

## A Morphological Study of Adult Human Larynx in Jharkhand Population

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### **Abstract:**

**Background:** The larynx is an air passage which extends from the tongue to trachea. Its functions include protection the lower respiratory tract and production of voice. Morphometric data of the larynx is useful during procedures like intubation, endoscopy, laryngeal micro-surgeries in cases of sub-glottic stenosis and post intubation stenosis and surgery of laryngeal framework such as partial or total laryngectomies. So, precise knowledge of the morphometry of the larynx is important.

**Materials and Methods:** In this observational study, 30 adult human larynges from cadavers of different age group between 30 to 60 years of both sexes were used. Out of 30 larynges, 22 were from male and 8 from female adult cadavers. Measurement of various external and internal structures of larynges was taken using digital vernier calliper and thread and scale. Mean and standard deviation were used to assess the variation in measurements.

**Results:** The mean of the various measurements showed statistically significant differences in both both internal and external parameters. There was no statistically significant difference in the measurements on right and left side of the bilateral structures.

**Conclusion:** There was a considerable variation in various external and internal dimensions of larynges both in male and female groups of larynges as well as between male and female.

**Key Word:** Morphometry, Human larynx, External and internal dimension

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### I. Introduction

The larynx is an air passage, a sphincter and an organ of phonation. It extends from the tongue to trachea. It projects ventrally between the great vessels of the neck and is covered anteriorly by skin, fasciae and the infrahyoid strap muscles that lower the hyoid bone and the larynx. Above it opens into the laryngopharynx and forms its anterior wall; below, it continues into the trachea.

It is mobile on deglutition. At rest, the larynx lies opposite 3<sup>rd</sup> to 6<sup>th</sup> cervical vertebrae in adult males; it is somewhat higher in children and adult female.

Until puberty the male and female larynges are similar in size. After puberty, the male larynx enlarges considerably in comparison with that of the female, all the cartilages increase in size and weight, the thyroid cartilage projects in the anterior midline of the neck and its sagittal diameter nearly doubles. The male thyroid cartilage continues to increase in size until 40 years of age after which no further growth occurs.<sup>1</sup>

The larynx is the upper part of the respiratory tract. Its main function is to protect the lower respiratory tract so that foreign bodies do not enter the trachea. If a foreign body comes in contact with the mucosa of the larynx, it reflexly gives rise to violent coughing till the foreign body is expelled.<sup>2</sup>

Another function of the larynx is the production of voice. Hence the name voice box. The anterior border of each thyroid lamina fuses with its partner at an angle of 90<sup>0</sup> in men and 120<sup>0</sup> in women. The shallower angle in men is associated with laryngeal prominence, the greater length of the vocal cords and the resultant deeper pitch of voice.<sup>1,2</sup>

From embryologic, anatomic, physiologic and surgical standpoints, the larynx is one of the most complex organs of the human body.<sup>3</sup>

The increasing application of sophisticated electro-physiological and radiological methods for the diagnosis and treatment of laryngeal disorders requires an extensive knowledge of the size and proportions of the human larynx and its cartilaginous components.<sup>3,4</sup>

Recent interest in the condition of subglottic stenosis and post-intubational stenosis of the lower respiratory tract led to a search through the literature to ascertain the measurements of the various cartilages of the larynx.<sup>3,4,5</sup>

Morphometric data of the larynx is useful in otorhinolaryngology during procedures like intubation, endoscopy, laryngeal micro-surgeries<sup>6,7</sup> and surgery of laryngeal framework (partial/total laryngectomy).<sup>6,7,8,9</sup>

Pure anthropometry of laryngeal framework has potential application to studies in laryngeal physiology, advanced methods of laryngeal imaging techniques and advanced surgical procedures of the larynx.<sup>8,9</sup>

The elaboration of new surgical concepts for the treatment of phonatory disorders has recently awakened new interest in larynx morphometry.<sup>9,10</sup>

They are critical to the accurate placement of needles and probes in laryngeal electro-myography, vocal cord injection and medialization procedures.<sup>10</sup>

The most common form of committing suicide in our region is "hanging". We can expect the fracture of the Thyroid cartilage both in hanging and strangulation. The detailed description of Thyroid cartilage morphology can be used in further research to determine the connection between the location of the Thyroid cartilage fracture in strangulation, the level of ossification and the force applied in strangulation.<sup>11</sup>

Precise knowledge of the morphometry of the laryngeal cavity is useful in various interventions like bronchoscopy and endoscopy. Morphometric data is also useful in Otorhinolaryngology procedures such as partial or total laryngectomies, laryngeal microsurgery in cases of sub-glottic stenosis and post intubation stenosis.

