



## Study of Extra laryngeal Branching of Recurrent Laryngeal Nerve in Thyroid Surgery

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### Abstract

**Objective:** Recognition of extralaryngeal branching of the recurrent laryngeal nerve is essential because prevention of vocal cord functions requires preservation of all branches of the recurrent laryngeal nerve. We have assessed the prevalence of extralaryngeal branching of the recurrent laryngeal nerve and the median branching distance from the point of bifurcation to the entry point of the nerve into the larynx.

**Material and Methods:** Prospective operative data on recurrent laryngeal nerve branching were collected from 90 patients who underwent thyroid surgery between April 2017 to March 2018.

**Results:** A total of 113 recurrent laryngeal nerves were examined (60 right, 53 left). Overall, 65(57.5%) of 113 recurrent laryngeal nerves have extralaryngeal branching before entering the larynx. There were 37 (61.66%) branching nerves on the right and 28 (52.83%) branching nerves on the left. There was 35(58.33%) recurrent laryngeal nerve had bifurcation and 2(3.33%) recurrent laryngeal nerve had trifurcation in right side. There was no trifurcation found in left recurrent laryngeal nerve. Among 23(46RLN) patients who underwent bilateral exploration, 9 patient 39.13% (18RLN) were found to have bilateral branching, 15.21%(7 RLN) had unilateral branching and the remaining 45.65%(21RLN) had no branching. The median branching distance was 10 mm (5-20mm).

**Conclusion:** Extralaryngeal division of recurrent laryngeal nerve is a common and asymmetric anatomical variant. These variations can be easily recognized if the recurrent laryngeal nerve is identified at the level of the inferior thyroid artery and then dissected totally to the entry point of the larynx. Inadvertent division of a branch may lead to vocal cord palsy postoperatively, even when the surgeon believes the integrity of the nerve has been preserved.

**Keywords:** Thyroid surgery, anatomic variations, recurrent laryngeal nerve, laryngeal branches, vocal cord palsy

### Introduction

The recurrent laryngeal nerve (RLN) is the major structure at risk during thyroid surgery. The cricothyroid muscles.<sup>2</sup> RLN paralysis is the most serious postoperative complication in thyroid

recurrent laryngeal nerve innervates the intrinsic muscles of larynx except cricothyroid<sup>1</sup> and recently shown that RLN can also significantly innervate to surgery. Carefully exploration and identification of the RLN and its extralaryngeal branches is the gold

standard method to preserve this nerve during thyroid surgery<sup>3-8</sup>. Failure to identify these neural structures or inadequate knowledge of their variability can lead to an increased incidence of iatrogenic nerve injury<sup>9</sup>.

The thyroid gland is then meticulously dissected anteriorly from the RLN using a capsular dissection technique with multiple fine ligatures of absorbable material to fully display the last 2 cm of the RLN before its entry into the larynx under the cricothyroid muscle, only after complete display of this portion of the RLN is the lobe completely removed<sup>4</sup>.

We measured routinely the distance between the point of bifurcation or trifurcation to the entry of the RLN into the larynx beneath the cricothyroid muscle and defined this as the branching point distance. Only RLN dividing at a distance greater than 5 mm were considered to bifurcate or trifurcate. This is because most RLN will fan out in the terminal 5 mm before entry under the cricothyroid muscle. Each side was considered a separate entity<sup>10</sup>. The RLN courses usually between the two branches of inferior thyroid artery; however, it is inadvisable to use the inferior thyroid artery as an anatomic landmark to identify the RLN because of anatomic unpredictability.<sup>11</sup>

This mentioned division may occur within last 1-2 cm before RLN enters the larynx near the ligament of Berry. This site also represents the region of the RLN gene and this is the site of greatest risk to the RLN.<sup>12-14</sup> The functions of anterior & posterior branches of extralaryngeal bifurcation of the RLN is suggested that anterior branches is motor and posterior branches contain sensory fibers.<sup>15</sup>

The non recurrent laryngeal nerve is the most dangerous anatomical variation associated with complication risk during thyroidectomy in the right side.<sup>16</sup>

### Material and Methods

The collected prospective data of 90 patients including 113 neck sides undergo to thyroid surgery in between April 2017 and March 2018 were evaluated in this study. Each side of the operated

neck was considered as a separate entity. One hundred and thirteen RLNs that were followed along their courses until the larynx entry point were included in the study.

This study was approved by the local ethics committee of our hospital. Written informed consent was obtained from all the patients.

