



# The recurrent laryngeal nerve and extralaryngeal branches in relation to the inferior thyroid artery, Berry's ligament, tracheal groove, and Zuckerkandl tubercle: an experience of 60 thyroidectomies

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## Abstract

**Aim:** The aim of this study was to examine the anatomical variations of the inferior laryngeal nerve compared with its extralaryngeal branches, the inferior thyroid artery, Berry's ligament, the tracheal groove, and the tubercle of Zuckerkandl, as encountered during thyroid gland operations. This is a case series conducted at the Anticancer Hospital of Thessaloniki "Theageneio" between October 2021 and May 2022.

**Materials and methods:** Sixty patients underwent thyroidectomy under general anesthesia using a standardized surgical dissection technique by a single surgeon. In all cases, the extralaryngeal part of the inferior laryngeal nerve was identified and its anatomical relation were recorded.

**Results:** The most frequently found locations for the inferior laryngeal nerve were in the tracheal groove (66.4%), superficial to the ligament of Berry (77.6%), posterior to the tubercle of Zuckerkandl (69.2%), and posterior to the inferior thyroid artery (56.1%). Additionally, the inferior laryngeal nerve was predominantly with no branches in its extralaryngeal part (62.9%).

**Conclusion:** The study emphasizes the importance of a careful inferior laryngeal nerve identification in order to minimize the risk of injury and to ensure the safety and well-being of the patients.

## Keywords

anatomical variations of inferior laryngeal nerve

## Introduction

The inferior laryngeal nerve was first mentioned in India during the 6th century BC in the Sanskrit text *Sushruta Samhita*, where it was described as "Dhamanis" meaning

artery. In 100 AD, Rufus of Ephesus identified this anatomical structure as a nerve rather than an artery. A more detailed description of the inferior laryngeal nerve was provided by Galen during the second century AD.<sup>[1]</sup> Since then, several researchers have studied the anatomy and surgical implication of the inferior laryngeal nerve. To this

day, the anatomy of the extralaryngeal part of the inferior laryngeal nerve remains incompletely understood due to its great variability. This segment of the nerve is particularly significant as it is prone to injury during thyroid surgery. Such injuries can result in vocal paralysis that has a detrimental effect on the patient's quality of life. Respiratory discomfort and dysphonia are the main causes of the negative impact on the socio-psychological condition of the patient with nerve paralysis.<sup>[2]</sup> The rate of nerve injury in thyroid surgery remains quite significant<sup>[3-5]</sup>, which highlights the need for further study of the nerve's anatomical features. The preservation of the nerve during thyroidectomy is based solely on its identification, specific knowledge of its course and anatomical relationships. Most textbooks do not describe them in detail, despite their many anatomical variations. Such variants are not anatomically standard and may differ based on geographical distribution.

## Aim

The purpose of this study was to highlight the anatomical variations of the nerve and the relationships in the population of northern Greece.

## Materials and methods

We performed thyroidectomy on 60 patients of both sexes and over the age of 18 years. Surgical technique: Through Kocher's incision, the skin flaps were raised subplatysmally. Superior thyroid vessels and middle veins were ligated with preservation of external branch of superior laryngeal nerve and superior parathyroid. The inferior laryngeal nerves were then exposed and the anatomical relations with the inferior thyroid artery, Berry's ligament, tubercle of Zuckerkandl and tracheal groove were examined.

## Results

Out of our 60 patients, 71.7% (n=43) patients were women and 28.3% (n=17) were men. Their mean age was 51 years (SD±10.42), with the minimum age being 26 years and maximum being 77 years. All patients underwent total thyroidectomy. Post-operative vocal cord paralysis was found

only in one patient, who later died after suffering a heart attack some hours post operation.

The recurrent laryngeal nerve was identified in 58 patients on both sides; in the remaining two patients, the inferior laryngeal nerve was not identified, neither left nor right. No nonrecurrent laryngeal nerve was identified in those patients.

The tubercle of Zuckerkandl was found in 26 patients (44.8% incidence of tubercle of Zuckerkandl), in 24 of whom it was found on both sides, with two patients having it located only on the right side. The inferior laryngeal nerve was mostly posteriorly to the tubercle and in most cases there was similarity on both sides. In total, 36 inferior laryngeal nerves out of 52 were passing posteriorly to tubercle of Zuckerkandl (69.2%), and 16 inferior laryngeal nerves out of 52 were passing laterally (30.8%) (**Table 1**) (**Fig. 1**).

