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**Zhen Wu**

Beijing Tongren Hospital, Capital Medical University

**Jugao Fang** (✉ [fangjugao2@ccmu.edu.cn](mailto:fangjugao2@ccmu.edu.cn))

Beijing Tongren Hospital, Capital Medical University

**Hongzhi Ma**

Beijing Tongren Hospital, Capital Medical University

**Xiao Chen**

Beijing Tongren Hospital, Capital Medical University

**Qi Zhong**

Beijing Tongren Hospital, Capital Medical University

**Lizhen Hou**

Beijing Tongren Hospital, Capital Medical University

**Junwei Huang**

Beijing Tongren Hospital, Capital Medical University

**Ru Wang**

Beijing Tongren Hospital, Capital Medical University

**Xixi Shen**

Beijing Tongren Hospital, Capital Medical University

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## Research Article

**Keywords:** External Branch of the Superior Laryngeal Nerve, Transoral Endoscopic, Papillary Thyroid Cancer, Protection Function, Sternothyroid Muscle

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# Protection of the external branch of the superior laryngeal nerve in Transoral endoscopic thyroidectomy vestibular approach (TOETVA): an observational study

Zhen W<sup>1,2</sup>, Jugao F<sup>1\*</sup>, Hongzhi M<sup>1</sup>, Xiao C<sup>1</sup>, Qi Z<sup>1</sup>, Lizhen H<sup>1</sup>, Junwei H<sup>1</sup>, Ru W<sup>1</sup>, Xixi S<sup>1</sup>

1. Thyroid Center, Beijing Tongren Hospital, Capital Medical University, Beijing 100730, P.R. China;

2. Department of Thyroid and Breast Surgery, Liaocheng People's Hospital, Liaocheng hospital affiliated to Shandong first medical university, Liaocheng 252000, Shandong, China

Correspondence to: Dr Jugao Fang, Thyroid Center, Beijing Tongren Hospital, Capital Medical University, Beijing 100730, P.R. China.

E-mail: fangjugao2@ccmu.edu.cn

## Abstract

**Background:** Avoiding injury of the external branch of the superior laryngeal nerve (EBSLN) is one of the major challenges during thyroid surgery, especially in transoral endoscopic thyroidectomy vestibular approach (TOETVA). This study aimed to investigate the protective strategies of the EBSLN during TOETVA.

**Methods:** In order to protect the EBSLN during TOETVA, we adopted the method of identification the nerve by anatomy and localization. The method of anatomy involves the dissection of EBSLN by complete transection of the sternothyroid muscle in the attachment of the thyroid cartilage. The method of localization involves nerve stimulation localization, which produces cricothyroid contractile activity through intraoperative nerve monitoring stimulation (IONM). Concurrently, patients were evaluated preoperatively and at 1 and 3 weeks postoperatively in an individual prospective cohort study using a stroboscopic laryngoscope and the voice handicap index-10 (VHI-10). The VHI-10 score was used to evaluate voice changes.

**Results:** We retrospectively analyzed patients with papillary thyroid cancer (PTC) who underwent TOETVA in the thyroid center of the Beijing Tongren hospital between February 2018 and June 2020. Patients with recurrent laryngeal nerve (RLN) damage were excluded. Sixty patients were enrolled in this study, of which four underwent total thyroidectomy. Intraoperatively, 56 EBSLNs were located (56/64, 87.50%). Among these, the left EBSLN was identified in 20/25(80.00%) and the right EBSLN was identified in 36/39 (92.31%) cases. One week postoperatively, a blinded stroboscopic laryngoscope examination showed that no patient had paresis of the EBSLN. However, the VHI-10 score was significantly higher than the preoperative value ( $10.58 \pm 4.54$  vs.  $3.00 \pm 1.54$ ,  $p < 0.01$ ). At three weeks postoperatively, the overall score was still different from that preoperatively ( $4.83 \pm 3.34$  vs.  $3.00 \pm 1.54$ ,  $p < 0.01$ ); however, the vast majority of patients returned to their preoperative status.

**Conclusion:** In TOETVA, the EBSLN can be well exposed by transection of the sternothyroid muscle, and combined with IONM, the protection of the function of the EBSLN can be guaranteed. Simultaneously, we observed that TOETVA could cause a short-term voice handicap in patients, with such changes generally returning to normal within three weeks.

**Keyword:** External Branch of the Superior Laryngeal Nerve; Transoral Endoscopic; Papillary Thyroid Cancer; Protection Function; Sternothyroid Muscle

## 1. Introduction

Due to the advantage of leaving no scars, transoral endoscopic thyroidectomy (TOET) gradually developed in China<sup>[1]</sup> and abroad and quickly became a hot research topic. In 2016, Anuwong<sup>[2]</sup> reported for the first time the transoral endoscopic thyroidectomy vestibular approach (TOETVA). More and more reports indicate that TOETVA is a safe and cosmetic alternative for well-selected patients<sup>[2-5]</sup>. However, TOETVA still has some problems, including oncologic concerns of cancer seeding and local recurrence, the significant learning curve, and the potential for injury to the recurrent laryngeal nerve (RLN) or the mental nerve (MN)<sup>[6-8]</sup>. Meanwhile, due to the problem of the TOETVA approach, the superior extreme of the thyroid is difficult to be exposed, and the injury of the external branch of the superior laryngeal nerve (EBSLN) may occur, but there are few reports in this regard<sup>[9-10]</sup>. Some scholars have pointed out that during TOETVA, the superior thyroid artery and vein are ligated as close to the thyroid as possible, and the EBSLN is preserved by avoiding its anatomical exposure<sup>[11]</sup>.

However, the EBSLN is in closed anatomical proximity to the superior thyroid vessels and there is heterogeneity in the anatomy of the EBSLN. The EBSLN can be easily injured when the vessels of the superior thyroid are separated close to the gland, especially when it is difficult to expose the superior pole of the thyroid from the perspective of TOETVA surgery in a cephalic to caudal manner<sup>[12]</sup>. In addition, in endoscopic surgery, only an ultrasonic device can be used to cut off the blood vessels. When used blindly, thermal damage by the ultrasonic device may cause damage to the EBSLN. We believe that dissection to expose the EBSLN may provide better protection. However, surgical dissection to locate the EBSLN may result in unnecessary trauma and adversely affect voice quality.

What are the more appropriate ways of protecting the EBSLN during TOETVA surgery? To address this question, this study was undertaken to identify the feasibility associated with a safe preservation of the EBSLN with transection of the sternothyroid muscle.