### Surgical Technique

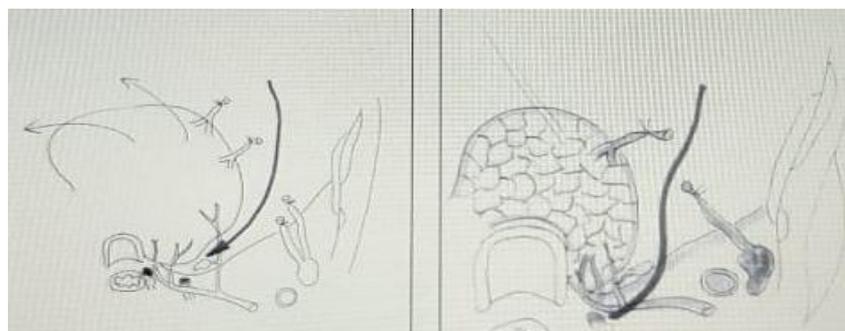
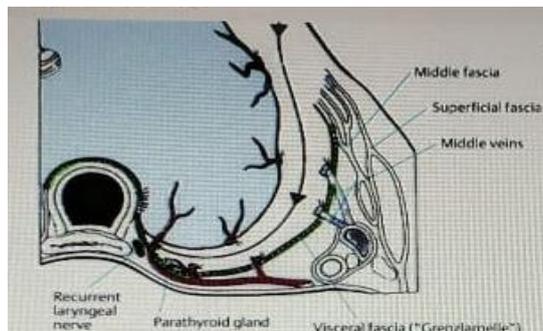
**Capsular Dissection:** It is a technique of dissection of thyroid where ligation of arteries is done as close to the gland as possible on the thyroid capsule itself. After 4-6 cm collar transverse incision was made, superior and inferior sub-platysmal flaps are elevated and the thyroid region was entered through the strap muscles. A plane is created between the terminal branches of inferior thyroid artery and the true capsule of the gland. The arteries are ligated individually on the surface of the gland as they enter the capsule into the substance of the gland. This helps to preserve the Vasculature of the parathyroid's and best way to dissection to identify the bifurcation and trifurcation of the RLN.

Any RLN had extralaryngeal branching was recorded. The distance between the point of bifurcation or trifurcation and the laryngeal NEP was measured in millimetres with a digital vernier calliper and defined as the branching distance.

Only RLNs branching before entering the larynx at distances of 5 mm and greater were considered to be branched nerves; those branching in the last 5 mm were not categorized as branched because most RLNs branch fanning out in the last 5 mm before entering under the cricopharyngeal muscle.

It was found that some branching nerves bifurcated again from the anterior or posterior branches after the first bifurcation or trifurcation was recorded.

At the end of each surgery, the demographic data of the patients, the indications for surgery, the surgical approach, and the anatomical data regarding the RLN were recorded in a Microsoft Excel table prepared at the beginning of the study.



**Statistical Analysis**

Descriptive statistical analysis has been carried out in the present study using computer software. The qualitative data were expressed in proportion and percentage whereas the quantitative data expressed in mean and standard deviations and mean difference was analysed by using student T test. Significance level for tests was determined as 95% (P< 0.05).

**Results**

The median age of the 90 patients (74 Female & 16 Male) enrolled in this study was 39years (range 16-73 years). The female male ratio was 4.6:1. The indications for surgery and the surgical procedures are summarized in following tables:

**Table no. 1:** Distribution of the cases according to Diagnosis by FNAC

Diagnosis	Number	Bethesda Grading	Percentage (%)
Thyroid nodule	64	II	71.11
Papillary carcinoma	19	V	21.11
Follicular neoplasm	3	IV	3.33
Follicular carcinoma	4	V	4.44
<b>Total</b>	<b>90</b>		<b>100.00</b>

**Table no. 2:** Distribution of the cases according to Operation

Operation	Number	Percentage (%)
Left HT	53	46.90
Right HT	60	53.09
Total thyroidectomy	22	24.44
Total thyroidectomy with central compartment clearance	1	1.11

Extralaryngeal branching was detected in 65 of the 113 RLNs (60 Right & 53 Left) evaluated in the study. Sixty three out of 65 extralaryngeal branching nerves had 2 branches, and the remaining two had 3 branches before cricothyroid insertion of RLNs into the larynx. Extralaryngeal bifurcation

was detected in 35 (58.33%) of 60 nerves on the right side and 28 (52.83%) of 53 nerves on the left side. Extralaryngeal trifurcation detected in 2(3.33%) of 60 RLNs only in the right side. There was no significant difference in the extralaryngeal branching rates in both sides.

