

# Useful Landmarks in Arytenoid Adduction and Laryngeal Reinnervation Surgery

Bob B. Armin, MD; Christian Head, MD; Gerald S. Berke, MD; Dinesh K. Chhetri, MD

**Objective:** Knowledge of the location of the muscular process of the arytenoid cartilage and the recurrent laryngeal nerve is essential to performing a successful arytenoid adduction and laryngeal reinnervation surgery. We describe external landmarks useful in locating these structures. **Study Design:** Cadaveric laryngeal dissection. **Methods:** Posterior laryngeal dissection was performed in 16 human larynges. The position of the muscular process of the arytenoid was measured bilaterally relative to the inferior and superior borders of the thyroid lamina. The recurrent laryngeal nerve was followed distally from slightly below the level of the cricothyroid joint to its genu where its vertical course changes to an oblique intralaryngeal course. **Results:** The muscular process of the arytenoid was usually found halfway between the roots of the superior and inferior cornu of the thyroid lamina. The recurrent laryngeal nerve was found just deep to the cricothyroid joint and lateral to the posterior cricoarytenoid muscle. There were no other nerves in this area. **Conclusions:** This study finds that the superior and inferior borders of the thyroid lamina are useful intraoperative landmarks to locate the muscular process of the arytenoid. The cricothyroid joint provides a good starting point to locate the recurrent laryngeal nerve, which can be identified slightly deeper between it and the posterior cricoarytenoid muscle. **Key Words:** Arytenoid adduction, laryngeal reinnervation, laryngeal framework dimensions.

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## INTRODUCTION

The arytenoid adduction operation is an important surgical technique in the treatment of unilateral vocal fold

paralysis. The advantages of arytenoid adduction over a type 1 thyroplasty operation include better closure of the posterior glottis and physiologic rotation of the cricoarytenoid joint, leading to better height match during phonation.<sup>1–5</sup> Most laryngologists would recommend this procedure for a unilateral vocal cord paralysis with a large posterior glottic chink.

Although arytenoid adduction is a more physiologic operation for vocal cord paralysis, it is more technically demanding because dissection is performed in the posterior aspect of the larynx. The key steps are to successfully locate the muscular process of the arytenoid cartilage, to avoid injury to the piriform sinus mucosa, and to place the adduction stitch at the correct tension. If the adduction suture is not placed in the muscular process, the voice outcome will be suboptimal, and if the piriform sinus mucosa is injured and goes unrecognized, saliva and food will leak into neck tissues by way of the pharyngeal perforation. Commonly recommended suggestions for finding the muscular process include finding the posterior cricoarytenoid muscle (PCA) muscle and following its insertion into the muscular process of the arytenoid and removing a 1.0 cm strip of the posterior lamina to better access and palpate the muscular process.<sup>2</sup> These are quite useful suggestions. However, dissection over the PCA muscle requires elevation of a large portion of the ipsilateral piriform sinus and postcricoid mucosa. Furthermore, sometimes the muscular process is difficult to palpate, and extensive dissection may be required to locate it. Extensive dissection can lead to more bleeding in the surgical field and postoperative dysphagia.<sup>6</sup>

The goal of this study was to anatomically define the position of the muscular process of the arytenoids in relation to the posterior border of the thyroid lamina and the roots of the superior and inferior cornu. The posterior border of the thyroid lamina is an easily palpable structure during laryngeal surgery, and the roots of the superior and inferior cornu can be easily delineated. Defining the relationship of the muscular process to the posterior border of the thyroid lamina could assist the surgeon in locating the muscular process quicker, leading to less posterior laryngeal dissection, reduced operative time, and improved postsurgical swallowing and voice outcomes.

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From the Department of Head and Neck Surgery, David Geffen School of Medicine at UCLA, Los Angeles, California, U.S.A.

