Accepted Manuscript online: 2022-12-28 Article published online: 2023-03-16

Immediate Intraoperative Microsurgical Repair of the Recurrent Laryngeal Nerve: A Fifteen-Year Institutional Experience

J. Reed McGraw, BS[1] Corey M. Bascone, MD, MBA[1] Ivan A. Jaimez, BS[1] Carlos E. Barrero, BS[1] Joshua Fosnot, MD[1] Douglas L. Fraker, MD[2] Stephen J. Kovach III, MD, FACS[1]

[1] Division of Plastic Surgery, Department of Surgery, Hospital of the University of Pennsylvania, Philadelphia, Pennsylvania
[2] Division of Endocrine and Oncologic Surgery, Department of Surgery, Hospital of the University of Pennsylvania, Philadelphia, Pennsylvania

Address for correspondence Stephen J. Kovach, III, MD, FACS, Division of Plastic Surgery, 3400 Civic Boulevard, Perelman Center for Advanced Medicine, 14th Floor, South Tower, Philadelphia, PA 19104 (e-mail: Stephen.kovach@pennmedicine.upenn.edu).

J Reconstr Microsurg Open 2023;8:e32–e37.

Abstract

Background Recurrent laryngeal nerve (RLN) injury carries significant morbidity. Microsurgical repair of the RLN has proven promising for enhancing patient recovery of vocal function; however, data remains limited.

Methods This retrospective cohort study included patients who underwent RLN repair from 2007 to 2022. Demographics and medical history were collected. The location and etiology of RLN injury, as well as the repair technique, were collected. Follow-up data were collected at the initial postoperative visit, at 6 months and at 1 year. Hoarseness was classified as mild, moderate, or severe. Of patients who underwent nasopharyngolaryngoscopy (NPL) following repair, the glottic gap was measured. Vocal interventions performed were also recorded. This study utilized descriptive statistical methods.

Results Eleven patients underwent RLN repair. All patients underwent immediate repair. Fifty-four percent ($n = 6$) of RLN injuries resulted from tumor inflammation or nerve encasement. Eighty-two percent ($n = 9$) underwent direct RLN coaptation, 9% ($n = 1$) underwent vagus-RLN anastomosis, and 9% ($n = 1$) underwent an interposition nerve graft. Technical success was 100%. Seventy-three percent ($n = 8$) required otolaryngology referral, and of those, 50% ($n = 4$) required intervention. At initial evaluation, 91% ($n = 10$) suffered from mild to severe hoarseness, and of patients who underwent NPL, all had a glottic gap. At 1 year, 82% of patients ($n = 9$) improved to having mild to no appreciable hoarseness. Of the patients who underwent NPL, 62% ($n = 5$) had closure of the glottic gap.

Conclusion Patients undergoing repair of the RLN following injury showed excellent recovery of vocal function and resolution of glottic gap at 1 year.

Keywords
- laryngeal nerve
- nerve repair
- thyroid

received
June 23, 2022
accepted after revision
September 29, 2022
accepted manuscript online
December 28, 2022

DOI https://doi.org/10.1055/a-2004-0113.
ISSN 2377-0813.

Thieme Medical Publishers, Inc., 333 Seventh Avenue, 18th Floor, New York, NY 10001, USA

The recurrent laryngeal nerve (RLN) holds important function, serving as the primary source of motor innervation to the vocal cords. Anatomically, the right and left RLNs originate from the vagus nerves bilaterally and then course in a recurrent manner, looping around the right subclavian artery and the aortic arch, respectively, before coursing within the tracheoesophageal groove posterior to the thyroid gland to find their ultimate destination in the larynx.[1] This recurrent course places the RLNs at heightened susceptibility to injury during thyroid surgery, and the reported incidence of permanent RLN palsy following thyroid surgery is approximately 2 to 3%.[2] Injury to the RLN holds important functional consequence for patients, as it can lead to paralysis of the true vocal cord, in turn causing patients to suffer from dysphonia, hoarseness, dysphagia, and a potentially heightened infectious risk.[3,4] The introduction of intraoperative nerve monitoring aimed at RLN preservation has been largely equivocal based on recent meta-analyses, and the incidence of RLN injury during thyroid surgery has remained relatively stable.[5,6]