## 2. Materials and methods

### 2.1 Patients

This retrospective study was undertaken in the thyroid center of the Beijing Tongren hospital from February 2018 to June 2020. Inclusion criteria for patients followed the expert consensus of Chinese thyroid surgeons consisted of all patients diagnosed with papillary thyroid cancer by preoperative fine needle aspiration biopsy and those who underwent total thyroidectomy for bilateral micropapillary thyroid carcinoma. Exclusion criteria for this study included (1) patients with confirmed intraoperative injury of the RLN, and (2) patients who could not complete the follow-up task. This study was approved by our hospital. Written informed consent was obtained from each patient and the study was conducted in accordance with the Declaration of Helsinki.

### 2.2 Surgical technique

In this study, we completely transected the sternothyroid muscle near the attachment of the thyroid cartilage (Figure 1) and opened an avascular plane between the superior pole and

the thyroid cartilage, which is called Joll's space [9] (Figure 2). In this space, the EBSLN could be identified beneath the thyroid suspensory ligament. Meanwhile, using intraoperative nerve monitoring stimulation (IONM) to stimulate the EBSLN at 1.0 mA, we assessed the cricothyroid muscle (CTM) twitch and electromyography (EMG) response. IONM was realized by connecting the nerve monitor wire with the electrocoagulation hook. We could safely continue to dissect and ligate the superior thyroid vessels. If the CTM twitching was weak and the estimation of the location of the EBSLN was difficult, we would ligate the superior thyroid artery and vein as close to the superior thyroid pole as possible.

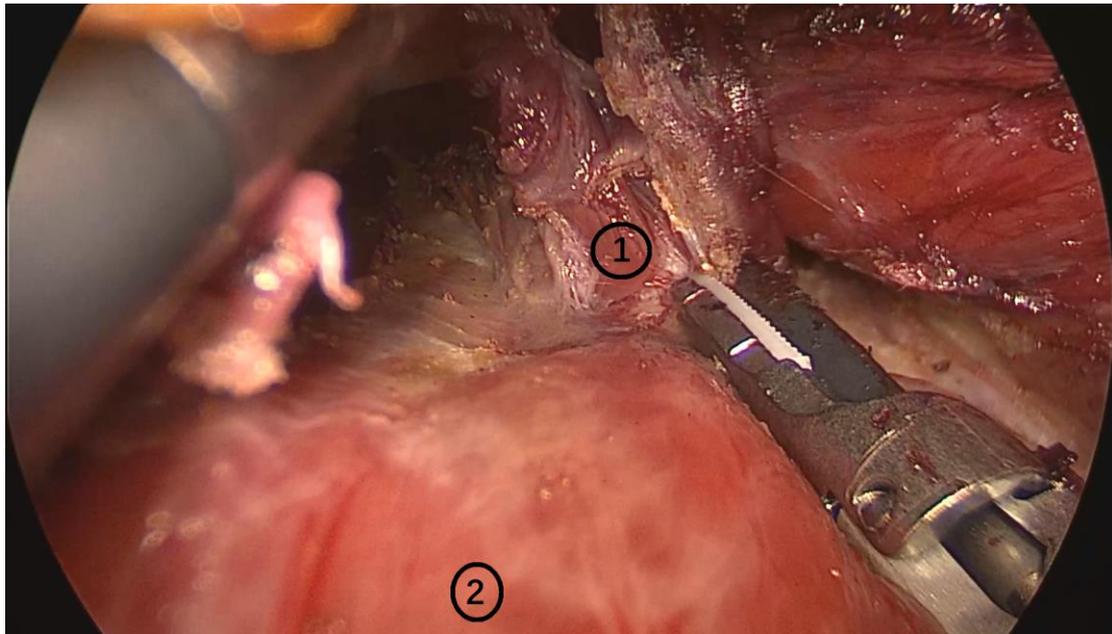


Figure 1 The sternothyroid muscle was transected at an attachment point on the thyroid cartilage, and was pushed to the sternal side, exposing the lobe of the thyroid gland. Here, ① represents the transverse sternothyroid muscle, and ② represents the thyroid gland lobe.

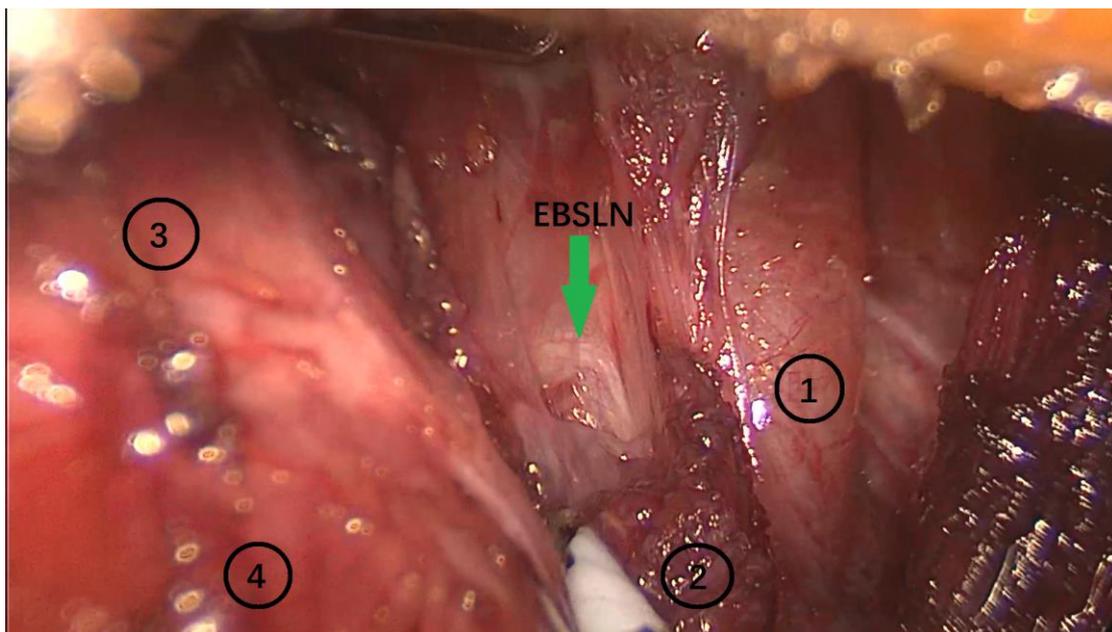


Figure 2 The thyroid gland was pulled outward and downward to expose Joll's space. In Joll's

space, we looked for the EBSLN. ① is the superior polar gland of the thyroid; ② is the transverse sternothyroid muscle; ③ is the cricothyroid muscle (CTM) and ④ is the throat.

### 2.3 Objective voice analysis

Stroboscopic laryngoscopy was performed one week postoperatively, to further exclude any damage to the RLN and observe whether there was damage to the EBSLN. Patients with special symptoms were reevaluated three weeks later. We evaluated the voice changes in all patients using the voice handicap index-10 (VHI-10). Patients filled in the 10-item VHI-10 questionnaire<sup>[13]</sup>. The VHI-10 is one of the most psychometrically robust, well-studied, and efficient instruments among various instruments used to measure self-perceived voice related quality of life. The investigation time nodes were designed preoperatively, and at one and three weeks postoperatively.

