

Superior Laryngeal Nerve Preservation in Open Thyroid Surgery: Focus on the External Branch

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Abstract

Loss of upper register, projection, or vocal endurance after thyroidectomy can be missed when both vocal folds move normally. Injury to the external branch of the superior laryngeal nerve (EBSLN) is one possible cause. This narrative review examines the anatomy that matters during open thyroidectomy, dissection of the superior pole, intraoperative neural monitoring (IONM), and the investigation of postoperative voice symptoms. The EBSLN lies close to the superior thyroid vessels and is the superior laryngeal branch most likely to be encountered during routine thyroidectomy. The internal branch takes a higher course and presents a different clinical problem. Cernea and Friedman classifications are helpful for anticipating exposure, although neither can define the nerve's position in an individual operative field. Safe dissection still depends on seeing the structures around the upper pole, avoiding sustained traction, and controlling small vascular branches close to the capsule. Energy devices require the same attention. Stimulation can help locate the nerve and document conduction, but a cricothyroid twitch and an endotracheal electromyographic waveform should be interpreted separately. Randomized studies generally report better identification with IONM. Findings for voice are less uniform, in part because the studies used different endpoints and follow-up periods. An intraoperative loss of signal is therefore not equivalent to a permanent clinical deficit. Routine use of IONM depends on local equipment and experience; it is particularly useful when the nerve is displaced, hidden, or difficult to separate from the superior pedicle. When postoperative symptoms persist, evaluation should include other neural, structural, and intubation-related causes. Preservation is best judged from the preoperative voice, the operative record, and subsequent functional assessment.

Keywords

Thyroidectomy, Open Thyroid Surgery, External Branch of the Superior

Laryngeal Nerve, Cricothyroid Muscle, Intraoperative Neuromonitoring, Voice Outcomes

1. Introduction

EBSLN dysfunction is often noticed only during demanding voice use. A patient may converse without obvious hoarseness yet struggle to sing, teach, speak loudly, or maintain the voice through a long day. The cricothyroid muscle adjusts vocal-fold tension and contributes to pitch control, which explains this pattern. Even so, the history is not specific. Intubation injury, edema, altered laryngeal mechanics, and excessive compensatory muscle activity can produce similar complaints [1]. Normal vocal-fold movement and a change in upper range should prompt further assessment rather than an immediate diagnosis of EBSLN palsy.

Operative risk is concentrated at the superior pole. Here the EBSLN crosses the superior thyroid pedicle at a variable height, and a large gland may draw the nerve into the dissection plane. The position also changes with retraction. Voice guidelines include preservation of the EBSLN among the goals of thyroid surgery, and international monitoring standards describe methods of stimulation and functional mapping [2] [3]. The following sections consider how much exposure is useful, what IONM actually shows, and how postoperative symptoms should be investigated after open surgery.

2. Review Scope and Evidence Selection

PubMed/MEDLINE was searched from inception through September 8, 2026. The main terms were “superior laryngeal nerve,” “external branch of the superior laryngeal nerve,” “EBSLN,” “thyroidectomy,” “open thyroid surgery,” “superior pole,” “cricothyroid,” “intraoperative neuromonitoring,” “voice,” “dysphonia,” “laryngoscopy,” “stroboscopy,” and “laryngeal electromyography.” We combined related terms with AND and OR and limited the search to English-language publications. References cited in major guidelines, reviews, and randomized trials were checked for additional studies.

We included guidance documents, anatomical and operative studies, randomized trials, comparative observational studies, systematic reviews, and meta-analyses relevant to adults undergoing conventional open thyroidectomy. Older reports were retained when they established an anatomical classification or operative concept still used today. Studies confined to remote-access thyroidectomy were excluded unless the finding also applied to open surgery. Small diagnostic series were used for questions that had not been addressed in larger cohorts. Mechanistic studies of energy devices were considered only when discussing thermal injury. Because this was a narrative review, records were not screened independently by two reviewers, formal risk-of-bias scoring was not undertaken, and no new pooled analysis was performed. We kept visual identification, electrophys-

iological findings, and patient-reported voice outcomes separate during interpretation.

