ECRONICON OPEN ACCESS

EC CLINICAL AND EXPERIMENTAL ANATOMY
Research Article

New Perspective of Hyoid Bone Morphology

Sushama Kalidas Chavan* and Mohini M Joshi

Department of Anatomy, Rural Medical College Loni, Pravara Institute of Medical Sciences, Ahmednagar, Maharashtra, India

***Corresponding Author:** Sushama Kalidas Chavan, Department of Anatomy, Rural Medical College Loni, Pravara Institute of Medical Sciences, Ahmednagar, Maharashtra, India.

Received: March 25, 2019; **Published:** May 02, 2019

Abstract

Hyoid bone, although small, proportionately play very vital role in the biodynamic system that regulates mastication, deglutition, and phonation. Large amount of literature has accumulated showing the sex and age-related differences in the hyoid bone. To substantiate this metrical and non-metrical studies have been carried which includes the shape of the bone, weight of the bone, various dimensions like length and height of individual part and various angles subtended by the various parts of the bone. Isometric or anisomery of bone also been studied. Many authors extensively worked on the hyoid bone in North West Indian, but no such data is available for western region of India. We have carried out detailed metrical and non-metrical study of fifty hyoid bone, collected over a period of two years. In general height and width of the body, length of greater cornu of right and left, distance between tip of greater cornu, length of lesser cornu, inter-cornuel distance were studied. Morphological features discussed and tried to correlate with its dynamic nature.

Keywords: *Hyoid; Biodynamic; Morphological Features; Body of Hyoid; Angle; Greater Cornu*

Abbreviations

Rt: Right; Lt: Left

Introduction

Hyoid, a small bone hyoeides meaning shaped like a letter upsilon or shaped like 'U' (os hyoideum, lingual bone), is an elevator of larynx and forms a part of hyo-laryngeal complex. Greek word -It is the only bone in the body not articulated to any other bone and suspended from base of skull only by stylohyoid ligaments. Ten pairs of muscles are attached to it, through the action of these muscles, hyoid bone is not only kept in position; but also influences the movements of tongue, base of skull, thyroid cartilage, mandible, sternum, scapula and pharynx. Through these structures hyoid biodynamic plays an important role in regulating mastication, deglutition, and phonation. Though non- articulated, the muscular attachments on it affects its biodynamic, this may in turn lead to variations in hyoid morphology.

Most of the standard books only have given the salient features of the morphology of hyoid, and most studies done on hyoid, focuses on the metrical parameters and few non-metrical parameters like its shape, size, and symmetry. Kelvin WP Miller [1] describe age and sex-related variation in the hyoid bone morphology. Koebke and Saternus [2] in his radiological study described the shape of hyoid bone along with other metrical parameters. N. Papadopoulos, G. Lykaki-Anastopoulou and EL. Alvanidou [3] have studied about the size and shape of hyoid and given the alternative classification. We have extensive data on morphometric parameters studying size, shape, weight etc. of Indian population particularly of North West side. Harjeet and Jit I [4] studied hyoid bone for size and shape for sexual dimorphism. Rajith and Pillai [5] studied hyoid for sexual dimorphism using weight as parameters. However, none has described the details of specific anatomical features in foreign or Indian studies on hyoid bone. In our study of hyoid on metrical parameters we observed and noted, some

of the morphological features which we like to highlight here. Attempt has been made to explore the morphological picture of hyoid that will not only enhance the anatomical facts but also help to understand biodynamic of hyoid bone.

Materials and Methods

The study was carried out in Department of Anatomy, Rural Medical College, Pravara Institute of Medical Sciences (DU), Loni, Ahmednagar (Maharashtra). Fifty-four cadavers used for dissection by students have been utilized for study purpose. All the cadavers were beyond forty years of age. All specimens of hyoid removed from cadavers and meticulously dissected to remove all soft tissues. Both sexes were included as part of study. The bones that were broken or those bones from which soft tissue separation not possible completely, and obscuring the morphological characteristics were excluded. As sample size of female bones was less, dimorphic study could not be attempted.

