods and the outcome indicators are not comprehensive. In this study, we aimed to compare improvements of rhinitis symptoms, quality of life and drug usage of patients who underwent VN and HSVN Fig. 1.

Results

Patient characteristics

Table 1 showed the general characteristics for both groups. A total of 125 patients (85 in Group VN and 40 in Group HSVN) were enrolled until December 2021. In group VN, 77 patients were followed up for more than 1 year, 42 for more than 2 years, and 16 for more than 3 years. In Group HSVN, 35 patients were followed up for more than 1 year, 32 for more than 2 years, and 16 for more than 3 years.

Efficacy evaluation of VN

The efficacy of VN was evaluated from three aspects, that is, VAS, RQLQ, and medication score (Fig. 2).

First, VAS was mainly used to evaluate the rhinitis symptoms in patients. The preoperative rhinorrhea, sneezing, nasal itching, along with nasal congestion self-assessment scores ranging from 7.29 ± 3.14 to 8.67 ± 1.78, suggested that these patients suffered from severe rhinitis symptoms and were consistent with surgical indications. The rhinorrhea, sneezing, nasal itching, along with nasal congestion self-assessment scores ranged from 1.01 ± 1.89 to 1.42 ± 2.18 at postoperative 3 months (p<0.001), ranged from 2.63 ± 2.81 to 3.06 ± 2.46 at postoperative 3 years (p<0.001).

Second, the five aspects of RQLQ were significantly improved post operation. The preoperative self-assessment scores of activity restrictions were 12.58 ± 5.01, to 1.62 ± 3.52 at postoperative 3 months (p<0.001), to 3.56 ± 4.93 at postoperative 3 years (p<0.001). The preoperative self-assessment scores of sleep disorders were 8.92 ± 6.05, to 0.99 ± 2.18 3 months post operation (p<0.001), to 3.37 ± 4.08 3 years post operation (p<0.001). The preoperative self-assessment scores of non-nasal symptoms were 18.61 ± 11.17, to 1.97 ± 4.77 3 months post operation (p<0.001), to 2.63 ± 7.61 3 years post operation (p<0.001). The preoperative self-assessment scores of eye symptoms were 5.14 ± 5.33, to 0.64 ± 1.50 at postoperative 3 months (p<0.001), to 1.85 ± 3.16 at postoperative 2 years (p = 0.002). The preoperative self-assessment scores of emotional disorders were 11.57 ± 7.78, to 1.36 ± 3.48 at postoperative 3 months (p<0.001), to 3.00 ± 6.11 at postoperative 3 years (p = 0.001).

Third, the preoperative scores of medication score was 2.62 ± 1.14, to 0.94 ± 1.06 at 3 months post operation (p<0.001), to 1.06 ± 1.40 2 years post operation (p<0.001). The medication score of medication score decreased significantly 2 years post operation.

The results showed significant improvements in rhinitis symptoms, quality of life, and drug usage. The improvement of medication in patients by VN decreased over time.

Efficacy evaluation of HSVN

Similarly, the efficacy of the HSVN was evaluated according to three aspects (Fig. 3).

First, VAS was mainly used to evaluate the rhinitis symptoms in patients. The preoperative rhinorrhea, sneezing, nasal itching, along with nasal congestion self-assessment scores ranging from 6.46 ± 3.97 to 8.57 ± 2.86, suggested that these patients suffered from severe rhinitis symptoms and were consistent with

