

An objective evaluation of the laryngeal roof

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Abstract

Aim: The anatomic measurements of the thyroid cartilage, which is an important part of the laryngeal roof, were calculated using computed tomography (CT) and the data obtained were compared in two groups of male and female.

Material and Methods: A total of 148 adult patients were examined in this retrospective, cross-sectional study. All the patients were aged over 18 year and presented to emergency ward between 2015 and 2016 due to trauma. Cervical vertebra CT was taken and the reformatted two-dimensional images were examined. Measurements were taken on the images at two separate levels of the interlaminar angle (ILA), thyroid prominence angle and the distance of the vocal cords from the lower edge of the thyroid.

Results: The ILA in the glottis region was measured as $74.02 \pm 17.23^\circ$ for males and as $98.00 \pm 12.78^\circ$ for females. The difference between the genders was statistically significant ($p < 0.001$). The distance of the vocal cords from the lower edge of the thyroid cartilage was measured as 7.12 ± 2.29 mm for males and 5.15 ± 2.06 mm for females.

Conclusion: The results of the ILA measurements in this study were observed to be narrower in both genders than the measurements given in classic reference books. The ILA in both the regions of glottis and supraglottis was measured as a narrower angle in males than in females. These results show the presence of sexual dimorphism in the Kahramanmaraş region where the study was conducted.

Keywords: Thyroid Cartilage; Interlaminar Angle; Thyroid Prominence; Vocal Cords; Cervical Vertebra; Computed Tomography.

INTRODUCTION

With rapid developments in imaging methods (optic fibres, computed tomography [CT], magnetic resonance imaging [MRI]), sophisticated operations such as chondroplasty and thyroplasty have been more commonly and successfully applied to evaluate changes in the laryngeal roof, and in the last 20 years, this led to an increase in the interest of clinicians in the complex anatomic and physiological structure of the larynx. Thus, it has been aimed to increase phonetic quality, which is one of the basic markers not only affecting patient satisfaction but also in the avoidance of complications (1-3). In classical medical literature, the interlaminar angle (ILA) is defined as 90° in males and 120° in females (4-7).

Apart from a few recent studies, the studies in literature that evaluated the anatomic structure of the larynx are the cadaver studies that were conducted a long time ago. An extremely wide range of ILA measurements have been reported in those studies, as 63° - 90° for males and 80° - 120° for females (7-9), and it has been emphasized that these differences are associated with

methodological differences arising from, such as, the level of the measurement and the cross-section planes used (7). That the studies were conducted in very different geographical regions can also be considered to have contributed to these differences. In recent studies using imaging methods (3,7), the values can be seen to be more consistent as the evaluation methods and methodology were similar.

This study aimed to provide current data for literature and to ensure the standardization of treatment methods with an evaluation of the effect of gender and ethnic variables of the individuals in our geographic region and to evaluate the effects of different geographic areas and sexual dimorphism on the anatomic structure.

MATERIAL and METHODS

The study protocol was applied in accordance with the Helsinki II Declaration. Approval for the study was granted by the Clinical Research Ethics Committee of Kahramanmaraş Sutcu Imam University (approval no. 01, dated 18.01.2017).

Received: 14.06.2018 **Accepted:** 16.08.2018 **Available online:** 03.09.2018

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A retrospective study was carried out with the adult patients who presented at the Emergency Department between 2015 and 2016 because of trauma. CT images of cervical vertebrae were taken. Neck CT images of a total of 156 patients, comprising 103 males and 53 females, were examined. Exclusion criteria were applied to eight patients; five patients with a history of neck surgery and cervical trauma and three patients undergoing radiotherapy for a diagnosis of nasopharynx cancer. Length and angle measurements were made on the two-dimensional reformatted CT images which were retrospectively examined. Patients were excluded if there were mobile artifacts on the images, if there was a history of neck surgery or known head-neck malignancy or any findings of traumatic cervical injury. Thus a total of 148 patients, comprising 98 (66.2%) males with a mean age of 35.19 ± 14.39 years (range, 18-73 years) and 50 (33.8%) females with a mean age of 45.00 ± 15.89 years (range, 18-70 years), were evaluated (Table 1).

