ORIGINAL ARTICLE

Eur. J. Anat. 20 (3): 205-213 (2016)

Anatomical and functional aspects of cricothyroid joint: a cadaveric study

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SUMMARY

The pivotal role in the adjustment of the pitch of the human voice is played by the cricothyroid joint. The purpose of our study was to provide data of the morphology of articular surfaces and the range of movements occurring at the cricothyroid joints and to study the ligaments associated with the latter. The cricothyroid joints of two hundred and fifty larynges obtained from fetal, neonatal, children and adult autopsied subjects were opened to study the articular surfaces. Range of maximum possible gliding and rotational movements at the cricothyroid joints was studied in forty larynges derived from another group of autopsied subjects (18 to 80 years). The articular surface of the inferior cornu of the thyroid cartilage exhibited facet more often than cricoid and the incidence of facet increased with age. Facets were round or oval shaped and bigger on the cricoid than the inferior cornu of the thyroid cartilage. Average ventro-dorsal gliding movement in males and females were 1.88±0.76 mm and 2.08±1.20 mm respectively. Average vertical gliding movement in craniocaudal direction in males and females were 1.87±0.92 mm and 1.71±1.22 mm respectively. The average permissible rotational movement was 2.27±0.71 mm in males and 2.65±0.53 mm in females. The possible lengthening of vocal folds by rotational movement was 4.08±1.24 mm in males and 3.89±1.60 mm in females. We believe that the results of this study would contribute to understanding of the mobility at the cricothyroid joint and the data provided can be of use for surgeons during laryngeal framework surgery such as cricothyroid approximation.

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Key words: Cricothyroid articulation – Cricothyroid approximation – Transsexual – Vocal pitch

INTRODUCTION

The cricothyroid joint (CTJ), often described as diarthric joint of the hinge, syndesmoses or synchondroses type plays important role in modulation of pitch of human voice. The biomechanical property of this joint is exploited in upcoming phonosurgical procedures. Since the first description of basic procedures to alter the laryngeal framework by Isshiki in 1974, phonosurgical procedures such as cricothyroid approximation to raise the pitch of the voices of male-to-female transsexuals (Brown, 2000; Kanaglingam, 2005) are emerging as a rapidly growing subspecialty of laryngology. The pitch of the voice can be altered by changing the length and tension of vocal cord. A good correlation between elevation in voice pitch and the change in vocal fold length by increasing the length by 2-5 mm has been reported by various workers (Kitajima, 1979; Neumann and Welzel, 2004; Matai, 2003). Investigations on anatomical and functional principles of CTJ may help the surgeons. The rotatory action permitted at CTJ allows the cricoids and thyroid cartilage to be tilted upon each other and increase or decrease the distance between them (Hollinshed, 1982). A detailed description of these joints is missing from the standard text books of Anatomy (Williams et al., 1995) and otolaryngology. Functional anatomy and morphology of this joint of the human larynx have been paid less attention and only a handful of articles have been published on this subject (Maue and Dickson, 1971; Isshiki et al., 1983; Vilkman et al., 1987; Matai et al., 2003; Hammer et al., 2010). The present study was planned to provide a detailed account of functional anatomy of the CTJ, which can be of use for the surgeons during laryngeal frame-

Submitted: 22 March, 2016. *Accepted:* 28 April, 2016.

work surgery. An attempt was also made to analyze the changes in articular surfaces of laryngeal cartilages with age.

MATERIALS AND METHODS

Specimens consisted of two sets

Set A for the study of interior of CTJ: comprised of 500 CTJ of 250 larynges (150 adults of 18 to 80 years comprising of 100 males and 50 females; 50 children of 2 to 17 years; 25 newborns and 25 fetuses of CR length 250 mm to 299 mm).

Set B for the study of movements of CTJ: comprised of 80 CTJ of 40 larynges (25 males and 15 females; age 18 to 80 years).

After getting approval from the institutional ethical committee and informed consent of relatives, the entire larynx from the hyoid bone to the upper part of trachea was separated during autopsy and later preserved in 10% formalin in the laboratory of Anatomy. All the fetuses used in this study were unclaimed spontaneously aborted. Extrinsic muscles of the larynx were removed carefully to expose the CTJ. Care was taken to preserve the joint capsule and ligaments. Larynges with any macroscopic abnormalities or injuries were excluded from this study.