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Send correspondence to Bob Armin, UCLA Surg-Hd & Nk, Box 951624, 62-132 CHS, Los Angeles, CA 90095-1624. E-mail: barmin@ucla.edu

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We offer arytenoid adduction to younger patients with vocal fold paralysis, and we also routinely perform concurrent ansa cervicalis to recurrent laryngeal nerve (RLN) reinnervation with arytenoid adduction. Our experience, in general, has been that voice outcomes are better after adduction with reinnervation than adduction alone.<sup>7,8</sup> In this study, we performed cadaver laryngeal dissections to define the position of the muscular process of the arytenoid cartilage in relation to the posterior border of the thyroid lamina. In addition, the course and location of the RLN as it enters the larynx was also evaluated.

## MATERIALS AND METHODS

Sixteen cadaver larynges were harvested from autopsy specimens at the David Geffen School of Medicine at the University of California, Los Angeles within postmortem days 1 through 3. The specimens included intact thyroid and cricoid cartilages, two or more tracheal cartilages, and the pharyngeal musculature. The larynges were not submitted for fixation. Laryngeal dissection was performed within 2 days of the harvest, with most being completed on the day of the harvest.

The laryngeal specimens were dissected similarly to how we perform an arytenoid adduction. The strap muscles were removed and the thyroid cartilage exposed. Next, the posterior edge of the thyroid ala was exposed by dividing the inferior constrictor muscle along the posterior border of the thyroid lamina. The piriform sinus mucosa was now exposed (Fig. 1) and elevated to identify the PCA. The muscle fibers of the PCA muscle were followed superiorly and anteriorly to their insertion at the muscular process of the arytenoid. Microscopic dissection of the region between the cricothyroid joint and the PCA muscle was then performed to locate the RLN (Fig. 2). The location of the RLN and the presence of other nerves in the area were noted.

The location of the muscular process of the arytenoid was measured in relation to the roots (the intersection of the thyroid cornu and the thyroid lamina) of the superior and inferior cornu of the thyroid ala (Fig. 3). The roots are easily identified after division of the inferior constrictor muscles during arytenoid adduction surgery. The locations of the roots and the location of the muscular process in a horizontal plane were marked on the posterior border of the thyroid lamina. The distance between the markings was measured to obtain the distance between the roots (labeled A in Fig. 3), the distance from the muscular process of the arytenoid to the root of the superior cornu (A-sup), and the distance from the muscular process of the arytenoid to the root of the inferior cornu (A-inf).

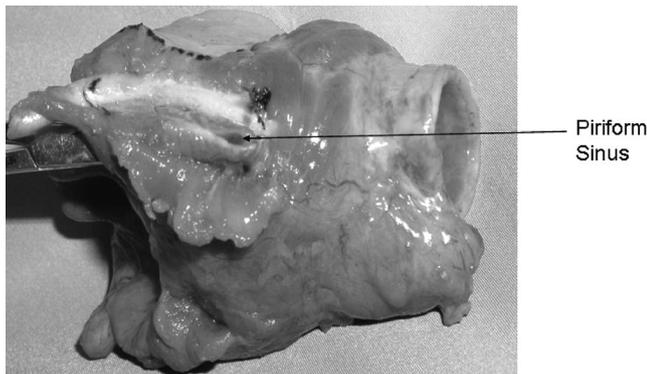


Fig. 1. Piriform sinus is exposed by incising thyropharyngeal muscle and perichondrium of posterior edge of thyroid lamina.

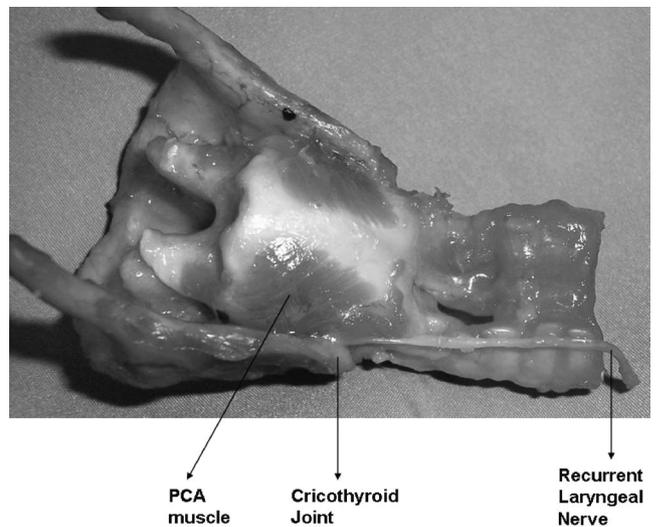


Fig. 2. Recurrent laryngeal nerve is located just deep and medial to cricothyroid joint and lateral to posterior cricoarytenoid muscle.