3. Anatomy That Changes the Operation

3.1. External and Internal Branches

The superior laryngeal nerve leaves the vagus and divides into internal and external branches at a variable level. The external branch descends beside the inferior pharyngeal constrictor toward the cricothyroid muscle and passes close to the superior thyroid pedicle. Its small caliber and partial muscular coverage may make stimulation positive before the nerve is visible [1]. By contrast, the internal branch travels with the superior laryngeal artery through the thyrohyoid membrane and supplies much of the supraglottic sensation. It usually lies above the plane used for superior-pole vessel control. Injury to this branch becomes a consideration when sensory loss or impaired airway protection is suspected [4].

Anatomical communications between the laryngeal nerves can complicate interpretation. Galen's anastomosis joins the internal laryngeal nerve to the recurrent laryngeal nerve; it is not the usual motor pathway of the EBSLN [5]. Separate connections between the EBSLN and recurrent laryngeal nerve have also been demonstrated [6]. These connections may carry an evoked response to muscles detected by an endotracheal electrode. Their presence and size vary, so they cannot be assumed to preserve cricothyroid function after EBSLN injury.

3.2. Complementary Classifications

Cernea classification describes the crossing point of the EBSLN relative to the upper pole. A type 1 nerve crosses the superior thyroid vessels more than 1 cm above the pole. Type 2a crosses within 1 cm, whereas type 2b passes below the upper border of the gland and directly enters the usual area of pedicle division [7]. The classification is an operative relationship rather than a fixed measurement in the neck. Enlargement of the gland and the direction of traction may alter the position seen during surgery.

Friedman classification addresses muscular coverage. The nerve may remain superficial to the inferior constrictor, run partly within its lower fibers, or be covered by the muscle. This distinction is useful when deciding whether further visual exploration is likely to help [8]. The frequency of each pattern varies across published series. In a meta-analysis of 56 studies and 13,444 hemilarynges, identification rates and subtype distributions differed between cadaveric and operative studies [9]. Surgeons should therefore avoid treating a prevalence estimate from one series as an anatomical rule.

Neither classification measures nerve function. Their main value is to warn that exposure may be difficult. A prospective cohort of 136 patients found associations between some low-crossing or partly intramuscular courses, intraoperative amplitude changes, and postoperative acoustic findings [10]. These results support closer attention to such anatomy, but they do not predict injury in an individual

patient. A small amplitude change also cannot establish permanent palsy without clinical follow-up.

4. Establishing a Meaningful Preoperative Baseline

The preoperative interview should cover existing voice change, fatigue, loss of high notes, swallowing difficulty, previous neck surgery, and the amount of voice use required at work. Ordinary conversation in the clinic may fail to reproduce a problem that appears after prolonged speaking or singing. Guidelines recommend documenting the preoperative voice in every patient. Examination of vocal-fold mobility is indicated when the voice is abnormal and in selected higher-risk cases, including previous relevant neck surgery and suspected extrathyroidal tumor extension [2]. A recorded baseline is essential when postoperative symptoms are later compared with pre-existing function.

Assessment of a professional voice user should include a task that resembles the intended work. Randolph *et al.* reported outcomes in 27 singers and other vocal professionals who underwent monitored thyroidectomy. All returned to performance, but fatigue, restricted upper range, and reduced pitch control were common during recovery [11]. Without a control group, the study cannot attribute this course to monitoring. It does illustrate the need for individualized counseling: return to ordinary speech may precede a comfortable return to professional use. A singing-specific questionnaire or recorded vocal sample may capture this difference better than a general voice score.

5. Protection during Superior-Pole Dissection

5.1. Exposure and the Extent of Identification

Superior-pole dissection should begin with a view of the upper pole, cricothyroid muscle, inferior constrictor, and the vessels that will be divided. The medial plane beside the pole and the sternothyroid insertion on the thyroid cartilage help orient the search. Ng *et al.* identified the EBSLN in 111 of 127 attempted lobectomies and related its entry into muscle to the sternothyroid insertion [12]. This landmark is useful for orientation. The reported distance, however, should not be used as a fixed point for incision in another patient.

Extensive exposure of the EBSLN is seldom necessary. The surgeon needs enough information to protect the nerve during the next step: a short visible segment, its direction, or a repeatable stimulation response may be adequate. Friedman *et al.* reported high identification rates with a systematic anatomical approach [8]. A recent prospective series visualized 82 of 100 nerves [13], leaving nearly one fifth unconfirmed by sight. When the nerve is covered by constrictor muscle, cutting additional fibers simply to display a longer segment may increase risk without improving vessel control.

