

# The Effect of Different Hemostatic Systems on the Injury of the External Branch of the Superior Laryngeal Nerve in Thyroidectomy

## Tiroidektomi Ameliyatında Kullanılan Farklı Damar Kapama Sistemlerinin Süperior Laringeal Sinirin Eksternal Dalı Yaralanması Üzerine Etkisi

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### ABSTRACT

**Introduction:** Vessel-sealing and ultrasonic coagulation systems that provide rapid and effective hemostasis are widely used in thyroid surgery. An important disadvantage of these systems is injury to the neighboring anatomical structures by thermal damage. However, data on injury to the external branch of the superior laryngeal nerve is limited. The aim of this study was to evaluate the effect of different vascular closure systems on this nerve injury in thyroidectomy.

**Methods:** A total of 45 patients who underwent thyroidectomy for benign thyroid disease between October 2008 and February 2009 were included in the study. Patients were randomized and divided into three groups, each consisting of 15 patients. Systems used were vessel-sealer in the first group, harmonic scalpel in the second group and conventional suture ligation technique in the third group. Laryngeal electromyography findings and voice complaints were compared.

**Results:** There were 37 female (82%) and 8 male patients. The mean age was 47.9±11.1 years. Demographic features and surgical procedures were statistically similar in all groups (p>0.05). The control electromyography of 84 nerves with preoperatively confirmed normal findings showed that three (10.7%) of the 28 nerves in the vessel sealer group, two (7.1%) of the 28 nerves in the harmonic scalpel group, and two (7.1%) of the 28 nerves in the suture ligation group had complete or partial nerve injury (p>0.05). No significant difference was found between the groups in terms of voice complaints (p>0.05).

**Conclusion:** Compared to the conventional suture ligation technique, the use of vascular closure devices does not increase the risk of injury to the external branch of the superior laryngeal nerve.

**Keywords:** Electromyography, external branch of the superior laryngeal nerve, nerve injury, thyroidectomy, vascular closure systems

### ÖZ

**Amaç:** Hızlı ve etkin bir şekilde hemostaz sağlayan damar mühürleyici ve ultrasonik koagülasyon sistemleri tiroid cerrahisinde yaygın bir şekilde kullanılmaktadır. Bu sistemlerin bir dezavantajı termal hasar yolu ile komşu anatomik yapılara zarar verebilmesidir. Ancak süperior laringeal sinirin eksternal dalının yaralanması ile ilgili veriler sınırlıdır. Bu çalışmanın amacı tiroidektomi ameliyatında kullanılan farklı damar kapama sistemlerinin bu sinir yaralanması üzerine olan etkisini değerlendirmektir.

**Yöntemler:** Çalışmaya Ekim 2008 ile Şubat 2009 tarihleri arasında selim tiroid hastalığı nedeni ile tiroidektomi ameliyatı yapılan toplam 45 hasta dahil edildi. Hastalar randomize edilerek her biri 15'er hastadan oluşan toplam üç gruba ayrıldı. Ameliyatta ilk grupta damar mühürleyici, ikinci grupta harmonik kesici ve üçüncü grupta klasik sütür ile bağlama tekniği kullanıldı. Hastaların laringeal elektromiyografi bulguları ve ses şikayetleri karşılaştırıldı.

**Bulgular:** Hastaların 37'si kadın (%82), 8'i erkek ve yaş ortalaması 47,9±11,1 yıl idi. Demografik özellikler ve cerrahi işlemler tüm gruplarda istatistiksel olarak benzer bulundu (p>0,05). Ameliyat öncesi elektromiyografi bulguları normal olan 84 adet sinirin kontrol incelemesinde damar mühürleyici grubunda 28 sinirin 3'ünde (%10,7), harmonik kesici grubunda 28 sinirin 2'sinde (%7,1) ve klasik sütür ile bağlama grubunda 28 sinirin 2'sinde (%7,1) tam veya parsiyel sinir yaralanması mevcuttu (p>0,05). Ses şikayetleri açısından gruplar arasında anlamlı fark saptanmadı (p>0,05).