### 2.4 Statistics

Statistical analysis was performed using SPSS 20.0 (IBM SPSS statistics 20.0.0; SPSS Inc, Chicago, IL). Continuous data are summarized as mean  $\pm$  interval of confidence 95%. Vocal motility was evaluated with the Student's t-test, for paired sample test on parametric variables. P values below 0.05 were considered significant.

## Results

The data of 60 patients who underwent TOETVA were retrieved from the clinical database. All patients had papillary thyroid carcinoma and underwent central lymph node dissection. Four underwent total thyroidectomy and 56 underwent lobectomy. There were 50 females and 10 males, with an average age of  $36.98 \pm 9.27$  years. Median operation time was  $240.63 \pm 66.39$  min. Mean postoperative drainage volume was  $111.79 \pm 38.24$  ml, and average postoperative hospital stay was  $4.04 \pm 1.35$  days. The clinical data of all patients including postoperative complications are shown in Table 1.

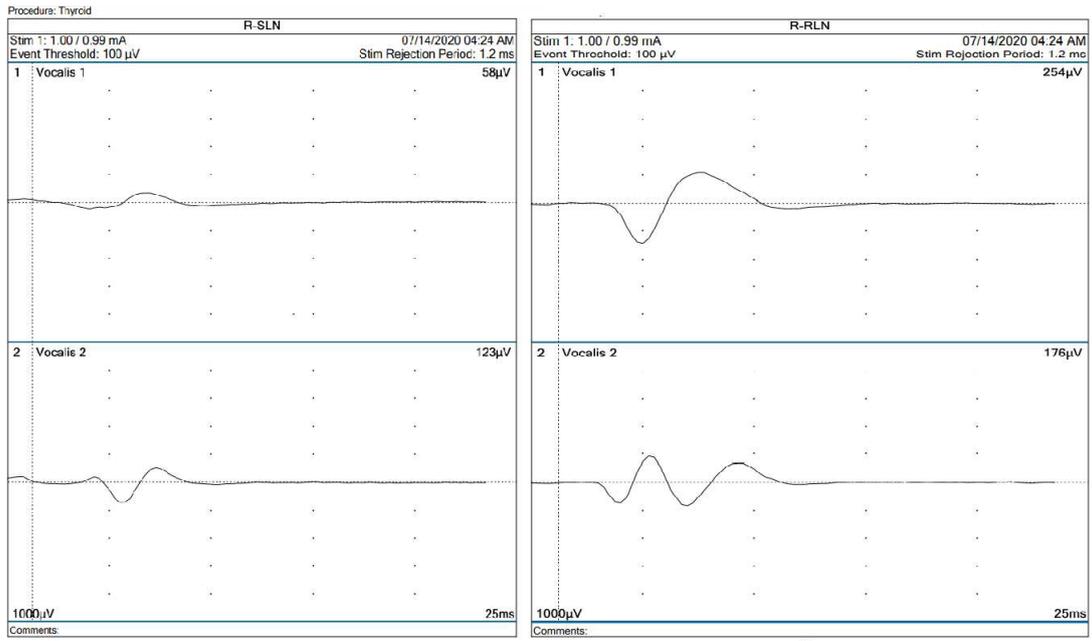
In this study, left lobectomy was performed in 25 cases, and right lobectomy was performed in 39 cases. In all these 64 lobes, the EBSLN was identified in 56/64 cases (87.50%) and unidentified in 8/64 (12.50%) cases. Among these, the left EBSLN was identified in 20/25 (80.00%) and the right EBSLN was identified in 36/39 (92.31%) cases. CTM twitching was observed in all patients, and potentiometric wave images were present in some patients (Figure 3).

After completely transecting the sternothyroid muscle, the superior polar vessels of the thyroid could be severed under direct vision. Even the presence of superior pole vascular bleeding could be easily managed to avoid injury to the EBSLN (Figure 4).

One week postoperatively, stroboscopic laryngoscope monitoring showed that no patients had changes in vocal cord tension. In all patients, the VHI-10 score was significantly higher than that of the preoperative value ( $10.58 \pm 4.54$  vs.  $3.00 \pm 1.54$ ,  $p < 0.01$ ). After three weeks, the overall score was still different from that preoperatively ( $4.83 \pm 3.34$  vs.  $3.00 \pm 1.54$ ,  $p < 0.01$ ); however, the vast majority of patients returned to their preoperative status (Figure 5).

Table 1 demographic data and operative details

Characteristics and details	Value
Age (median, years)	36.98±9.27
Sex (male/female)	10/50
Tumor location (left lobe/right lobe)	21/39
Operation time (median, min)	240.63±66.39
Postoperative drainage (median, ml)	111.79±38.24
postoperative hospital stay (median, days)	4.04±1.35
Postoperative complication (cases)	
infection	1
seroma	1
Skin damage	1
Tracheal injury	0
Postoperative bleeding	0
Conjunctivitis	1
Permanent RLN palsy	0
Mental nerve injury	0
Permanent hypoparathyroidism	3



**a**

**b**

Figure 3 When IONM stimulated the EBSLN, CTM twitching was observed in all patients, and potentiometric wave images were present in some patients (see Figure 3a), and the waveform of the EBSLN was completely different from that of the RLN (see Figure 3b).

