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THE MORPHOLOGY AND MORPHOMETRY OF ADULT HUMAN THYROID CARTILAGE – A CADAVERIC STUDY IN NORTH INDIAN POPULATION

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ABSTRACT

The aim of the present work was to study morphological and morphometric study of thyroid cartilages in adult human cadavers. The material for present study comprised of 30 adult (M:F::25:5) apparently normal cadaveric larynges, obtained from the Anatomy Department of Govt. Medical College, Amritsar. Material used were a vernier caliper with least count of 0.01 mm to measure the different straight distances, unbraided silk thread for measuring the curved distances of the laryngeal cartilages, Indian ink for marking ends of unbraided silk thread, scale, protractor for measuring different angles. All the larynges were removed along with hyoid bone and trachea up to third tracheal ring. All the muscles and ligaments attached to larynx were removed carefully. Different morphological features were observed; measurements were taken and recorded on the predesigned proforma. All the major measurements of thyroid cartilage were found to be more in males as compared to females except upper breadth of thyroid cartilage on anterior aspect, thyroid angle. Length and breadth of thyroid laminae in both sexes were larger on left side as compared to right one. In males the left superior horn and in females right superior horn was longer. In males, the inferior horn was longer on right side while in females; the left inferior horn was longer. Both in males and females length of left oblique line was more than right oblique line. When compared between the two sexes, on the right side, it was more in males while on left side it was more in females.

Keywords: Thyroid Cartilage, Males, Females, North Indian Population

INTRODUCTION

Larynx is an air passage, a sphincter and an organ of phonation .Skeletal framework of larynx is formed by series of cartilages viz. unpaired thyroid, cricoid and epiglottis and paired arytenoid, cuneiform and corniculata (Sato *et al.*, 2002).

A basic knowledge of anatomy of larynx is necessary from clinical point of view. It is necessary for those who are involved in fields of surgical treatment of larynx such as speech therapists, anesthetists, oncologists, pulmonologists, radiologists, general practitioners, ENT specialist and phoniatricians (Kutta *et al.*, 2007). A variant anatomy of laryngeal cartilages even influences morphology of blunt injuries of neck (Svetlakov *et al.*, 1997).

A knowledge of dimensions of cartilages of larynx and trachea is a must for transplantation, stenting, intubation, cricothyroidotomy and endoscopic procedures (Randestad *et al.*, 2000). Subglottic stenosis and postintubational stenosis of lower respiratory tract were two main factors which led anatomists to work for measurements of various cartilages in early nineties (Ajmani, 1990).

The increasing application of sophisticated electrophysiological, radiological and surgical methods for the diagnosis and treatment of laryngeal disorders requires profound knowledge of size and proportion of human larynx and its cartilaginous components (Eckel *et al.*, 1994; Jain and Dhall, 2008).

Such data on endolaryngeal angles, airway lumina and thickness of parts of laryngeal skeleton can be helpful in planning of endolaryngeal surgical intervention or transcutaneous placement of electrodes for laryngeal electromyography or the analysis of CT and MRI scans of the larynx (Eckel *et al.*, 1994).

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Symmetry of larynx is extremely important as a rotated thyroid cartilage with dislocation of superior thyroid cornu projecting into ipsilateral piriform fossa may lead to globus pharyngeous, sticking of food in upper neck, dysphagia or odynophagia (Hajjioannou *et al.*, 2010). It has also been hypothesized that foramen thyroideum may provide a pathway for adenocarcinoma and pyriform recess or transglottic tumors but remains as resistant to laryngeal cancer as rest of thyroid lamina (Krichner *et al.*, 1989). Jackson and Jackson (1935) opined that cutting through the thyroid cartilage (Laryngofissure) and removing the inner perichondrium and everything inward of that in an area of carcinoma is effective in a high percentage of carefully chosen cases. They further emphasized that this approach avoids the necessity of removing the entire larynx.

Park *et al.*, (2003) believed that the identification of sex is possible on the basis of morphometric analysis of thyroid cartilage in Koreans. Recently, Kovac *et al.*, (2010) found statistically significant differences between all analysed parameters of thyroid cartilage in male and female samples.