Given the morbidity that RLN injury carries for patients, there exists a number of conservative and surgical therapies for RLN healing,[7] as well as a growing interest in innovative therapies involving electrical stimulation and tissue engineering.[8,9] However, these therapies are limited physiologically, as axonal regeneration is generally limited and slow.[10] Of the growing armamentarium of RLN therapies, those that hold perhaps the most promise include microsurgical techniques aimed at direct RLN coaptation at the site of injury, which are often performed immediately following laceration.[11] A number of microsurgical techniques have been proposed, including direct epineural coaptation of the RLN,[12–14] proximal vagus-RLN anastomosis,[15] and ansa cervicalis-RLN anastomosis.[16] A growing number of case series have been published in the literature on microsurgical repair of the RLN, often reporting high technical success rates as well as high rates of glottic closure within 1 year following repair.[12–14,17–24]

Despite this, overall evidence regarding microsurgical repair of the RLN remains limited, as most reports have been limited by small sample size and variation in surgical technique by center. Furthermore, the existing literature is geographically limited, as all but one documented study have come from Asian centers (the only other being a European center). Therefore, the purpose of this study is to provide the first case series from the United States examining patient vocal and laryngeal outcomes following immediate microsurgical repair of the RLN following intraoperative injury.

Methods

This retrospective cohort study received approval from the review board on human research at the Hospital of the University of Pennsylvania, and the requirement for informed consent was waived. The surgical logs of the microsurgeons (S.J.K. and J.F.) at our institution were queried from January 2007 to May 2022 for all cases of microsurgical repair of the RLN. Patients were excluded if they were under 18 years of age or if they underwent microsurgical repair of any nerve other than the RLN. Patients were indexed by the date of their initial surgery leading to RLN injury.

Patient demographics, medical history, surgical history, and index surgical data were collected from the electronic medical record. The indication for the index thyroid operation leading to injury was recorded, along with histories of prior surgery or radiation to the neck. Operative notes from the index endocrine surgeon were utilized to determine the location and the etiology of RLN injury, classified as being due to either (1) inflammatory changes, (2) planned sacrifice, (3) variant anatomy, (4) accidental transection, or (5) traction injury. Operative notes from the index microsurgeon were utilized to gather surgical repair details including: (1) surgical technique, (2) necessity of additional nerve mobilization or trimming, and (3) technical success.

Patient outcomes were then gathered from the electronic medical record, including length of stay during the index operation, repeat surgical intervention during the index admission, as well as surgical complications including hematoma, seroma, localized infection, and wound breakdown. Patient follow-up was then assessed for up to 1 year following microsurgical RLN repair. Referral to otorhinolaryngology (ENT) was noted, and postoperative follow-up visit notes were reviewed to assess subjective vocal outcomes and objective nasopharyngolaryngoscopy (NPL) findings of glottic closure. Patient vocal quality was retrospectively classified as none, mild, moderate, or severe hoarseness based on the grade, roughness, breathiness, and asthenia strain scale utilizing the vocal quality documented at follow-up.[25] NPL findings, when available, were recorded, and glottic gap, if present, was classified as small, moderate, or large based on the available report. Subjective vocal quality and glottic closure were compared between the initial and final postoperative visits. Any ENT interventions performed within 1 year as a result of RLN paralysis were recorded. This study utilized descriptive statistical methods, and all values were reported as frequencies and percent unless otherwise noted.

Results

Patient Population and Clinical History

Over the duration of the study, 11 patients met inclusion criteria. Demographic and clinical characteristics of the patients are summarized in ►**Table 1**. The median age was 48, and all patients were female. The cohort was predominantly white (8 of 11). All patients in the cohort underwent index surgery for thyroid pathology, including 46% ($n = 5$) with papillary carcinoma of the thyroid (one patient presented with nodal recurrence and metastatic disease involving the vagus nerve following prior thyroidectomy), 27% ($n = 3$) with goiter, 18% ($n = 2$) with thyroid nodules, and 9% ($n = 1$) with Graves' disease. Eighteen percent ($n = 2$) had previously undergone surgery to the neck, and none had previously underwent radiation. Eighty-two percent ($n = 9$) underwent total thyroidectomy (four underwent concurrent neck dissection), 9% ($n = 1$) underwent a right thyroid lobectomy, and 9% ($n = 1$) underwent a repeat neck dissection for recurrent disease.