The study consisted of three parts

I *Visual observations of interior of the CTJ joint: This was done in set A specimens*

Following removal of extrinsic muscles of larynx the articular capsule of CTJ was removed to expose the articular surfaces. The inferior cornu and the cricoids cartilage were studied for presence of a well-defined articular facet. Shapes and dimensions of facets were studied in children and adults. For measuring dimensions a digital vernier caliper (Mitutoyo, Japan) of 0.02 mm precision was used.

For purposes of statistical analysis, the sexual difference between the means of various measurements was calculated by student's "t" test. To find the difference between the incidences of articular facets in the two sexes, chi-square test was applied. Statistics were considered significant when $p<0.05$.

II *Study of range of various movements of CTJ: This was done in set B specimens. (Fig. 1)*

1 *Horizontal gliding movement*: The horizontal distance between the inferior cornu of the thyroid cartilage and the most anterior point on the upper border of the arch of the cricoids was measured in two positions.

1a. Inferior cornu was manually moved posteriorly to its maximum limit and the horizontal distance measured represented the uppermost limit of the horizontal gliding movement (maximum).

1b. Inferior cornu was manually moved anteriorly to its maximum limit and the horizontal distance measured represented lowermost limit of the horizontal gliding movement.

2 *Vertical gliding movement*: The vertical distance between the inferior cornu of thyroid cartilage and the inferior border on the lateral side of the cricoid cartilage was noted in two positions.

2a. Inferior cornu was manually moved upward to its maximum limit, the distance measured represented upper limit of vertical gliding movement.

2b. Inferior cornu was manually moved downwards to its maximum limit the distance measured represented the lower limit of vertical gliding movement.

3 *Rotational movements*: The width of cricothyroid space between the inferior notch of the thyroid cartilage and the upper border of the cricoid arch in the midline for rotational movement was measured in two positions.

3a. The thyroid cartilage was manipulated backward; the distance measured represented the maximum width of the cricothyroid space.

3b. The thyroid cartilage was manipulated forward; the distance measured represented the minimum width of cricothyroid space.

4 *Change in the length of vocal folds associated with rotational movement*- The maximum and minimum distance between the inner surface of the thyroid angle just above the attachment of the vocal folds and the upper border of the cricoid lamina in the mid line were obtained by moving the thyroid cartilage forwards and backwards respectively.

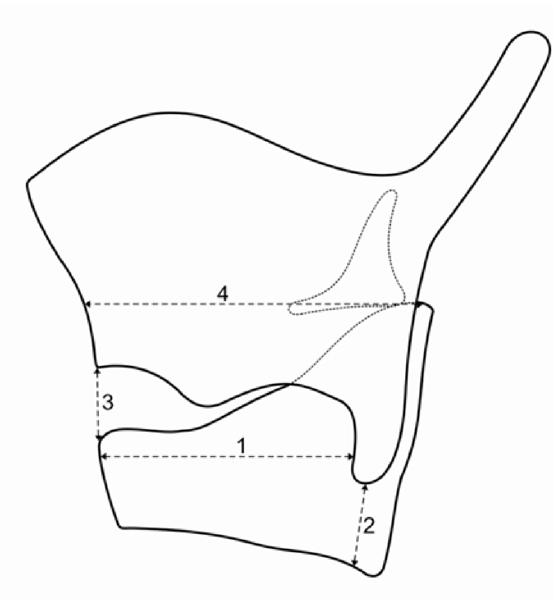


Fig. 1. Schematic diagram of crocothyroid cartilage complex showing measurements done. 1: Horizontal distance between the inferior cornu of thyroid cartilage and anterior most point on upper border of arch of cricoids; 2: Vertical distance between the inferior cornu of thyroid cartilage and the inferior border on the lateral side of cricoid cartilage; 3: Width of cricothyroid space between inferior notch of thyroid cartilage and upper border of cricoid arch in the midline; 4: Distance between inner surface of thyroid angle just above the attachment of vocal folds and upper border of cricoid lamina in the midline (length of vocal fold).

III *Set B specimens were studied for the presence of cricothyroid ligaments.*

RESULTS

I Visual observations of interior of the CTJ joint *(Table 1)*

Three types of articular surfaces were noticed.

Type 1 Well defined facet on the articular surfaces of the thyroid or cricoid cartilage (Figs. 2 and 3)

The position of the facet at the junction of the lamina with the arch of the cricoid cartilage varied from midway between upper and lower border to the junction of upper 2/3rd with lower 1/3rd.

Out of 50 CTJ of fetuses, well marked facets were seen on 7(14%) inferior cornu of thyroid cartilages (3bilateral and 1 unilateral) and 6(12%) cricoids cartilages (2bilateral and 2 unilateral). Out of 50 CTJ of newborns, 5(10%) had facet on thyroid cartilages (1bilateral, 3 unilateral) and 6 (12%) had facets on cricoid cartilages (2 bilateral, 2 unilateral).

