

Morphometric Study of Vocal Folds in Indian Cadavers

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ABSTRACT:-

Introduction: -The larynx is an air passage and a sphincteric device used in respiration and phonation. The larynx, from inside outwards has a framework of mucosa surrounded by fibro-elastic membrane which in turn is surrounded by cartilages and then a layer of muscles. Vocal folds are intrinsic ligament of larynx covered by mucosal folds. Larynx generates sound through rhythmic opening and closing of the vocal folds. The perceived pitch of human voice mainly depends upon fundamental frequency of sound generated by larynx. **Aim:** - The aim of present study is to measure various dimensions of vocal folds in Indian cadavers. **Material & Methods:** - 50 larynx were obtained from embalmed cadavers, of which 10 larynx were of females. Vocal cords were dissected from the larynx and morphometric analysis was done. **Results and Conclusions:** - The average total length of the vocal folds was found to be 16.11 mm. \pm 2.62 mm. in male and 14.10 mm. \pm 1.54 mm. in female cadavers. The average width of the vocal folds was found to be 4.38 mm. \pm 0.74 mm. in male and 3.60 mm. \pm 0.64 mm. in female cadavers. The average total length of the membranous part of the vocal folds was found to be 11.90 mm. \pm 1.86 mm. in male and 10.45 mm. \pm 1.81 mm. in female cadavers. The average ratio of the length of the membranous and the cartilaginous parts of the vocal folds was calculated to be 3.10 \pm 0.96 in male and 2.85 \pm 0.73 in female cadavers.

Key words: - Larynx, vocal folds

Introduction:-

Larynx has been an organ of interest for researchers and scientists for a long time because it drew considerable attention due to its unique ability to produce sound. The larynx is an air passage and a sphincteric device used in respiration and phonation. The larynx, from inside outwards has a framework of mucosa surrounded by fibro-elastic membrane which in turn is surrounded by cartilages and then a layer of muscles. Larynx is having a fibro-elastic membrane within the framework of laryngeal cartilages. This elastic sheet is interrupted on both sides of the larynx by the horizontal cleft dividing the membrane into an upper portion known as quadrangular membrane and a lower portion known as cricothyroid membrane. The upper free margin of cricothyroid membrane is composed entirely of elastic tissue called as vocal ligament, which is attached anteriorly to thyroid cartilage and posteriorly to arytenoid cartilage. The vocal ligaments form the interior of the vocal folds (vocal cords). Vocal cord vibrates and modulates the flow of air being expelled from lungs during phonation. The frequency, or pitch, of the sound is determined by changes in the length and tension of the vocal ligaments¹. The difference in vocal fold length and thickness between males and females causes a difference in vocal pitch. So morphometric analysis of vocal cords will be

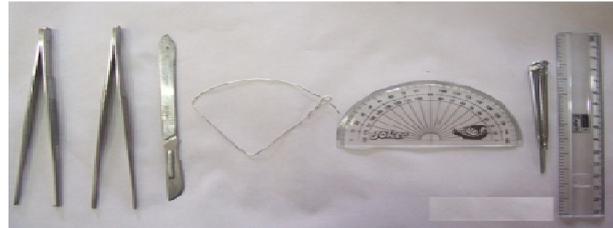
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helpful in understanding mechanism of sound production.

Material & Methods:-

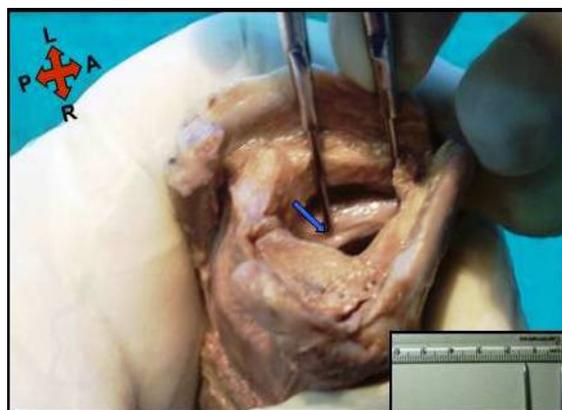
Fifty specimens of Larynx were dissected from embalmed cadavers. The study consists of meticulous dissection using standard dissection kit. The methodology of this study is based on the observation of morphology and various measurements pertaining to the Vocal cords of larynx. The study protocol was prepared in the form of a proforma. Measurements were taken with the help of a divider, a protractor, a scale and a wire loop. Instruments used in dissection and measurement are shown in Image.1