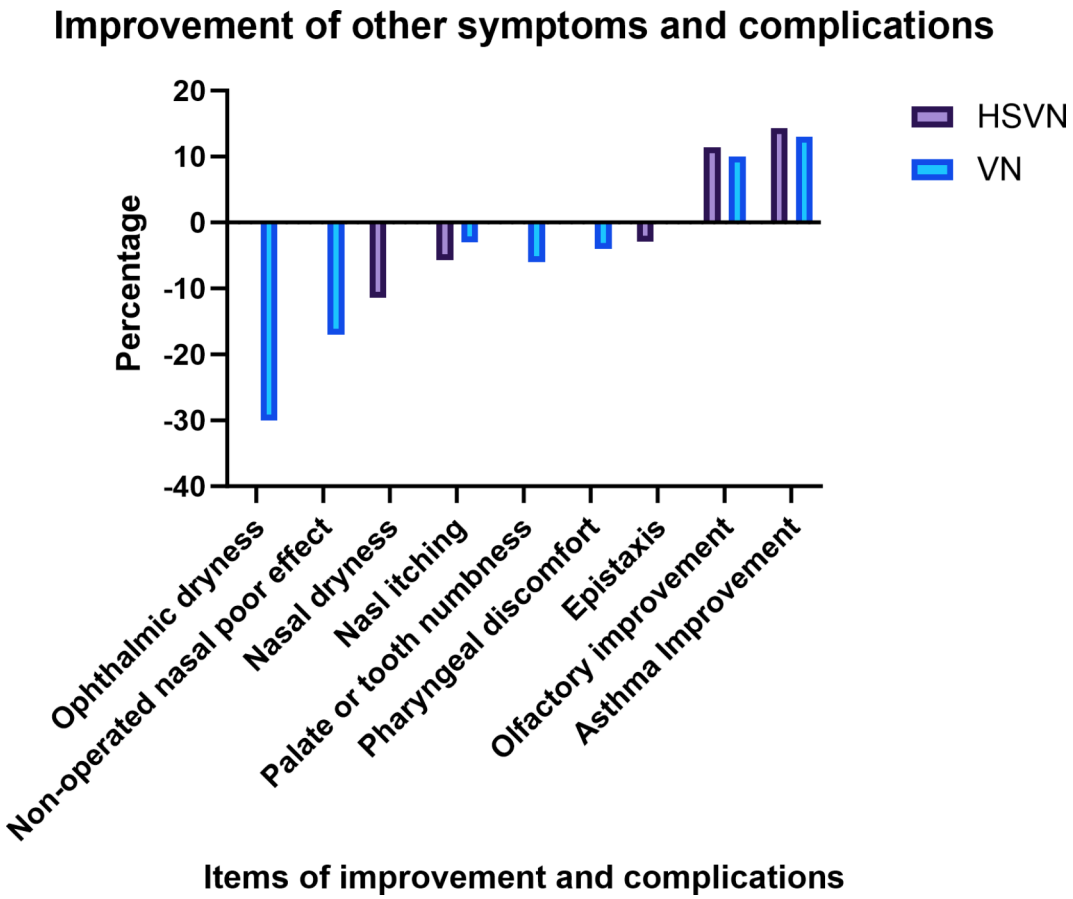

Fig. 2. The results showed that all VAS scores decreased post operation and was statistically significant from 3 months to 3 years post operation. RQLQ activity restrictions, sleep disorders, non-nasal symptoms and emotional disorders scores decreased post operation and were statistically significant from 3 months to 3 years post operation. Postoperative eye symptoms and medication scores showed statistically significant declines until 2 years post operation. VN, vidian neurectomy; RQLQ, rhinoconjunctivitis quality of life questionnaire; VAS, visual analog scale.