5.2. Vessel Control and Traction

Branches of the superior thyroid vessels are usually safest when isolated and con-

trolled one at a time close to the capsule. The segment placed in a ligature, clip, or sealing device should be short and visible. Capsular dissection limits unnecessary lateral work but does not create an absolute safe zone, since a type 2b nerve may also lie near the gland. An apparently avascular plane can still contain neural tissue. Visual identification or stimulation should clarify the intended vessel division rather than encourage a larger field of dissection [3] [13].

Retraction is useful only while it improves the view. When the upper pole is held under excessive tension, the nerve may be stretched and the tissue planes become harder to judge. Releasing the pole or changing the angle of traction is appropriate if the next vessel cannot be seen [3]. Bleeding should first be managed with pressure and suction until the vessel stump and surrounding tissue are visible. Blind application of a broad clamp can include the EBSLN [1] [3]. A normal response to stimulation before this event documents function at that moment; it does not protect the nerve during subsequent hemostasis.

5.3. Energy Devices and the Planned Extent of Resection

The amount of heat delivered near a nerve varies with the device, power setting, activation time, intervening tissue, and residual jaw temperature. Most experimental safety data concern the recurrent laryngeal nerve and often come from animal models. They support short activation, physical separation, and adequate cooling, but they cannot provide a universal 3 - 5 mm margin for every device and operative setting [14]. In a confined field where the EBSLN cannot be separated confidently, cold division followed by a tie or clip may give better control [1] [14]. Recently activated jaws can remain hot after the device has stopped, including the surface turned away from the nerve.

Nerve protection should not compromise the planned thyroid resection. There is no established role for routinely leaving upper-pole tissue to protect the EBSLN. Similarly, a suspected tumor should not be opened to create more working space. Failure to separate the nerve warrants a fresh assessment of the exposure and the likely cause, which may be displacement, scar, or true invasion. Any decision to limit resection or sacrifice an involved structure belongs to the oncological strategy and informed consent, rather than to routine mobilization of the upper pole.

6. What Intraoperative Neural Monitoring Adds

6.1. Identification and Interpretation

During stimulation, conduction through the EBSLN is suggested by contraction of the ipsilateral cricothyroid muscle. Stimulating the muscle directly does not test the proximal nerve. Endotracheal surface electrodes may record an evoked laryngeal waveform, while some studies use a needle electrode placed in the cricothyroid muscle. A stable response obtained before superior-pole dissection and again after the vessels have been divided documents continuity at those two time points [3].

The cricothyroid twitch and the endotracheal waveform should be documented separately. Anatomical connections may transmit the stimulus to muscles in con-

tact with the tube electrode, but this pathway is variable [6]. Waveform quality also depends on tube position, electrode contact, neuromuscular blockade, stimulation technique, and the tissue between probe and nerve. Loss of a trace requires technical troubleshooting before nerve injury is diagnosed. Conversely, a preserved final waveform cannot rule out all causes of postoperative dysphonia. Intermittent stimulation provides selected checks during the operation; it is not continuous surveillance.

6.2. Comparative Evidence

Barczyński *et al.* randomized 210 women to visual identification alone or visual identification combined with IONM. Final analyses included 101 patients and 202 nerves in the visual group and 100 patients and 200 nerves in the monitored group. Identification was a nerve-level outcome; voice was assessed by patient. Videostrobolaryngoscopy was performed preoperatively and on postoperative day 1, with repeat examinations at 3 and 6 months if abnormalities persisted. Phonation testing took place at 2 - 3 weeks and 3 months. Early deterioration meant a decrease of at least 10% in maximum phonation time, voice level, or fundamental frequency, or an increase of more than four GRBAS points. IONM increased identification from 34.3% to 83.8% and was associated with fewer early abnormalities. The voice differences were no longer present at 3 months [15]. Thus, the trial supports improved identification and a short-term functional benefit but does not demonstrate the same reduction in permanent disability.