Table 1 Demographic and clinical characteristics of the patients

Characteristic	Value ($n = 11$)
Demographic	
Age (y; median, Q1, Q3)	48 (38, 60)
Female sex	11 (100)
Race or ethnic group	
White	8 (73)
Black	2 (18)
Asian/Pacific Islander	1 (9)
Clinical	
Prior neck surgery	2 (18)
Prior neck radiation	0 (0)
Active immunosuppression	0 (0)
Indication for index operation	
Papillary carcinoma of thyroid[a]	5 (46)
Benign thyroid disease[b]	4 (36)
Thyroid nodules	2 (18)
Index operation	
Total thyroidectomy	5 (46)
Right thyroid lobectomy	1 (9)
Total thyroidectomy with neck dissection	4 (36)
Repeat neck dissection	1 (9)

Note: Q1 = quartile one, Q3 = quartile three. Unless otherwise noted, values are summarized as frequency (percent).
[a]One patient presented with recurrent papillary carcinoma of the thyroid with tumor involvement of the vagus nerve.
[b]Includes goiter (3) and Graves' disease (1).

Table 2 Details of recurrent laryngeal nerve injury and repair

Characteristic	Value ($n = 11$)
Injury	
Laterality	
Right	4 (36)
Left	7 (64)
Location	
Superior pole	3 (27)
Inferior pole	5 (46)
Other[a]	3 (27)
Etiology of injury	
Inflammatory changes	3 (27)
Planned sacrifice	3 (27)
Variant anatomy	2 (18)
Accidental transection	2 (18)
Excess traction	1 (10)
Repair	
Immediate intraoperative repair	11 (100)
Additional nerve mobilization prior to repair	7 (64)
Nerve trimming prior to repair	7 (64)
Repair technique	
Primary epineural repair of transected RLN	9 (82)
Vagus nerve to RLN epineural coaptation	1 (9)
Nerve graft	1 (9)
Technical success	11 (100)

Abbreviation: RLN, recurrent laryngeal nerve.
Note: Values are summarized as frequency (percent).
[a]Other locations of RLN injury include: proximal vagus nerve, ectopic anterior RLN branch, adjacent to larynx.

Details of Microsurgical Repair

Characteristics of RLN injury and repair are summarized in ►**Table 2**. RLN lacerations that underwent repair in this cohort were predominantly left-sided (7 of 11) and located adjacent to the inferior pole of the thyroid gland (5 of 11). RLN injury was primarily attributed to tumor-associated inflammation leading to difficult dissection or tumor involvement of the RLN in 54% of patients ($n = 6$). Other etiologies of injury include variant RLN anatomy in 18% ($n = 2$), accidental transection in 18% ($n = 2$), and traction injury in 9% ($n = 1$). Three of 11 RLN injuries were planned sacrifices.

All patients in the cohort underwent immediate intraoperative evaluation by the on-staff microsurgeon following injury. Nerve repair was performed under 3.5× loupe magnification. Sixty-four percent ($n = 7$) required additional nerve mobilization prior to repair, and 64% ($n = 7$) required further trimming of the lacerated nerve to yield healthy endoneural fascicles. Eighty-two percent ($n = 9$) underwent primary RLN coaptation utilizing interrupted 8-0 nylon suture. One patient required extensive resection of the proximal vagus nerve and the proximal RLN due to metastatic recurrence with nerve involvement. This patient underwent proximal vagus-distal RLN anastomosis utilizing interrupted 8-0 nylon suture. Finally, one patient was found to have tumor encasement of the left RLN. Planned RLN sacrifice yielded a 3.25-cm defect at the time of microsurgical evaluation. This defect was repaired with a 3-cm Avance Nerve Graft (Axogen Corporation, Alachua, FL) with conduit connectors sutured to the free nerve ends with interrupted 8-0 nylon suture. Technical success was reported in all 11 patients (100%).

Patient Outcomes

One patient underwent a repeat operation during the index admission for a suspected thoracic duct leak related to the initial oncologic resection. No other surgical complications were reported in the cohort. Seventy-three percent of patients ($n = 8$) in the cohort received referral to ENT for evaluation of vocal cord dysfunction. Clinical details of patient follow-up, including evaluating specialty, vocal quality, NPL findings, and interventions, are summarized