Thus a knowledge of different parameters of various laryngeal cartilages is necessary before attempting different surgical or other interventions. So the present study was designed to attain this information in detail.

MATERIALS AND METHODS

The material for present study comprised of 30 adult (M:F::25:5) apparently normal cadaveric larynges, obtained from the Anatomy Department of Govt. Medical College, Amritsar.

All the larynges were removed along with hyoid bone and trachea up to third tracheal ring. All the muscles and ligaments attached to larynx were removed carefully. Then these were serialised from 1-30 with suffix M or F for male or female respectively. Different morphological features were observed, measurements were taken and recorded on the predesigned proformas.

Any larynx with any cartilage having broken or indistinct margins were excluded from the study.

Following instruments were used for taking different measurements.

1. A vernier caliper with least count of 0.01 mm to measure the different straight distances.
2. Unbraided silk thread for measuring the curved distances of the laryngeal cartilages.
3. Indian ink for marking ends of unbraided silk thread.
4. Scale.
5. Protractor for measuring different angles.

Following measurements of thyroid cartilage were taken:-

1. Upper breadth of thyroid cartilage (termed as maximum thyroid breadth at superior tubercles by Jain and Dhall (2008) and maximum thyroid breadth by Ajmani (1990):-It was measured with vernier caliper as straight distance between the two superior tubercles.
2. Upper breadth of thyroid cartilage on anterior aspect:- For measuring this distance, the unbraided silk thread was kept between the two superior tubercles and passing along the anterior aspects of two thyroid laminae. It was marked with Indian ink at the designated points (two superior tubercles). Then the thread was lifted off the larynx and distance between two marked points was noted by spreading it along a metric scale.
3. Lower breadth of thyroid cartilage (termed as maximum thyroid breadth at inferior tubercles by Jain and Dhall (2008):- it was measured with vernier caliper as straight distance between two inferior tubercles.
4. Lower breadth of thyroid cartilage on anterior aspect:- it was measured as distance between two inferior tubercles with unbraided silk thread, by the same method as sr. no.3 vide supra.
5. Upper breadth of thyroid cartilage on posterior aspect:- it was measured with vernier caliper as distance between bases of two superior horns on posterior aspect. (Ajmani, 1990; Jain and Dhall, 2008)

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6. Lower breadth of thyroid cartilage on posterior aspect:- it was measured with vernier caliper as distance between bases of inferior horns on posterior aspect. (Ajmani, 1990; Jain and Dhall, 2008)
7. Breadth of thyroid cartilage at midpoint of posterior border of laminae on posterior aspect (termed as maximum breadth between posterior borders by Jain and Dhall (2008) It was measured with vernier caliper as distance between midpoints of posterior borders of laminae from posterior aspect.
8. Length of both right and left lamina of thyroid cartilage was measured with vernier caliper as the vertical distance from highest point on upper border of thyroid lamina to lower border of lamina. (Ajmani, 1990; Jain and Dhall, 2008)
9. Breadth of both right and left lamina of thyroid cartilage:- It was measured with vernier caliper as horizontal distance from laryngeal prominence to posterior margin of lamina. (Ajmani, 1990; Jain and Dhall, 2008)
10. Length of superior horns:- It was measured on both sides with vernier caliper as distance from tip to base of the horn. (Ajmani, 1990; Jain and Dhall, 2008)
11. Length of inferior horns:- It was also measured on both the sides with vernier caliper as distance from tip to base of the horn. (Ajmani, 1990; Jain and Dhall, 2008)
12. Ventral thyroid height (termed as main height of larynx by Ajmani (1990) and Jain and Dhall (2008):- It was measured with vernier caliper as distance from upper to lower thyroid incisure.
13. Dorsal thyroid height :- It was measured on both the sides with vernier caliper as vertical distance between tips of superior and inferior horns. (Ajmani, 1990; Jain and Dhall, 2008)
14. Length of oblique line:- It was measured with vernier caliper as oblique distance between superior tubercle and inferior tubercle on both the laminae.
15. Depth of suprathyroid notch:- It was measured with vernier caliper as the vertical distance from highest level of laminae to floor of superior thyroid incisures. For measuring this distance, a scale was kept touching the highest point of two laminae and crossing over the suprathyroid notch. Then distance between this scale and floor of suprathyroid notch was measured with a vernier calliper (Ajmani, 1990; Jain and Dhall, 2008)
16. Thyroid angle was measured as angle between two thyroid laminae. It was measured with help of protractor and two scales. For measuring this angle, two scales were kept touching the anterior surface of two thyroid laminae near their upper borders. Then the angle between these two scales was measured with the protractor. (Ajmani, 1990; Jain and Dhall, 2008)