In the trial by Masuoka *et al.*, 252 patients were assigned to recording-based monitoring or conventional hand-held stimulation. Nerve identification was reported per nerve. The secondary clinical endpoint was patient-level voice impairment at 3 months, assessed by phonation testing and the EBSLN Voice Impairment Index-5. Visual identification occurred in 48.8% of monitored nerves and 17.8% of conventionally stimulated nerves; the corresponding rates for identification by stimulation were 89.2% and 17.8%. Women in the monitoring group reported less subjective impairment [16]. The control group was not unstimulated, so the study compared different approaches to mapping and recording. It did not equate an intraoperative electrical event with permanent palsy.

Uludag *et al.* enrolled 133 patients with 211 nerves at risk. Sixty-five patients (105 nerves) underwent superior-pole dissection without a deliberate attempt to identify the EBSLN. In the monitored arm, 68 patients (106 nerves) underwent IONM-assisted identification. Injury was defined by loss of the intraoperative cricothyroid electromyographic response after dissection. Results were reported both per patient and per nerve, and Voice Impairment Index-5 scores were obtained before surgery and at 1, 3, and 6 months. Electrophysiological injury was recorded in 9 of 105 control nerves and 1 of 106 monitored nerves; postoperative voice scores also favored monitoring [17]. These figures should always be quoted with their nerve-level denominator.

Aygun *et al.* published a randomized study in 2026 using a cohort enrolled dur-

ing 2015-2016. Both groups underwent recurrent laryngeal nerve monitoring during superior-pole dissection, but only the intervention group had specific mapping of the EBSLN. The study defined injury as absent or lost cricothyroid electromyographic activity after completion of thyroidectomy and analyzed the result per nerve at risk. The endpoint occurred in 15.4% of control nerves and 2.1% of monitored nerves [18]. Since the measurement was made at the end of surgery, these values represent intraoperative electrophysiological events rather than permanent clinical palsy rates.

The same pattern appears in the pooled evidence. A 2019 meta-analysis of seven studies found a higher EBSLN identification rate with IONM [19]. Evidence for a lasting improvement in voice remains less secure. Control procedures, denominators, definitions of injury, and voice tests varied between studies, as did the timing of assessment. An event recorded immediately after dissection cannot be combined uncritically with a deficit that persists months later.

Deliberate protection of the EBSLN is part of every superior-pole dissection, but device use may reasonably differ between institutions. Routine IONM is practical where equipment, trained staff, and a consistent protocol are available. In other settings, selective use is most defensible for large goiters, upper-pole tumors, reoperations, or anatomy that remains uncertain after exposure. This position follows current guidance: monitoring adds functional information but does not replace direct, controlled dissection [2] [3].

7. Situations That Require Additional Planning

A large goiter or upper-pole nodule can shift the EBSLN downward into the working plane. In an early series of very large goiters, Cernea *et al.* observed a type 2b course in 7 of 13 nerves [20]. The sample is too small for a reliable prevalence estimate. It nevertheless shows why a landmark derived from an undistorted gland may be misleading. The nerve-vessel relationship should be reassessed as mobilization proceeds, and vessel division should wait until the immediate anatomy is clear. Stimulation is especially helpful when the nerve is only partly visible.

Hypervascular disease and reoperative surgery create different problems. Bleeding can rapidly obscure a plane that was previously clear, whereas scar may remove the expected plane entirely. Preoperative control of the underlying disease, review of prior operative notes, and the availability of an experienced team are therefore important. Neither situation justifies blind high ligation of the superior thyroid artery or mandatory dissection from a distant landmark. The approach should begin through identifiable, relatively undisturbed tissue. IONM may be helpful, although trials dominated by uncomplicated primary operations do not directly establish its effect in every high-risk subgroup [9] [19].

8. Recognizing and Managing Suspected Injury

8.1. Assessment after Surgery

Postoperative assessment should ask about the activity that exposes the problem:

high notes, sustained speech, projection, or a familiar singing task. Flexible laryngoscopy documents vocal-fold movement and may reveal edema or another structural cause. If mobility is preserved, stroboscopy and selected acoustic measures may clarify persistent symptoms. In three patients with electromyographically confirmed superior laryngeal weakness, phonatory findings included ipsilateral bowing and shortening, unequal vocal-process height, and false-fold hyperadduction; there was no shared abnormality at rest [21]. A three-case report cannot define a diagnostic pattern. Cricothyroid needle electromyography is useful when confirmation of denervation would alter diagnosis or counseling, but the value of the study depends on timing and operator experience [22]. Permanent injury should not be assigned on the basis of a single early visit.