In male children 13(26%) CTJ (5 bilateral; 3unilateral) and 4(8%) CTJ had a well-defined facet on the thyroid and cricoid cartilages respectively. In female children 11(22%) CTJ (4 bilateral; 3 unilateral) showed facet on the thyroid and 11(22%) CTJ (2 bilateral and 7 unilateral) on the cricoid cartilage.

In adult male larynges, the facets on inferior cornu were well defined in 122 (61%) CTJ (49 bilateral and 24 unilateral) and 51 (51%) CTJ (20 bilateral; 11 unilateral) of adult female larynges (Table 1). The facets were reciprocally present on the cricoid cartilage in72/200 (36%) and 27/100 (27%) CTJ males and females respectively. We studied the trend of occurrence of facets in children and adults. An increasing trend in the incidence of occurrence of facet on thyroid and cricoid cartilages was noticed after the 6th year and 15th year respectively in male children and after the 15th year in both cartilages in female children. After the third decade a gradual increase in the occurrence of facet on inferior cornua was observed. The highest incidence was recorded in the 41-50 years age group (87% in males; 75% in females). On cricoid cartilages of males, a steady increase in appearance of facet with the highest incidence in the 41-

Table 1. Summary of morphology of articular surfaces of cricothyroid joint (Cricoid cartilage and inferior cornu of thyroid cartilage)

		Children				Adults			
		Males N=25, CTJ=50		Females N=25, CTJ=50		Males N=100, \CTJ=200		Females N=50, CTJ=100	
		Thyroid	Cricoid	Thyroid	Cricoid	Thyroid	Cricoid	thyroid	Cricoid
Type 1 Well marked facets	**Bilateral**	5 (20%)	1 (4%)	4 (16%)	2 (8%)	49 (49%)	28 (28%)	20 (40%)	8 (16%)
	Round	-	1	-	1	14	6	6	2
	Oval	1	-	3	-	21	18	9	5
	Round on right & oval on left	1	-	1	1	9	-	3	-
	Oval on right & rounded on left	3	-	-	-	5	4	2	1
	Unilateral	3 (6%)	2 (4%)	3 (6%)	7 14%	24 (12%)	16 (8%)	11 (11%)	11 (11%)
	Round	1	-	1	6	14	7	5	4
	Oval	2	2	2	1	10	9	6	7
Type 2 Facet absent	**Bilateral**	17 (68%)	12 (48%)	18 (72%)	11 (44%)	27 (27%)	31 (31%)	19 (38%)	16 (32%)
	Unilateral	3 (6%)	4 (8%)	3 (6%)	4 (8%)	24 (12%)	15 (7.5%)	11 (22%)	11 (11%)
Type 3 Protuberance present	**Bilateral**	-	6 (24%)	-	3 (12%)	-	17 (17%)	-	8 (16%)
	Unilateral	-	6 (12%)		7 (14%)	-	17 (8.5%)	-	14 (14%)

Fig. 2. Types of articular surfaces of cricothyroid joint in fetuses. (**A**) Well defined facet on inferior cornu of thyroid cartilage; (**B**) Absence of facet/ protuberance on cricoids cartilage; (**C**) Facet on cricoids cartilage; (**D**) Protuberance at articulation site on cricoids cartilage.

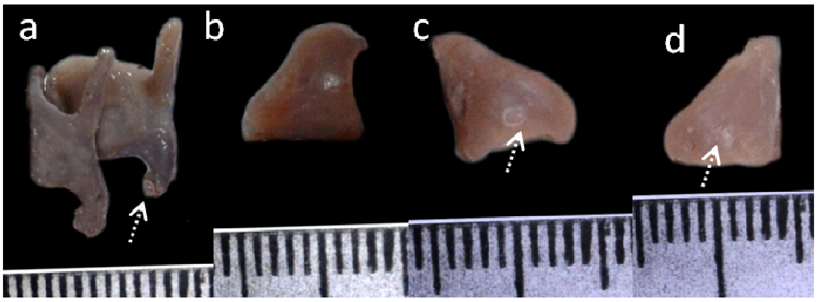
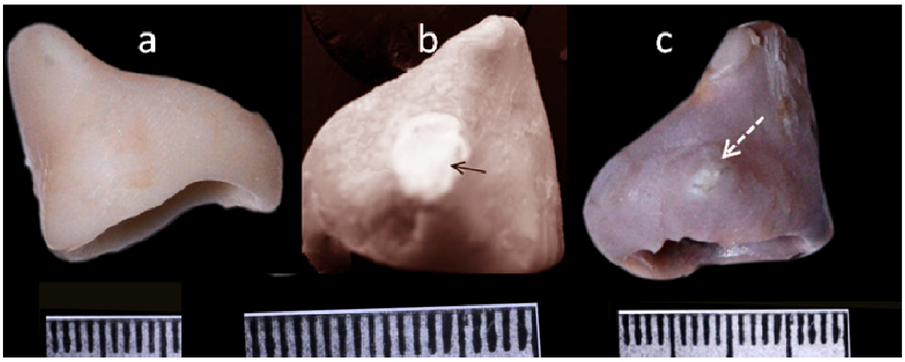