Results

During our study, we observed some interesting morphological features (Figure 1 and 2) on body of hyoid (basihyal) (Table 1). In the study, transverse ridge (Figure 1A) was observed over the body of hyoid. Transverse ridge was most constant feature found in all 50 (100%) cases. It is thick bar of compact bone and found to be continuous with lesser horn in 20 (40%) cases. Lesser cornu of hyoid (Figure 1B) was present in 39 cases, and in 6 cases, not seen on both sides. Out of 39 cases, lesser cornu was arising from body of hyoid in 15 cases, from the greater cornu in 22 cases and from the junction of body and greater cornu in two cases. Line of fusion between body and greater cornu was seen in 27 cases. In 23 cases, it was completely ossified. Lesser cornu was continuous with transverse ridge present on anterior aspect of body in 17 cases. In all these cases, lesser cornu was arising from body or from the junction of body with greater cornu. Right angle to transverse ridge, was a vertical median ridge (Figure 1C) present on anterior superior surface was limited to superior aspect, is found in 17 cases (34%) in the present study and divided superior aspect into two half. Among these, three bones showed extension of ridge on anterio-inferior surface. Prominent tubercle (Figure 1D) in the middle of the anterio-superior surface, replaced the vertical median ridge in 19 cases (34%). In few cases tubercle was as high as 3 - 4 mm. On either side of ridge or tubercle there are shallow depression (Figure 1E). 'V' shaped ridge: (Figure 1F) was found dividing the superior aspect into three shallow depression one median, placed between limbs of 'V' and two were lateral to the limbs in 7 cases (14%). Single large fosse (Figure 1G) was occupying the whole of the anterio-superior aspect of body of hyoid with absence of vertical ridge or tubercle in seven cases (14%). Posterior surface of body of hyoid while cleaning the hyoid for our study purpose it was very difficult to remove the soft tissue element from posterior surface of hyoid. This surface filled to the depth with dense connective tissue element has already been described in literature. After digging up the soft tissue and clearing the surface, we came across a large fossa occupying almost whole of the posterior surface of body of hyoid (Figure 1H). The fossa is larger of the depth ranging 0.9 mm to as deep as 6 millimeter; mean being 2.27 mm. Large amount of thick connective tissue element filled the fossa that appeared to be elastic in nature. The attachment of genio-hyoid muscle found to extend in periphery of this fossa. This fossa over the posterior surface found in all hyoid.

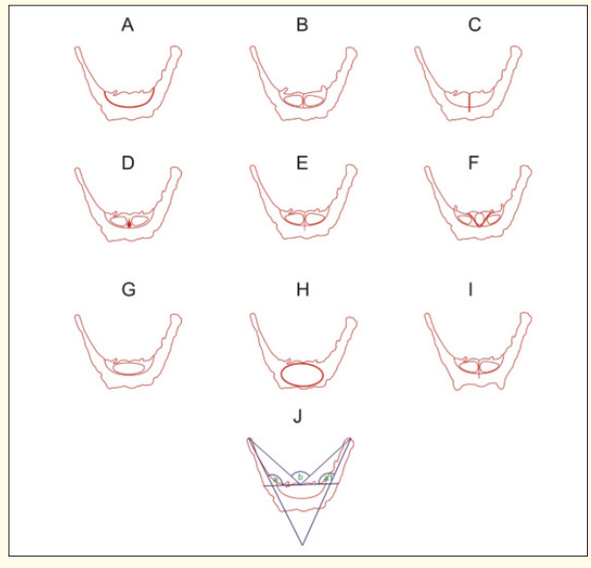

Figure 1: *Diagrammatic features of hyoid bone.*

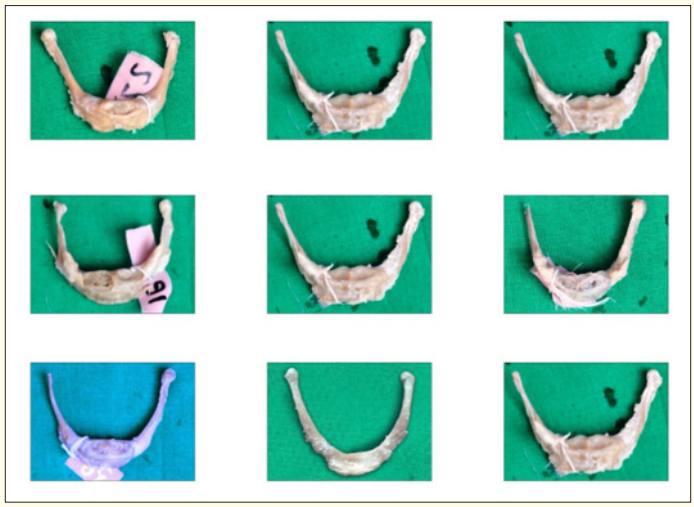

Figure 2: *Morphological features of hyoid bone.*

Morphological Parameters	Numbers	Percentage
Transverse ridge	50	100%
Vertical Median ridge	17	34%
Tubercle	19	38%
V Shaped	7	14%
Single, large fossa on superior surface	7	14%
Fossa on posterior aspect of body	50	100%