**Table no. 3:** Distribution of the cases according to Branching of RLN

Branching	Number	Percentage (%)
Right side	37	61.66
Left side	28	52.83

**Table no. 4:** Distribution of the cases according to Branching of RLN

Branching	Number	Percentage (%)
<b>RIGHT SIDE</b>		
Bifurcation	35	58.33
Trifurcation	2	3.33
<b>Total</b>	<b>37</b>	
<b>LEFT SIDE</b>		
Bifurcation	28	52.83
Trifurcation	0	0.00
<b>Total</b>	<b>28</b>	
<b>B/L Bifurcation</b>	18	39.13
<b>Total Branching</b>	<b>65</b>	

On bilateral exploration with total thyroidectomy 9(39.13%) patient had bilateral bifurcation of 23 patients (46 RLNs).

Distance of branching site of RLN to cricothyroid insertion:

The mean  $\pm$  SD distance of branching site in right side (mm) was 10.26 $\pm$ 2.52 mm (min to max as 7 to

16 mm) and on left side (mm), mean  $\pm$  SD was 8.89 $\pm$ 2.12 mm (min to max as 5.8 to 14 mm). Significant difference was observed in distance of branching site of RLN to cricothyroid insertion. Mean was significantly more in Distance of branching site in right side (mm) as compared in left side (P=0.025 S).

**Table no. 5:** Descriptive Statistics of Distance of branching site of RLN to the cricothyroid insertion

Descriptive Statistics						
	N	Minimum	Maximum	Mean	Std. Deviation	P value LS
Distance of branching site in right side(mm)	35	7	16	10.26	2.52	0.025S
Distance of branching site in left side(mm)	28	5.8	14	8.89	2.12	

## Discussion

A precise, anatomic knowledge of the extralaryngeal branching pattern of the RLN has important operative implications to avoid the postoperative complication. Surgeons have advocated the routine identification of the RLN and its dissection through its entire course could achieve minimum rates of injuries to the nerve.<sup>43-45</sup>

Knowledge of the precise course, variations, and anomalies of the RLN will aid in avoidance of injury to the nerve during thyroid surgery.

It is clear that the RLN less chance to injured when cricothyroid and the posterior crico-arytenoid muscles not supplied by posterior branch of RLN, which also proved that the posterior branch to be

sensory and its function is sensory supply to below the vocal cord<sup>10</sup>

The lesion in a posterior (sensory) laryngeal branch has no immediate critical outcome, but section of anterior (motor) branch laryngeal branch causes a laryngeal paralysis, which can lead to suffocation if the nerve injury occurs on bilateral sides.

The concept of 'encountering' routinely the RLN and using the technique of capsular dissection has been advocated as the technique to be emulated to avoid injuring the nerve. The identification and preservation of the RLN is essential to avoid injury to this nerve.

This prospective study of the RLN anatomy demonstrated a high incidence of extralaryngeal

branching. Indeed, in our study we observed 113 RLN in the 90 patient. Out of them, 65 RLN have ELB with overall incidence of extralaryngeal branching is 57.52%, Incidence of Bifurcation 63 (55.75%), Incidence of Trifurcation 2 (1.77%) and Incidence of Bilateral bifurcation was observed in 18 (39.13%) RLN in out of 46 RLN with 23 total thyroidectomy patients

Serpell et al<sup>21</sup> reported a lesser incidence of this anatomic variation, including 24% in 838 nerves, and Hisham and Lukman<sup>46</sup> 33% in 491 nerves. Others have reported greater rates, including Ardito et al<sup>12</sup> 72% in 2626 nerves, Cernea et al<sup>11</sup> 64.5% in 1390 RLNs, Katz<sup>17</sup> 58% in 721 nerves, Rustad<sup>18</sup> 43% in 100 nerves, and Nemiroff and Katz<sup>5</sup> 41% in 153 nerves and Wang et al<sup>47</sup> 76% in 63 RLNs.

We found bilateral bifurcation of the RLN to occur in 39.13% of cases with total thyroidectomy. In a similar series, Nemiroff and Katz<sup>5</sup> and Katz<sup>17</sup> found bilateral bifurcation rates of 14% and 24%, respectively. This implies that bilateral bifurcation is not uncommon. When undertaking a bilateral procedure, the presence of bifurcation on the right side (61%) had a significantly greater incidence in this study.