Researchers have worked on geometric characterisation of laryngeal cartilage for biomechanical modelling. This can help in adjustments in the prephonatory its periodicity in vibration and to ease of phonation. Moreover in electrophysiology in radiodiagnostic studies like EMG, CT, MRI and surgical treatments like thyroplasty and arytenoid adduction, canine model is used for the study of mechanics and physiology of voice production, due to similarities in morphometry.

The laryngeal diameter in senile and its usefulness in ORL diagnostic and operational methods. To select right operational tools, sizes, the technique of choice, preoperative designing and building virtual and plastic models for physician training.

### **Aims and Objectives**

The aims of the present study were-

1. To measure the dimension of larynges in the cadavers available for dissection.
2. To analyze variation in the dimension of larynx in subjects under study.

## **II. Material And Methods**

This study was carried out in the Department of Anatomy, Rajendra Institute of Medical Sciences, Ranchi for a period of 2 years from December 2017 to November 2019. Donated and unclaimed embalmed cadavers meant for the purpose of medical teaching, training and researches were used for the study after obtaining the clearance from institutional ethical committee. The study sample included 30 specimen of larynx dissected from cadavers. Fully developed normal adult human larynges of different age group between 30 to 60 years of both sexes were used for the study. Out of 30 larynges, 22 were from male and 8 from female adult cadavers.

The study consisted of meticulous dissection using standard dissection kit. Measurements were taken using Digital Vernier callipers, measuring tape/thread and scale. Data taken was transferred to Master chart and then analyzed.

### **PROCEDURE**

Larynx specimen was dissected extending from suprahyoid to upper part of the trachea and stored in 10% formalin. The specimen was cleaned to remove extra laryngeal soft tissue so that all the laryngeal landmarks used in this study were easily seen.

Following measurements were taken-

#### **External dimensions (Length of larynx): (Image 1)**

1. From the floor of Thyroid notch to lower border of Cricoid cartilage(L1)
2. From upper border of Hyoid bone to lower border of Cricoid cartilage (L2)
3. Length from tip of Epiglottis to lower border of Cricoid cartilage (L3)

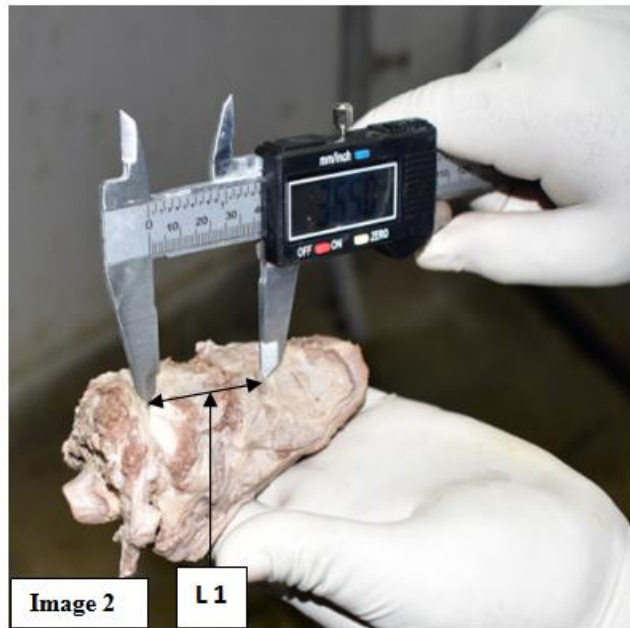
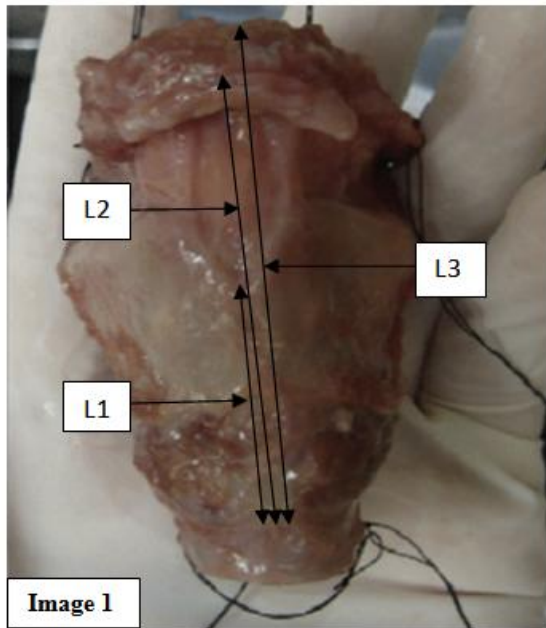
#### **Internal dimensions (Laryngeal cavity): (Image 5, 6, 7 and 8)**