In addition to the above measurements, several other measurements on the laryngeal framework were made for comparison with prior studies on dimensions of laryngeal framework. The height of the posterior midline of the cricoid lamina was marked superiorly and inferiorly using straight needles and the distance between the needles measured using a millimeter measurement tape (labeled X). The distance between the thyroid notch and inferior border of the thyroid cartilage was similarly measured by marking the location of the thyroid notch and inferior border of the thyroid cartilage with straight needles and measuring the distance between (labeled Y). Representative digital photographs of the dissections were taken. An identical dissection was repeated for the opposite side.

## RESULTS

Sixteen larynges were dissected to assess the location of 32 muscular processes. There were 10 male larynges (one 15-yr-old pediatric) and 6 female larynges, with average age of 56 for both sexes. Tables I and II list the

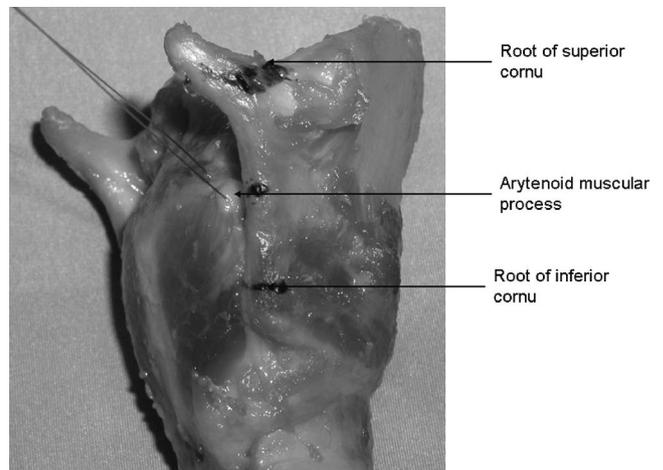


Fig. 3. Muscular process of arytenoid was found approximately halfway between roots of superior and inferior cornu of thyroid lamina.

TABLE I.  
Measurements of External Landmarks in Male Larynx.

No.	Age (yr)	Left				Right				X (mm)	Y (mm)
		A (mm)	A-sup (mm)	A-inf (mm)	Offset (mm)	A (mm)	A-sup (mm)	A-inf (mm)	Offset		
1	15	19	9	10	+0.5	18	8	10	+1.0	21	16
2	44	23	12	11	-0.5	23	12	11	-0.5	25	16
3	20	23	11	12	+0.5	20	12	8	-2.0	20	20
4	35	24	13	11	-1.0	24	13	11	-1.0	22	16
5	100	24	13	11	-1.0	20	11	9	-1.0	28	19
6	47	25	13	12	-0.5	24	13	11	-1.0	26	17
7	86	25	16	9	-3.5	25	15	10	-2.5	29	21
8	Adult	27	12	14	+1.5	25	12	13	+0.5	26	15
9	51	28	15	13	-1.0	29	16	13	-1.5	28	18
10	62	28	17	11	-3.0	25	13	12	-0.5	29	22
Average	55.6	24.6	13.1	11.4	-0.8	23.3	12.5	10.8	-0.9	25.4	18.0

A = height of posterior thyroid lamina between roots of superior and inferior cornu; A-sup = distance from muscular process of arytenoid to root of superior cornu; A-inf = distance from muscular process of arytenoid to root of inferior cornu; Offset = distance off midpoint of posterior thyroid lamina that muscular process was actually located (positive values signify closer to superior cornu; negative values signify closer to inferior cornu); X = height of posterior cricoid lamina; Y = distance between thyroid notch and inferior border of thyroid cartilage.

measurements for each individual dissection and average values for male and female larynges, respectively.