**Sonuç:** Damar kapama cihazlarının kullanımı klasik sütür bağlama tekniği ile karşılaştırıldığında, süperior laringeal sinirin eksternal dalı yaralanması riskini artırmadığı görülmektedir.

**Anahtar Kelimeler:** Elektromiyografi, süperior laringeal sinirin eksternal dalı, sinir yaralanması, tiroidektomi, damar kapama sistemleri



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Cite this article as/Atıf: Özben V, Özgültekin R, Adatepe N, Kaytaç A. The Effect of Different Hemostatic Systems on the Injury of the External Branch of the Superior Laryngeal Nerve in Thyroidectomy. İstanbul Med J 2019; 20(2):119-24.

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Received/Geliş Tarihi: 31.01.2018

Accepted/Kabul Tarihi: 16.10.2018

## Introduction

Thyroidectomy requires good anatomic exposure, careful dissection and adequate hemostasis. The principles of safe and effective thyroid surgery were standardized by Emil Theodor Kocher and Theodor Billroth between 1873-1883, and the mortality rate decreased to less than 5% thanks to this technique that reduces bleeding with the ligation of the arteries of the thyroid gland (1). Although this principle is still valid, morbidity rates have decreased with the increase in experience and the use of modern techniques.

In recent years, alternatives to electrocoagulation have been developed and been widely used in thyroid surgery, such as bipolar vessel sealer and ultrasonic cutter, which provide rapid and effective hemostasis (2-4). However, a disadvantage of these systems is that they can damage adjacent anatomical structures by direct or lateral thermal spread (5-7). These adjacent structures include the external branch of the superior laryngeal nerve (EBSLN), and in particular, injury to the nerve occurs during the dissection of the upper pole of the thyroid gland (8,9). EBSLN is the only nerve that innervates the cricothyroid muscle, which is the tensor of the vocal cords, and its injury may lead to hoarseness, loss of strength of the voice, vocal fatigue and inability to achieve high pitch tasks (10,11).

Although there are many studies in the literature on the effect of vascular closure systems on postoperative complications in thyroid surgery, there is little data on EBSLN injury (12). Therefore, in this study, we aimed to evaluate the effect of different vascular closure systems on iatrogenic EBSLN injury in patients undergoing thyroidectomy.

## Methods

For the study, approval was obtained from İstanbul University, Cerrahpaşa Faculty of Medicine, Ethics Committee of Medical, Surgical and Pharmaceutical Research (decision no: 35792). A total of 45 patients who underwent thyroidectomy at the Endocrine Surgery Service of İstanbul University, Cerrahpaşa Faculty of Medicine between October 2008 and February 2009 were included in the study. Patients who had undergone previous thyroid surgery, patients with recurrent disease or thyroid cancer, and patients with voice complaints prior to surgery were excluded from the study. All patients were informed about the procedures and written informed consent was obtained.

The patients were randomized by computer program and divided into three equal groups, each consisting of 15 patients. All patients underwent thyroid function tests, thyroid ultrasonography, scintigraphy or fine needle aspiration biopsy for preoperative diagnosis. Standard bilateral thyroidectomy (total, near-total or subtotal) was performed. All patients were operated by the same surgical team. LigaSure Precise® (Valleylab Corp., Tyco Healthcare Group LP, Colorado, US) was used for vascular ligation in the first group (LigaSure group) (Figure 1), Ultracision® harmonic scalpel (Ethicon Endo-Surgery, Ohio, US) in the second group (Ultracision group) (Figure 2), and conventional suture ligation technique in the third group (suture group) (Figure 3).

Under general anesthesia, the patient was placed in a supine position with the neck extended. After proper skin cleansing, Kocher's collar incision was made, and upper and lower skin flaps were developed.