Fig. 3. Lateral view of cricoid cartilages of adults showing types of articular surfaces for inferior cornu of thyroid cartilage (**A**) Flat surface (**B**) Well defined articular facet (black arrow) (**C**) well defined protuberance at articulation site and no facet absent (white arrow).



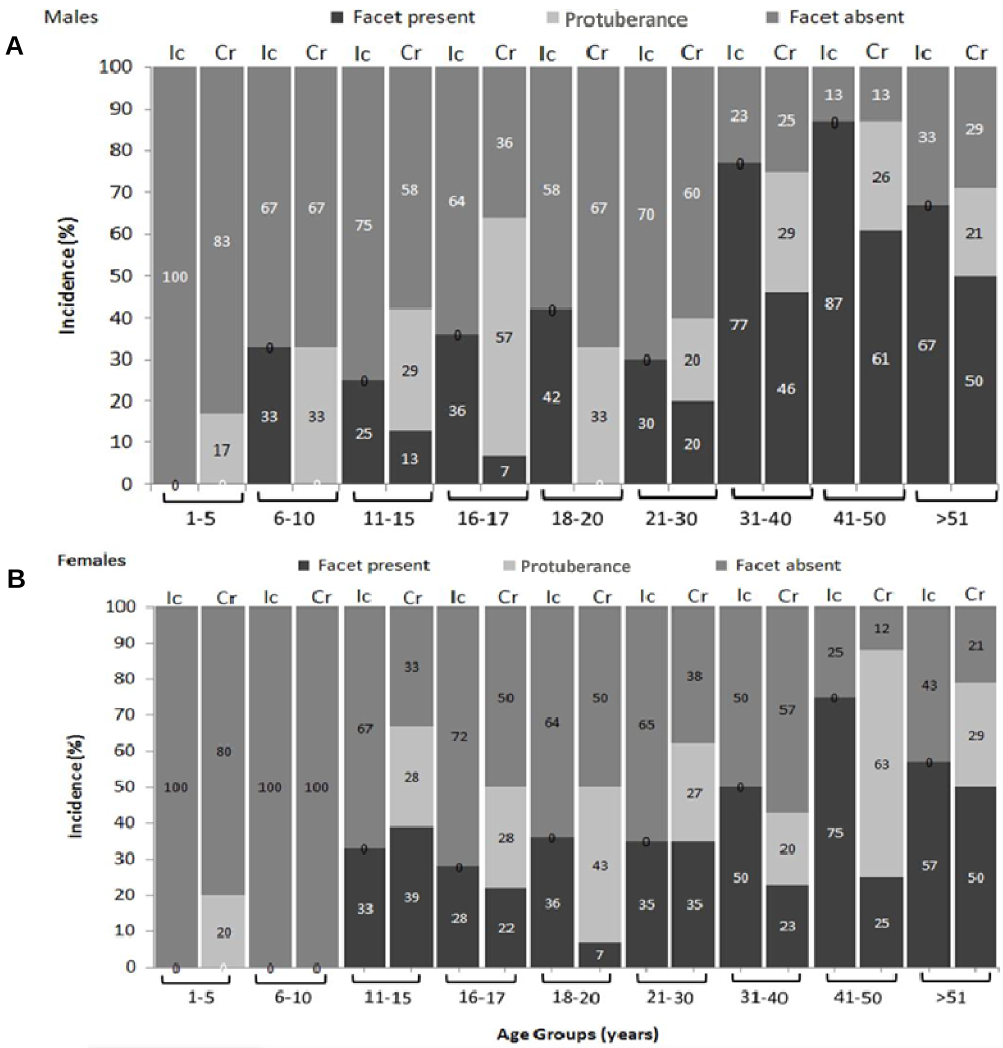


Fig. 4. Incidence of types of articular surfaces on inferior cornu (Ic) and cricoids cartilage (Cr) across different age groups of in males (**A**) and females (**B**).