Image.1 Instruments used in Dissection and Measurement



The specimen was cleaned to remove the extra laryngeal soft tissue so that all the laryngeal landmarks used in this study were easily seen. Upper part of the epiglottis was excised taking care not to damage the vocal folds. Tips of the divider were then passed into the laryngeal cavity and opened antero-posteriorly so that one tip touched the anterior commissure and the other touched the posterior end of the true vocal fold on one side and thus the total length of the vocal fold was measured. Similarly, the measurement was done on the other side. Divider was again placed in the similar manner but this time, the tip touching the anterior commissure was kept fixed and the other arm of the divider was made to slide anteriorly on the free border of the true vocal fold on one side. The sliding arm soon dipped at the junction of the membranous and the cartilaginous part of the true vocal fold and the measurement of the length of the membranous part of the true vocal fold was taken as shown in Image 2 which was then repeated on the other side also. One tip of the divider was then placed at the junction of cartilaginous and membranous parts of the true vocal fold on one side and other tip touched the corresponding lateral wall of the laryngeal sinus and the width of the true vocal fold was similarly measured on the other side.

Image 2 Measurement of length of Membranous part of True Vocal Cord



Statistical Analysis

All these measurements were statistically analyzed by calculating the Mean (\bar{x}) and Standard Deviation (SD).

The Mean (\bar{x}) and the Standard Deviation (SD) was calculated using following formulae.

Observations & Results:-

Total length of the vocal folds

Total length of the vocal folds was measured on both sides. The findings were as shown in Table 1.

Table 1: Total Length of the Vocal Folds

Sex	Side	No. of specimens	Minimum (mm.)	Maximum (mm.)	Mean (mm.)	SD
Male	Right	40	11	21	16.11	2.62
	Left	40	11	21	16.11	2.62
Female	Right	10	10	15	14.10	1.54
	Left	10	10	15	14.10	1.54

Same measurements were observed on right and left both in male and female specimens.

Total length of the vocal folds in male cadavers ranged between 11 mm. and 21 mm. and the average was found to be 16.11 mm. \pm 2.62 mm.

Total length of the vocal folds in female cadavers ranged between 10 mm. and 15 mm. and the average was found to be 14.10 mm. \pm 1.54 mm.

Width of the vocal folds at the junction of the cartilaginous and the membranous part

Width of the vocal folds was measured on both sides at the junction of the cartilaginous and the membranous part and the findings were as shown in Table 2.

Table 2: Width of the Vocal Folds

Sex	Side	No. of specimens	Minimum (mm.)	Maximum (mm.)	Mean (mm.)	SD
Male	Right	40	3	6	4.33	0.74
	Left	40	3	6	4.33	0.74
Female	Right	10	3	5	3.60	0.64
	Left	10	3	5	3.60	0.64

Same measurements were observed on right and left both in male and female specimens.

Width of the vocal folds in male cadavers ranged between 3 mm. and 6 mm. and the average was found to be 4.33 mm. \pm 0.74 mm.

Width of the vocal folds in female cadavers ranged between 3 mm. and 5 mm. and the average was found to be 3.60 mm. \pm 0.64 mm.

Length of the membranous part of the vocal folds

The membranous part of the vocal folds was measured on both sides and the findings were as shown in Table 3.

Table 3: Length of the Membranous Part of the Vocal Folds

Sex	Side	No. of specimens	Minimum (mm.)	Maximum (mm.)	Mean (mm.)	SD
Male	Right	40	8	16	11.90	1.86
	Left	40	8	16	11.90	1.86
Female	Right	10	7	13	10.45	1.81
	Left	10	7	13	10.45	1.81

Same measurements were observed on right and left both in male and female specimens.

Total length of the membranous part of the vocal folds in male cadavers ranged between 8 mm. and 16 mm. and the average was found to be 11.90 mm. \pm 1.86 mm.

Total length of the membranous part of the vocal folds in female cadavers ranged between 7 mm. and 13 mm. and the average was found to be 10.45 mm. \pm 1.81 mm.

Ratio of length of the membranous and length of the cartilaginous part of the vocal folds

The ratio of the length of the membranous and the cartilaginous parts of the vocal folds was calculated both in case of male and female and the findings were as shown in Table 4.

Table 4: Ratio of Length of the Membranous and Cartilaginous Parts of the Vocal Folds

Sex	Side	No. of specimens	Mean (Ratio)	SD
Male	Right	40	3.10	0.96
	Left	40	3.10	0.96
Female	Right	10	2.85	0.73
	Left	10	2.85	0.73

Same ratios were observed on right and left both in male and female specimens.

