

Gender Differences in Thyroid Notch on Computed Tomography in Thailand

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Background: The prominence of the Adam's apple can cause dissatisfaction with physical appearance among transgender people. However, there seems to be no difference of the particular organ between Thai males and females.

Objective: To analyze variations between the genders in the interlaminar angle (IA) and the convex distance (CD) of the thyroid cartilage. Additionally, measurements from the thyroid cartilage's most prominent point to the thyroepiglottic ligament's attachment point as the Notch-to-Epiglottis (NTE) were compared.

Materials and Methods: The present study was a retrospective cross-sectional study. Data were collected from patients that attended Rajavithi Hospital for neck computed tomography (CT) in the two-year period between 2019 and 2020. These patients were divided into two groups, one consisted of 100 males and the other of 100 females, all of whom were aged 18 to 60 years. The IA, CD, and the NTE of the two genders were analyzed.

Results: The IA was measured at $65.3 \pm 9.4^\circ$ for males and $88.9^\circ \pm 11.3^\circ$ for females. The CD was measured at 9.9 ± 2.1 mm and 7.8 ± 1.5 mm for males and females, respectively, while the NTE was measured at 7.4 ± 1.2 mm and 6.1 ± 1.1 mm, respectively. All of these differences between the genders were statistically significant ($p < 0.001$). Previous neck radiation and thyroid disease did not affect differences in the IA, CD, or NTE.

Conclusion: Based on the population samples, it was observed that, in comparison to females, males exhibited a more acute IA, a notably larger CD, and a greater NTE measurement. Developing a comprehensive understanding of the thyroid notch can help to reduce the occurrence of complications in chondrolaryngoplasty.

Keywords: Protuberant thyroid notch; Thyroid cartilage

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The prominence and distinct edges of the thyroid notch have a significant impact on the symptoms of gender dysphoria in transfeminine individuals. The more masculine physical attributes they possess, which contrast with their desired gender identity, the more they feel subjected to considerable stigmatization.

Gender dysphoria, originating from the incongruence between a person's assigned birth gender and gender identity, is experienced by some transgender individuals. While gender dysphoria

can begin in childhood, it may also emerge during adolescence.

In transwomen, a pronounced thyroid cartilage, colloquially known as the "Adam's apple" or "pomus Adamus", contributes to their feelings of gender dysphoria. This prominence is made more noticeable not only by its larger size but also by the more acute angle formed by the anterior borders of the thyroid cartilage, accentuating the laryngeal prominence^(1,2).

The thyroid notch (Figure 1), serves as the opening in the midline's upper portion, leading to the thyroid prominence. Before puberty, the thyroid cartilages of the two genders are similar in size, however, with the rise in testosterone levels, the thyroid cartilage enlarges, and its upper aspect becomes more noticeable⁽³⁾.

There is a scarcity of research related to thyroid cartilage characteristics in the available literature, with most studies concentrating on Caucasian populations. Past medical textbooks defined the interlaminar angle as 90° for adult males and 120° for females. However, cadaveric investigations have

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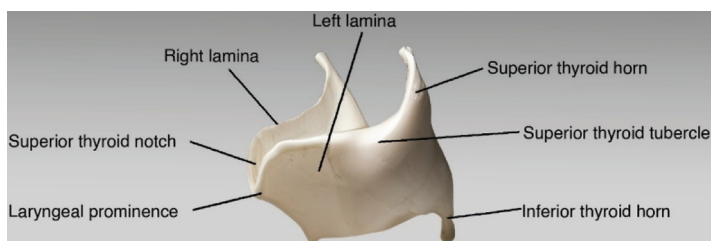


Figure 1. Anatomy of thyroid cartilage.

shown variations ranging from 63° to 90° in males and 80° to 120° in females⁽⁴⁾. None of those studies focused on Thailand, and computed tomography (CT) findings of Thai individuals' necks have indicated significant variability in the angular dimensions of the thyroid cartilage⁽⁴⁻¹¹⁾.

The present study aimed to compare the interlamellar angle (Figure 2A, B) and the convex distance of the thyroid cartilage (Figure 2C, D) of the two genders in Thai population using neck CT. In addition, measurements from the thyroid cartilage's most prominent point to the thyroepiglottic ligament's attachment point (Figure 2E, F) were also compared.