Table 1. Demographic data of patients

Characteristic	Male (n = 98)	Female (n = 50)	P
Age (years)	35.19 ± 14.39	45.00 ± 15.58	0.38
Glotticplane	74.02 ± 17.23	97.62 ± 12.78	0.001
Supraglotticplane	68.23 ± 15.27	93.22 ± 10.59	0.001
Thyroidprominenceangle	21.25 ± 7.56	13.04 ± 6.15	0.001
Loweredge of thethyroidcartilage	7.12 ± 2.29	5.15 ± 2.06	0.001

Data are expressed as the mean \pm SD, unless otherwise noted
Independent T Test(Bootsrap) -)

For the CT scan, a 16-detector CT device was used (Alexion, Toshiba Medical Systems, Nasu, Japan). Images were taken at slice thickness of 2mm at 120 kV and 120 mAs. The reconstructed axial and sagittal images were transferred to a 27-inch iMac computer (Apple Inc., Cupertino, California, USA). The images were evaluated on the workstation by a radiology specialist with more than 10 years of experience.

Measurements were made on the axial slices in a manner consistent with the measurement levels used by Sagivet al. The ILA was measured at two separate levels; at the vocal cord level (glottic level) and at 5mm upper than the glottis region (supraglottis level). Measurements at the glottis level were made at the level of the vocal processes of the arytenoids and both thyroarytenoid muscles (Figure 1) and the measurements at the supraglottis level were made 5mm upper and parallel to this level. Using the sagittal plane reformatted images, the thyroid prominence angle measurements in the mid-sagittal plane were calculated as the angle between the line drawn tangential to the cricothyroid membrane and the line drawn from the lower tip of the thyroid cartilage towards the most prominent tip (Figure 2). The distance of the vocal cords from the lower edge of the thyroid cartilage was determined by evaluating the sagittal and axial reformatted images together.

Statistical Analysis

The data obtained in the study were analyzed using SPSS for Windows v22.0 software (IBM, Armonk, New York, USA). The differences among individuals in respect of measurement values and parameters were examined with the Student's t-test.

Data were stated as mean \pm standard deviation (SD). Multiple groups were evaluated using variance analysis (ANOVA with Tukey HSD). In the evaluation of paired groups, the Independent t-test was used. In all tests a value of $p < 0.05$ was accepted as statistically significant.

RESULTS

The ILA in the vocal cord plane was measured as $74.02 \pm 17.23^\circ$ for males and as $97.62 \pm 12.78^\circ$ for females (Figure 1). The ILA in the supraglottis plane was measured as $68.23 \pm 15.27^\circ$ for males and as $93.22 \pm 10.59^\circ$ for females ($p < 0.001$). The thyroid prominence angle was measured as $21.25 \pm 7.56^\circ$ for males and as $13.04 \pm 6.15^\circ$ for females. The distance of the vocal cords from the lower edge of the thyroid cartilage was measured as 7.12 ± 2.29 mm for males and 5.15 ± 2.06 mm for females (Table 2).



Figure 1. The image obtained from the Aksiel plane is also seen in the interlaminar angle Measurements at the glottic level were made at the level of the vocal processes of the arytenoids and both thyroarytenoid muscles



Figure 2. Sagittal plan reformat image, the thyroid prominence angle measurements in the mid-sagittal plane were calculated as the angle between the line drawn tangential to the cricothyroid membrane and the line drawn from the lower tip of the thyroid cartilage towards the most prominent tip

Table 2. Comparison of larynx anatomical structures by gender					
Groups	Glottic plane	Supraglottic plane	LETC	TPA	
Man (n:98)	≤30/yil (n:50)	75.02 ±17.13	67.42±14.69	6.50±1.67	22.80±7.32
	31-40/yil (n:17)	81.70±18.05	75.29±15.46	7.76±2.60	19.91±7.50
	41-50/yil (n:10)	70.50±15.04	67.10±18.94	7.25±2.20	18.35±8.68
	51-60/yil (n:14)	63.50±16.28	61.28±14.31	7.50±2.59	21.85±5.55
	≥61/yil (n:7)	76.40±14.20	73.40±10.59	7.54±2.11	13.20±8.10
	p	0.054	0.123	0.842	0.039
Woman (n:50)	≤30/yil (n:12)	100.50±10.49	91.91±8.38	5.17±1.62	15.83±4.85
	31-40/yil (n:6)	98.66±10.36	91.83±11.30	4.88±1.43	11.83±7.19
	41-50/yil (n:11)	95.09±10.05	92.45±9.27	4.83±1.61	12.90±4.98
	51-60/yil (n:11)	91.45±11.12	89.36±12.60	4.77±2.30	14.00±7.53
	≥61/yil (n:10)	103.10±18.62	100.70±9.87	6.05±2.97	9.50±5.60
	P	0.244	0.144	0.640	0.177

Data are expressed as the mean ±SD, unless otherwise noted.
 Independent T Test(Bootstrap) - Mann Whitney U Test(Monte Carlo) - Fisher Exact Test (Monte Carlo) - One-Way ANOVA
 TPA: Thyroid prominence angle
 LETC: Lower edge of the thyroid cartilage

DISCUSSION

The evaluation of the data obtained in the study showed a statistically significant difference between the groups in respect of gender. The ILA of males in both the glottis and supraglottis planes was seen to be narrower than in females, whereas the thyroid prominence was at a narrower angle in females. Although the distance of the vocal cords from the lower edge of the thyroid cartilage was similar in the two genders, there was a greater distance of approximately 2mm in males.