Thyrohyoid and sternohyoid muscles were divided vertically in the midline, and surgical field was entered. The right lobe of the thyroid was dissected free from the middle thyroid vein. The superior parathyroid gland was identified and preserved. The superior thyroid artery and vein were dissected and ligated from the level close to the thyroid capsule. In the meantime, no dissection was performed to

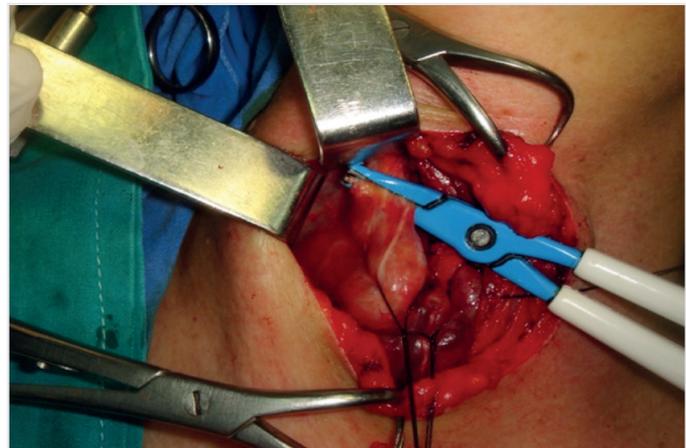


Figure 1. Release of the upper pole of the right thyroid gland with LigaSure Precise®

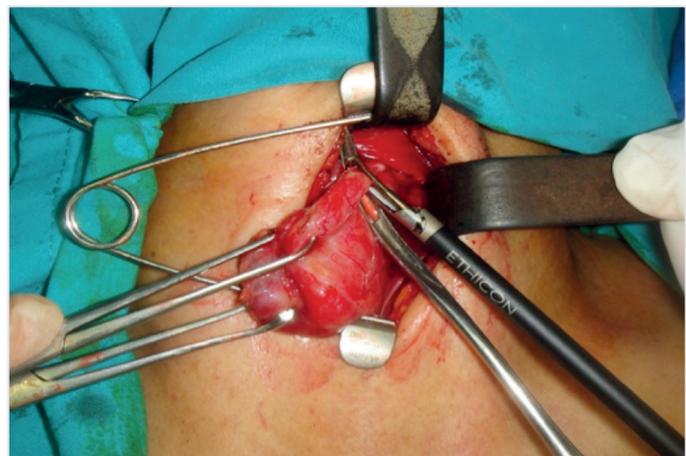


Figure 2. Release of the upper pole of the left thyroid gland with Ultracision®

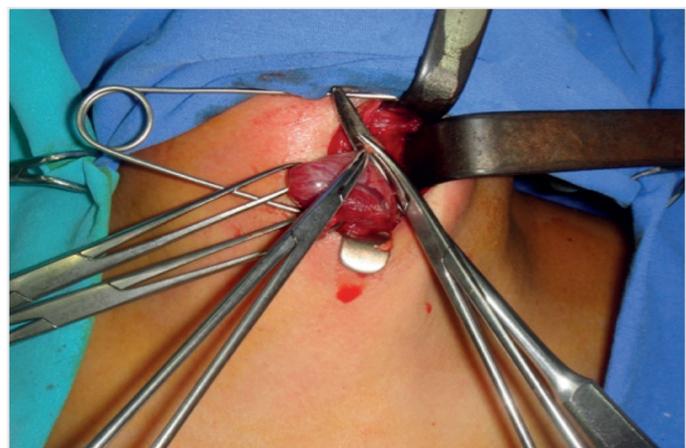


Figure 3. Release of the upper pole of the left thyroid gland with conventional suture ligation technique

reveal the EBSLN. The right recurrent laryngeal nerve was preserved in the anterolateral tracheal area. Subsequently, the inferior pole vessels were ligated by preserving inferior parathyroid gland. The contralateral thyroid lobe was removed in a similar manner. Thyroidectomy procedure was completed with removal of the specimen along with the isthmus. Following hemostasis, a drain was placed. The midline muscles and skin were closed and the operation was terminated.