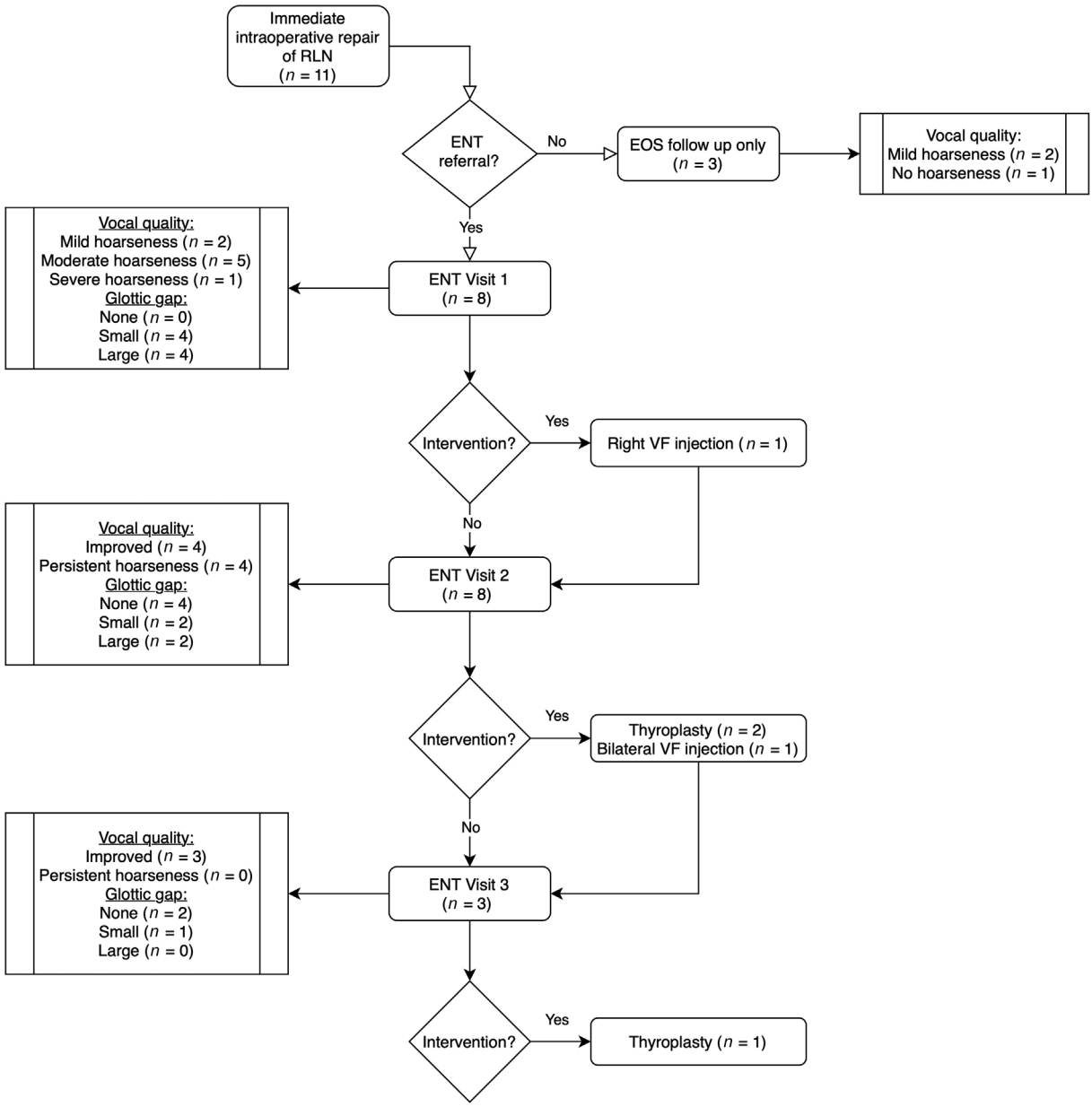

Fig. 1 A flowchart demonstrating patient follow-up, subsequent interventions, and vocal outcomes following immediate intraoperative repair of the recurrent laryngeal nerve. RLN, recurrent laryngeal nerve; ENT, otorhinolaryngology; EOS, endocrine/oncologic surgery; VF, vocal fold.

in ►**Fig. 1** and ►**Table 3**. Of patients who did not receive ENT referral, evaluation by the index endocrine surgeon found one patient to have no hoarseness and two to have mild hoarseness. None of these patients suffered from dysphagia. Given their mild symptoms, further vocal cord evaluation and intervention was not performed.