Table 2. Dimensions (mm) of cricothyroid facets on thyroid and cricoid cartilages (adults)

	Males		Females	
	N=122/200		N=51/100	
Inferior cornu of thyroid cartilage				
Round facet	56	3.76±3.12	22	2.93±0.52
Oval facet				
Vertical diameter	66	4.66±0.77	29	3.75±1.10
Transverse diameter	66	4.09±1.04	28	3.19±1.21
Cricoid Cartilage				
Round facet	23	4.23±1.02	9	4.29±0.58
Oval facet				
Vertical diameter	49	5.43±1.32	18	4.87±1.05
Transverse diameter	49	5.12±1.22	18	4.56±1.09

Table 3. Range of various movements of CTJ

	Horizontal gliding movement				Vertical gliding movement			
	Males (N= 25)		Females (N= 15)		Males (N= 25)		Females (N= 15)	
	Mean± SD	Range	Mean ± SD	Range	Mean± SD	Range	Mean ± SD	Range
Maximum	25.02±2.39	20.0-29.0	22.57±2.49	18.0-26.0	9.69±1.69	5.5-12.0	9.13±1.24	7.8-11.0
Minimum	23.44±2.51	18.5-30.0	20.39±2.57	16.0-23.5	7.95±1.47	4.0-12.0	7.33±1.13	5.5-9.0
Difference	1.88±0.76	0-3	2.08±1.20	0-4	.87±0.92	0-3	1.71±1.22	0-4

50 years was noticed (Fig. 4a). In females no such pattern was seen (Fig. 4b).

In children and adult category incidence of occurrence of facet was higher in males than females, but the difference was not statistically significant ($p>0.05$).

Facets were round or oval shaped. Details of shape are given in Tables 1 and 2. Oval shape was more common on both articular surfaces in either sex (both children and adults). The mean diameter of articular facet on the inferior cornu of the thyroid and cricoid cartilage is given in Table 2.

Type 2 Facet absent on thyroid and cricoid cartilages

Facets were absent on thyroid cartilages in 43 (86%) CTJ of fetuses and 45(90%) CTJ of newborns. On cricoid cartilages facets were lacking in 34 CTJ of fetuses and 25CTJ of newborns. In male children the facets were not seen in 37(74%) and 28(56%) of thyroid and cricoid cartilages respectively. In female children facets were not seen in 39(78%) of thyroid 26(52%) of cricoid cartilages.

In adult males facets were absent on 78 (39%) thyroid and 77 (38.5%) cricoid cartilages. In adult females the facet was absent on 49 (49%) thyroid and 43(43%) cricoid cartilages respectively.

Type 3 Tiny protuberance on articular surface of cricoid cartilage (Figs. 2 and 3)

Protuberance at articulation site was present in 20% of CTJ of fetuses (6 fetuses: 4 bilateral, 2 unilateral) and 38% CTJ of newborns (11 newborns: 8 bilateral, 3 unilateral).36% CTJ of male and 26% CTJ of female children and in 26% CTJ of adult males and 30% of adult females.

II Study of range of various movements of CTJ: *(Table 3)*

Horizontal gliding movements: In the male larynges the mean range of horizontal gliding movement was 1.88±0.76mm (range 0-3mm). In female larynges the mean range was 2.08±1.20 mm (range 0-4 mm).

Vertical gliding movement: In the male larynges the mean range of horizontal gliding movement was 1.87±0.92mm (range0-3mm) and in female larynges the mean range was mm1.71±1.22 mm (range 0-4 mm).

Rotation movement: The maximum and minimum

Table 4. Length of cricothyroid space and length of rima glottidis

	Cricothyroid space				Length of rima glottidis			
	Males (N= 25)		Females (N= 15)		Males (N= 25)		Females (N= 15)	
	Mean± SD	Range	Mean ± SD	Range	Mean± SD	Range	Mean ± SD	Range
Maximum (mm)	8.33±1.42	6-11.0	8.92± 1.74	6- 11	30.85±3.08	23.5-35.0	30.56±1.85	29.4-33
Minimum (mm)	6.31+1.36	4.5-9.0	6.72±0.81	6.0-8.0	26.85±2.56	21.4-31.5	26.6±2.15	25.5-31.6
Difference (mm)	2.27±0.71	1.0-3.2	2.65±0.53	2-3.2	4.08±1.24	2.1-6.6	3.89±1.60	20-6.5

distances between the inferior border of the thyroid and the upper border of the cricoid in males were 8.33±1.42 mm (range 6.0-11.0 mm) and 6.31±1.36 mm (range 4.5-9.0 mm) respectively. The mean difference between maximum and minimum distances, i.e. the range of rotational movement was 2.27±0.71 mm. In females the respective maximum distance was 8.92±1.74 mm (range 6.0-11.0 mm) and minimum distance was 6.72±0.81 mm (range 6.0-8.0 mm). The mean difference between maximum and minimum distance was 2.65±0.53 mm (Table 4).