1. **Length of the Vestibule (a)** – From tip of Epiglottis to upper border of Vestibular folds.
2. **Length of Sinus (b)** – Between Vocal and Vestibular
3. **Length of Infraglottic cavity (c)** – From Vocal folds to lower border of Cricoid cartilage
4. **Total length of laryngeal cavity (d)** – From tip of Epiglottis to lower border of Cricoid cartilage

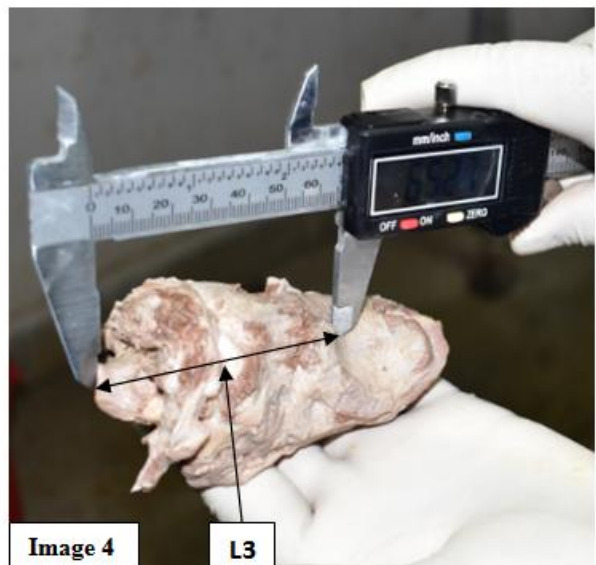
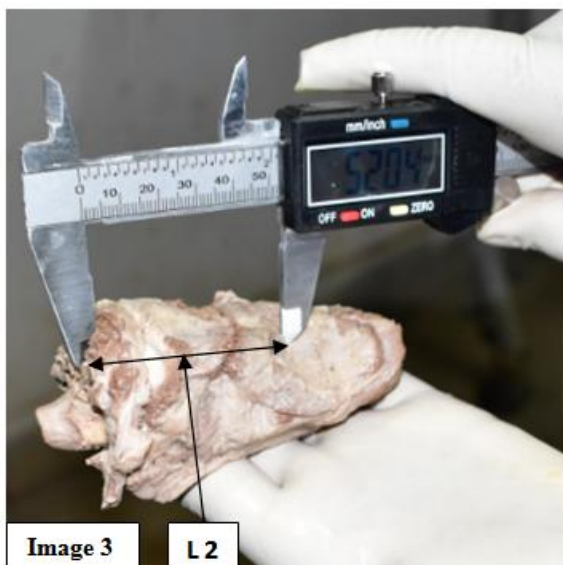
**5. Length of Vestibular folds (VeF) and Vocal folds (VoF)** – Bilaterally measured with the help of thread and scale.