Of the eight patients who presented to their initial ENT office visit, 25% ($n = 2$) had mild hoarseness, 63% ($n = 5$) had moderate hoarseness, and 12% ($n = 1$) had severe hoarseness. NPL was performed in all patients. Half ($n = 4$) were found to have a small glottic gap, and the other half ($n = 4$) were found to have a large glottic gap. Following initial evaluation, only one patient underwent a right vocal fold injection.

At 6 months, 73% ($n = 8$) were found to have none to mild hoarseness, improved from baseline. No patients were found to have severe hoarseness at this time point. Forty-five percent ($n = 5$) did have persistent dysphagia. All four patients with a small glottic gap at the time of initial NPL were found to have vocal cord medialization and glottic gap closure. Of the patients with a large glottic gap at baseline, only two patients were found to have a persistent large glottic gap. Of the patients with a persistent glottic gap, one underwent vocal cord injection, and two underwent thyroplasty.

At 12 months, overall, 36% ($n = 4$) had complete resolution of hoarseness, and 45% ($n = 5$) had persistent mild hoarseness—improved from 6 months. Eighteen percent ($n = 2$) had persistent moderate hoarseness, while no patients had severe hoarseness at 1 year. Persistent dysphagia was now only present in 18% ($n = 2$). At this time point, of patients who underwent NPL, 63% ($n = 5$) were found to have complete glottic closure, and 32% ($n = 3$) were found to have a

Table 3 Patient follow-up and outcomes

Parameter	Value ($n = 11$)
Length of stay (d; median, Q1, Q3)	2 (1, 2)
Repeat operation[a]	1 (9)
ENT referral	8 (73)
Initial evaluation	
No hoarseness	1 (9)
Hoarseness – mild	5 (45)
Hoarseness – moderate	4 (36)
Hoarseness – severe	1 (9)
Dysphagia	7 (64)
No glottic gap	0 (0)
Glottic gap – small	4 (50)
Glottic gap – large	4 (50)
6-mo outcomes	
No hoarseness	2 (18)
Hoarseness – mild	6 (54)
Hoarseness – moderate	2 (18)
Hoarseness – severe	1 (9)
Dysphagia	5 (45)
No glottic gap	4 (50)
Glottic gap – small	2 (25)
Glottic gap – large	2 (25)
12-mo outcomes	
No hoarseness	4 (36)
Hoarseness – mild	5 (45)
Hoarseness – moderate	2 (18)
Hoarseness – severe	0 (0)
Dysphagia	2 (18)
No glottic gap	5 (62)
Glottic gap – small	3 (38)
Glottic gap – large	0 (0)
ENT intervention performed	4 (36)[b]
Thyroplasty	3
VF injection	2
Vocal therapy	4 (36)

Abbreviations: ENT, otorhinolaryngology; VF, vocal fold.
Note: Q1 = quartile one, Q3 = quartile three. Values are summarized as frequency (percent).
[a]One repeat operation performed for elevated Jackson-Pratt drain output concerning for thoracic duct leak.
[b]Four patients underwent five interventions. One patient underwent failed vocal fold injection followed by definitive thyroplasty.

small gap. Of note, the patient in the cohort who underwent an interposition nerve graft repair was found to have a persistent small glottic gap unresponsive to vocal fold injection, and was set to undergo definitive thyroplasty at the time of the presented study. Additionally, the patient in the cohort who underwent proximal vagus-distal RLN anastomosis did not require ENT referral and was found to have no hoarseness or dysphagia at 6 months.

Discussion

There remains limited definitive evidence regarding microsurgical repair of the RLN following iatrogenic injury as a modality for enhancing patient vocal recovery. The purpose of this study was to provide 15 years of microsurgical experience at a major academic center examining patient vocal and laryngeal outcomes following repair of the RLN to augment the existing literature on RLN repair. To the authors' knowledge, this is the first case series out of the United States to report on patient outcomes following microsurgical RLN repair. Overall, at 12 months compared to baseline, the incidence of no hoarseness increased fourfold, and the incidence of moderate-to-severe hoarseness decreased by 60%. Of patients who underwent NPL, five were found to have total medialization of the vocal folds (compared to zero at baseline) at 12 months.