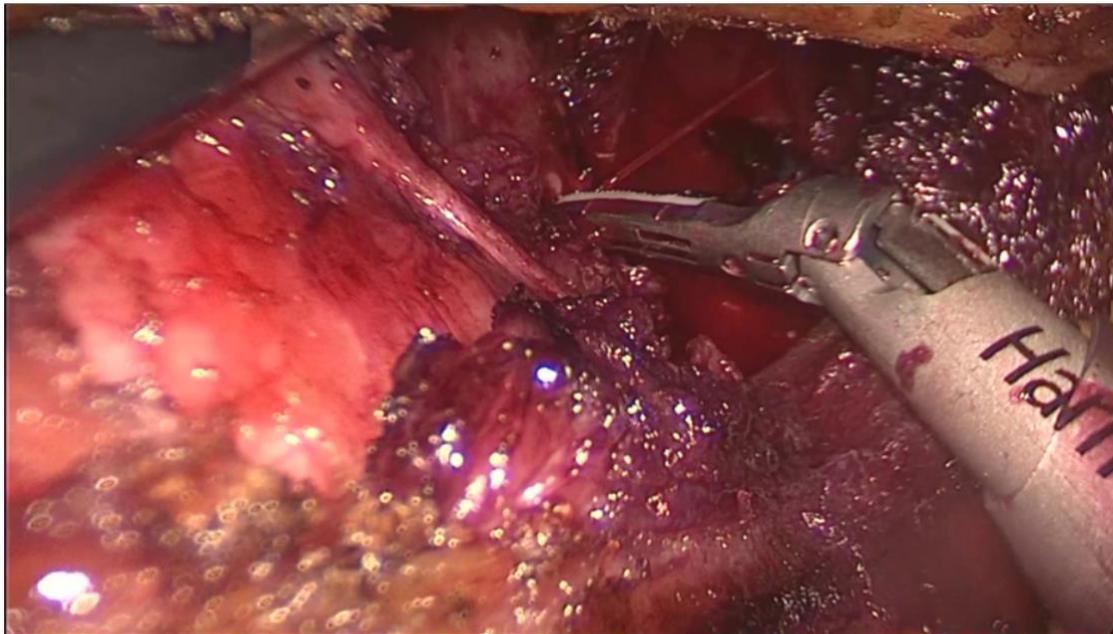


Fig 4a

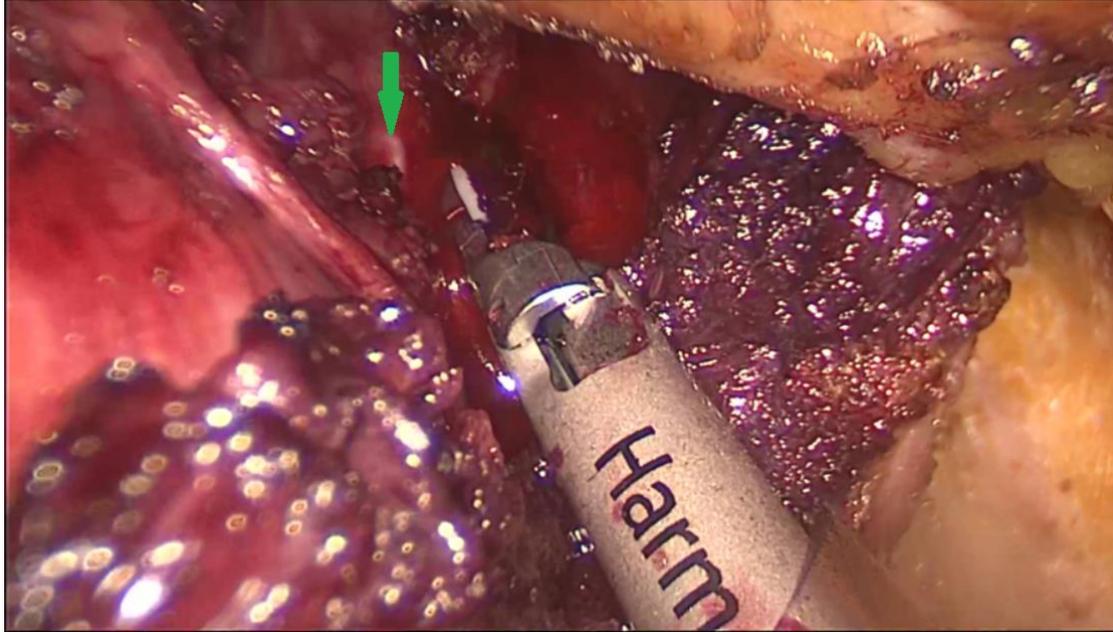


Fig4b

Figure 4 The bleeding point of the superior thyroid artery could be found under direct vision. The bleeding point could be clipped with an ultrasonic knife, and the non-functional head of the ultrasonic knife could be kept away from the EBSLN to avoid injury to the EBSLN. The arrow in the figure indicates the EBSLN.

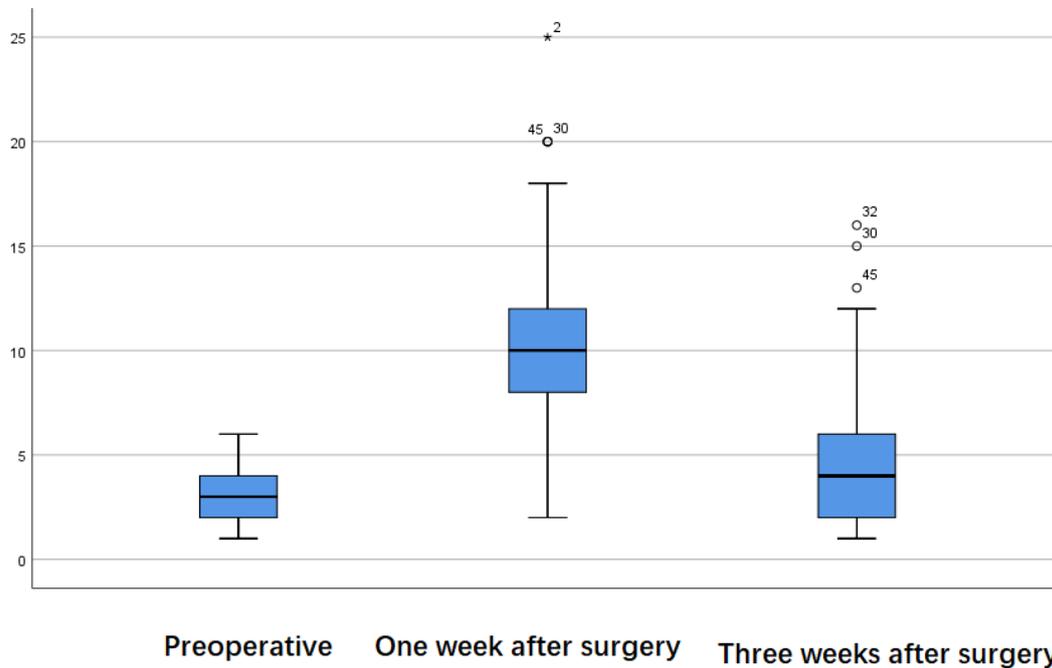


Figure 5 Three weeks postoperatively, the vast majority of patients returned to their preoperative status.

#### 4. Discussion

Due to the angle of approach, it is difficult to expose the upper pole of the thyroid during

TOETVA surgery, which may lead to the injury of the EBSLN. Moreover, EBSLN has an average diameter of only 0.8 mm<sup>[14]</sup> and is closely related to the vessels of the upper pole of the thyroid gland, which is prone to misbinding, thermal damage and even disconnection. The reported prevalence of EBSLN injury varies widely. It is reported in the literature that the EBSLN is injured in up to 58% of patients undergoing thyroidectomy<sup>[15]</sup>. Our previous study showed that in most cases (56%), the EBSLN is located close to the thyroid superior pole under physiological conditions, and it is prone to be injured during thyroid surgery<sup>[16]</sup>.