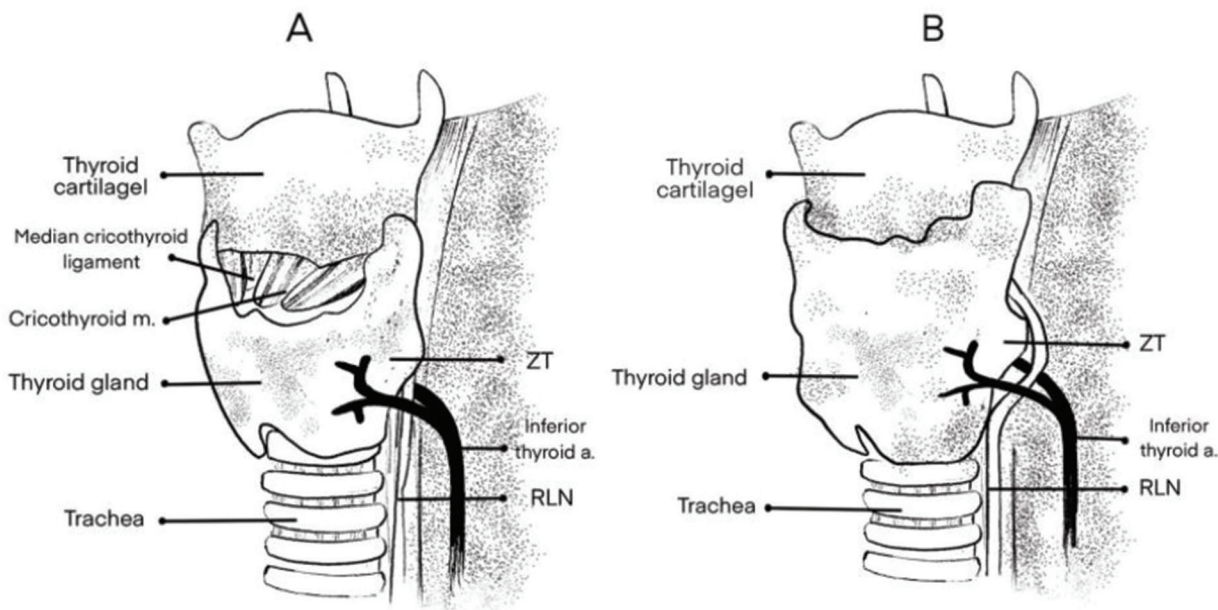
In the majority of the patients, the inferior laryngeal nerves were passing superficially to Berry's ligament and there was absolute similarity in both sides. We did not identify any cases of the nerve passing laterally or deeply in relation to Berry's ligament. Specifically, in 13 out of 58 patients, the nerve was passing through Berry's ligament (22.4%) and in 45 patients the nerve was passing superficially (77.6%) (**Table 2**) (**Fig. 2**).

Regarding the relation between the inferior laryngeal nerve and the tracheal groove, in the majority of the cases the nerves were found to be within the groove, on both sides with great similarity. In 37 patients, both nerves were passing into the tracheal groove and in three patients the left laryngeal nerve was passing only into the left tracheal groove (66.4%) (**Table 3**). The nerve was found lateral to the tracheal groove in 14 patients (12%), anterolateral to the groove in 9 patients (7.8%), and posterior to the tracheal groove in 16 patients (13.8%) (**Fig. 3**).

The inferior laryngeal nerve was found to be posterior to the inferior thyroid artery in the majority of the patients. The inferior laryngeal nerve of 32 patients passed posterior to the inferior thyroid artery in both the left and right sides; in one patient, only the left inferior laryngeal nerve passed behind the inferior thyroid artery (56.1%). In 18 patients, the inferior laryngeal nerve passed through the branches of the inferior thyroid artery on both sides (31%). In 7 patients, the nerve passed anterior to the artery on both sides, and in one patient only, the right inferior laryngeal nerve passed anterior to the inferior thyroid artery (12.9%) (**Table 4**) (**Fig. 4**).