Voice guidelines recommend documenting postoperative change between 2 weeks and 2 months and arranging laryngeal examination when a change is present [2]. Earlier assessment is warranted for severe dysphonia, airway concern, or suspected aspiration. Dysphagia and choking deserve a separate evaluation because they are not specific for internal-branch injury. When aspiration is suspected, instrumental swallowing assessment can define the impairment and guide diet or rehabilitation [23].

A stepwise evaluation is useful when voice symptoms persist despite normal vocal-fold mobility. The first step is to document the complaint with a patient-reported measure and a task that reproduces it. Flexible laryngoscopy follows, with stroboscopy when the initial examination is unrevealing. Cricothyroid laryngeal electromyography is reserved for cases in which the result would change the diagnosis, prognosis, or discussion with the patient. Referral to a laryngologist and speech-language pathologist then allows treatment to be matched to the identified disorder [2] [22] [23]. This sequence also reduces the chance of labeling structural, inflammatory, or compensatory dysphonia as EBSLN palsy.

8.2. Response to Functional Loss

An unexpected loss of intraoperative response requires a pause. The team should first check the equipment, tube or electrode position, neuromuscular blockade, and stimulation method, then review the last operative step. Traction can be released immediately. A recently placed ligature should be reassessed if signal loss followed its application [3] [22]. Confirmed transection requires specialist judgment about repair, as no single reconstructive method has been shown to restore normal dynamic cricothyroid function reliably. Voice during the first postoperative days is too early to judge neural recovery or the result of repair.

Treatment of persistent dysfunction is guided by the cause and by how much the deficit affects the patient. Voice therapy may lessen excessive effort and maladaptive compensation. Structural or neuromuscular procedures require laryngological assessment [23]. Nasser and Maragos reported improvement in most of nine patients treated with combined type IV and type I thyroplasty for unilateral superior laryngeal weakness [24]. This small uncontrolled series does not provide

routine indications for patients after thyroidectomy. Vitamins and so-called neurotrophic medication also lack evidence for restoration of EBSLN function. Decisions about further treatment should follow serial symptoms and objective findings rather than a promised recovery interval or an automatic operation at 6 months.

9. Remaining Evidence Gaps

Future trials should distinguish four endpoints: visual identification, stimulation-confirmed continuity, cricothyroid denervation, and voice disability that persists after recovery. Identification is an operative process measure and cannot show whether a singer, teacher, or other professional voice user has regained previous performance. The control dissection must also be described in detail, because adding IONM often changes how the surgeon searches for the nerve. Baseline voice testing, transparent control-group methods, results reported by both patient and nerve at risk, and longer follow-up would make comparisons between studies more meaningful.

The field may benefit more from consistent documentation than from another anatomical subtype. A prospective operative record could note the superior-pole relationship, the length of nerve exposed, and the response before and after each critical vascular step. Operating time and cost should be reported, together with access to postoperative voice assessment. New recording methods will matter clinically only if they are linked to durable voice function and outcomes that patients can recognize.

10. Conclusion

EBSLN preservation during open thyroidectomy begins with exposure of the superior pole, limited traction, individual control of vascular branches, and careful use of energy. IONM improves nerve identification and has shown advantages for some early outcomes, although evidence for prevention of permanent voice disability remains limited. Institutions with an established protocol may use monitoring routinely; selective use is reasonable when the anatomy is distorted or uncertain. The internal branch has a different course and function, so sensory or swallowing complaints require separate consideration. In clinical practice, the strongest evidence of preservation comes from agreement between the preoperative voice, documented findings during surgery, and structured postoperative follow-up.

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Ethics Approval and Consent to Participate

The study was approved by the Institutional Ethics Committee of Jingzhou First People's Hospital (approval No. YJ202525). This retrospective study was based on

an existing clinical database and was conducted in accordance with institutional ethical requirements.

Consent for Publication

Not applicable.

Availability of Data and Materials

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Author Contributions

Lei Tang: Conceptualization, data curation, formal analysis, investigation, methodology, and writing—original draft. Chuanchang Yin: Conceptualization, methodology, supervision, and writing—review and editing. All authors read and approved the final manuscript.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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