**6. Length of Aryepiglottic folds (AEF)** – Bilaterally measured with the help of thread and scale.

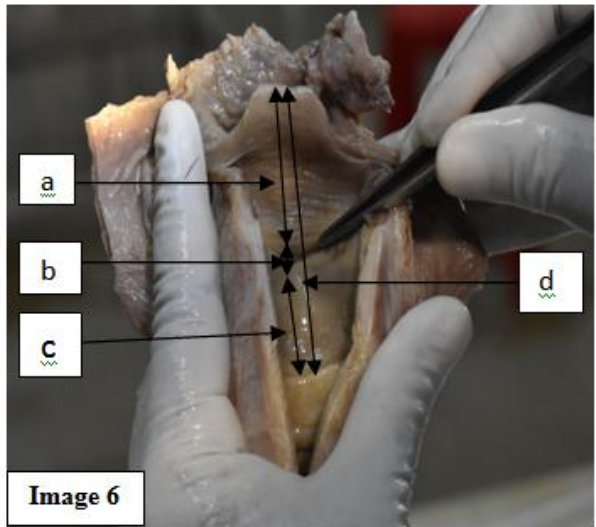
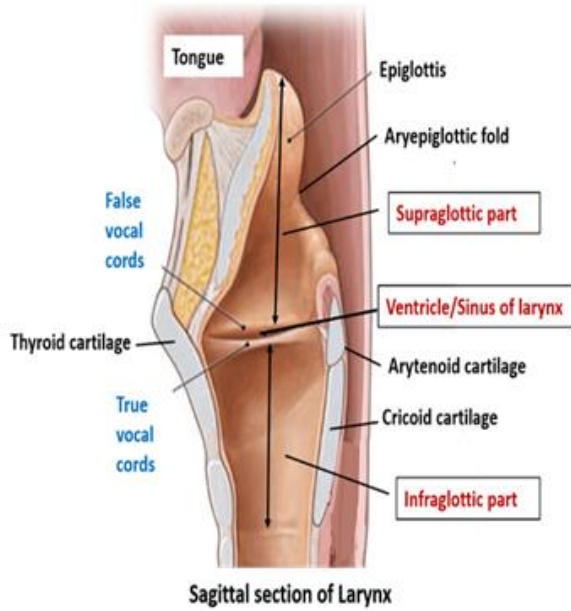
**Statistical Analysis:** Data of all external and internal measurements were transferred to Master chart. Data was analysed using Microsoft Office Excel 2007 version. For each parameter, the Mean, Range and SD were calculated. Z-value was used to test significant variation. P- value <0.05 was taken significant.



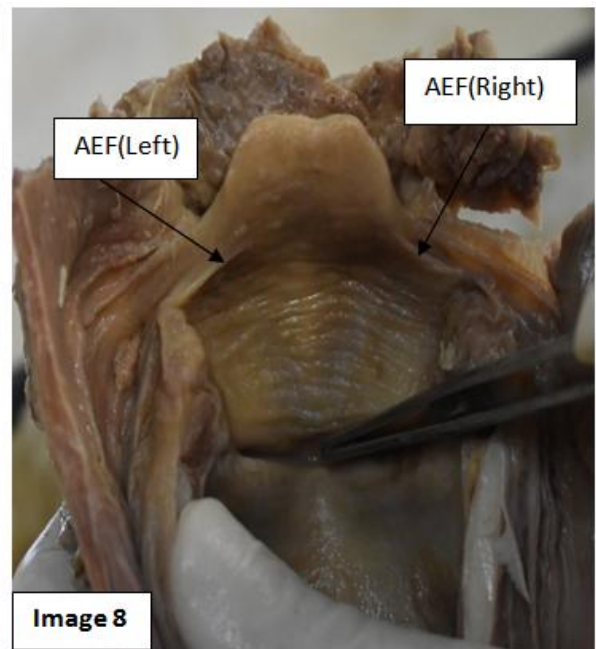
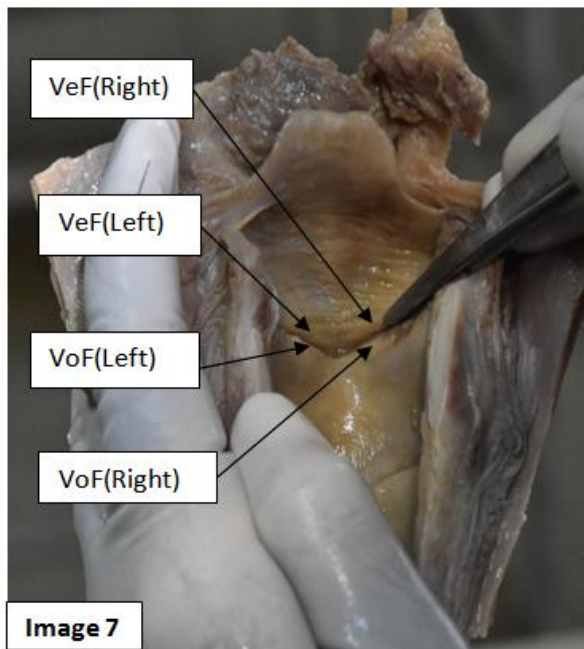
**Image 1:** Front view of larynx showing external measurement; **Image 2:** Showing length from the floor of Thyroid notch to lower border of Cricoid cartilage(L1)



**Image 3:** Showing length from upper border of Hyoid bone to lower border of Cricoid cartilage(L2); **Image 4:** Showing length from tip of Epiglottitis to lower border of Cricoid cartilage (L3)



**Image 5: Dimensions of laryngeal cavity** **Image 6: Showing various dimensions of laryngeal cavity**



**Image 7: Showing Vestibular folds(VeF) and Vocal fold(VoF) (Bilaterally);** **Image 8 :Showing Aryepiglottic Folds(AEF) (Bilaterally)**