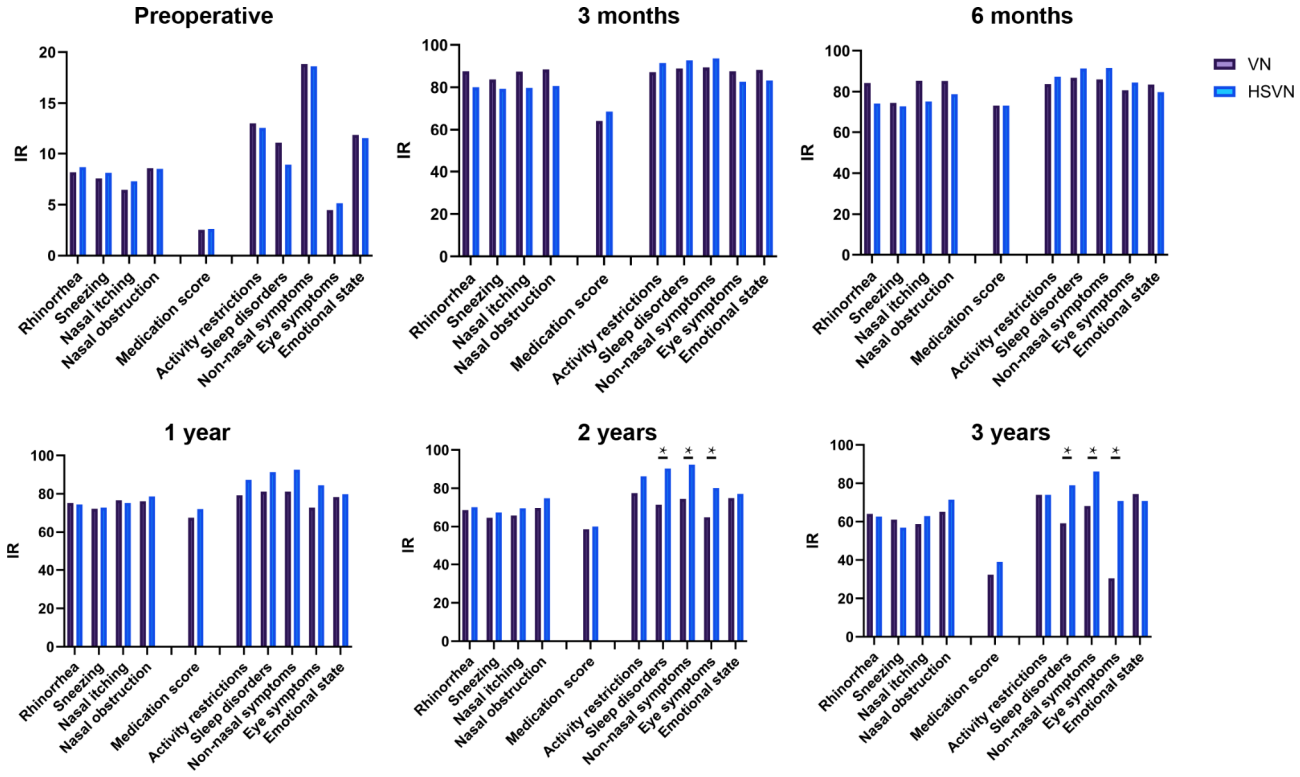

Fig. 3. The results showed that the VAS score decreased post operation and was statistically significant from 3 months to 3 years post operation. The results showed that all RQLQ scores decreased post operation and were statistically significant from 3 months to 3 years post operation. Postoperative medication scores showed statistically significant declines until 2 years post operation. HSVN, highly selective vidian neurectomy; RQLQ, rhinoconjunctivitis quality of life questionnaire; VAS, visual analog scale.

surgical indications. The rhinorrhea, sneezing, nasal itching, along with nasal congestion self-assessment scores ranged from 1.31 ± 2.71 to 1.66 ± 2.45 3 months post operation ($p<0.001$), ranged from 2.25 ± 3.62 to 3.69 ± 3.26 3 years post operation ($p<0.001$).

Second, the five aspects of RQLQ were significantly improved post operation. The preoperative self-assessment scores of activity restrictions were 13.03 ± 4.31, to 1.11 ± 2.82 3 months post operation ($p<0.001$), to 3.44 ± 5.35 3 years post operation ($p<0.001$). The preoperative self-assessment scores of sleep disorders were 11.43 ± 6.34, to 0.83 ± 2.44 3 months post operation ($p<0.001$), to 2.25 ± 4.96 3 years post operation ($p=0.001$). The preoperative self-assessment scores of non-nasal symptoms were 18.83 ± 13.38, to 1.20 ± 4.95 3 months post operation ($p<0.001$), to 2.63 ± 7.32 3 years post operation ($p<0.001$). The preoperative self-assessment scores of eye symptoms were 4.77 ± 5.09, to 0.83 ± 1.84 3 months post operation ($p<0.001$), to 1.27 ± 2.43 3 years post operation ($p=0.036$). The preoperative self-assessment scores of emotional disorders were 11.89 ± 8.93, to 2.00 ± 4.17 3 months post operation ($p<0.001$), to 3.50 ± 6.34 3 years post operation ($p=0.013$).

Third, the preoperative scores of medication score was 2.54 ± 1.65, to 0.80 ± 1.10 3 months post operation ($p<0.001$), to 1.06 ± 1.44 2 years post operation ($p<0.001$). The medication score decreased significantly 2 years post operation.

The results showed significant improvements in rhinitis symptoms, quality of life, and drug usage. The improvement of medication in patients by VN decreased over time.

Comparison of efficacy between VN and HSVN

As it can be seen from Table 1, the preoperative VAS score, medication score, and RQLQ score did not significantly differ between the VN and HSVN groups, which explains the randomness and rationality of these two groups.

As shown in Fig. 4, IR of VAS, RQLQ and medication were used to improve the efficacy between VN group and the HSVN group. There were no significant differences in IR of rhinitis symptoms, quality of life, and drug usage between the two groups from preoperative to one year post operation. At 2 and 3 years post operation, the IR of sleep disorders, non-nasal symptoms and emotional disorders in the HSVN group was significantly greater than that in the VN group ($p<0.05$), although there was no significant difference in IR of rhinitis symptoms and drug scores between the two groups.