In this study, a total 90 case were evaluated. Among 90 study patients, 58% (n=52) of the patients were in the young age group of 21-40 years, 15.56% (n=14) in the age group of 41-50 years and 11.11% (n= 10) in the age group of above 60 years. The mean age of patients was 39.06±14years. Range of patients was 16 to 73 years. This study shows that thyroid disease is more common in young age group<sup>(21-40)</sup> (table and figure no. 1).

There were 74 female patients(82.22%) and 16 male patients (17.78%), age group 16-73 years mean age is 39.6 years and female male ratio is 4.6:1 (table no 2 and figure no 2) so that thyroid disease is female dominant similar to other study, Cernea et al<sup>11</sup> 1256 female patients (76.68%) and 382 male patients (23.32%).

A total 113 (right 60, left 53) RLNs in the 90 patient undergoing thyroidectomy (total 23, hemi 67) and one is central lymph node dissection. Overall 63(55.75%) RLNs bifurcate prior to enter in the

larynx. These bifurcation occurred on the right in 35 (58.33%) and left 28 (52.83%) and bilateral bifurcation occurred in 18 (39.13%) of the 23 patient undergoing total thyroidectomy, bifurcation more common in right side (58.33%) then on the left side (52.83%). Other series have similar result Beneragama and Serpell<sup>(4)</sup> on right side bifurcation 43.6% and on left side 28.1%. (Table &figure no. 4) In our study we identified 2 recurrent laryngeal nerves had trifurcation in out of 113 RLNs in 90 patients, these trifurcation found only in right side, no trifurcation found on left side. The incidence of the trifurcation is 1.77%, it is similar to studies Cernea et al<sup>11</sup> 133 (11.9%) RLNs had three branches in 2154 RLNs and Beneragama and Serpell<sup>4</sup> were trifurcation seen in 8 RLNs, 7 on right side and 1 on the left side.

65 RLNs (57.9%) had extralaryngeal branches before entry to cricothyroid joint. The distance of extralaryngeal branching site from the cricothyroid joint ranged 5.8 mm to 16 mm with the mean distance in the right side is 10.26 mm and in the left side is 8.89mm (table & figure no. 8).

In this study all branching occurs before enter in the larynx at cricothyroid joint consider as extralaryngeal branches, others series Kandil et al<sup>10</sup> patients with branching in the terminal 5 mm were excluded, because most RLNs will fan out in the terminal 5 mm prior to entry deep to the cricopharyngeus muscle. In the study by Katz<sup>17</sup>, 58% of the examined nerves branched more than 0.5 cm from the cricoids cartilage, median distance from the point of bifurcation of the RLN to cricothyroid membrane to be 8.3 mm on the right and 7.5 mm on the left. Beneragama and Serpell<sup>4</sup>, 213 RLNs in 137 patients, median distance from bifurcation to the cricothyroid joint was 18 mm on the right side and 13 mm on the left side, Armstrong and Hinton<sup>26</sup> reported the bifurcation to be at a distance of 0.5–1 cm.

Guglielmo Ardito<sup>12</sup> reported that this extralaryngeal branching point of the nerve may be an important pitfall of thyroid surgery. This important anatomic point is in the region of the last part of the extralaryngeal course of the RLN where it is at

greatest risk rostral to the inferior thyroid artery and posterolateral to the ligament of Berry. Injury to RLN may be occur due to two reason one is glandular traction may cause embedded nerve fibres to be pulled forward and thus become vulnerable to injury, second suturing the remnant gland to obtain hemostasis may entrap and, therefore, damage the nerve<sup>12</sup>.

In our study the functions of the anterior and posterior extralaryngeal bifurcation of RLNs is not known. Schweizer et al<sup>7</sup> suggested that the motor branches are solely in the anterior division, and the sensory fibres are solely in the posterior division. But some other studies by Sunderland and Swaney<sup>19</sup> however, suggest that there is a mixture of fibres, both sensory and motor, in both the anterior and the In contrast, if the posterior branch alone has been identified and the technique of capsular dissection is used, it is possible that the surgeon may believe the RLN in its entirety is safe, and in this setting, the anterior branch may be at risk of injury, resulting in vocal cord palsy<sup>4</sup>. If, having identified the RLN, it appears to be small in diameter, this finding should alert the surgeon to the possibility of bifurcation, and extra care should be taken to ensure that a further bifid branch is not present.

The motor fibres for adduction and abduction of the vocal folds were located exclusively in the anterior branch of the RLN. Great care is required following presumed identification of recurrent laryngeal nerve to ensure that no unidentified anterior branch is inadvertently cut which causes postoperative vocal fold paralysis.