**Table 1.** Relation of inferior laryngeal nerve with tubercle of Zuckerkandl

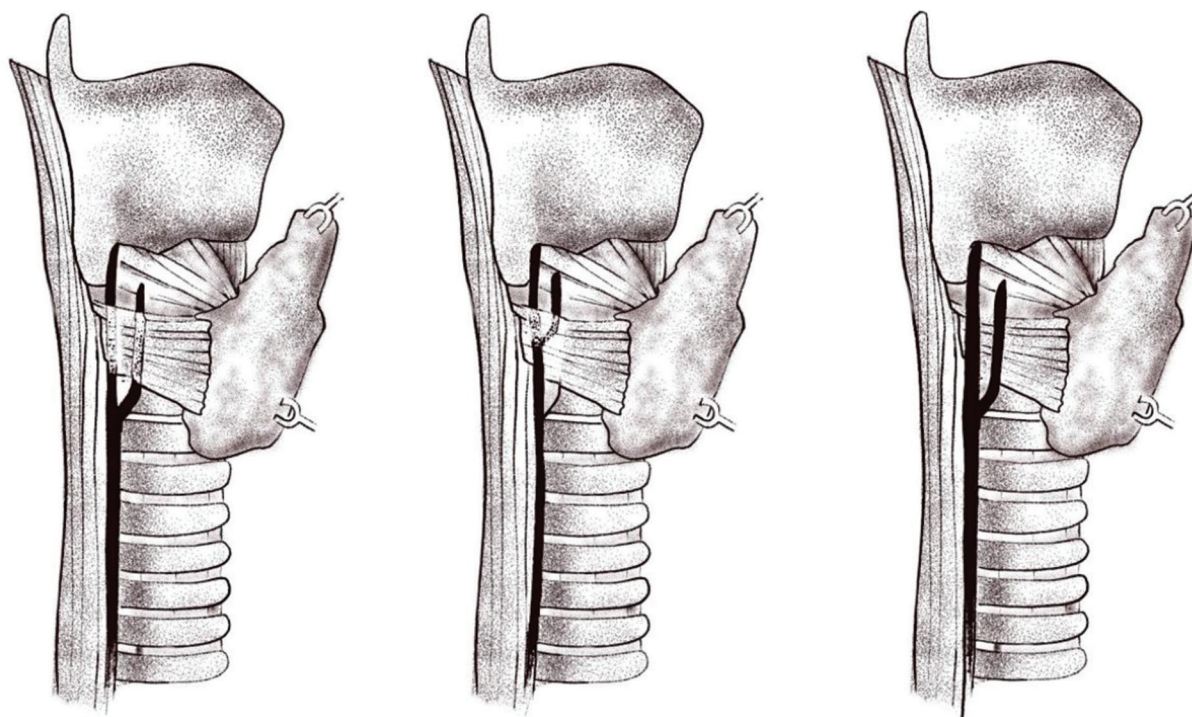
	Posterior to tubercle of Zuckerkandl	Lateral to tubercle of Zuckerkandl	Total nerves
Both sides (right and left in the same patient)	16 sides = 32 nerves	6 sides = 12 nerves	
One side left	2	1	
One side right	2	3	
Total nerves	36	16	52



**Figure 1.** The relation between the inferior laryngeal nerve and Zuckerkandle's tubercle of the thyroid gland.

**Table 2.** Relation of inferior laryngeal nerve with ligament of Berry

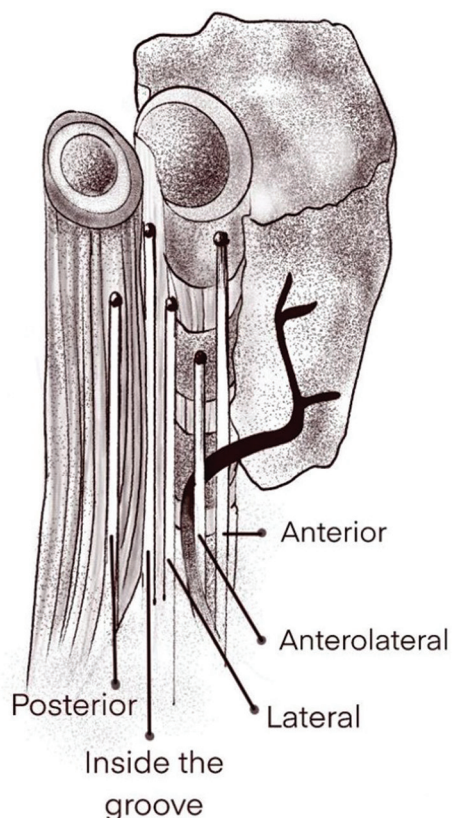
	Lateral to Berry's ligament	Deep to Berry's ligament	Superficial to Berry's ligament	Through Berry's ligament	Total nerves
Both sides	0	0	45 = 90 nerves	13 = 26 nerves	116



**Figure 2.** Types of relationship between the recurrent laryngeal nerve and Berry's ligament (deep, through, superficial.)