Improvement of other symptoms and complications

As shown in Fig. 5, in Group VN, the ratio of improved olfactory function and asthma were 10.39% and 12.99%, respectively. The complications were as follows: 29.87% of patients had ophthalmic dryness in the short term

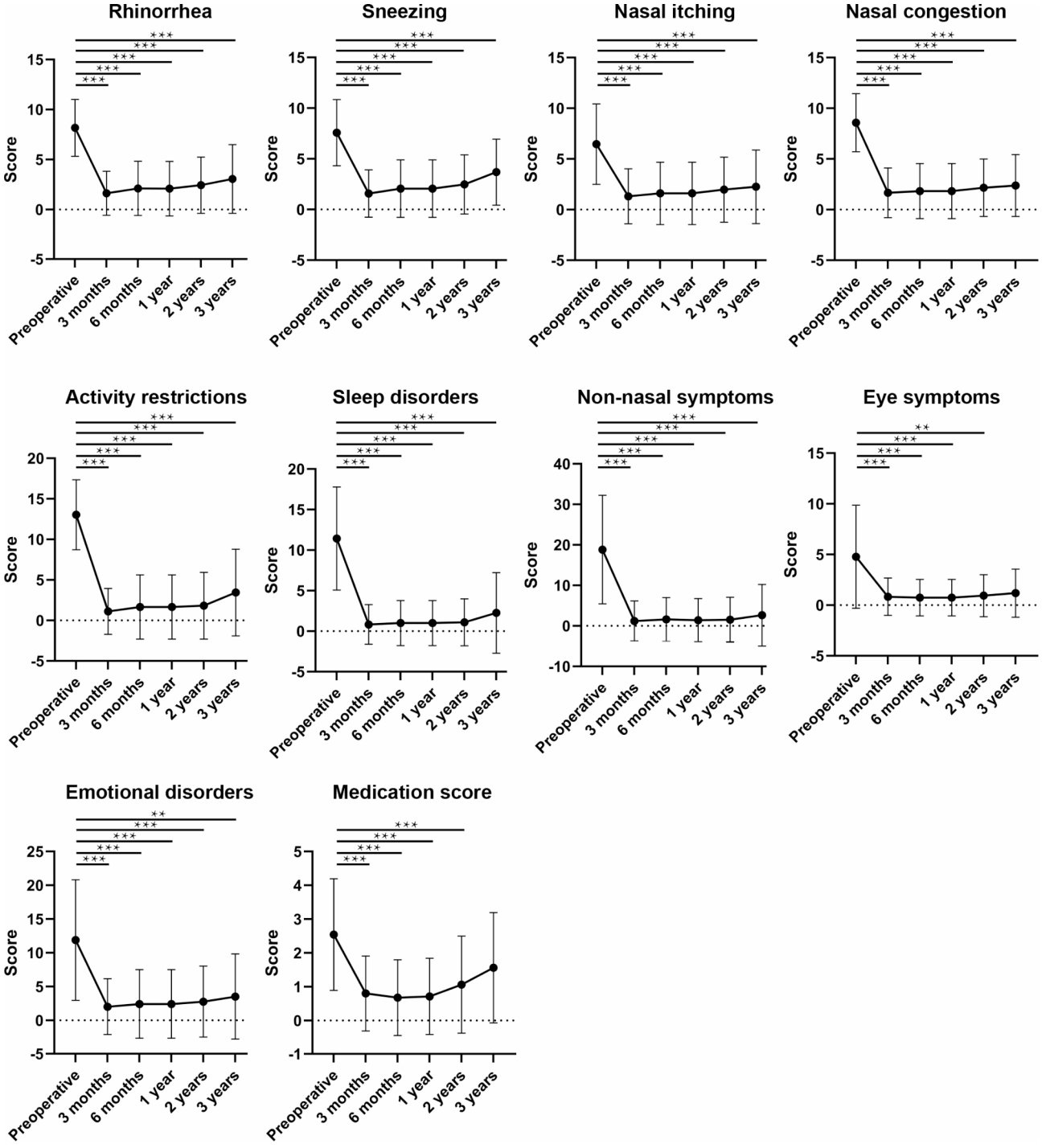

Fig. 4. The all rhinitis symptoms of VAS and medication score show no significant differences between the two groups preoperatively and postoperatively. The all symptoms of RQLQ show no significant differences between the two groups preoperatively. HSVN group improved RQLQ's sleep disorders, non-nasal symptoms and emotional disorders better than VN group at 2 and 3years post operation. HSVN, highly selective vidian neurectomy; VN, vidian neurectomy; RQLQ, rhinoconjunctivitis quality of life questionnaire; VAS, visual analog scale.

post operation, and the symptoms resolved within 2 months after the use of sodium hyaluronate eye drops. Furthermore, 16.88% of patients showed poor effect on the non-operated side of the nasal cavity. In addition, 6.49% of patients reported hard palate or tooth numbness, 3.9% reported pharyngeal discomfort; and 2.5% had new nasal itching.