Sasaki and Mitra<sup>47</sup> suggested that posterior branches of the RLN may also provide innervations to the cricopharyngeus muscle, interfering with swallowing process and with phonation. Dysphagia after thyroidectomy, which I have occasionally encountered, might be explained by damage to the esophageal branches from the recurrent laryngeal nerves. During operation, the tracheoesophageal groove and esophagus and area of ligament of berry are carefully dissected. The recurrent laryngeal nerve always identified and carefully retracted.

posterior branches and Barczynski et al<sup>40</sup> motor fibres in both branches in out of 8 patients from 613. In our study, we carried out capsular dissection around this point where RLN having more chance to injured, identified all ELB branches of RLNs and preserved it.

If the surgeon does not appreciate that the RLN has bifurcated, then either the anterior or posterior branch, whichever one has not been identified, will be put at increased risk. It is possible in this circumstance that a single branch could be presumed to be the whole nerve, and therefore the other branch would be at risk. If the anterior branch has been identified, it is less likely that the more posteriorly situated branch would be damaged if a capsular dissection technique is used. The non-recurrent laryngeal nerve is an especially dangerous anatomical variation for obvious reasons. The surgeon who always expects to find the RLN in its normal position may overlook a non-recurrent laryngeal nerve on right side because of its strange direct transverse course towards the larynx<sup>48</sup>. To minimize the complication rate, the head and neck surgeon must be aware of the possible anatomical variations of the RLN, including various relations with the inferior thyroid artery, the non-recurrent laryngeal nerve, and ELBs.

In this serious of 113 RLNs in 90 subjects no non-recurrent laryngeal nerve find out but some author suggested coexistence, first described by Sanders et al<sup>49</sup>, and later is confirmed by Katz and Nemiroff.<sup>17</sup> We routinely identified intra-operatively the recurrent laryngeal nerve and its branches in all cases, in an attempt to investigate the impact of anatomical variants on the incidence of postoperative RLN palsy and identified the whether the branching phenomenon put the RLN at increased risk of postoperative palsy.

### Summary and Conclusion

The following are key observations which summarize our results and study:

- The present study, a series of 113 RLNs conducted in 90 patients, was undertaken for the intra-operative observation of the recurrent

laryngeal nerve for its extralaryngeal branching pattern and distance of branching site to the cricothyroid joint before enter to the larynx during thyroid surgery.

- Out of 113 RLNs, 65 RLNs (57.52%) having extralaryngeal branching, were we found 63(55.75%) RLNs with bifurcation and two RLNs with trifurcation, right side bifurcation 35 (58.33%) in out of 60 RLNs and left side bifurcation 28 (52.83%) in out of 53 RLNs, bilateral bifurcation 18 (39.13%) in out of 46 RLNs with 23 total thyroidectomy and 2(1.77%) RLNs trifurcation on right side.
- The most of the subject were in young age group 21-40 years (58%) followed by 41-60 years (24.44%) and 11.11% patients above the 60 years of age, concluded that young age group more commonly involved in thyroid disorder.
- Among the most of the patient are female 74(82%), 16 (18%) male patient, in out of them 67 patient undergo for hemi-thyroidectomy and in the 23 patients do total thyroidectomy.
- This study has shown that extralaryngeal branching of the RLN is a common anatomical variant, particularly on the right side RLNs which is frequently bifurcate then the left side, but on occasionally the nerve may trifurcate and in other patients It may be bilaterally bifurcated.
- In our study, we identified all recurrent laryngeal nerve and its branches and preserved, resulting no single patient noted with postoperative vocal palsy in 65 RLNs with ELB out of 113 RLNs. This conclude that the RLNs carefully dissect and identified its branches in all patient undergo to thyroid surgery to avoid to postoperative vocal cord paralysis.
- The nerve tends to bifurcate within the range of 5 to 20 mm before entry into the larynx. Therefore, Awareness of this anatomical variation is essential during capsular dissection of the thyroid to reduce risk of RLN injury.

## Conclusion

Extralaryngeal division of recurrent laryngeal nerve is a common and asymmetric anatomical variant. These variations can be easily recognized if the recurrent laryngeal nerve is identified at the level of the inferior thyroid artery and then dissected totally to the entry point of the larynx. Inadvertent division of a branch may lead to vocal cord palsy postoperatively, even when the surgeon believes the integrity of the nerve has been preserved.

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