RESULTS AND DISCUSSION

Upper Breadth of Thyroid Cartilage

When measured as a straight distance between two superior tubercles, it was found to be 36.36 ± 5.41 mm (Range= 29.73-49.05) in males and 32.26 ± 1.48 mm (Range=30.31-34.17mm) in females, the difference being statistically significant in males (p value-0.1). Earlier Jain and Dhall had found it to be 45.5 ± 5.6 mm and 42.0 ± 5.8 mm in males and females respectively. Thus our values were less than those of Jain and Dhall (2008).

Upper Breadth of Thyroid Cartilage on Anterior Aspect

Contrary to the straight distance between two superior tubercles, this distance was more in females as compared with males. (See Table I). No data could be found in the accessible literature for comparison.

Lower Breadth of Thyroid Cartilage

It was found to be 25.59 ± 2.71 mm (Range=21.56-31.51mm) in males and 20.94 ± 1.81 mm (Range=19.1-23.89 mm) in females, the difference being statistically significant (p value- 0.001). Earlier Jain and Dhall found it to be 29.6 mm in males and 20.9 mm in females. Thus their values are higher than ours in males but almost same in females.

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Lower Breadth of Thyroid Cartilage on Anterior Aspect

It was found to be 3.43 ± 0.80 cm (Range=3.1-5.1cm) in males and 2.60 ± 0.40 cm (Range=2.1-3.1cm) in females, the difference between males and females being statistically significant (p value- 0.024). No data could be traced in the accessible literature for comparison.

Upper Breadth of Thyroid Cartilage on Posterior Aspect

It was found to be 36.43 ± 5.06 mm (Range=27.2-48.38mm) in males and 33.17 ± 1.38 mm (Range=31.43-35.12mm) in females. Thus it was more in males as compared to females. However the difference was statistically insignificant (p value- 0.169). Table I compares the upper breadth of thyroid cartilage on posterior aspect as seen in the present study with the earlier works. It is evident that our values are much lesser than those observed by Ajmani (1990) and Jain and Dhall (2008).

Lower Breadth of Thyroid Cartilage on Posterior Aspect

It was found to be 30.01 ± 3.61 mm (Range=23.35-39.78 mm) in males and 29.29 ± 1.77 mm (Range=26.18-30.54mm) in females. Thus it was little more in males than females. However, the difference was statistically insignificant. Table I shows the comparison of lower breadth of thyroid cartilage on posterior aspect with earlier authors. It is evident from the table that lower breadth of thyroid cartilage on posterior aspect is quite less in males of the present study as compared with males of earlier studies. However the difference is not much in case of females, though our values are on the lower side.

Breadth of Thyroid Cartilage at Midpoints of Posterior Borders of Laminae on Posterior Aspect

It was found to be 34.32 ± 5.29 mm (Range= 26.39-46.85 mm) in males and 31.85 ± 1.74 mm (Range=30.12-34.15mm) in females. Thus it was larger in males as compared to females though the difference was statistically insignificant (p value- 0.316). Table I compares the mean value of this parameter as observed in the present study with the only earlier study by Jain and Dhall (2008). It is seen that our values are lesser in both the sexes.