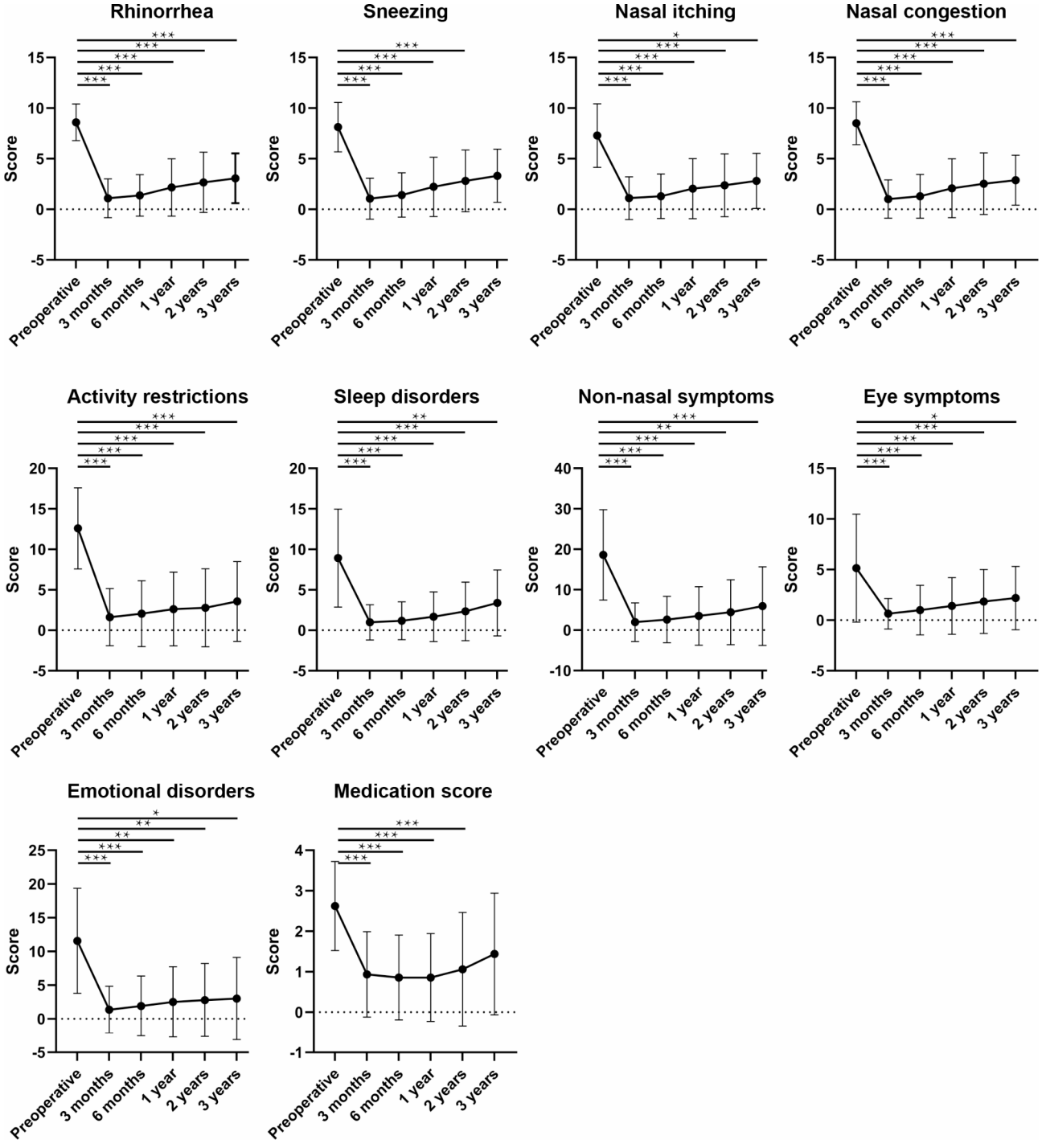

Fig. 5. Improvement of other symptoms and complications. Postoperative improvement symptoms (mainly including olfactory function and asthma) and complications reported in VN and HSVN groups. HSVN, highly selective vidian neurectomy; VN, vidian neurectomy.