Materials and Methods

The present study was a retrospective, single-center, institutional review board-approved study of all patients who underwent CT of the neck at Rajavithi Hospital between January 2019 and December 2020. The study was approved by the Research Ethics Committee of Rajavithi Hospital (No. 074/2564). Images of individuals aged 18 to 60 years who underwent neck CT scan were included in the study. Patients having histories of neck trauma, a laryngeal tumor, or previous laryngectomy were excluded, also those who underwent intubation or a CT scan while unresponsive or uncooperative. Duplicate imaging of the same patient and misaligned or low-quality images were excluded. Using computer software, the remaining CT scans were divided into two groups of males and females.

Measurement methods

All patients underwent the same global standard CT protocol⁽¹²⁾. Imaging with a CT scanner began at the frontal air sinus and ended at the sternoclavicular joint. Both the contrast and non-contrast phases of the CT had a 2 mm thickness. The contrast phase had a 48-second delay. NaCl 30 mL was initially injected at a flow rate of 3.5 mL/second followed by contrast media 80 mL at a flow rate of 2.7 mL/second, and finally the NaCl 30 mL was injected

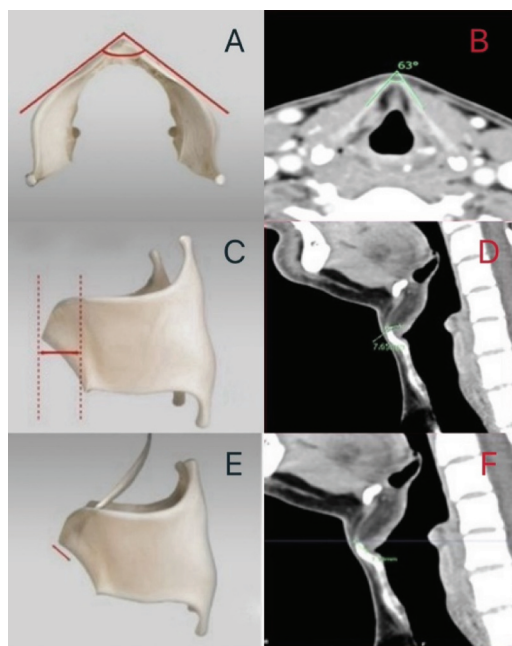


Figure 2. Interlamellar angle (A, B) measured on an axial plane at the level of the first displaying the bilaminar separation. Convex distance (C, D) and Notch-to-Epiglottis (E, F) measured on a sagittal plane reflecting the midline of vertical axis of the C2 spine.

at a flow rate of 2.7 mL/second. For alignment precision, each imaging underwent standard laser-assisted positioning before scanning commenced and a multiplanar reconstruction after scanning. The SOMATOM Definition AS (Siemens Medical Solutions USA, Inc.) was the only CT device used in the present investigation.

The authors utilized a standard Picture Archiving and Communication system or PACs software (FUJIFILM SYNAPSE 5, version 5.7.100, FUJIFILM Corporation) in accordance with the head and neck radiologist's instructions.

To determine the interlamellar angle (Figure 2A, B), the axial-view CT scan was scrolled from the lowest image until it displayed the bilaminar separation. This CT cut was then selected, and the

angle was measured. Using the Intellilink function, the authors chose the sagittal picture for the convex distance (Figure 2C, D) that correlated with the midpoint of the separation from the previously selected axial image. As a result, the sagittal image reflecting the midline was obtained. The authors first marked the vertical axis of the C2 spine and then a perpendicular horizontal line. A vertical line parallel to the horizontal line was then constructed starting from the thyroid cartilage's most anterior bottom limit, after which the convex distance was calculated. Using the previous true sagittal imaging, the final measurement, the Notch-to-Epiglottis distance (Figure 2E, F), was calculated from the cartilage's most prominent portion to the superior margin of the adherent point of the thyroepiglottic ligament.

Statistical analysis

All analyses were performed with IBM SPSS Statistics, version 22.0 (IBM Corp., Armonk, NY, USA). Data were presented as mean and standard deviation (SD) unless otherwise noted. Chi-square test was used for comparisons between two categorical variables, and Student's t-test was employed to compare numerical variables of males and females. The univariate and multivariate relationships between gender and various other factors were analyzed using a general linear model. A p-value of less than 0.05 was considered statistically significant⁽¹³⁾.

Results

Patient demographics

The present study involved 200 patients, with 100 in the male group and 100 in the female group. Male and female characteristics are compared in Table 1. There were no statistically significant differences between the groups in terms of age, nationality, or medical co-morbidity. Only prior neck radiation and thyroid disease demonstrated a statistically significant difference between male and female patients.

Thyroid notch parameters

Males had a mean interlaminar angle of 65.3°, whereas females had an angle of 88.9°. The mean convex distance for males was 9.9 mm while for females it was 6.8 mm. Furthermore, the mean Notch-to-Epiglottis distance was 7.4 mm for men and 6.1 mm for women. As shown in Table 2, all differences between the genders were statistically significant.