For evaluating the change in length of rima glottidis the maximum distance between the inner lamina of the thyroid and the upper border of the cricoid lamina was 30.85±3.08 mm and 30.56±1.85 mm in the male and female larynges respectively. The minimum distance in males was 26.85±2.56 mm, while in females it was 26.6±2.15 mm. The mean difference between maximum and minimum distances was 4.08±1.24 mm in males and 3.89±1.60 mm in females (Table 4).

Ligaments associated with cricothyroid joint *(Fig.5)*

In set B specimens the cricothyroid joint was found to be strengthened by three ligaments, i.e., posterior, lateral and anterior cricothyroid ligaments

Posterior crico-thyroid ligament

A well-defined band on the posterior aspect of the joint started from the posterior margin of the facet on the inferior cornu of the thyroid cartilage and the adjacent part of the cricoid cartilage, and extended upwards and medially under the posterior cricoarytenoid muscle to get attached on the posterior surface of the upper part of the cricoid lamina, about 3-5 mm below the upper border of the cricoid cartilage. It was 7-8 mm long and 4-5 mm broad and its upper and deeper fibers were somewhat smaller than the posterior fibers.

Lateral crico-thyroid ligament

This ligament was also located on the posterior aspect of the joint and was average 5 mm long and 5 mm broad. It extended downwards and medially from the postero-inferior border of the inferior cornu of the thyroid to the posterior surface of the lower part of the lamina of the cricoid cartilage. Its fibers were less well defined than the posterior ligaments.

Anterior crico-thyroid ligament

When distinctly present, fibers extended forwards, downwards and medially from the antero-inferior border of the inferior cornu of the thyroid cartilage to the lateral side of the posterior part of the arch of the cricoid cartilage above its inferior border. It was about 7 mm long and 4 mm broad. This ligament was better defined than the lateral cricothyroid ligament, but not as well defined as the posterior-cricothyroid ligament.

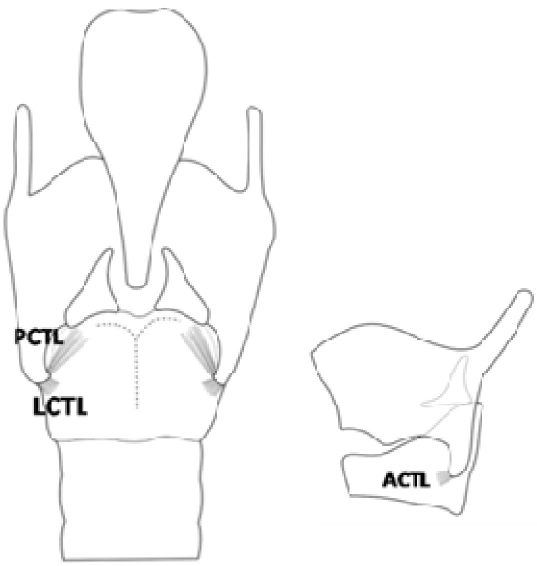


Fig. 5. Schematic diagram showing PCTL (posterior cricothyroid ligament), LCTL (lateral cricothyroid ligament) and ACTL (anterior cricothyroid ligament) ligaments.

DISCUSSION

The cricothyroid joint by permitting rotational movements along the transverse axis passing through both the inferior cornu alters length of vocal cords and thus plays an important role in the modulation of the vocal pitch. Regarding the functional anatomy of CTJ, different explanations have been presented in the literature. According to Braus and Elze (1956) looseness of capsule is important for rotational movement to occur. Hollinshead (1982) added that by rotation of inferior cornu on cricoid cartilage the distance between cricoid and thyroid cartilage is decreased or increased which is translated in terms of shortening or lengthening of the vocal cords. Later Vilkman et al. (1987), Hammer et al. (2010) and, Windisch et al. (2010) observed that besides rotational movement it also permits gliding movement.