As shown in Fig. 5, in Group HSVN, the ratio of improved olfactory function and asthma were 11.43% and 14.29%, respectively. The complications included nasal dryness (11.42%), nasal itching (5.7%), and sphenopalatine artery hemorrhage, (2.9%).

There was no significant difference between the two groups in terms of improved olfactory function and asthma. The VN group experienced more side effects, including ophthalmic dryness and palate numbness, while the HSVN group may have had postoperative sphenopalatine artery hemorrhage (Fig. 5).

Discussion

In the early 1860s, Golding-Wood first cut the vidian nerve through the sinus approach and later proposed the palatal, nasal septum, and mesonasal approaches[18]. In the 1890s, endoscopy-assisted transnasal operation promoted widespread application of VN[19].

Some studies showed that nasal discharge and sneezing symptoms in AR and VMR patients were improved immediately after VN operation[15]. The patient quality of life and rhinitis symptoms were significantly improved from 3 months to 3 years after VN operation[19–21], Similar studies have found that in addition to improving rhinitis symptoms in AR and VMR patients, HSVN can also improve patient quality of life[22,23]. The results of this study were similar to those of previous studies. The results showed that VN and HSVN groups also significantly improved rhinitis symptoms and quality of life treatment from 3 months to 3 years, and the improvement in medication score was statistically significant from 3 months to 2 years post operation. The results showed that VN significantly improved eye symptoms from 3 months to 2 years, and the improvement of HSVN group was statistically significant from 3 months to 3 years post operation. This study also found that HSVN group improved RQLQ's sleep disorders, non-nasal symptoms and emotional disorders better than VN group at 2 and 3years post operation. This also showed that HSVN has more advantages in improving the quality of life. With consistent improvements in olfactory function and asthma, HSVN had fewer operation-related complications.

The standard treatment for allergic rhinitis and vasomotor rhinitis is medication, which costs approximately $100–500 per year and is generally not reimbursed by medical insurance. The cost of vidian neurectomy is approximately $2000, and employee medical insurance can reimburse 80%. Compared with standard treatment, the reimbursement is equivalent to the patient's medication costs for 1–2 years. Compared to standard treatment, vidian neurectomy has advantages in terms of cost and treatment effectiveness, making it a suitable treatment option for moderate to severe allergic rhinitis and vasomotor rhinitis.

This study had some limitations. The number of patients included is not large enough, and follow-up studies with a larger sample size are required. Next, our team will conduct a study involving eosinophils, Th1/Th2 related cells and cytokines with more patients and longer follow-up.

Materials and methods

Case selection

This study was approved by Shandong Provincial ENT Hospital Medical Ethics Committee (approval number, 3701047593066) and adhered to the principles of the Declaration Helsinki. Informed consent was obtained from all subjects and/or their legal guardian(s). In this study, 125 patients with moderate to severe persistent AR or VMR treated at Shandong ENT Hospital were included in the study. The patients were primarily enrolled between January 2019 and December 2021 and were aged 18–75 years. The diagnostic criteria were based on the Rhinitis 2020: A practice parameter update. All patients had experienced more than 2 years of failed medication therapies. For the allergen examination, the IgE detection (uniCAP; Phdia, Immuno CAP 100) method was used in all patients according to the recommended instructions. AR patients were found to be positive for at least one serum specific IgE. VMR patients showed negative results for serum total IgE and specific IgE, with no increase in eosinophils.

Grouping

The 125 patients were divided into two groups, Group VN and Group HSVN. The VN surgical side was selected mainly according to the tear secretion test, and the side with more tears was usually selected. All patients in HSVN group underwent bilateral HSVN surgery. In Group VN, the date of surgery for the first patient was January 13, 2019, and the last was December 2, 2021. In Group HSVN, the date of surgery for the first patient was November 3, 2019, and the last patient was December 15, 2021. Because Group VN physicians started screening patients earlier, the number of patients in Group VN was more than that in Group HSVN.

Treatment

Operative methods

For VN, plasma was used to sever the nerve at the anterior orifice of the vidian nerve tube until the bony anterior orifice was completely exposed (Fig. 1A, B). For HSVN, plasma was used to separate outwardly until the sphenopalatine artery was cut off, the palatal sheath nerve was removed and the vidian nerve exposed (Fig. 1 C, D).

Conservative treatment

Nasal corticosteroids combined with nasal irrigation were administered during the perioperative period. Post operation, medication with nasal corticosteroids, oral antihistamines, and oral corticosteroids was continued according to the patients' conditions.