Both univariate and multivariate analyses were performed (Table 3) with significance set at p smaller

Table 1. Comparison of male and female characteristics

Characteristics	Male (n=100)	Female (n=100)	p-value
Age (years); mean±SD	38.5±12.8	38.9±12.9	0.826
Nationality; n (%)			0.344
Thai	92 (92.0)	90 (90.0)	
Lao	3 (3.0)	4 (4.0)	
Cambodian	4 (4.0)	2 (2.0)	
Burmese	0 (0.0)	3 (3.0)	
Indian	1 (1.0)	0 (0.0)	
Chinese	0 (0.0)	1 (1.0)	
Previous neck radiation; n (%)			0.002*
Yes	28 (28.0)	10 (10.0)	
No	72 (72.0)	90 (90.0)	
Thyroid disease; n (%)			<0.001*
Yes	5 (5.0)	25 (25.0)	
No	95 (95.0)	100 (100)	
Other malignancy; n (%)			0.190
Yes	43 (43.0)	33 (33.0)	
No	57 (57.0)	67 (67.0)	

SD=standard deviation

p-value from Student's t-test and chi-square test was considered,

* Significant at p<0.05

Table 2. Comparison of thyroid notch parameters between males and females

Thyroid notch parameters	Male mean±SD	Female mean±SD	p-value
Interlaminar angle	65.3±9.4	88.9±11.3	<0.001*
Convex distance	9.9±2.1	6.8±1.5	<0.001*
Notch-to-Epiglottis	7.4±1.2	6.1±1.1	<0.001*

SD=standard deviation

p-value from Student's t-test was considered, * Significant at p<0.05

than 0.05. While B was the mean difference of the variable between males and females, when adjusted for previous neck radiation and thyroid disease, gender was found to be the only variable with a statistically significant impact on the interlaminar angle, the convex distance, and the Notch-to-Epiglottis distance. All of these were unaffected by previous neck radiation or thyroid disease, which varied across the two populations. The results of adjusted multivariate analysis indicated that the males had a 23.64-degree more acute angle than that of their female counterparts. Gender alone had a statistically significant effect, as determined by the convex distance, with the results of multivariate analysis indicating that males had a convex distance that was 3.04 mm greater than that of females. In addition, with regard to the final parameters, the Notch-to-Epiglottis distance, gender was again the

Table 3. Univariate and Multivariate analysis of thyroid notch parameters between males and females

Thyroid notch parameters	Crude B (difference of mean)	95% CI	p-value	Adjusted B (difference of mean)	95% CI	p-value
Interlaminar angle (male-female)	-23.52	-26.62 to -20.63	<0.001*	-23.64	-26.72 to -20.56	<0.001*
Convex distance (male-female)	3.10	2.59 to 3.61	<0.001*	3.04	2.50 to 3.59	<0.001*
Notch-to-Epiglottis (male-female)	1.31	0.96 to 1.63	<0.001*	1.33	1.00 to 1.67	<0.001*

CI=confidence interval

Adjusted for sex, thyroid disease, previous neck radiation and other malignancy, p-value from general linear model was considered, * Significant at $p < 0.05$

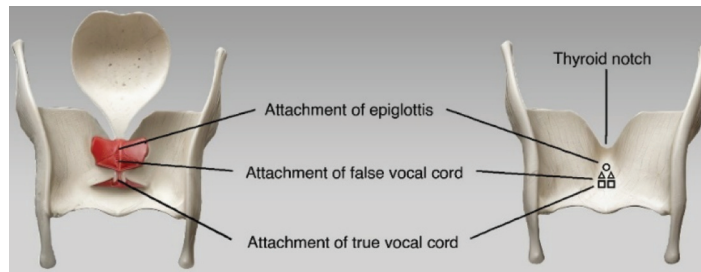


Figure 3. Attachment points at the inner surface of thyroid cartilage.

sole statistically significant variable. In the adjusted results, males had a 1.33 mm greater Notch-to-Epiglottis distance than females.

Discussion

Chondrolaryngoplasty, or reduction of the thyroid cartilage, is the only treatment for people with gender dysphoria due to the prominence of thyroid cartilage, which does not respond to female hormonal therapy^(3,13-16). This surgery is aimed at achieving a physical appearance close to that of a female and is called feminization surgery. It involves surgical reduction of the convexity of the Adam's apple to flatten it to resemble the appearance of a female throat.