The distance between the superior and inferior cornu (measurement A) ranged between 23 and 28 mm in adult males and 16 to 20 mm in females. Left versus right measurements differed by 0 mm in three, 1 mm in three, 2 mm in one, 3 mm in two, and 4 mm in one male larynx. In females, this finding was 0 mm difference in one, 1 mm in four, and 2 mm in one. During our dissections, we found that the margin of error per marking was 1 mm. Therefore, only measurements of greater than 2 mm would be significant. Thus, 4 of 10 (40%) male larynges and 0 of 6 (0%) female larynges had significantly different lengths of the posterior lamina between the superior and inferior cornu.

On the basis of our clinical experience during arytenoid adduction surgery, we developed the hypothesis that the muscular process is located halfway between the roots of the superior and inferior cornu of the posterior thyroid lamina. Therefore, the actual location of the muscular

process was compared with the expected location at the midpoint of the posterior border of the thyroid lamina. After measurements of the A-sup and A-inf, the actual location of the muscular process was calculated as millimeters "offset" from the expected location (Tables I and II). Thus, if the process was located superior to the midpoint, then it was offset in a positive direction, and if it was located inferior to the midpoint, then it was offset in a negative direction. The offset calculations and frequency in males were as follows (n = 20): +1.5 mm = 1, +1.0 mm = 1, +0.5 mm = 3, -0.5 mm = 4, -1.0 mm = 6, -1.5 mm = 1, -2.0 mm = 1, -2.5 mm = 1, -3.0 mm = 1, and -3.5 mm = 1. The offset calculations and frequency in females were as follows (n = 12): 0 mm = 5, -0.5 mm = 3, -1.0 mm = 1, -1.5 mm = 1, and -2.0 mm = 2. An offset of  $\pm 2$  mm from midline during arytenoid adduction surgery would probably be clinically insignificant (for instance, the width of the closed tips of the Jake or Jacobson hemostats we use for surgical dissection is 1 mm). Therefore, 3 of 20 (15%) muscular processes in males and 0 of 12

TABLE II.  
Measurements of External Landmarks in Female Larynx.

No.	Age (yr)	Left				Right				X (mm)	Y (mm)
		A (mm)	A-sup (mm)	A-inf (mm)	Offset (mm)	A (mm)	A-sup (mm)	A-inf (mm)	Offset (mm)		
1	36	16	8	8	0	16	8	8	0	21	13
2	49	16	9	7	-1.0	17	9	8	-0.5	21	14
3	Adult	18	9	9	0	17	9	8	-0.5	19	14
4	51	19	10	9	-0.5	18	11	7	-2.0	21	14
5	Adult	20	10	10	0	18	11	7	-2.0	20	14
6	86	20	10	10	0	19	11	8	-1.5	20	15
Average	55.5	18.2	9.3	8.8	-0.3	17.5	9.8	7.7	-1.1	20.3	14.0

A = height of posterior thyroid lamina between roots of superior and inferior cornu; A-sup = distance from muscular process of arytenoid to root of superior cornu; A-inf = distance from muscular process of arytenoid to root of inferior cornu; Offset = distance off midpoint of posterior thyroid lamina that muscular process was actually located (positive values signify closer to superior cornu; negative values signify closer to inferior cornu); X = height of posterior cricoid lamina; Y = distance between thyroid notch and inferior border of thyroid cartilage.

(0%) muscular processes in women were significantly offset from the midpoint of the posterior thyroid lamina between the superior and inferior cornu. Clinically significant offset locations were always negative, toward the inferior cornu.

On both sides of all 16 larynges (n = 32), the RLN was always located just deep and medial to the cricothyroid joint and lateral to and at the level of the PCA (Fig. 2). No other nerves were identified in this area.