The function of EBSLN was evaluated by laryngeal electromyography (EMG). Recordings were performed before and after surgery in all patients, and bilateral cricothyroid muscles were examined. Preoperative muscular pathologies were investigated and repeated after one month because of abnormal spontaneous discharges. Before the control EMG, the patients were questioned in terms of phonation disorders (hoarseness, loss of strength of the voice, vocal fatigue and inability to achieve high pitch tasks). Neuropack MEB-9102K (Nihon Kohden, Tokyo, Japan) device was used for laryngeal EMG. Recordings were performed

with concentric bipolar needle electrodes (size: 50x45 mm) (Myoline, Spes Medica, Italy). The ground electrode was placed in the neck area far from the needle entrance site and the patient was placed in the supine position. Local anesthetic agent or premedication was not performed because the procedure was relatively painless and anesthetic agents could cause artifact in action potentials in the cricothyroid muscle. A needle electrode was inserted into the cricothyroid muscle to evaluate the function of EBSLN. For this purpose, the neck of the patient was extended and the needle electrode was inserted into the cricothyroid membrane in the midline and directed 30-45 degrees laterally (Figure 4). After making sure that the tip of the electrode was in the muscle by phonation, the input activity of the needle, the presence of spontaneous activity at rest, the shape, duration and amplitudes of the motor unit action potentials during active contraction of the muscle were recorded via an audiomonitor and oscilloscope. Wave morphology was evaluated by the same neurologist in terms of EBSLN injury.

Demographic data, pathological diagnoses, surgical procedure, EMG findings and vocal complaints that occurred within one month after surgery were recorded in the follow up forms prepared for each patient.

**Statistical Analysis**

Data were analyzed by using SPSS 11 (SPSS Inc., Chicago, IL, USA), and comparisons between groups were performed using ANOVA post hoc Tukey and chi-square tests. Values were given as mean ± standard deviation. P<0.05 was considered statistically significant.

**Results**

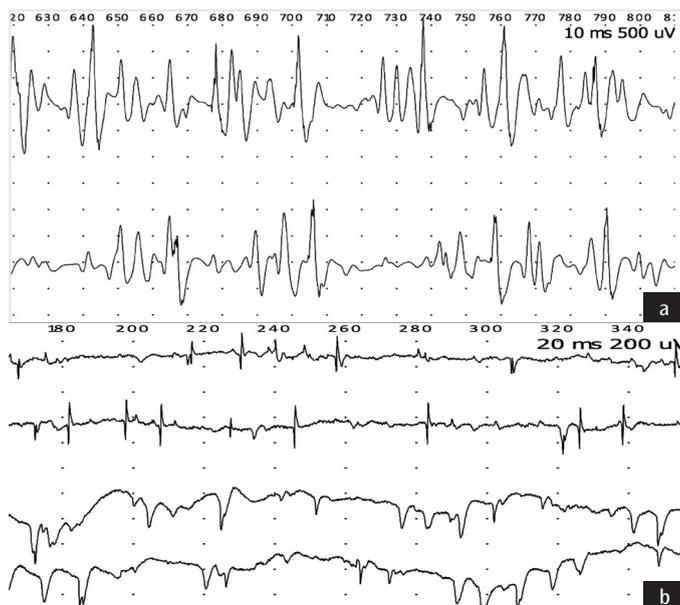
Of the 45 patients included in the study, 37 were female (82%) and 8 were male (18%). The mean age of the patients was 47.9±11 (range: 21-68) years. Demographic data and clinical findings of the patients are presented in Table 1. The rate of female patients was 87% in the LigaSure group and 80% in the Ultracision and suture groups. Histopathological examination revealed no malignancy. There was no statistically significant difference between the demographic data and the surgeries performed (p>0.05).