**Figure 9:** Showing measurement of length of vestibule(a); **Figure 10:** Showing measurement of length of Sinus cavity (b)



**Figure 11:** Showing measurement of length of infraglottic cavity(c); **Figure 12:** Showing measurement of total length of laryngeal cavity (d)

### III. Result

The data obtained from this research work showed that mean length of larynx (L1) was  $34.03 \pm 2.91$  mm, mean height of larynx from Hyoid bone to Cricoid cartilage (L2) was  $52.00 \pm 4.22$  mm and mean height of Larynx from tip of Epiglottis to Cricoid cartilage (L3) was  $62.42 \pm 7.54$  mm in male. The same measurement in female was  $28.30 \pm 1.36$  mm,  $37.97 \pm 3.83$  mm and  $46.09 \pm 1.41$  mm respectively. (Table 1, Figure 1)

The mean length of Vestibule(a) was  $35.05 \pm 3.61$  mm, mean length of Sinus (b) was  $2.71 \pm 0.60$  mm, mean length of Infraglottic cavity(c) was  $26.06 \pm 4.58$  mm and mean total length of laryngeal cavity(d) was  $66.16 \pm 9.24$  mm in male.

Corresponding length in female was  $25.70 \pm 2.35$  mm,  $1.04 \pm 0.28$  mm,  $19.63 \pm 0.55$  mm,  $40.11 \pm 7.66$  mm respectively. (Table 2, Figure 2)

In larynges obtained from male cadavers, mean length of Vestibular fold(VeF) on right side was 16.01±1.53mm and on left side was 16.08±1.56mm.

In female larynges, it was 12.99±0.18mm on right side and 13.03±0.23mm on left side.

The mean length of Vocal folds(VoF) was 15.82±1.54mm on right side and 15.81±1.54mm on left side in male larynges whereas 12.79±0.17mm on right side and 12.83±0.19mm on left side in female larynges.

(Table 3, Figure 3)

Mean length of aryepiglottic folds(AEF) was 15.21±2.34mm on right side and, 15.8±2.34mm in male larynges. The AEF in female larynges was 10.34±0.82mm on right and 10.40±0.81mm on left side respectively.

(Table 4, Figure 4)

Table 1: External measurement of larynx

S. No	External measurement of larynx	Mean± S.D.(mm)		Range(mm)	
		M	F	M	F
1	L1	34.03 ±2.91	28.30 ±1.36	30.6 - 40.72	25.98 - 30.2
2	L2	52.00 ±4.22	37.97 ±3.83	45.1- 60.43	34.05 -45.09
3	L3	62.42 ±7.54	46.0 ±1.41	48.0 - 75.04	43.67 -48.03

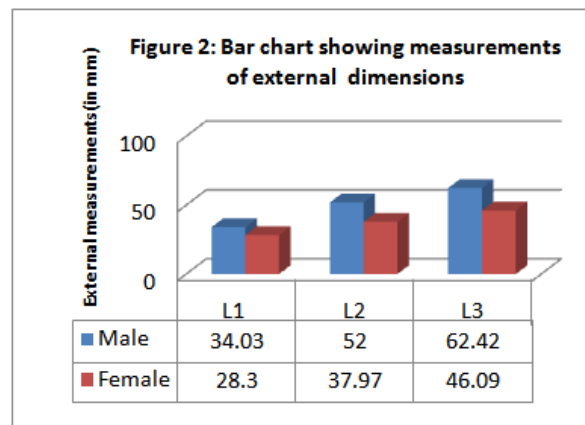


Table 2: Measurement of laryngeal cavity

S. No	Measurement of laryngeal cavity	Mean ± S.D.(mm)		Range(mm)	
		M	F	M	F
1	a	35.05±3.61	25.70±2.35	28.76 - 40.65	20.67- 27.76
2	b	2.71±0.60	1.04±0.28	1.98 - 3.85	0.79- 1.65
3	c	26.06±4.58	19.63±0.55	20.54 - 34.78	19.04 -20.34
4	d	66.16±9.24	40.11±7.66	54.45 - 80.95	28.1- 48.28