The main features which play an important role in deciding the type of movement to occur at any joint are the morphology of articular surfaces and the ligaments joining the articular components. A handful of articles describing the morphology and morphometry of facets of the laryngeal cartilages are available (Maue and Dickson, 1971; Vilkman et al., 1987; Hammer et al., 2010; Windisch et al., 2010).

Hammer et al. (2010) and Windisch et al. (2010) categorized the articular surfaces into three types viz. articular facet present, articular facet absent, flat surface or presence of protuberance. Following the same classification, we studied the trend of appearance of the facet on articular surfaces of CTJ right from the fetal age to 80 years. Larynx specimens used in earlier studies were taken from subjects of age 37 to 80 years (Maue and Dickson, 1971; Hammer et al., 2010; Windish et al., 2010).To the best of our knowledge before this, no study has ever analyzed CTJ of children. Incidence of definable facets increased with increasing age. Independent of gender and laterality, facets were noticed on the inferior cornu of larynges of 14%fetuses, 10% newborns, 24% children and 57.6% adults. In male children the facet appeared first on the inferior cornua in the sixth and on the cricoid cartilage in the fifteenth year. Incidence increased with age and the highest was recorded in the 5th decade. In females, facet appeared first on both articular surfaces in the fifteenth year. Highest incidence on the inferior cornu facet was also recorded in the fifth decade. On cricoid cartilages facets were maximally seen in the fifth decade in males and sixth decade in females. In male children the facet was seen bilaterally or unilaterally on the inferior cornu more commonly than the cricoid cartilage. In female children the same trend was observed. In adult males, a similar trend as male children was maintained. Likewise, adult females followed the same trend as female children. We observed no statistically significant sexual difference in any age group. Incidence of facets on inferior cornu of thyroid cartilage in present study differed from earlier studies which may be due to relatively smaller sample size studied by them. Maue and Dickson (1971) noticed well-defined facets in 20% of the larynges bilaterally and in few cases unilaterally. Vilkman et al. (1987) observed well developed articular facets on cricoid cartilage in 50% of cases while poorly developed in 30% and absent in 20% instances. Hammer et al. (2010) found facet in two-thirds of CTJ of male and half of female larynges. Hammer et al. (2010) found the facet bilaterally in 44% and unilaterally in 8% larynges. In our earlier study (Harjeet and Jit, 1989) calcification in the inferior cornu of the thyroid cartilage was seen to commence at 18 to 20 years and become completely calcified at 25 years of age. The maximum calcification of thyroid lamina was noted at the age of 48 years in both sexes. Cricoid cartilage facets begin to calcify at 23 years, arch and cricoid lamina were completely calcified by 50 years. Incidence of facets could be related to presence of calcification on inferior cornu as well as on lateral wall of cricoid cartilage as the hardening due to calcification might have created impression on the articular sites on inferior cornu of thyroid and cricoid cartilages.

Filho et al. (2005) observed greater difficulties in exposing the arytenoid cartilage during laryngeal framework surgery in men, possibly due to more posterior position of the criothyroid articulation in relation to cricoid cartilage. According to them the average length on articular surface of the cricoid cartilage was 5.46±0.58 mm in men and 3.90±0.74 mm in women, average 1.56±0.36 mm wider in men ($p=0.001$). The breadth of articular surface was 3.60±0.70 mm in males and 2.98±0.50 mm in females with no significant difference between two sexes. In the present study the length of the facet on the cricoid was 5.43±1.32 mm in males and 4.87±1.05 mm in females while the breadth of the facet was 5.12±1.22 mm in males and 4.56±1.09 mm in the females. No sexual difference was found between these diameters. Tayama et al. (2001) measured the length and breadth of facet as 6.15±1.12 mm and 4.73±0.72 mm in men and 5.96±0.79 mm and 3.73±0.49 mm in women, respectively. They also mentioned the ratio of major diameter to minor diameter of CT articular facet as 1.3 to 1 for men and 1.60 to 1 for women. The dimension and geometric position of CT facet with respect to laryngeal framework are biomechanically important as they contribute to the determination of CT translational and rotational movements which are critical for length changes and posturing of vocal folds.

A second type of articular surface was without any discernible facet. On the thyroid, only two types of articular surfaces were found. In the adult group this type of articular surface was less prevalent than type one (Table1). In the cricoid, absence of the facet was more commonly seen than presence of the facet in both genders. Some of the cricoid cartilage had soft tissue facets and removal of this soft tissue showed either a protuberance or flat surface beneath it. This type was present bilaterally in 17% males and 16% females and unilaterally in 17% males and 28% females. This third type of articular surface was not seen on thyroid. Hammer et al. (2010) found such type bilaterally in 8% and unilaterally in 24% of males.