The distribution of preoperative and postoperative EMG findings of groups is given in Table 2. When all groups were taken into account, a total of five EBSLN had pathologic EMG findings in the preoperative period. These were unilateral weak activity in one patient and unilateral activity loss in one patient in the LigaSure group, unilateral activity loss in one patient and unilateral neurogenic involvement in one patient in the Ultracision group, and unilateral weak activity in one patient in the suture group. In addition, unilateral EBSLN function could not be evaluated in one patient in the suture group because of postoperative technical failure. As a result, a total of 84 nerves were included in the statistical analysis, except for one nerve that could not be evaluated due to technical failure and five nerves with preoperative pathology in the EMG.

While EMG findings were normal in the preoperative period, one patient (6.7%) in the LigaSure group and one patient (6.7%) in the suture group had a unilateral cricothyroid muscle denervation pattern in the postoperative period (Figure 5). In addition, two patients (13.3%) in the LigaSure group, two patients (13.3%) in the Ultracision group



**Figure 4.** Insertion of the needle electrode into the cricothyroid muscle for the evaluation of superior laryngeal nerve function in a patient who underwent postoperative electromyography



**Figure 5.** (a) Normal motor unit action potential pattern and (b) denervation pattern in laryngeal cricothyroid muscle electromyography

and one patient (6.7%) in the suture group developed unilateral weak action potential patterns in the postoperative period despite normal preoperative EMG findings. Denervation and weak action potential patterns were consistent with EBSLN injury (Table 2).

In the postoperative control EMG of 84 EBSLNs with preoperative normal EMG findings, pathology was detected in three of the 28 EBSLN in the LigaSure group, two of the 28 EBSLN in the Ultracision group, and two of the 28 EBSLN in the suture group. There was no statistical difference between the groups (p=0.61) (Table 3).

Postoperative vocal complaints were present in three patients in the LigaSure group, three patients in the Ultracision group and two patients in the suture group. No significant difference was found between groups in terms of vocal complaints (p=0.60) (Table 3).

### Discussion

Thyroidectomy is one of the common surgeries in general surgery clinics. Although the principles of surgery have not changed much, new devices

have been put into use with developing technology in order to make hemostasis faster and safer. LigaSure®, also known as electrothermal vessel sealing system, is a dissection and coagulation device developed in recent years. Ultracision® provides simultaneous coagulation and cutting with ultrasonic energy, and also has achieved a place in thyroid surgery in a short time (2-4). However, a significant disadvantage of these systems is that they may cause nerve injuries in thyroid surgery depending on the energy used (5-7). The results obtained in this study that specifically analyzed EBSLN injury showed that the use of these vascular closure systems in thyroidectomy surgery did not increase this complication compared to the classical suture ligation technique.

In the studies comparing vascular closure systems and conventional suture technique in the literature, complications such as postoperative hemorrhage, recurrence laryngeal nerve injury and hypoparathyroidism were evaluated in the morbidity parameters (3,4,6,7), and data on EBSLN injury were insufficient. The only study in this regard is a prospective randomized study by Arslan et al. (12) that compares the harmonic scalpel with conventional suture ligation technique in thyroidectomy.

**Table 1. The distribution of demographic characteristics and surgical procedures according to groups**

	LigaSure group	Ultracision group	Suture group	p
Age, years ± SD	44.4±11	46.6±12	50.8±11	0.4
Female/male, n (%)	13/2 (87)	12/3 (80)	12/3 (80)	0.6
Surgery, n (%)				0.3
Total thyroidectomy	10 (67)	7 (47)	10 (67)	-
Near-total/subtotal thyroidectomy	5 (33)	8 (53)	5 (33)	-