Most commonly, patients suffered injury to the RLN during thyroid surgery because of tumor-associated inflammation or tumor encasement of the RLN requiring resection. All patients in this series underwent immediate intraoperative evaluation by the on-staff microsurgeon at our center. Though not examined specifically in RLN injury, prompt surgical repair has been implicated in maximizing nerve regeneration following injury.[26] Consistent with prior series,[13,14] most defects were amenable to direct RLN coaptation, though the majority (64%) required further nerve dissection and mobilization to assure a tension-free anastomosis. Two patients presented with larger defects necessitating alternative surgical approaches. One patient underwent successful nerve grafting utilizing a 3-cm interposition graft with nerve conduits, and the other underwent proximal vagus-RLN anastomosis. Though limited by small sample size, the overall surgical approach (aside from the utilization of nerve graft) did not appear to be associated with differences in long-term function.[22,23] These results suggest that perhaps surgical technique for RLN repair should be tailored to the underlying defect anatomy, as primary RLN coaptation or proximal vagus-RLN anastomosis were both associated with excellent vocal recovery.

Overall long-term outcomes for patients undergoing microsurgical repair of the RLN were generally excellent. Following repair, 27% of patients elected to forego further workup for vocal issues as they were largely asymptomatic or mildly symptomatic. Of those that sought further evaluation, only half required additional intervention for persistent glottic gap. Even without intervention, the majority of patients had closure of the glottic gap and none to mild hoarseness at 1 year. These results suggest that microsurgical repair of the RLN is an effective augmenter to physiologic neuronal regeneration following a potentially morbid injury. Patients should be appropriately counseled that despite repair, resolution of symptoms may take up to 1 year. Additionally, if initially unresponsive to conservative management at 6 months, they may strongly benefit from ENT intervention.

This study suffers from several limitations, most of which are derived from its retrospective nature and small sample size. The sample was designed to include all patients who underwent microsurgical repair of the RLN following injury. As such, there was no control group included. A 15-year period was used for the sample; however, only 11 patients met inclusion criteria, which limited the use of statistical analyses. Surgical repair technique was not controlled for and was operator-dependent based on the presented defect at the time of evaluation. Patient follow-up was also not consistent due to the retrospective nature of the study, as not all patients underwent ENT evaluation, nor did they undergo follow-up at prespecified intervals. Lastly, vocal quality and NPL findings were subjectively recorded from office notes and retrospectively classified. This therefore limited the generalizability of vocal outcomes, as patients or providers may have perceived the quality of their voice differently. Documentation of voice quality may have also been inconsistent.

Conclusion

Overall, microsurgical repair of the RLN following injury during thyroid surgery was a safe procedure with a technical success rate of 100%. Though evidence regarding management of RLN injury remains limited, the results of this study suggest that RLN repair may play a key role in RLN regeneration and patient recovery of vocal function, as at 1 year, the majority of patients had no or mild hoarseness and resolution of glottic gap. Further studies may be warranted to examine how differences in surgical technique, as well as novel adjuncts to RLN regeneration therapy may further impact patient recovery.

Funding
None.

Conflict of Interest
None declared.