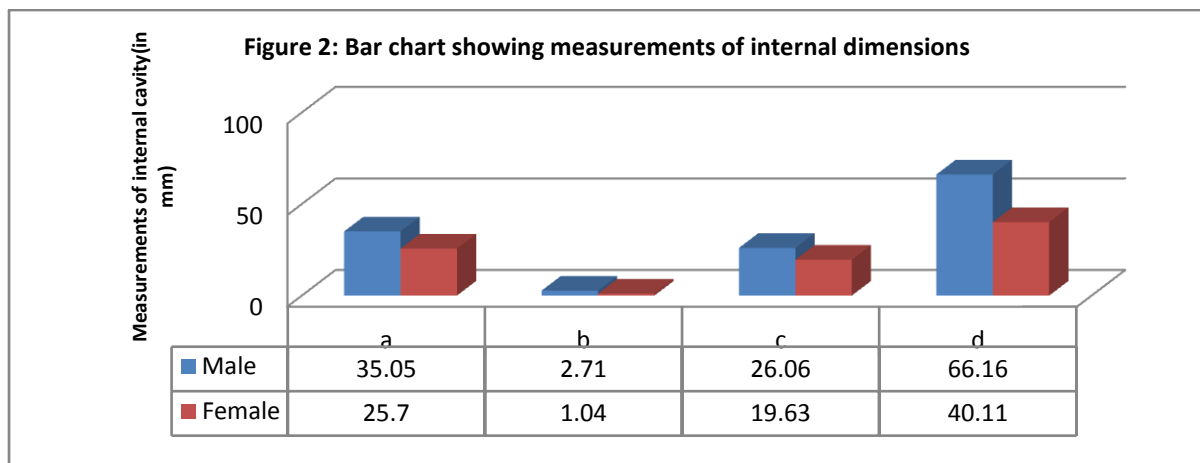
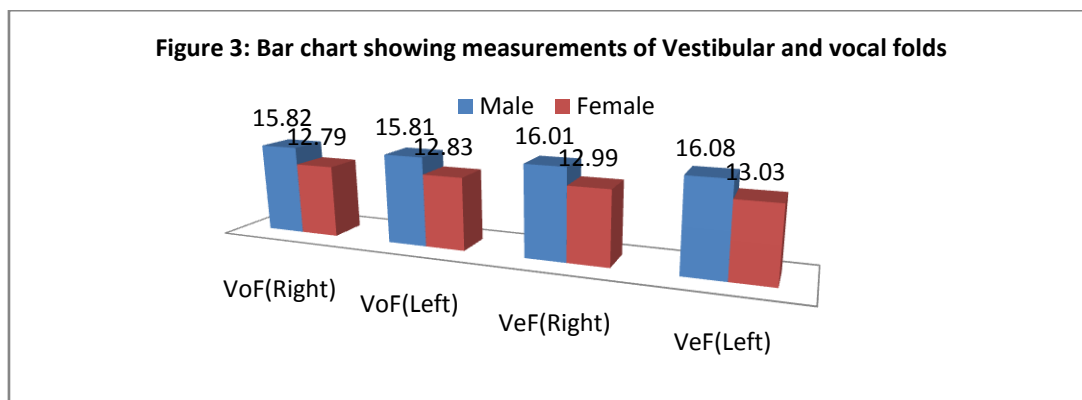


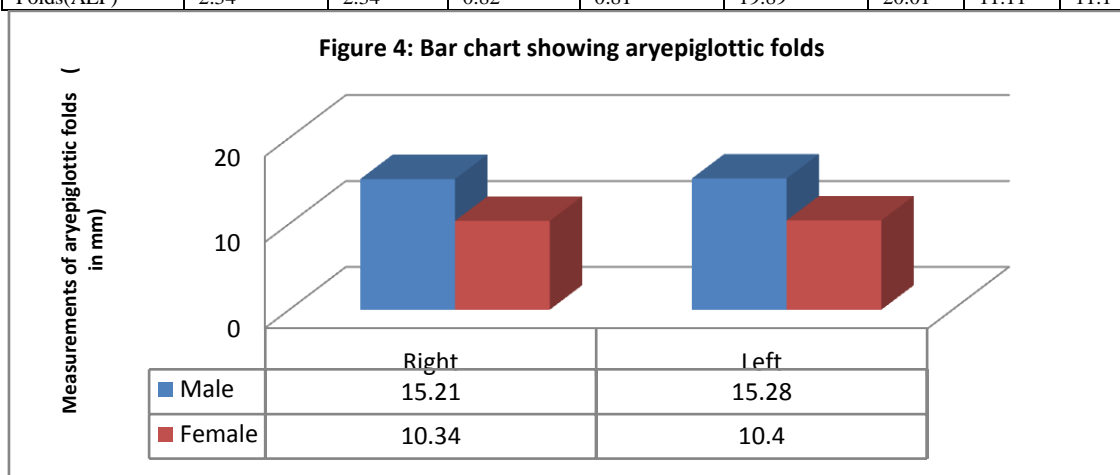
Table 3: Showing the measurements of fold length.