**Table 3.** Relation of inferior laryngeal nerve with the tracheal groove

	Into the tracheal groove	Lateral to tracheal groove	Anterolateral to tracheal groove	Anterior to tracheal groove	Posterior to tracheal groove	Total nerves
Both sides	37=74 nerves	5=10 nerves	3= 6 nerves	0	7=14 nerves	
Left side	3	1	2	0	0	
Right side	0	3	1	0	2	
Total nerves	77	14	9	0	16	116



**Figure 3.** Possible locations of the recurrent laryngeal nerve in relation to the tracheal groove.

The inferior laryngeal nerve was identified with no branches in most of our patients. In 36 patients, both inferior laryngeal nerves were found without branches, while in one patient only the left inferior laryngeal nerve was found with no branches (62.9%). The inferior laryngeal nerves of 18 patients were bifurcated on both sides and in one patient only the right inferior laryngeal nerve was found double

(31.9%). In three patients, both right and left nerves were found to exhibit trifurcation (5.2%) (Table 5) (Fig. 5).

The most common anatomical patterns of the recurrent laryngeal nerve were identified in relation to key structures. The recurrent laryngeal nerve was most frequently found posterior to the inferior thyroid artery (65/116 nerves), superficial to the ligament of Berry (90/116 nerves), and into the tracheal groove (77/116 nerves). Regarding the tubercle of Zuckerkandl, the nerve was most often located posteriorly (36/52 nerves). Finally, the majority of nerves (73/116) exhibited no extralaryngeal branches (Table 6).

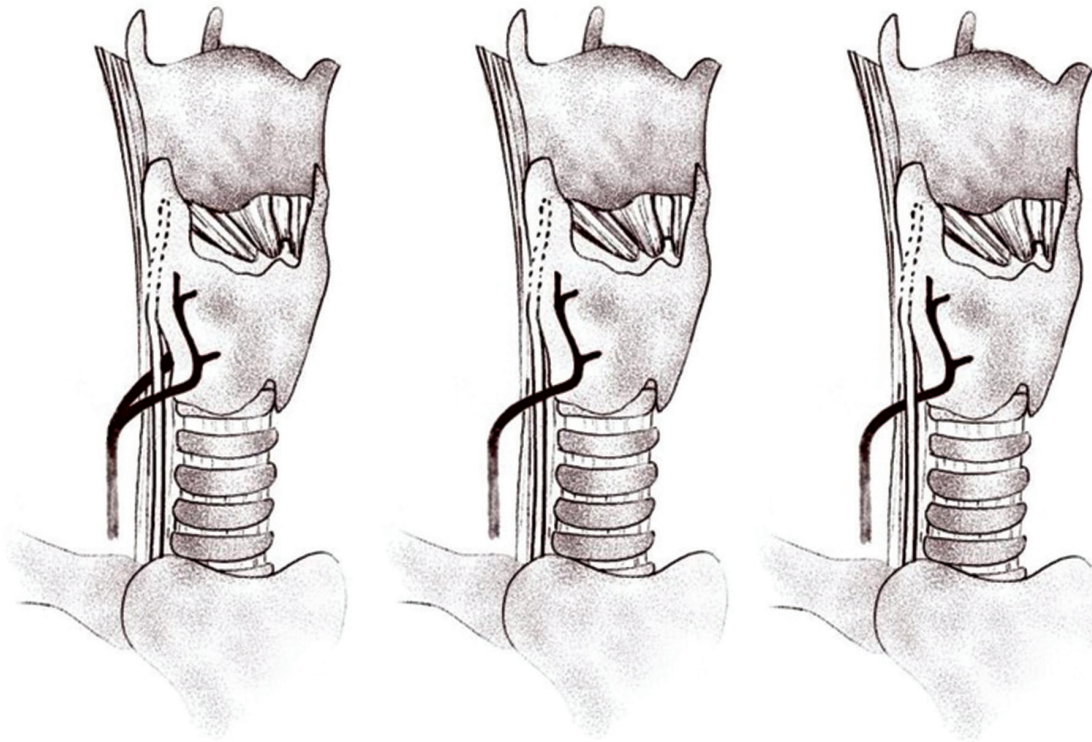
### Discussion

Nowadays, the pathology and surgery of thyroid gland has taken on other dimensions, as thyroidectomies are becoming daily routine and the science of surgery has reached the level of laparoscopic and robotic gland removal.<sup>[6-8]</sup> This requires the parallel development of surgical anatomy in order to clarify the inferior laryngeal nerve in more detail as well as its relationship with structures in its proximity in order to further decrease the rate of nerve injury.