Follow-up period

The follow-up period was from January 2019 to December 2021, and the follow-up time points were preoperative, 3 months, 6 months, 1 year, 2 years, and 3 years postoperative. The follow-up was performed mainly via face to face, and ended on June 1, 2023.

Efficacy evaluation method

VAS, medication score, and RQLQ were used to observe the improvement of postoperative rhinitis symptoms, quality of life and drug usage. The VAS included five items, overall symptoms, nasal itching, sneezing, rhinorrhea, nasal congestion. The RQLQ scale is composed of 28 items covering six aspects, activity restrictions, sleep

disorders, non-nasal symptoms, rhinitis symptoms, eye symptoms, and emotional disorders. Rhinitis symptoms of VAS were sufficient to cover RQLQ rhinitis symptoms, and the statistical trend was consistent; therefore, RQLQ rhinitis symptoms were not mapped. For the medication score, the administration of oral and/or local antihistamines (nasal and ocular) was allocated 1 point, nasal hormone 2 points, and oral glucocorticoids 3 points. The cumulative score for all medication records was calculated as the total medication score.

Improvement of other symptoms and complications

During the postoperative follow-up, the postoperative improvement symptoms (mainly including olfaction and asthma) and complications reported by patients were recorded. The incidence was calculated using the formula: incidence = number of patients reported/ total number of patients in each group × 100.

Statistical analysis

Data were analyzed using the SPSS software (version 19.0). Chi-square test was used to analyze general characteristics, such as AR, VMR ratio and sex in general data, and $p < 0.05$ was considered statistically significant. The RQLQ, VAS, and medication **scores** before and post operation were compared and analyzed of the two groups using independent sample t-tests, $p < 0.05$ was considered statistically significant. The difference between VN and HSVN groups was compared using independent sample T test with improvement rate (IR) of RQLQ, VAS, medication scores, $p < 0.05$ was considered statistically significant. Improvement rate (IR) = preoperative store- postoperative store/preoperative store ×100.