SD: standard deviation

**Table 2. Distribution of electromyography findings according to groups**

	LigaSure group		Ultracision group		Suture group	
	Preoperative	Postoperative	Preoperative	Postoperative	Preoperative	Postoperative
<b>EMG findings, n (%)*</b>						
Bilaterally normal	13 (87)	11 (73)	13 (87)	12 (80)	14 (93)	11 (73)
Unilateral weak activity	1 (7)	3 (20)	0 (0)	2 (13)	1 (7)	2 (13)
Unilateral activity loss	1 (7)	0 (0)	1 (7)	0 (0)	0 (0)	0 (0)
Unilateral neurogenic involvement	0 (0)	0 (0)	1 (7)	1 (7)	0 (0)	0 (0)
Unilateral denervation	0 (0)	1 (7)	0 (0)	0 (0)	0 (0)	1 (7)
Technical failure	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (7)
<b>EMG findings, n (%)**</b>						
Normal	28 (93)	26 (87)	28 (93)	27 (90)	29 (97)	26 (87)***
Pathologic	2 (7)	4 (13)	2 (7)	3 (10)	1 (3)	3 (10)

EMG: electromyography, \*numbers and percentages refer to the number of patients, \*\*numbers and percentages refer to the number of nerves, \*\*\*since the nerve could not be found on one side due to technical failure, it was not taken into consideration

**Table 3. Comparison of superior laryngeal nerve injury and postoperative phonation disorders among groups**

	LigaSure group	Ultracision group	Suture group	p
Surgical SLN injury, SLN number (%)	3/28 (10.7)	2/28 (7.1)	2/28 (7.1)	0.6
Phonation disorder, number of patients	2	2	2	0.6

SLN: superior laryngeal nerve, SD: standard deviation

A total of 206 patients were included in this study, and temporary and permanent EBSLN injuries were detected in four (4%) and three (%) patients in the harmonic scalpel group and in two (1.9%) and two patients (1.9%) in the other group, respectively. No significant difference was found between the groups. The authors concluded that the use of a harmonic scalpel was safe for EBSLN injury.

The superior laryngeal nerve is separated from the vagus around the skull base; it descends from the medial of the carotid vessels and is divided into two branches as internal and external at the level of hyoid bone. The internal branch provides the sensation of epiglottis and larynx. EBSLN runs with superior thyroid vessels, and provides motor innervation of the cricothyroid muscle and determines the style of the voice by tensing the vocal cords (8,10,11). As a result of trauma to the nerve, the vocal cord in that side becomes flaccid and this creates difficulty in phonation. This is especially important for those who practice their profession using their voice continuously (teacher, announcer, singer, etc.) (8,11).

Vocal changes related to EBSLN injury were first described by Moran and Castro (13) in 1951, and later Cernea et al. (14) reported the anatomical classification of the different localizations of the nerve and reported high-risk location for surgical injury. According to this classification, EBSLN has a high-risk of injury during the release of thyroid upper pole. Later, Selvan et al. (15) described a new classification system on the anatomical localization of the nerve accompanied by EMG findings by performing EBSLN monitoring. According to this classification, the area with the highest risk of injury is defined as the area 1 cm superior-posterior of the artery before entering the thyroid gland. In the light of this anatomical information, some authors stated that the EBSLN should be explored directly or by intraoperative nerve monitoring before ligation of the artery (16-18), while others stated that even careful dissection in this area could damage the nerve (15,19). In our study, EBSLN was not visualized in none of the patients as it was thought to increase the risk of nerve injury and dissection was performed close to the capsule of the thyroid gland.