## DISCUSSION

Arytenoid adduction is an important procedure in medializing a paralyzed vocal fold with a wide posterior glottal gap.<sup>1</sup> However, many surgeons may be reluctant to perform this operation because it is perceived to be anatomically challenging. What adds to this challenge is the potential for laryngeal edema and postoperative airway complications, which are related to the precision and extent of dissection as well as the length of time required to perform the operation.<sup>6</sup> The precise knowledge of anatomic landmarks is a fundamental prerequisite to performing any surgical procedure. Therefore, studies on the location of the muscular process of the arytenoid in relation to the external laryngeal framework are valuable and would aid the surgeon in locating it more quickly and easily. This would in turn reduce the extent of dissection as well as the length of the operation.

Commonly suggested recommendations for locating the muscular process include tracing the PCA fibers superiorly and anteriorly to their insertion at the muscular process of the arytenoid, following the posterolateral cricoid cartilage superiorly to the cricoarytenoid joint, and palpating the posterior aspect of the arytenoid.<sup>2,9,10</sup> We present an additional method. The roots of the thyroid lamina are easily palpated during surgery and provide an external landmark for locating the muscular process. Our results indicate that the muscular process is usually located halfway between the roots of the superior and inferior cornu of the thyroid cartilage. This method is unique in that the other methods used for locating the muscular process are based on the internal anatomy of the larynx and require extensive dissection of the postcricoid and arytenoid region to provide adequate exposure for locating the muscular process. The surgeon can now focus on locating the muscular process in a plane halfway between the cornus of the posterior thyroid lamina. Some have recommended that a strip of the posterior lamina be removed to provide better access to the posterior larynx.<sup>2</sup> This is a technique that we have frequently found useful, especially in males, and now we recommend that if this step is performed, then the strip be removed at the posterior midline halfway between the thyroid cornus.

Sprinzel et al.<sup>11</sup> studied the dimensions of the laryngeal cartilage in 96 cadavers, and Eckel et al.<sup>12</sup> also studied the dimensions of the laryngeal framework in 53 cadavers. Our data are consistent with their measurements of the height of the thyroid lamina between the base of the greater and lesser cornu, the height of the cricoid lamina, and the distance between the thyroid notch and inferior border of the thyroid cartilage. The distance from the

muscular process to the base of the greater and lesser cornu was not measured in either of these studies.

In studying the human larynx and in performing laryngeal framework surgery, it is critical to take into account the sexual dimorphism that exists because the dimensions of the male human larynx change considerably during puberty. Therefore, it is not too surprising that the male larynges displayed the most variance in measurements. The single pediatric case of a male larynx in this study from a 15 year old closely matched the female larynges. Given that asymmetry does exist, especially in the male larynx, and that our data are limited to 16 larynges, it is critical that the surgeon not depend solely on any single landmark in locating the muscular process. Instead, this method should be used in conjunction with the previously mentioned recommendations to improve the precision and length of surgery. We believe that the midpoint of the posterior thyroid lamina between the superior and inferior cornu provides an excellent starting point for locating the muscular process, and this can allow the surgeon to hone in on the location of the muscular process. Other methods can then be used for further verification. With the techniques discussed here, we do not find it necessary to dislocate the cricothyroid joint to identify the muscular process.

We routinely perform the arytenoid adduction procedure in conjunction with ansa cervicalis to RLN reinnervation. We believe that adductor reinnervation by the ansa cervicalis provides an increased and better tension match during phonation than that provided by any residual innervation (aberrant or inadequate) that may be present. Therefore, we also dissected the location of the RLN in each larynx. We found that the RLN was always located just deep to the cricothyroid joint and lateral to the PCA. There were no other nerves in this area. This is consistent with our clinical experience as well.

## CONCLUSIONS

This study finds that the superior and inferior cornus and the posterior border of the thyroid lamina are useful intraoperative landmarks to locate the muscular process of the arytenoid. The muscular process was found halfway between the roots of the superior and inferior thyroid cornus in a majority of larynges. The remaining significantly offset locations were all inferior to this midpoint. The cricothyroid joint provides a good starting point to locate the RLN, which can be identified slightly deeper between it and the PCA muscle. These findings will aid the surgeon to hone in on these anatomic structures with more confidence during arytenoid adduction surgery.

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