Currently, both open and endoscopic surgery are available. For a male's Adam's apple to resemble a female's, surgical corrections must be made to the angle of the thyroid cartilage and the size of its convexity.

According to conventional anatomy textbooks⁽⁴⁾, males have a significant narrower interlaminar angle than females. The present study's investigation indicated a lower average interlaminar angle than that stated in the textbook for both genders with 65.3° versus 90° for males and 88.9° versus 120° for females. The average angle found in the present study of this sample group of Thais was moderate when compared to the results of studies among Israelis^(1,17) and Iranians⁽¹⁸⁾ with 65.3°, 63.5°, and 83.8° in males and 88.9°, 93.3°, and 87.0° in females. Further investigation of different races should be conducted.

Given that males have a greater convex distance than females, 9.9 mm in males and 6.8 mm in females, the authors may anticipate that during chondrolaryngoplasty, the surgeon must not only smooth out the notch but also reduce its prominence to make it appear comparable to the female notch.

Focusing on the anatomy of the thyroid cartilage, the attachment points of the thyroepiglottic ligament (Figure 3), which extends to the epiglottis, lies on the inner surface below the thyroid notch. The false and true vocal cords are attached below the thyroepiglottic ligament attachment site, and the thyroepiglottic ligament must be considered during thyroid cartilage shaving. Even though epiglottic destabilization has not been reported as yet, it is a known danger that could theoretically lead to dysphagia⁽¹⁹⁾.

Resection is performed more inferiorly, and the false and true vocal cords may be damaged, resulting in hoarseness or difficulty in breathing. Destabilizing the anterior commissure tendon through overaggressive resection can have significant and irreversible effects on the voice of the patient. This is especially distressing for transgender women, as a lower voice can be painful, and it can be a difficult obstacle for them to overcome. Hence, aesthetic outcomes must be balanced with the more important objective of reducing the danger of over resection and voice alteration.

The safe distance for surgery is between the notch and the level of the thyroepiglottic ligament's adhesion point. Theoretically, an extension below this level could cause injury to the anterior commissure

attachment, resulting in impaired vocal cord function.

Apart from gender variations, the present study exemplifies the exact margins employed in ASEAN surgery, which average 7.4 mm in males and 6.1 mm in females, to prevent injury to the thyroepiglottic ligament and ensure that both vocal cords are protected.

Normally, skeletal maturation occurs in females aged 18 to 20 and males aged 19 to 21, but currently, there has been no research aimed at identifying the age group with thyroid cartilage maturation in Thailand. The present study focused on the period when skeletal maturation begins, so there might be incomplete maturation of the thyroid cartilage, and measurements obtained may therefore have underestimated actual sizes. The authors suggest that future research should measure populations older than 21 years⁽²⁰⁻²³⁾.

The limitation of the present study was its purely retrospective nature. Therefore, it is probable that certain CT images were not precisely oriented to produce absolute symmetry. Despite the authors' best efforts to select suitable images, and the radiologist's attempts to orient those images, when necessary, some may remain imperfect. A prospective analysis is recommended for further study to ensure greater accuracy. Furthermore, the present study included patients from a single center and may not be entirely representative of the Thai people. Therefore, further research should be conducted employing data collected from multiple centers.

According to research, the thyroepiglottic ligaments are not necessary for epiglottic stabilization due to the absence of reported postoperative problems, despite the likelihood of total ligament rupture. Scarring between this ligament and the anterior soft tissue of the neck is sufficient for suspension. Thus, the relationship between the detached thyroepiglottic ligament and epiglottic destabilization should be investigated further. The safe distance, however, remains unchanged.

Conclusion

In comparison to females, males had a more acute interlaminar angle, a longer convex distance, and a greater Notch-to-Epiglottis distance. These factors may have an impact on chondrolaryngoplasty; therefore, greater knowledge of the thyroid notch can help surgeons performing surgery on transgender patients to mimic the female thyroid notch, and complications can be avoided by being aware of the safe distance.

What is already known on this topic?

Research in the past provided data on thyroid cartilage characteristics, specifically the interlaminar angle, which was 90° for males and 120° for females, unique to the Caucasian group only. However, there is a lack of research on thyroid cartilage characteristics, Notch-to-Epiglottis between males and females in the ASEAN population.

What does this study add?

The added information obtained from this research shows that the interlaminar angle is less than in the textbook for both genders with 65.3° versus 90° for males and 88.9° versus 120° for females, and the Notch-to-Epiglottis is 7.4 mm for men and 6.1 mm for women. This data can help surgeons plan chondrolaryngoplasty procedures in a safe zone to prevent complications.

Conflicts of interest

The authors declare no conflict of interest.

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