Parameters	Mean±SD(mm)				Range(mm)			
	M		F		M		F	
	R	L	R	L	R	L	R	L
Vestibular Folds (VeF)	16.01 ±1.53	16.08 ±1.56	12.99 ±0.18	13.03 ±0.23	13.71 - 19.04	13.71 - 19.12	12.87 - 13.41	12.86 - 13.58
Vocal Folds (VoF)	15.82 ±1.54	15.81 ±1.54	12.79 ±0.17	12.83 ±0.19	13.3 - 18.95	13.38 - 19.00	12.63 - 13.05	12.65 - 13.18



**Table 4: Showing the length of the Aryepiglottic folds.**

Parameters	Mean(mm) ±SD (mm)				Range			
	M		F		M		F	
	R	L	R	L	R	L	R	L
Aryepiglottic Folds(AEF)	15.21±2.34	15.28±2.34	10.34±0.82	10.40±0.81	11.45 - 19.89	11.46 - 20.01	9.08 - 11.11	9.2 - 11.1



#### IV. Discussion

The present study provides a thorough detail of external and internal measurements of larynx. The external and internal measurements of the laryngeal cavity in the present study was similar to the work done by and Poornima et al (2017)<sup>12</sup> and M M Joshi et al (2013)<sup>13</sup>.

Parameter	Present study		Poornima et al (2017)	M M Joshi et al (2013)
	M	F		
L1	34.03±2.91mm	28.30±1.36mm	33.51±3.6mm	32.42±3.41mm
L2	52.00±4.22mm	37.97±3.83mm	50.43±6.77mm	54.39±6.04mm
L3	62.42±7.54mm	46.09±1.41mm	60.17±8.12mm	57.13±7.32mm
a	35.05±3.61mm	25.70±2.35mm	33.45±6.37mm	32.11±5.77mm
b	2.71±0.60mm	1.04±0.28mm	2.32±1.01mm	2.87±1.37mm
c	26.06±4.58mm	19.63±0.55mm	24.21±3.52mm	23.05±3.13mm
d	66.16±9.24mm	40.11±7.66mm	62.31±11.18mm	62.31±11.18mm
VeF	Right: 16.01±1.53mm Left: 16.08±1.56mm	Right: 12.99±0.18mm Left: 12.79±0.17mm	Right: 12.42mm, Left: 12.86mm	Right: 14.84mm, Left: 14.86mm
VoF	Right: 15.82±1.54mm Left: 15.81±1.54mm	Right: 12.79±0.17mm Left: 12.83±0.19mm	Right: 12.94mm, Left: 12.98mm	Right: 14.89mm, Left: 14.92mm
AEF	Right: 15.21±2.34mm Left: 15.28±2.34mm	Right: 10.34±0.82mm Left: 10.40±0.81mm	Right: 12.97mm , Left: 13.01mm	Right: 16.43mm, Left: 15.85mm

In the present study, mean length from the floor of Thyroid notch to lower border of Cricoid cartilage(L1) was  $34.03\pm 2.91$ mm in male and  $28.30\pm 1.36$ mm in female as compared to the finding in study conducted by Poornima et al (2017) and M M Joshi et al (2013) which was  $33.51\pm 3.6$ mm and  $32.42\pm 3.41$ mm respectively. The mean length from upper border of Hyoid bone to lower border of Cricoid cartilage(L2), was  $52.00\pm 4.22$ mm in male and as compared to the that of study of Poornima et al (2017) and M M Joshi et al (2013) which was  $50.43\pm 6.77$ mm and  $54.39\pm 6.04$ mm respectively. The mean length from tip of Epiglottis to lower border of Cricoid cartilage (L3) was  $62.42\pm 7.54$ mm in male and  $46.09\pm 1.41$ mm in female as compared to the finding in study conducted by Poornima et al (2017) and M M Joshi et al (2013) which was  $60.17\pm 8.12$ mm and  $57.13\pm 7.32$ mm respectively. (See Table 5, Figure 5)

Ajmani [1990] observed higher length of larynx from floor of thyroid notch to lower margin of Cricoid cartilage(L1) in Nigerians which was  $45.06\pm 8.41$  mm in males and  $38.08\pm 8.25$ mm in females which in present study was  $34.03\pm 2.91$ mm in male and  $28.30\pm 1.36$ mm in female respectively.<sup>5</sup>