References

1 Netter FH. Atlas of Human Anatomy. 7th ed. Philadelphia, PA: Elsevier; 2019
2 Jeannon J-P, Orabi AA, Bruch GA, Abdalsalam HA, Simo R. Diagnosis of recurrent laryngeal nerve palsy after thyroidectomy: a systematic review. Int J Clin Pract 2009;63(04):624–629
3 Nouraei SAR, Allen J, Kaddour H, et al. Vocal palsy increases the risk of lower respiratory tract infection in low-risk, low-morbidity patients undergoing thyroidectomy for benign disease: a big data analysis. Clin Otolaryngol 2017;42(06):1259–1266
4 Joliat G-R, Guarnero V, Demartines N, Schweizer V, Matter M. Recurrent laryngeal nerve injury after thyroid and parathyroid surgery: incidence and postoperative evolution assessment. Medicine (Baltimore) 2017;96(17):e6674
5 Cirocchi R, Arezzo A, D'Andrea V, et al. Intraoperative neuromonitoring versus visual nerve identification for prevention of recurrent laryngeal nerve injury in adults undergoing thyroid surgery. Cochrane Database Syst Rev 2019;1(01):CD012483
6 Ku D, Hui M, Cheung P, et al. Meta-analysis on continuous nerve monitoring in thyroidectomies. Head Neck 2021;43(12):3966–3978
7 Tian H, Pan J, Chen L, Wu Y. A narrative review of current therapies in unilateral recurrent laryngeal nerve injury caused by thyroid surgery. Gland Surg 2022;11(01):270–278
8 Kurz A, Volk GF, Arnold D, Schneider-Stickler B, Mayr W, Guntinas-Lichius O. Selective electrical surface stimulation to support functional recovery in the early phase after unilateral acute facial nerve or vocal fold paralysis. Front Neurol 2022;13:869900
9 Gaudin R, Knipfer C, Henningsen A, Smeets R, Heiland M, Hadlock T. Approaches to peripheral nerve repair: generations of biomaterial conduits yielding to replacing autologous nerve grafts in craniomaxillofacial surgery. BioMed Res Int 2016;2016:3856262
10 Wujek JR, Lasek RJ. Correlation of axonal regeneration and slow component B in two branches of a single axon. J Neurosci 1983;3 (02):243–251
11 Simó R, Nixon IJ, Rovira A, et al. Immediate intraoperative repair of the recurrent laryngeal nerve in thyroid surgery. Laryngoscope 2021;131(06):1429–1435
12 Chou F-F, Su C-Y, Jeng S-F, Hsu K-L, Lu K-Y. Neurorrhaphy of the recurrent laryngeal nerve. J Am Coll Surg 2003;197(01):52–57
13 Gurrado A, Pasculli A, Pezzolla A, et al. A method to repair the recurrent laryngeal nerve during thyroidectomy. Can J Surg 2018; 61(04):278–282
14 Hong JW, Roh TS, Yoo H-S, et al. Outcome with immediate direct anastomosis of recurrent laryngeal nerves injured during thyroidectomy. Laryngoscope 2014;124(06):1402–1408
15 Ward GM, Sauder C, Olson GT, Nuara MJ. Longitudinal voice outcomes following laryngeal reinnervation via vagus-to-recurrent laryngeal nerve anastomosis after vagal nerve sacrifice: a case series. Ann Otol Rhinol Laryngol 2015;124(02):153–157
16 Miyauchi A, Ishikawa H, Matsusaka K, et al. Treatment of recurrent laryngeal nerve paralysis by several types of nerve suture [in Japanese]. Nippon Geka Gakkai Zasshi 1993;94(06):550–555
17 Yuan Q, Hou J, Liao Y, Zheng L, Wang K, Wu G. Selective vagus-recurrent laryngeal nerve anastomosis in thyroidectomy with cancer invasion or iatrogenic transection. Langenbecks Arch Surg 2020;405(04):461–468
18 Miyauchi A, Matsusaka K, Kihara M, et al. The role of ansa-to-recurrent-laryngeal nerve anastomosis in operations for thyroid cancer. Eur J Surg 1998;164(12):927–933
19 Yumoto E, Sanuki T, Kumai Y. Immediate recurrent laryngeal nerve reconstruction and vocal outcome. Laryngoscope 2006;116 (09):1657–1661
20 Sanuki T, Yumoto E, Minoda R, Kodama N. The role of immediate recurrent laryngeal nerve reconstruction for thyroid cancer surgery. J Oncol 2010;2010:846235
21 Lee SW, Park KN, Oh SK, Jung C-H, Mok J-O, Kim C-H. Long-term efficacy of primary intraoperative recurrent laryngeal nerve reinnervation in the management of thyroidectomy-related unilateral vocal fold paralysis. Acta Otolaryngol 2014;134(11):1179–1184
22 Kumai Y, Kodama N, Murakami D, Yumoto E. Comparison of vocal outcome following two different procedures for immediate RLN reconstruction. Eur Arch Otorhinolaryngol 2016;273(04):967–972
23 Yoshioka K, Miyauchi A, Fukushima M, Kobayashi K, Kihara M, Miya A. Surgical methods and experiences of surgeons did not significantly affect the recovery in phonation following reconstruction of the recurrent laryngeal nerve. World J Surg 2016;40(12):2948–2955
24 Iwaki S, Maeda T, Saito M, et al. Role of immediate recurrent laryngeal nerve reconstruction in surgery for thyroid cancers with fixed vocal cords. Head Neck 2017;39(03):427–431
25 Dejonckere PH, Obbens C, de Moor GM, Wieneke GH. Perceptual evaluation of dysphonia: reliability and relevance. Folia Phoniatr (Basel) 1993;45(02):76–83
26 Jonsson S, Wiberg R, McGrath AM, et al. Effect of delayed peripheral nerve repair on nerve regeneration, Schwann cell function and target muscle recovery. PLoS One 2013;8(02):e56484