Length of Thyroid Lamina

On the right side it was found to be 24.03 ± 2.89 mm (Range =19.94-28.99 mm) in males and $21.18 \pm .43$ mm (Range =20.79-21.84 mm) in females, while on the left side it was 24.43 ± 3.55 mm (Range= 19.73-29.73mm) in males and $21.36 \pm .47$ mm (Range=20.87-21.97mm) in females. If we have a closer look at the Table I, it is seen that in the present study, in both sexes, the thyroid laminae was larger on the left side, though only marginally. Earlier Jain and Dhall (2008) had found it to be larger on left side in males and on right side in females. If we compare the two sexes in the present study it is seen that on both the sides, the lamina was larger in males though the difference was statistically significant only on the right side (p value= 0.039). Table I also compares the length of the thyroid laminae as seen in present study with the earlier ones. It can be inferred from the table that in males, the findings in the present study were less than given by other authors. In females, the present study was in consonance with Chievitz (1882), Harjeet and Jeet (1992), Eckel *et al.*, (1994), Jain and Dhall (2008). It was less than Ajmani *et al.*, (1980) and Ajmani (1990). The difference may be attributed to racial factors.

Breadth of Thyroid Laminae

In the present study, the mean breadth of right thyroid lamina was found to be 33.13 ± 5.80 mm (Range = 25.28-42.36 mm) in males and 26.92 ± 1.43 mm (Range = 25.61-29.27mm) in females. The corresponding values of left side were 33.17 ± 5.69 mm (Range=27.03-44.21mm) and 27.03 ± 2.14 mm (Range= 25.13-30.52mm). When compared between the two sides, both in males and females the breadth was more on the left side as compared to the right one. When compared between the two sexes, on both sides it was more in males, the difference being statistically significant (p value= 0.026 on both sides). Table I shows the comparison of breadth of thyroid laminae in different studies. It is seen that values of the present study are comparable to those of other studies done in Indians and Nigerians (Hajioannou *et al.*, 2010) but less than the one done in Germans (Harjeet and Jeet, 1992).

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Length of Superior Horn of Thyroid Cartilage

The mean length of right superior horn was found to be 13.93 ± 2.69 mm (Range=9.65-19.51 mm) in males and 11.84 ± 1.02 mm (Range = 10.15-12.84mm) in females. Length of left superior horn was 17.40 ± 3.74 mm (Range= 13.21-21.57mm) in males and 11.13 ± 1.15 mm (Range= 9.11-11.89mm) in females. When compared between two sides, in males the left superior horn and in females the right superior horn was longer. When compared between the two sexes, it was longer in males on both the sides, but the difference was statistically highly significant only on left side.

Table I compares the length of superior horn of thyroid cartilage as observed in the present study with the earlier ones. Earlier only Jain and Dhall (2008) had measured it on the two sides. Our values are slightly lesser than other authors on both the sides in females but only on right side in males. In almost all other studies the superior horn was longer as compared with ours.

Length of Inferior Horn

The mean length of right inferior horn was found to be 7.89 ± 1.70 mm (Range=4.95-10.86mm) in males and 6.75 ± 1.22 mm (Range= 4.95-8.34 mm) in females. Length of left inferior horn was 7.52 ± 1.55 mm (Range=4.95-17.01mm) in males and $6.92 \pm .89$ mm (Range = 5.38-7.62mm) in females. Thus in males, right inferior horn was longer than the left one while in females the reverse was true. Comparison of length of inferior horn in the present study with other studies is depicted in Table I. The findings in the present study were in consonance with Jain and Dhall (2008) and Eckel *et al.*, (1994).

Ventral Thyroid Height

It was found to be 17.47 ± 3.25 mm (Range=12.09-22.44mm) in males and while in females it was 16.00 ± 0.53 mm (Range=15.25-16.09mm) in females. Thus it was larger in males as compared to females. Table I compares the ventral thyroid height as observed in the present study with the earlier studies. It is seen that the values in males were in accordance with those of Eckel *et al.*, (1994), Jain and Dhall (2008) while in females these were in accordance with Chievitz (1882), Ajmani (1990), Eckel *et al.*, (1994).