It was found that the characteristics of the recurrent nerve for both sides in each patient were very similar; these findings are consistent with previous research.<sup>[9,10]</sup> The most common was an inferior laryngeal nerve with no branches that passed into the tracheal groove, passed posterior to Berry's ligament, posterior to the inferior thyroid artery, and posterior to the tubercle of Zuckerkandl, if present. Observations similar to our findings are mentioned in the meta-analysis of Henry et al.<sup>[11]</sup> about the tubercle of Zuckerkandl, the tracheal groove and Berry's ligament<sup>[12]</sup>, and in meta-analysis about the inferior thyroid artery<sup>[13]</sup>. Different results were found in regard to the branches of the recurrent laryngeal nerves in cadaveric specimens. Most commonly, we found the nerve to be with no branches

**Table 4.** Relation of inferior laryngeal nerve with inferior thyroid artery

	Anterior to inferior thyroid artery	Posterior to inferior thyroid artery	Through the branches of inferior thyroid artery	Total nerves
Both sides	7 = 14 nerves	32 = 64 nerves	18 = 36 nerves	
Left side	0	1	0	
Right side	1	0	0	
Total nerves	15	65	36	116

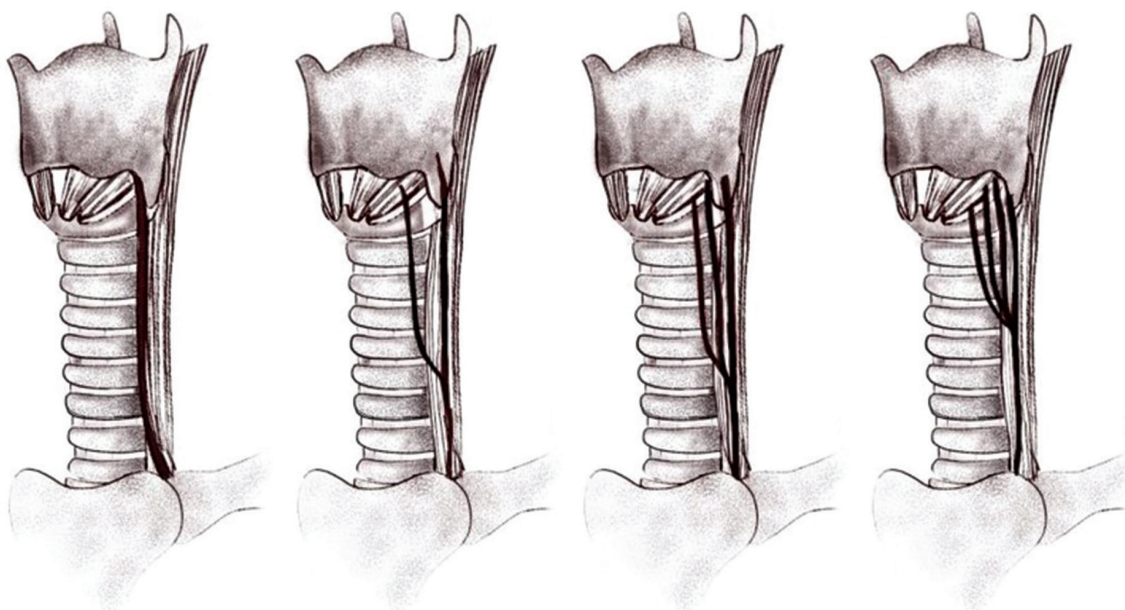


**Figure 4.** Types of recurrent laryngeal nerve to inferior thyroid artery relationships (through, anterior, posterior).