Although different methods are used for imaging in medical applications, CT was used in this study as it is the most suitable imaging method for the visualization of ossified structures and is readily available in many centers.

Electrophysiological tests for the diagnosis and treatment of laryngeal diseases, office methods, thyroplasty, chondroplasty (correction of the thyroid gland and thyroid prominence to give a more feminine appearance to the neck of trans-sexual patients) and sophisticated applications such as percutaneous injection laryngoplasty have increased the need for the knowledge of the characteristic properties of the larynx skeleton (7,10-13). It is well-known that the anatomy of the larynx is different between the genders (due to the thyroid prominence-Adam's apple) (13,14).

In previous cadaver studies on the thyroid cartilage ILA, a wide range of results were reported (13,15). This difference can most likely be explained by different methods used by each researcher. In the current study, using a methodology similar to that of two recent studies, the ILA was measured at the vocal cord level (glottis) and at a level 5mm upper (supraglottis).

In morphometric studies conducted related to the structure of the larynx, it has been reported that in childhood there is no sexual dimorphism in the larynx and the difference emerges during puberty. This has been associated with increased testosterone in adolescence (16-17). In cadaver studies by Jotz et al examining morphometric values of the larynx, sexual dimorphism was noticed with a statistically significant difference between males and females but it was reported that after the age of 40, the morphometric difference decreased (14). In the ILA measurement of the current study, the angle in the glottis and supraglottis regions was determined to be narrower in males than in females, which was consistent with literature, and these results showed the presence of sexual dimorphism. The thyroid prominence (Adam's apple, thyroid cartilage prominence) measurements were significantly more prominent in males than in females.

In the placement of electrodes during electrophysiological tests of the larynx and during operations such as trioplasty and chondroplasty, it is important to know the angle between the thyroid lamina and the projection of the vocal cords over the thyroid cartilage (8). Isshiki calculated the angle between the thyroid lamina from an average of three localizations and reported it to be 74° for males and 90° for females (19). In the current study the mean ILA was determined as 74.02°±17.23° for males and as 97.62°±12.78° for females, which were similar values to those reported by Isshiki. From studies in different countries, the ILA was reported as 77.17° for males and 89.9° for females by Tayama et al (Japan), as 78.7° for males and 89.92° for females by Ajmani et al (Nigeria) and as 78.83° for males and 94.14° for females by Kovac et al (Croatia) (5,8,19,20). Although the measurement results of males are similar in these studies carried out with different races in different countries, a difference is seen in the measurements of females, suggesting that there are racial differences.

In a cadaver study by Çınar et al, the distance of the vocal cord anterior commissure from the thyroid cartilage midline lower edge was reported to be 9.2mm for males and 8mm for females (10). In the current study, this distance was calculated as 7.12mm for males and 5.15mm for females. This difference can be considered to be due to the different reference points taken for the distance of the vocal cords from the thyroid cartilage lower edge. Çınar et al stated that the greatest distance was from the posterior of the vocal cord to the lower edge of the inferior tubercle of the thyroid area. In the current study, the measurements were based on the distance between the vocal cord anterior commissure and the lower edge of the thyroid midline.

As neck CT scans of healthy individuals could not be taken because of exposure to radiation and ethical reasons, the data of this study were obtained from the archives of the Radiology Dept. Therefore, this study had the limitations of lack of knowledge of the body mass index of the patients, lack of comprehensive patient information and no extra information or findings of laryngology.

CONCLUSIONS

Localization of the vocal cords shows a difference according to gender, and structural changes may be seen in the larynx that has a direct effect on the voice. More accurate measurements of vocal cord localization and of the thyroid cartilage are of fundamental importance both for good evaluation and for the recommended treatment of surgical procedure for operations of the larynx roof. Examination of the larynx with CT provides the surgeon with the dimensions of the larynx and shows differences among individuals. Therefore, it can be used in the planning and analysis of laryngeal surgery and can assist in reducing surgical failures associated with anatomical changes encountered during the operation.

Competing interests: The authors declare that they have no competing interest.

Financial Disclosure: There are no financial supports

Ethical approval: The study protocol was applied in accordance with the Helsinki II Declaration. Approval for the study was granted by the Clinical Research Ethics Committee of Kahramanmaraş Sutcu Imam University (approval no. 01, dated 18.01.2017).

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