Dorsal Thyroid Height

On the right side its mean value was found to be 36.49 ± 8.19 mm (Range= 16.47- 47.88mm) in males and 32.26 ± 2.02 (Range=30.42-35.65mm) in females. The corresponding values on left side were 31.20 ± 8.70 mm (Range=18.21-48.91mm) in males and 32.59 ± 3.24 (Range= 30.78-38.36mm) in females. As we compare on both sides, right dorsal thyroid height was larger than left dorsal thyroid height in males while the reverse was true in females. Table I compares the values of dorsal thyroid height with the earlier studies. It is seen that the values in present study were less than those given by the other authors. It could be due to racial factors.

Length of Oblique Line

The mean length of right oblique line were found to be 17.40 ± 2.74 mm (Range=13.21-21.57mm) and $13.95 \pm .58$ mm (Range=13.4-14.65mm) in males and females respectively. Corresponding values on left side were 18.58 ± 2.40 mm (Range=13.81-22.29mm) and 16.04 ± 1.38 (Range=14.11-17.89mm). The difference between the two sexes were statistically significant on both the sides (p value on right side =0.010 and on left side=0.031). In both sexes, the left oblique line was longer than the right one. This could not be compared with the previous studies as none could be traced in the accessible literature.

Depth of Suprathyroid Notch

Mean depth of suprathyroid notch was found to be 8.52 ± 1.78 mm (Range= 5.4-11.18mm) in males and $4.54 \pm .90$ mm (3.98-6.12mm) in females, difference between the two sexes being statistically highly significant (p value- 0.001). Table I compares the depth of suprathyroid notch as observed in the present study with earlier workers. It is evident that the values of the present study are quite less as compared with earlier studies especially in the females.

Thyroid Angle

Mean value of thyroid angle was found to be $86^0 \pm 5.95^0$ (Range= 75^0 - 100^0) in males and $108^0 \pm 8.37^0$ (Range= 100^0 - 120^0) in females. Thus it was more in females as compared to males. Table I compares the value of thyroid angle as observed in the present study with earlier workers. It is evident from the above table that thyroid angle was comparatively less in the present study as compared with earlier ones.

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Observation Table 1: Parameters of Thyroid Cartilage

Parameters (mm)	Jain and Dhall (2008)(Indians)		Ajmani (1990) (Nigerians)		Chievit (1882) (Europeans)		Ajmani <i>et al.</i> , (1980) (Indians)		Harjeet and Jeet (1992) (Indians)		Eckel <i>et al.</i> , (1994) (Germans)		Present study (North Indians)		
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	
Upper breadth of TC	45.5 ±5.6	42.0 ±5.8	-	-	-	-	-	-	-	-	-	-	36.36 ±5.41	32.26 ±1.48	
Upper breadth of TC on anterior aspect (cm)	-	-	-	-	-	-	-	-	-	-	-	-	5.78 ±1.14	5.82 ±.26	
Lower breadth of TC	29.6 ±4.1	20.9 ±5.2	-	-	-	-	-	-	-	-	-	-	25.59 ±2.71	20.94 ±1.81	
Lower breadth of TC on anterior aspect	-	-	-	-	-	-	-	-	-	-	-	-	3.43 ±0.80	2.60 ±.40	
Upper breadth of TC on post. Aspect	42.8 ±5.0	40.1 ±7.6	47.45 ±5.19	39.50 ±5.80	-	-	-	-	-	-	-	-	36.43 ±5.06	33.17 ±1.38	
Lower breadth of TC on post. Aspect	35.1 ±4.6	32.3 ±4.9	38.25 ±8.40	31.20 ±7.50	-	-	-	-	-	-	-	-	30.01 ±3.61	29.29 ±1.77	
Breadth of TC at midpoint of post. borders of laminae	38.7 ±5.9	34.9 ±4.5	-	-	-	-	-	-	-	-	-	-	34.32 ±5.29	31.85 ±1.74	
Length of RT Thyroid lamina	27.2 ±3.5	22.9 ±3.8	37.92 ±4.42	35.25 ±3.10	25.30 30	19. .60	29.20±9 ±6.00	24.60 2.17	26.22± ±1.17	19.75 ±2.47	27.4 ±2.85	22.20 2.47	RT LT	24.03 24.43	21.18 21.36 ±.43 ±.47
LT	27.5 ±2.9	22.7 ±3.8											LT	24.43 ±3.55	21.36 ±.47