**Table 5.** Extralaryngeal branches of the inferior laryngeal nerve

	No branches	Double	Triple	More branches	Total nerves
Both sides	36 = 72 nerves	18 = 36 nerves	3 = 6 nerves	0	
Left side	1	0	0	0	
Right side	0	1	0	0	
Total nerves	73	37	6	0	116

- No Branching
- Bifurcation
- Trifurcation
- Multiple Branches



**Figure 5.** Types of extralaryngeal branching patterns of the recurrent laryngeal nerve.

**Table 6.** Summary of recurrent laryngeal nerve anatomical relationships

Structure	Possible relationships	Most common pattern	Frequency (n)	Total nerves (n)
Inferior thyroid artery	Anterior, posterior, through branches	Posterior to the artery	65	116
Ligament of Berry	Lateral, deep, superficial, through ligaments	Superficial to the ligament	90	116
Tubercle of Zuckerkandl	Posterior, lateral	Posterior to the tubercle	36	52
Tracheal groove	Into, lateral, anterolateral, anterior, posterior	Into the tracheal groove	77	116
Extralaryngeal branches	No branches, bifurcation, trifurcation, multiple branches	No branches	73	116

while Henry et al., in their meta-analysis about extralaryngeal branches of recurrent nerve<sup>[14]</sup>, found bifurcation or further branching to be common. It is very important to emphasize the significant differences in the prevalence of extralaryngeal branches between cadaveric studies (73.3 %) and intraoperative studies (39.2 %) according to the meta-analysis of Henry et al.<sup>[14]</sup> This can be explained by the fact that intraoperatively any further branch is underestimated due to the difficulty of identification in a possible stained field of blood, a possible smaller diameter of the branch, edema and inflammation. In addition, during operation the surgeon is probably more hesitant to dissect for more branches of the nerve in contrast with the anatomist during the dissection of the cadaver. That is due to the need of less anesthetic time and less chance of injury in operated patients.

The prevalence of the tubercle of Zuckerkandl is estimated to be 70.2% according to Henry et al.'s meta-analysis.<sup>[11]</sup> We estimate this rate to be 44.8% in our patients. It is believed that the tubercle of Zuckerkandl is a normal part of the thyroid gland's anatomy and not a variant, thus warranting further examination.<sup>[11,15]</sup> There is a difference in the prevalence of the tubercle between cadaveric specimen and intraoperative patients with a lower rate observed in the former.<sup>[11]</sup> The question henceforth becomes one of size, the margins of which allow us to identify the observed mass as a tubercle or normal thyroid parenchyma. In most cases, the relation between the tubercle of Zuckerkandl and the inferior laryngeal nerve is the latter's course posteriorly to the tubercle, an observation agreed upon by other researchers.<sup>[16,17]</sup> The observation rate in our research was 69.2%, which is not considered enough to be deemed a reliable landmark.

The inferior laryngeal nerve typically passes into the tracheal groove. The percentage in our research was 66.4%, very similar to the rates found in other research.<sup>[12,18]</sup> This confirms that the tracheal groove cannot be considered a reliable landmark, alternative to Berry's ligament, for identifying the inferior laryngeal nerve. In contrast, the ligament of Berry can be a better anatomic landmark<sup>[12]</sup> because in most of the cases the nerve is superficial to the ligament,

present in 78.2% of cases in Henry et al.'s meta-analysis and 77.6% in cases in our research.

The area most susceptible to nerve injury is in the proximity of the inferior thyroid artery.<sup>[19]</sup> Data shows that in most cases, the nerve passes posterior to the inferior thyroid artery and its branches.<sup>[20,21]</sup> Similar to our results, in 56.1% of cases the nerve is posterior to the artery, making this the area least likely to cause injury to the nerve.<sup>[13]</sup> When it passes through or anterior to the thyroid artery, then there is a greater chance for the nerve to be injured due to the ligation of the inferior thyroid artery and stretching during the dissection of the gland.<sup>[13]</sup>

In summary, in the majority of cases, we observed anatomical variations present in any one side of the thyroid gland to be present on the opposite, at a reliable rate.

## Conclusions

The study of thyroidectomy in 60 patients revealed findings that can be used in surgical practice in regard to the symmetry and the anatomical variations of the recurrent laryngeal nerve. The anatomical points of Berry's ligament, the tubercle of Zuckerkandl, the inferior thyroid artery and the tracheal groove are assessed in order to determine the significance of these points during the thyroidectomy.

The study also showed the presence of extralaryngeal branches of the inferior laryngeal nerve which showed variations compared to prior cadaveric studies. Additionally, the study showed results similar to the literature data, indicating a significant similarity between the two sides of the thyroid gland and the structures related to the recurrent laryngeal nerve.

In order to perform a thyroidectomy, the surgeon needs to be fully informed about the variations of the extralaryngeal part of the inferior laryngeal nerve, to assure safe medical practice during nerve searching, identification and dissection of the thyroid gland. The study emphasizes the importance of a careful nerve identification to minimize the risk of injury and ensure the safety and well-being of the patients.

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## Competing Interests

The authors have declared that no competing interests exist.

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