The mean length of the vestibule (a) was  $35.05\pm 3.61$ mm in male and  $25.70\pm 2.35$ mm as compared to the finding in study conducted by Poornima et al (2017) and M M Joshi et al (2013) which was  $33.45\pm 6.37$ mm and  $32.11\pm 5.77$ mm respectively. The mean length of the sinus (b) was  $2.71\pm 0.60$ mm in male and  $1.04\pm 0.28$ mm in female as compared to the finding in study conducted by Poornima et al (2017) and M M Joshi et al (2013) which was  $2.32\pm 1.01$ mm and  $2.87\pm 1.37$ mm respectively. The mean length of the infraglottic cavity (c) was  $26.06\pm 4.58$ mm in male and  $19.63\pm 0.55$ mm in female as compared to the finding in study conducted by Poornima et al (2017) and M M Joshi et al (2013) which was  $24.21\pm 3.52$ mm and  $23.05\pm 3.13$ mm respectively. The mean total length of the vestibule (d) was  $66.16\pm 9.24$ mm in male  $40.11\pm 7.66$ mm in female as compared to the finding in study conducted by Poornima et al (2017) and M M Joshi et al (2013) which was  $62.31\pm 11.18$ mm and  $62.31\pm 11.18$ mm respectively. (Table 5, Figure 6)

Zielinski et al [2001] reported that mean height of Infraglottic cavity was  $25.90\pm 3.80$  mm in male and  $22.18\pm 3.67$  mm in female which in the present study was  $26.06\pm 4.58$ mm in male and  $19.63\pm 0.55$ mm in female.<sup>24</sup>

In the present study, the mean total length of vestibular fold(VeF) was  $16.01\pm 1.53$ mm on right side and  $16.08\pm 1.56$ mm on left side while  $12.99\pm 0.18$ mm on right side and  $12.79\pm 0.17$ mm on left side in female. The same parameter was  $12.42$ mm on right side and  $12.86$ mm on left side in study conducted by Poornima et al (2017) whereas  $14.84$ mm on right side and  $14.86$ mm on left side in study conducted by M M Joshi et al (2013).

The mean total length of vocal fold (VoF) was  $15.82\pm 1.54$ mm on right side and  $15.81\pm 1.54$ mm on left side in male whereas  $12.79\pm 0.17$ mm on right side and  $12.83\pm 0.19$ mm on left side in female. The same parameter was  $12.94$ mm on right side and  $12.98$ mm on left side in study conducted by Poornima et al (2017) whereas  $14.89$ mm on right side and  $14.92$ mm on left side in study conducted by M M Joshi et al (2013). (Table 5, Figure 7)

Eckel et al reported the average total length of vocal folds to be  $13.8$  mm.  $\pm 2.92$  mm. in males and  $10.7$  mm.  $\pm 1.63$  mm. in females. There was no difference between the right and the left side.

Rawal J D et al found the average total length to be  $16.11$  mm.  $\pm 2.62$  mm. in males and  $14.10$  mm.  $\pm 1.54$  mm. in females. They also did not find any difference between the right and left sides.<sup>25</sup>

Wysocki et al 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.<sup>26</sup>

The mean length of aryepiglottic fold(AEF) was  $15.21\pm 2.34$ mm on right side and  $15.28\pm 2.34$ mm on left side in male whereas  $10.34\pm 0.82$ mm on right side and  $10.40\pm 0.81$ mm on left side in female. The same parameter was  $12.97$ mm on right side and  $13.01$ mm on left side in study conducted by Poornima et al (2017) whereas  $16.43$ mm on right side and  $15.85$ mm on left side in study conducted by M M Joshi et al (2013). (Table 5, Figure 8)

The variation in measurements of various external and internal dimensions was highly significant (p-value < 0.01) in both male and female as well as between male and female. There was no significant differences (on left and right in measurements of bilateral structures such as vestibular fold, vocal folds and aryepiglottic folds( p-value >0.05).

## V. Conclusion

The data obtained from this research work showed that there is considerable variation in various external and internal dimensions of larynges in the given population. There is also a marked variation in various external and internal dimensions of the larynx between male and female. Variation in different dimensions and between male and female is of utmost importance and must be considered while performing endotracheal intubation, oncological or any microsurgery of larynx or preparing a plastic virtual model for training and teaching purposes.



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