The fact that the vocal change due to EBSLN injury in thyroid surgery is not noticed by both the patient and the surgeon, or the requirement of detailed analyzes in order to reveal the pathology even if it is noticed shows why less attention is given to this nerve than the recurrent laryngeal nerve. Recurrent laryngeal nerve injury can be detected by simple diagnostic methods such as indirect laryngoscopy or fiberoptic examination, EBSLN injury requires the use of more advanced techniques such as laryngeal videostroboscopy, spectrographic analysis and laryngeal EMG. Among these techniques, the more invasive and time-consuming cricothyroid muscle EMG is the most accurate diagnostic method (9,20). The risk of iatrogenic partial or complete EBSLN injury varies between 0% and 6% after thyroidectomy and this rate increases up to 60% when EMG is performed (12,14,18,21).

In our study, the muscle denervation pattern detected in one patient in the LigaSure group and one patient in the suture group in the postoperative period is the most objective finding indicating complete nerve injury. This finding was not observed in any patient in the Ultracision group. In addition, weak action potentials detected in two

patients in the LigaSure and Ultracision groups and one patient in the suture group indicate a mild axonal injury, namely partial nerve injury. There was no difference in EBSLN injury when all groups were compared.

Although surgical iatrogenic injuries are the most frequent, viral infectious diseases, trauma, peripheral neuropathies and some motor neuron diseases may cause loss of function in EBSLN and clinical symptoms may be subclinical (22). In our study, preoperative EMG was performed in all patients in order to determine if the postoperative nerve damage was iatrogenic or was an already existing pathological condition. When all study groups were considered, five patients had pathologic EMG findings in the preoperative period. If EMG is not performed in the preoperative period in such patients, the pathological EMG findings that may develop after surgery may lead to misinterpretations in terms of nerve damage. Similarly, the phonation disorders that can occur in patients with no obtained cricothyroid muscle activity in preoperative EMG, but with normal postoperative findings cannot be attributed to EBSLN injury. This suggests that the anatomical localization of the muscle may have changed due to the enlarged thyroid tissue. In our study, the right cricothyroid muscle could not be localized in one patient in the suture group. An additional interpretation could not be made for this muscle, which suggests that anatomical localization is impaired due to the displacement secondary to surgery.

#### Study Limitations

Lack of EMG control in the long term after surgery is an important limitation of our study. In laryngeal nerve paralysis, EMG findings may vary according to the severity and duration of nerve damage. In neuropraxia, neurogenic involvement that improves in a few weeks and decreased activity are observed in cricothyroid muscle. While denervation and reinnervation are seen in axonotmesis, denervation and loss of motor unit as well as inability to reinnervate are observed in neurotmesis (23). For this reason, EMG should be repeated after 6 or 12 months in order to monitor the course of axon damage in the nerve and to follow up the reinnervation in cases with mild nerve damage and denervation. In addition, the lack of evaluation of the vocal cords by laryngoscopic examination in order to reveal whether the cause of vocal complaints is EBSLN injury or any recurrent laryngeal nerve injury is another limitation of the study.

#### Conclusion

In this study, it was found that hemostatic vascular closure systems did not increase the risk of EBSLN injury in thyroid surgery compared to the conventional suture ligation technique. The choice of the device to be used should be made by considering factors such as experience and cost.

**Ethics Committee Approval:** For the study, approval was obtained from Istanbul University-Cerrahpaşa Faculty of Medicine Ethics Committee of Medical, Surgical and Pharmaceutical Research (decision no: 35792).

**Informed Consent:** All patients were informed about the procedures and written informed consent was obtained.

**Peer-review:** Internally peer-reviewed.

**Author Contributions:** Concept - V.Ö., R.Ö.; Design - V.Ö., R.Ö., N.A.; Supervision - R.Ö., N.A., A.K.; Resources - V.Ö., N.A., A.K.; Data Collection and/or Processing - V.Ö.; Analysis and/or Interpretation - V.Ö., R.Ö.; Literature Search - V.Ö., R.Ö.; Writing Manuscript - V.Ö., R.Ö., N.A., A.K.; Critical Review - N.A., R.Ö., A.K.

**Conflict of Interest:** The authors have no conflict of interest.

**Financial Disclosure:** The authors did not receive financial support for this study.

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