The mean width of cricothyroid space reported in the literature varies between 9 and 13.4 mm in males and 6.6 and 11.68 mm in females with highly significant sexual difference (Maue and Dickson, 1971; Windisch et al., 2010; Hammer et al., 2010). In the present study the width was 8.1±1.55 mm in males and 6.5 ±1.21 mm in the females. The distance between thyroid and cricoids cartilages is important, as it limits the possible amount of cricothyroid rotation and translation for increasing vocal fold length and frequency of cocal cord vibration control (Tayama et al., 2001).

For evaluating the change in length of rima glottidis, the maximum distance between the inner lamina of the thyroid and the upper border of the cricoid lamina was 30.85±3.08 mm and 30.56±1.85 mm in the male and female larynges, respectively. The minimum distance in the males was 26.85±2.56 mm, while in females it was 26.6±2.15 mm. The mean difference between maximum and minimum distances was 4.08±1.24 mm in males and 3.89±1.60 mm in females. Hammer et al. (2010) demonstrated that the extent of change in the in length of the vocal folds secondary to alteration of dimension of cricothyroid space in male larynges is nearly the same as in female specimens. Our observations were in corroboration with the suggestions of Hammer et al. (2010).

Vilkman et al. (1987) found synovial nature of CTJ in ten specimens where ventro-dorsal gliding movement was possible. Possibility of limited gliding movements in horizontal (ventro-dorsal) or vertical (cranio-caudal) directions besides rotational movement has been discussed by other researchers too (Maue and Dickson, 1971; Mayet and Mundnich, 1958). Hammer et al. (2010) and Windisch et al. (2010) demonstrated three different types of aticular surfaces and suggested that these varieties of articular surfaces might account for different types of movements. Horizontal gliding movements in their 100 CTJ were 3.8±1.79 mm in ventro-dorsal and 3.3±1.89 mm in the cranio-caudal directions. In our specimens, the horizontal ventro-dorsal gliding movements in males and females were 1.88±0.76 m and 2.08±1.20 mm respectively. Vertical gliding movements in cranio-caudal direction in males and females were 1.87±0.92 mm and 1.71±1.22 mm, respectively. Lower values recorded in our study could possibly be due to different preservation procedures.

Earlier studies present different observations regarding the ligaments of CTJ. Mayet and Mündnich (1958) demonstrated three ligaments: the anterior, the lateral and the posterior ceratocricoid ligaments, and the posterior is divided into two parts, transverse and oblique. Maue and Diskson (1971) found only lateral and posterior ligaments.

The first ligament described by them has been named by the present workers as anterior cricothyroid ligament which extended forwards and downwards from the joint to the antero-lateral part of the cricoid arch and corresponds to anterior ceratocricoid ligament, named as such and well illustrated (Schaeffer and Ramsay, 1966) and to lateral ceratocricoid ligament illustrated by Vilkman et al. (1987). The present workers found the second ligament described by Maue and Dickson (1971) and named it posterior cricothyroid ligament; it corresponds to posterior ceratocricoid ligament (Schaeffer and Ramsay, 1966; Vilkman et al., 1987). However, Vilkman et al. (1987) further stated in their illustration the transverse part of the posterior ceratocricoid ligament which was not encountered in the present study. The lateral cricothyroid ligament described by the authors corresponds to lateral ceratocricoid ligament named and well illustrated (Schaeffer and Ramsay, 1966) but contradict to Vilkman et al. (1987). The direction of fibers of lateral ceratocricoid ligament shown in their illustration is from inferior aspect of inferior cornu to the lateral aspect of posterior part of arch which in the present study corresponds to anterior cricothyroid ligament. Mayet and Mundnich (1958) described the three ligaments i.e anterior, lateral, and posterior cricothyroid ligaments. The anterior and lateral criothyroid ligaments are well illustrated but have not been labeled (Williams et al., 1995).

In conclusion, we believe that the results of this study would contribute to the understanding of the mobility at the cricothyroid joint, and the data provided can be of use for surgeons during laryngeal framework surgery such as cricothyroid approximation.

ACKNOWLEDGEMENTS

The authors are grateful to all donors for providing their tissue to make this study possible and Director General of Indian Council of Medical Research, New Delhi for financial assistance. We are also grateful to Late Emeritus Professor Indar Jit Dewan for his valuable guidance and Mr. Pradeep Singh for the art work.

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