However, EBSLN iatrogenic injury is considered the most commonly underestimated complication in thyroidectomy because vocal assessment underestimates such events and laryngoscopic postoperative evaluation does not show standardized findings<sup>[17]</sup>. Injury to the EBSLN can result in detrimental voice changes, which may impact the quality of voice with varying degrees of severity, which is more noticeable in professional voice users<sup>[18]</sup>. As the number of surgical patients, especially young women, increases every year, and postoperative quality of life becomes a major indicator of surgical success, more doctors realize that intraoperative protection of the EBSLN is as significant as that of the RLN. The protection of the EBSLN is very justified.

Recently, IONM provides multiple advantages in the EBSLN surgical approach. Several studies demonstrated that IONM was a more effective method than traditional visualization in localizing the EBSLN<sup>[19]</sup>. During EBSLN stimulation, CTM twitching is noted in patients. Therefore, some scholars have proposed that the process of dissecting exposed EBSLN may cause nerve damage, and the IONM region protection method can be used to protect the EBSLN. Close to the gland, the vessels in the upper pole of the thyroid are manipulated as if removing a hat<sup>[12]</sup>.

We believe that the treatment of the superior pole vessels closely attached to the gland may result in residual glands or inaccurate treatment of the superior pole vessels, resulting in postoperative bleeding. Furthermore, the use of a simple clingy gland treatment may also result in the disconnection of the EBSLN or in thermal damage by the ultrasonic scalpel. In particular, in some patients with superior pole vascular bleeding, such as the patients mentioned in this article, only the dissection of the EBSLN can avoid injury.

During surgery, we would cut off the sternothyroid muscle in the attachment of the thyroid cartilage, while pushing the muscle stump toward the head with the ultrasonic knife, concurrently, pulling the upper pole outwards and down with the uninjured grasping forceps. After sufficient separation of the body of the larynx from the superior polar gland, the EBSLN is usually exposed in an avascular area. The exposure rate of the EBSLN in our data was 87.50%; and the right EBSLN was more exposed. We found that the anatomical exposure of the EBSLN could permit a safer manipulation of the superior pole vessels, even with hemorrhage of the superior pole vessels, it could be clipped safely and avoided injury to the EBSLN. At the same time, pushing the transverse sternothyroid muscle to the side of the sternum can better expose the thyroid gland and lymph nodes in the central region, which is conducive for lymph node dissection in the central region.

Previous studies have confirmed that the disconnection of the sternothyroid muscle has no effect on sound changes after thyroid surgery<sup>[20]</sup>. IONM provides regional protection for hard-to-view EBSLN. Cricothyroid muscle tremor was observed with 1 mA stimulation to indicate the location of the EBSLN. Our data shows that it is better to use both methods to

protect the EBSLN. The steps to protect the EBSLN were outlined in the 2013 guidelines<sup>[14]</sup>: ①Expose of the space harboring the EBSLN; ②Bluntly dissect the tissues; ③Stimulate the tissues during dissection; ④Look for a cricothyroid twitch; ⑤Navigate your dissection using the technique of nerve mapping.

In addition, we found that after thyroid surgery, patients might present with pronunciation discomfort for a variety of reasons, possibly due to surgical stimulation or drainage tube placement. The VHI-10 score was significantly higher 1 week postoperatively than the preoperative values. However, most patients returned to normal after 3 weeks. In our study, stroboscopic laryngoscope monitoring showed that no patients had changes in vocal cord tension.

## **5. Conclusion**

In TOETVA, the EBSLN can be well exposed by transection of sternothyroid muscle, and combined with IONM, the function of the EBSLN can be well protected. At the same time, we observed that TOETVA could cause short-term voice handicap in patients, with such changes generally returning to normal within three weeks.

## **Acknowledgement**

Not applicable.

## **Authors' contributions**

ZW, HZM and XC participated in study design, operation technique and data analysis. JGF conceived the study. All authors read and approved the final manuscript.

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## **Availability of data and materials**

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

## **Ethics approval and consent to participate**

This study was approved by Capital Medical University affiliated Beijing Tongren hospital. Written informed consent was obtained from each patient and the study was conducted in accordance with the Declaration of Helsinki. Informed consents were received from the patient.

## **Consent for publication**

Written informed consent was obtained from each patient.

## **Competing interests**

The authors indicated no potential conflicts of interest.