Data availability

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

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References

1. Bernstein, D. I., Schwartz, G., Bernstein, J. A. & Allergic Rhinitis Mechanisms and treatment. *Immunol. Allergy Clin. North Am.* **36**, 261–278. https://doi.org/10.1016/j.iac.2015.12.004 (2016).
2. Greiner, A. N., Hellings, P. W., Rotiroti, G. & Scadding, G. K. Allergic rhinitis. *Lancet*. **378**, 2112–2122. https://doi.org/10.1016/S0140-6736(11)60130-X (2011).
3. Agnihotri, N. T. & McGrath, K. G. Allergic and nonallergic rhinitis. Allergy and Asthma Proceedings 40, 376–379, doi: (2019). https://doi.org/10.2500/aap.2019.40.4251
4. Zhou, F. et al. Emerging trends and research foci in allergic rhinitis immunotherapy from 2002 to 2021: a bibliometric and visualized study. *Am. J. Translational Res.* **14**, 4457–4476 (2022).
5. Settipane, R. A. & Kaliner, M. A. Chapter 14: nonallergic rhinitis. *Am. J. Rhinol. Allergy*. **27** (Suppl 1), S48–S51. https://doi.org/10.2500/ajra.2013.27.3927 (2013).
6. Han, X., Krempski, J. W. & Nadeau, K. Advances and novel developments in mechanisms of allergic inflammation. *Allergy*. **75**, 3100–3111. https://doi.org/10.1111/all.14632 (2020).
7. Meltzer, E. O. et al. Burden of allergic rhinitis: allergies in America, Latin America, and Asia-Pacific adult surveys. Allergy and Asthma Proceedings 33 Suppl 1, S113-S141, https://doi.org/10.2500/aap.2012.33.3603(2012).
8. Drazdauskaite, G., Layhadi, J. A. & Shamji, M. H. Mechanisms of Allergen Immunotherapy in allergic Rhinitis. *Curr. Allergy Asthma Rep.* **21**, 2. https://doi.org/10.1007/s11882-020-00977-7 (2020).
9. Scadding, G. Real world evidence of long-term benefits from allergen-specific immunotherapy (AIT). *Lancet Reg. Health-Europe*. **13**, 100283. https://doi.org/10.1016/j.lanepe.2021.100283 (2022).
10. Demoly, P. et al. A 300 IR sublingual tablet is an effective, safe treatment for house dust mite-induced allergic rhinitis: an international, double-blind, placebo-controlled, randomized phase III clinical trial. *J. Allergy Clin. Immunol.* **147**, 1020–1030. https://doi.org/10.1016/j.jaci.2020.07.036 (2021).
11. Brozek, J. L. et al. Allergic Rhinitis and its impact on Asthma (ARIA) guidelines-2016 revision. *J. Allergy Clin. Immunol.* **140**, 950–958. https://doi.org/10.1016/j.jaci.2017.03.050 (2017).
12. [Chinese guidelines for diagnosis and treatment of allergic rhinitis.]. Zhonghua Er Bi Yan Hou Tou Jing Wai Ke Za Zhi = Chinese Journal of Otorhinolaryngology Head and Neck Surgery 57, 2022). (2022), revision.
13. Ghosh, S. K., Dutta, M. & Haldar, D. Role of bilateral Inferior Turbinoplasty as an Adjunct to Septoplasty in improving nasal obstruction and subjective performance in patients with deviated nasal Septum Associated with allergic rhinitis: an interventional, prospective study. *Ent-Ear Nose Throat J.* **102**, 445–452, https://doi.org/10.1177/01455613211015440(2023).
14. Gunhan, K., Unlu, H., Yuceturk, A. V. & Songu, M. Intranasal steroids or radiofrequency turbinoplasty in persistent allergic rhinitis: effects on quality of life and objective parameters. *Eur. Arch. Otorhinolaryngol.* **268**, 845–850. https://doi.org/10.1007/s00405-010-1462-1 (2011).
15. Su, W. F., Liu, S. C., Chiu, F. S. & Lee, C. H. Antegrade transsphenoidal vidian neurectomy: short-term surgical outcome analysis. *Am. J. Rhinol. Allergy*. **25**, e217–e220. https://doi.org/10.2500/ajra.2011.25.3704 (2011).
16. Tan, G., Ma, Y., Li, H., Li, W. & 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.* **138**, 492–497. https://doi.org/10.1001/archoto.2012.284 (2012).
17. Lee, J. C. & Lin, Y. S. Endoscopic vidian neurectomy: update on techniques and evidence. *Curr. Opin. Otolaryngol. Head Neck Surg.* **20**, 66–72. https://doi.org/10.1097/MOO.0b013e32834e13d8 (2012).
18. Tan, G. L., Ma, Y. H., Liu, G. S., Wang, J. J. & Li, W. [Therapeutic effect of endoscopic vidian neurectomy on moderate-severe persistent allergic rhinitis]. *Zhonghua Er Bi Yan Hou Tou Jing Wai Ke Za Zhi*. **46**, 449–454 (2011).
19. Ma, Y. et al. Therapeutic effectiveness of endoscopic vidian neurectomy for the treatment of vasomotor rhinitis. *Acta Otolaryngol.* **134**, 260–267. https://doi.org/10.3109/00016489.2013.831478 (2014).
20. Xie, Q., Yuan, J. & Wang, Y. Efficacy of various surgical methods in the treatment of allergic rhinitis: a network meta-analysis. *Allergol. Immunopathol.* **51**, 137–147. https://doi.org/10.15586/aei.v51i2.726 (2023).
21. Shen, L. et al. Clinical efficacy and possible mechanism of endoscopic vidian neurectomy for House Dust Mite-Sensitive allergic rhinitis. Orl-Journal for Oto-Rhino-Laryngology Head and Neck surgery **83**, 75–84, https://doi.org/10.1159/000511711 (2021).

22. Gu, Y. et al. Effects of modified posterior nasal nerve neurectomy combined with accessory posterior nasal nerve neurectomy on controlling intractable allergic rhinitis. *Zhong Nan Da Xue Xue Bao Yi Xue Ban* **48**, 404–413, https://doi.org/10.11817/j.issn.1672-7347.2023.220593 (2023).
23. He, P., Jin, X. J. & Zhao, H. [Effects of highly selective branches neurotomy of vidian nerve with low temperature plasma on vasoactive intestinal peptide in nasal mucosal cells of patients with allergic rhinitis]. *Lin Chuang Er Bi Yan Hou Tou Jing Wai Ke Za Zhi* **32**, 167–170, https://doi.org/10.13201/j.issn.1001-1781.2018.03.002 (2018).

Author contributions

All authors made a substantial, direct, and intellectual contribution to the work. SJ.S. and AP.C. wrote the manuscript and designed the figures. L.S. and YZ. W. revised the manuscript and supervised the manuscript. SJ.S. and AP.C. contributed equally to the article.

Declarations

Competing interests

The authors declare no competing interests.

Additional information

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