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Breadth of thyroid lamina	RT	35.2 ±5.9	29.5 ±6.9	34.89 ±4.08	26.20 ±4.90	41.90 -	30. 20	29.60±8 .00	37.82± 2.69	28.27 ±1.82	41.9 0±3. 38	31.20 ±2.73	RT	33.13 ±5.80	26.92 ±1.43	
	LT	36.8 ±4.8	30.0 ±6.5										LT	33.17 ±5.69	27.03 ±2.14	
Length of SH	RT	14.1 ±4.5	13.1 ±3.9	20.70 ±2.99	20.92 ±3.01	-	-	15.40±4 .80	16.10 ±4.70	14.07 ±3.17	12.04 ±2.23	12.9 0±2. 94	RT	13.93 ±2.69	11.84 ±1.02	
	LT	15.1 ±3.5											LT	17.40 ±3.74	11.13 ±1.15	
Length of IH	RT	08.0 ±1.6	07.2 ±2.3	18.35 ±3.11	17.35 ±2.67	-	-	9.50 ±4.00	8.70 ±3.50	6.31 ±1.39	5.17 ±1.32	8.30 ±1.27	7.40 ±1.24	RT	7.89± 1.70	6.75 ±1.22
	LT	07.1 ±0.9	07.6 ±1.9										LT	7.52± 1.55	6.92 ±.89	
Ventral thyroid height		16.4 ±2.7	13.4 ±3.2	22.32 ±7.38	17.25 ±6.58	21.50 -	15. 80	-	-	15.88 ±1.74	11.77 ±1.39	18.5 0±2. 54	15.80 ±1.07	17.47±3.25	15.25 ±16.09	
Dorsal thyroid height	RT	38.8 ±6.9	34.0 ±6.3	44.82 ±6.45	37.25 ±7.47	-	-	-	-	38.96 ±4.49	30.40 ±2.67	43.9 0±4. 63	36.00 ±3.84	RT	36.49 ±8.19	32.26 ±2.02
	LT	36.2 ±5.7	35.1 ±6.7										LT	31.20 ±8.70	32.59 ±3.24	
Depth of ST notch	ST	11.2 ±2.7	09.7 ±2.7	11.68 ±0.97	10.20 ±0.51	-	-	-	-	-	-	-	-	8.52±1.78	4.54 ±.90	
Thyroid angle		85.25 4	99.85 7	89.92 13.6	106 ±28.3	-	-	78.70 ±10.20	106- 14.40	78.13 ±11.60	90.15 ±10.3	-	-	86±5.95 6	108 ±8.37	

❖ TC= Thyroid Cartilage, SH= Superior horn, IH = Inferior horn, RT= Right, LT= Left, ST= Suprathyroid Notch

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Conclusion

Height of larynx was more in males as compared with females. In all specimens, the thyroid laminae were quadrilateral with two laminae fused with each other in form of V at the junction of lower two-third and upper one-third of ant borders. All the major measurements of thyroid cartilage were found to be more in males as compared to females except upper breadth of thyroid cartilage on anterior aspect, thyroid angle. Length and breadth of thyroid laminae were larger in males as compared with females. In both sexes, these parameters were larger on left side as compared to right one. When compared between two sides, in males the left superior horn and in females right superior horn was longer. When compared between two sexes, it was longer in males on both sides but the difference was statistically highly significant only on left side. In males, the inferior horn was longer on right side while in females, the left inferior horn was longer as compared with right one. Ventral and dorsal thyroid height was found to be more in males as compared to females. Both in males and females length of left oblique line was more than right oblique line. When compared between the two sexes, on the right side, it was more in males while on left side it was more in females the difference being statistically significant on both the sides. Suprathyroid notch was observed to be deeper in males as compared to females. The difference being statistically highly significant. Thyroid angle was observed to be more in females as compared to males.

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