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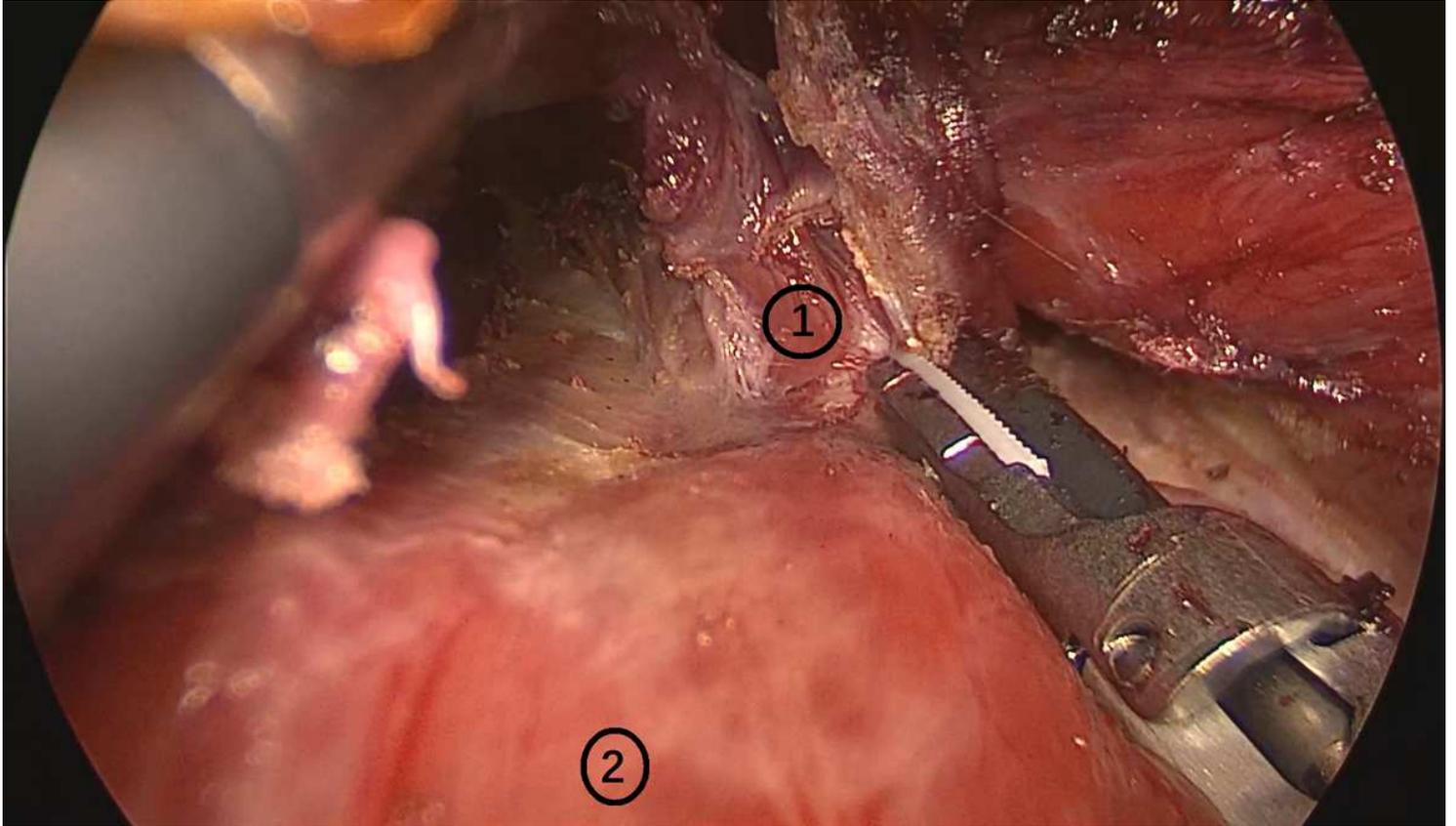
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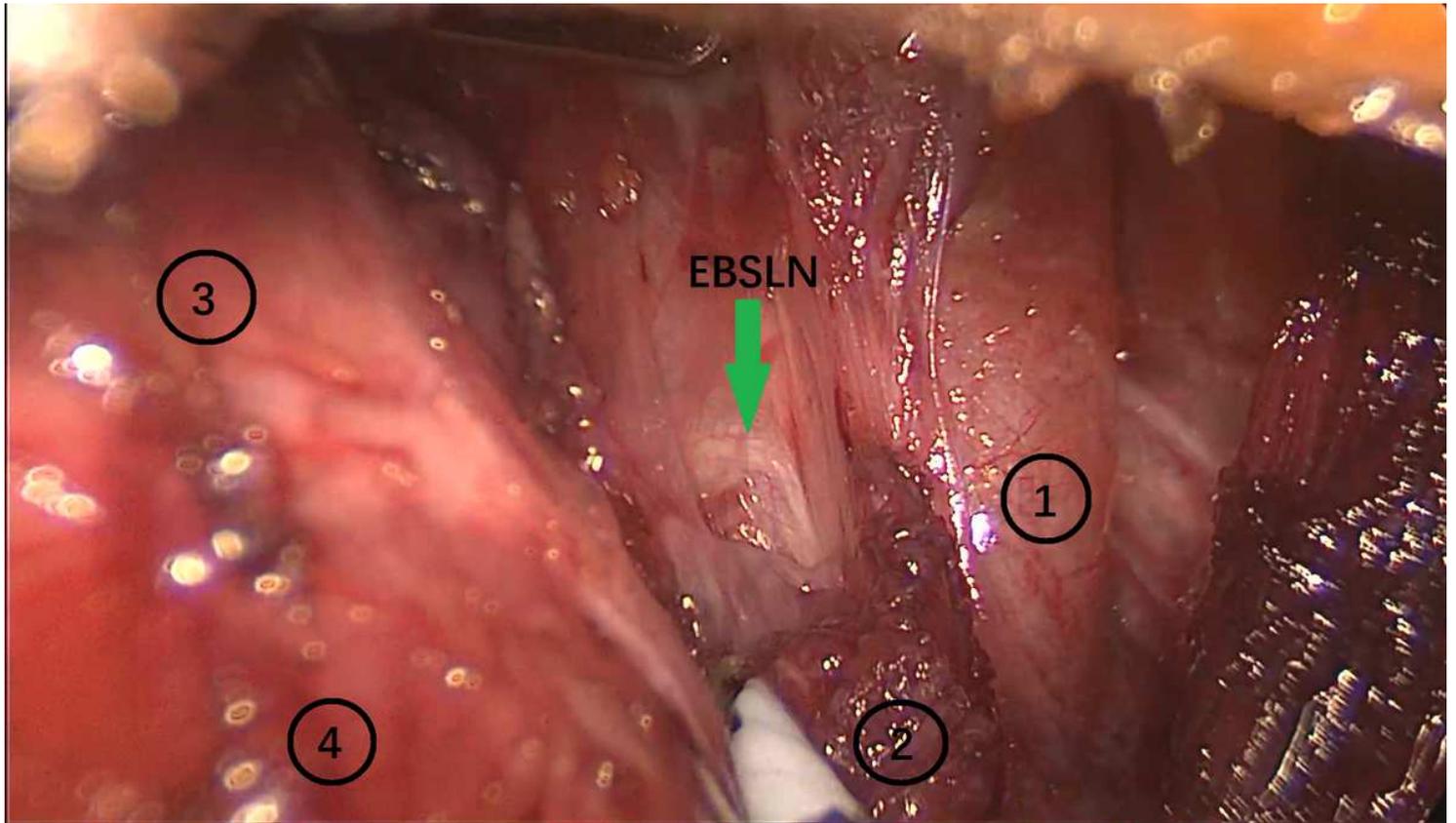
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## Figures