The average of the ratio in male cadavers was calculated to be 3.10 \pm 0.96.

In female cadavers, the average of the ratio was calculated to be 2.85 \pm 0.73.

Discussion:-

Morphometry of vocal cords has been studied by various researchers. Accurate anatomical knowledge is essential in diagnostic and therapeutic procedures in the field of laryngology. Aside from pure anthropometry, such information has potential application in

studies of laryngeal physiology, in advance methods of laryngeal imaging, and in surgery of the laryngeal framework, and also helpful in understanding the knowledge of sound production.

Eckel and Sittel² have reported the total length of the vocal folds in their study. They found the average total length to be 22.09 mm. ± 3.07 mm. in males and 17.55 mm. ± 0.92 mm. in females. Eckel et al³ reported the average total length to be 13.8 mm. ± 2.92 mm. in males and 10.7 mm. ± 1.63 mm. in females. In both studies, there was no difference between the right and the left side. In our study, we found the average total length to be 16.11 mm. ± 2.62 mm. in males and 14.10 mm. ± 1.54 mm. in females. We also did not find any difference between the right and left sides.

Eckel et al³ reported the average width of the vocal folds to be 4.2 mm. ± 1.02 mm. in males and 3.1 mm. ± 1.07 mm. in females. In our study we found the average width to be 4.38 mm. ± 0.74 mm. in males and 3.60 mm. ± 0.64 mm. in females. Width of the vocal folds in males had a nearly equal average measurement compared to the study of Eckel et al³ but the findings in females were not very conclusive.

Hirano et al⁴ worked on the length of vocal folds in 20 fixed specimens obtained from 10 male and 10 female cadavers of Japanese origin. Similar study had also been done by Eckel and Sittel² and these data were compared with our study. In our study we found the length of the membranous part to be 11.90 mm. ± 1.86 mm. in males and 10.45 mm. ± 1.81 mm. in females both on right and left sides.

Table 5 Comparison of Various studies for Length of Vocal folds

	Total Length (TL) in millimeters		Membranous Part (M) in millimeters		Cartilaginous Part (C) in millimeters		Ratio M / C		Ratio TL / C	
	M	F	M	F	M	F	M	F	M	F
Hirano et al	24.5	16.3	-	-	9.5	6.8	-	-	2.58	2.4
Eckel and Sittel	22.09	17.55	13.15	10.58	8.59	6.93	1.53	1.53	2.57	2.53
Our study	16.11	14.10	11.90	10.45	-	-	3.10	2.85	-	-

Hirano et al⁴ stated that the phrase “junction between the anterior and the middle third of vocal folds” meant the antero-posterior midpoint of the membranous vocal fold, postulating that there was a cartilaginous vocal fold which had a length of half that of membranous vocal fold.

Eckel and Sittel² stated that their study confirmed the usual belief of the cartilaginous portion being one-third of the membranous portion of the vocal cords. Wysocki et al⁵ commented on the sexual dimorphism in the length of the membranous part of the vocal fold which they said was significantly smaller in female than in males. They mentioned that in case of human larynx, sex did not significantly influence the laryngeal parameters in children. It was with advancing

age that the parameters showed gender dimorphism. They also commented that proportions of larynx depended mainly on age and not on sex. Eckel et al⁶ mentioned about the cartilaginous portion being 60 to 75 percent of the total vocal fold length in children below 2 years. Friedrich et al⁷ in their study on 19 laryngeal specimens from 11 male and 8 female cadavers stated that the cartilaginous portion of the vocal folds accounted for 37% of the total vocal fold length in males and for 42% in females which was longer than what was generally accepted.

In our study we found that the cartilaginous portion formed about 25% of the total length of vocal folds both in males and females. Taking into account the work of other researchers we found a great deal of difference amongst their findings and also between their and ours.

Conclusions:-

1. The average total length of the vocal folds was found to be 16.11 mm. \pm 2.62 mm. in male and 14.10 mm. \pm 1.54 mm. in female cadavers.
2. The average width of the vocal folds was found to be 4.33 mm. \pm 0.74 mm. in male and 3.60 mm. \pm 0.64 mm. in female cadavers.
3. The average total length of the membranous part of the vocal folds was found to be 11.90 mm. \pm 1.86 mm. in male and 10.45 mm. \pm 1.81 mm. in female cadavers.
4. The average ratio of the length of the membranous and the cartilaginous parts of the vocal folds was calculated to be 3.10 ± 0.96 in male and 2.85 ± 0.73 in female cadavers.

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