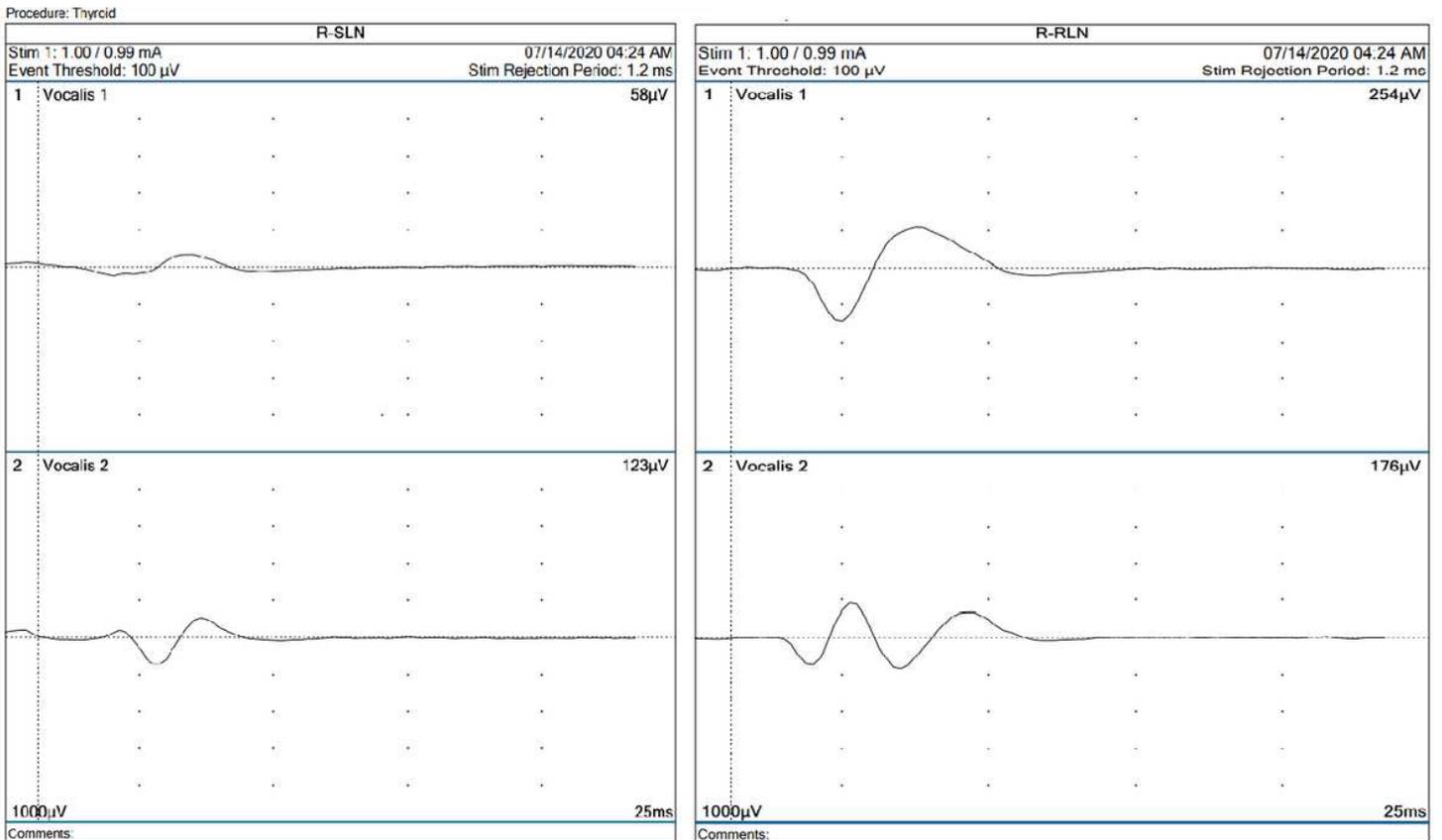
**Figure 1**

The sternothyroid muscle was transected at an attachment point on the thyroid cartilage, and was pushed to the sternal side, exposing the lobe of the thyroid gland. Here, ① represents the transverse sternothyroid muscle, and ② represents the thyroid gland lobe.



**Figure 2**

The thyroid gland was pulled outward and downward to expose Joll's space. In Joll's space, we looked for the EBSLN. (1) is the space, we looked for the EBSLN. (2) is the superior polar gland of the thyroid; (3) is the superior polar gland of the thyroid; (4) is the transverse sternothyroid muscle; (5) is the cricothyroid muscle (CTM) and (6) is the throat.) and (7) is the throat.

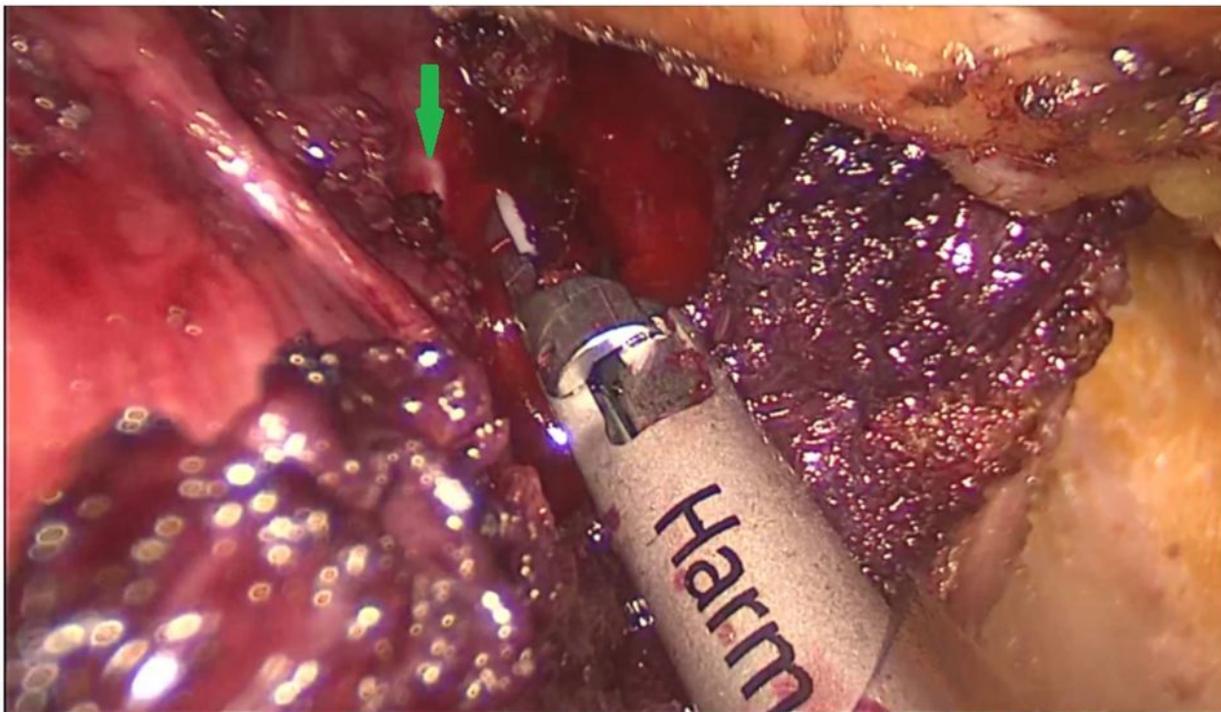
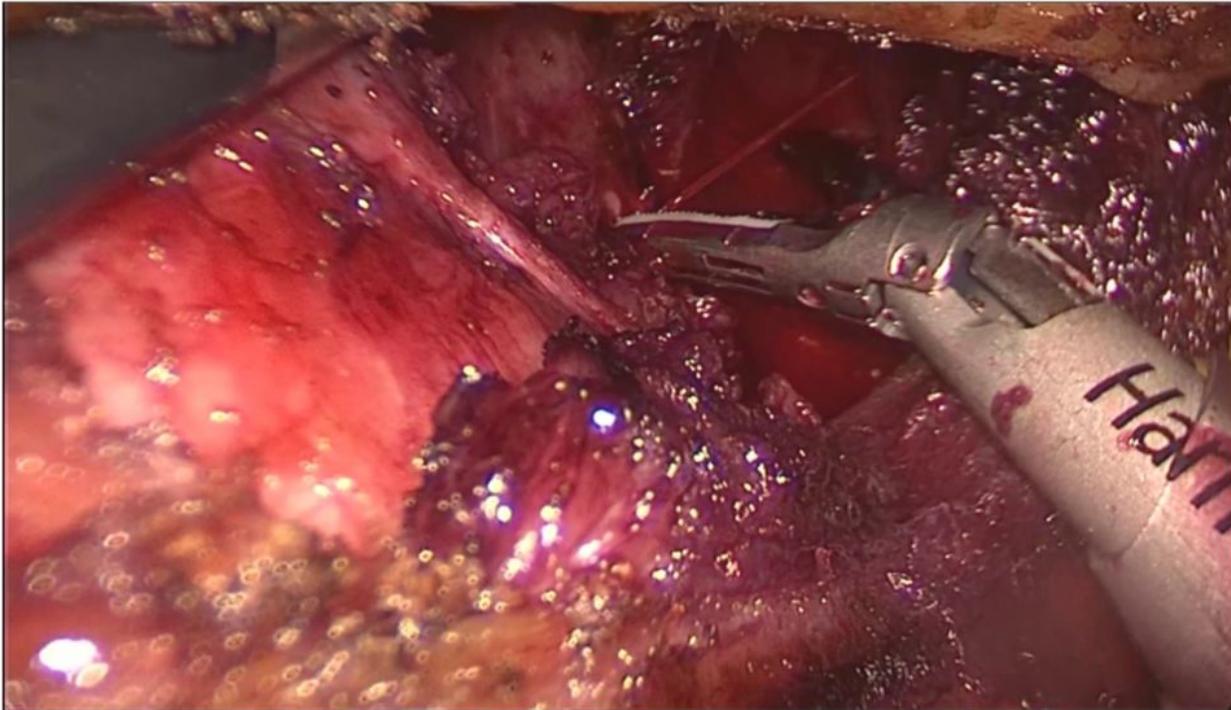


**a**

**b**

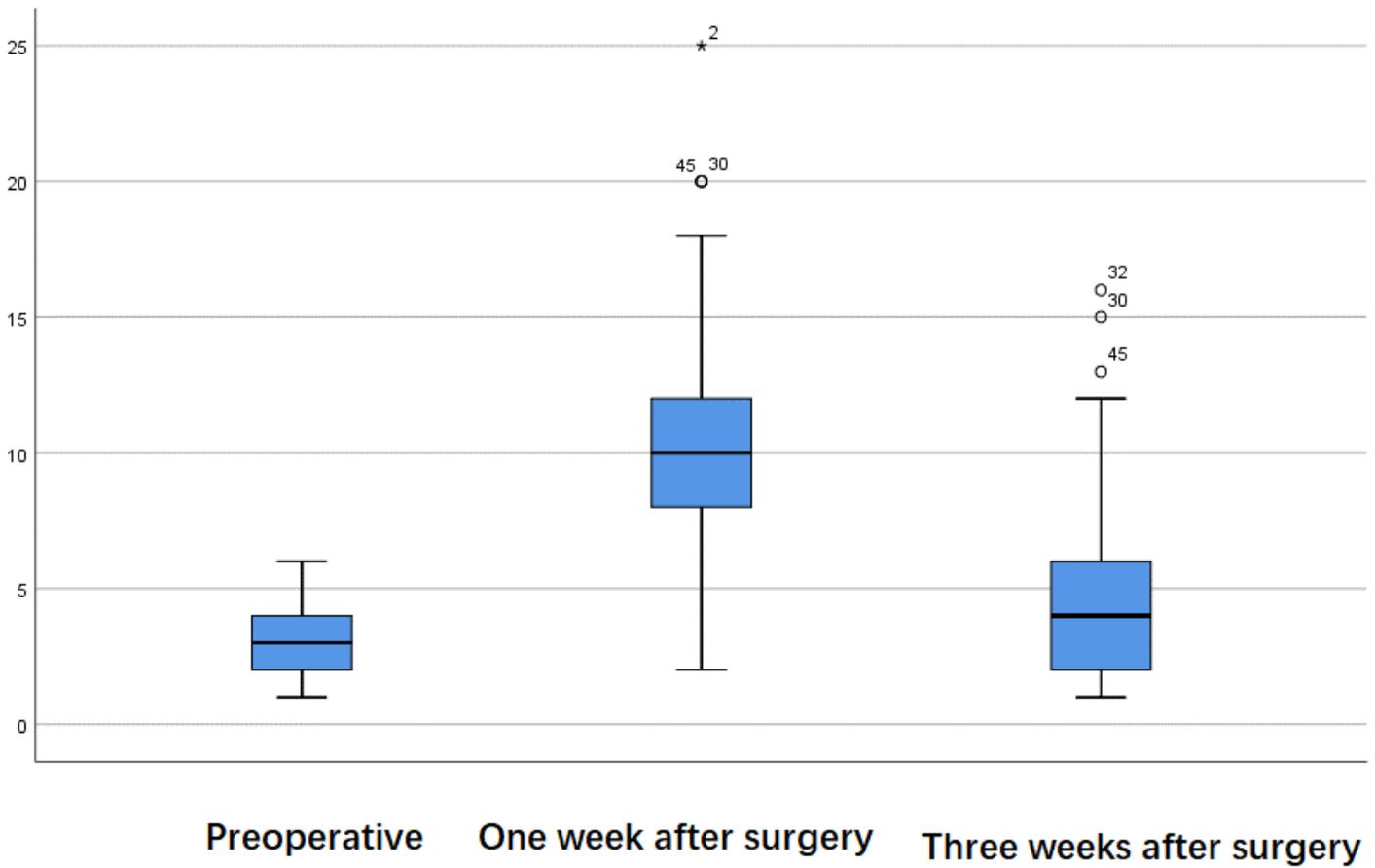
**Figure 3**

When IONM stimulated the EBSLN, CTM twitching was observed in all patients, and potentiometric wave images were present in some patients (see Figure 3a), and the waveform of the EBSLN was completely different from that of the RLN (see Figure 3b).



**Figure 4**

The bleeding point of the superior thyroid artery could be found under direct vision. The bleeding point could be clipped with an ultrasonic knife, and the non functional head of the ultrasonic knife could be kept away from the EBSLN to avoid injury to the EBSLN. The arrow in the figure indicates the EBSLN.



**Figure 5**

Three weeks postoperatively, the vast majority of patients returned to their preoperative status.