Table 1: *Morphologic variations of hyoid bone.*

Superior border of body of hyoid was thinner than the inferior border that found to be quite thick particularly at the attachment of omo-hyoid and sterno-hyoid muscles. Prominent projection (Figure 1H) observed on the inferior border of body of hyoid on either side at the junction of body and greater cornu of hyoid in 12 cases (24%).

The various metrical parameters of hyoid bone included in the study depicted with mean and standard deviations. Mean width of body and mean distance between tips of greater cornu of hyoid was as shown in the (Table 2).

Parameters	Mean (mm)	Standard deviation (Sd)
Body height A (anterior-inferior surface)	8.52	(± 1.74)
body height B (anterior superior surface)	6.7	(± 1.21)
width of body	30.16327	(± 4.10)
Depth of groove on posterior surface of body	2.27	(± 1.07)
Length of greater cornu RT	33.88	(± 3.32)
Length of greater cornu LT	33.0	(± 3.67)
Distance between tips of greater cornu	42.04	(± 6.5)
Length of lesser cornu RT	6.41	± 6.27
Length of lesser cornu LT	6.53	± 6.54
Intercornual distance	23.91	4.08

Table 2: *Mean and standard deviation of various parameters.*

It is evident from the (Table 3) that in shapes of hyoid, the proportion of Horseshoe shaped bone was maximum in the study subjects 24 (50%) whereas V shaped accounted at four (8%). With the application of Unpaired t test, significant association ($p < 0.0001$) was observed between the two variables for each respective shape. What the most literature on anatomy describes about the shape of hyoid bone as 'U' shaped from where its name is derived (voides or ypsiloides) is only accounts for 30% of the hyoid that we have studied. Fourteen percent bones are asymmetrical out of them 10% bones could be assign to one of the above shape. Another 4% we could not classify them because of their distorted morphology related to body and two horns.

Shapes of hyoid bone	Study subjects	Mean width	Sd	95%Cl	Mean distance	Sd	95%Cl	Unpaired t value	P
Horse shoe	24	28.04	3.56	26.53 - 29.54	41.91	3.95	40.24 - 43.57	12.77	< 0.0001
Boat	5	32	5.70	24.92 - 39.07	53.8	4.38	48.36 - 59.23	6.78	< 0.0001
U	15	33	2.95	31.36 - 34.63	36.67	4.13	34.38 - 38.95	2.80	< 0.0001
V	4	28	2.1	24.65 - 31.34	50.75	1.5	48.36 - 53.13	17.63	< 0.0001

Table 3: *Varied morphological shapes in relation to width and distance between tips of greater cornu.*

An attempt was made to study the correlation between various variables used in the study. There was no statistical significant correlation among the distance between tip of greater cornu and width of body ($r = 0.78$, 95% Cl 0.20 - 0.35, $P = 0.59$) and inter cornual distance ($r = 0.08$, 95%Cl 0.20 - 0.36, $P = 0.56$). The variables of angle b showed the significant positive correlation with angle 1 ($r = 0.40$, 95%Cl 0.13 - 0.61, $P = 0.004$) and angle 2 ($r = 0.38$, 95%Cl 0.10 - 0.60, $p = 0.007$) Signifying that increase or decrease in one variable influences the other variable in same manner. It is evident from (Table 4). That mean angle a1 is greater than angle a 2 followed by still decrement in angle b for each varied shape of bone. On application Of ANOVA test, a significant association observed between the means for each shape of bone.

Shapes of hyoid bone	Study subjects	Mean angle a1	Sd	Mean angle a2	Sd	Mean angle b	Sd	P
Horse shoe	24	120.12	8.16	115.04	7.36	77.79	8.02	< 0.0001
Boat	5	127.4	10.78	122.4	7.5	91.4	8.64	< 0.0001
U	15	117.73	9.48	116.8	6.54	66.2	11.49	< 0.0001
V	4	126	9.09	120	4.08	95	13.51	< 0.0001

Table 4: *Association between means of angles in relation to varied shapes of hyoid bone.*

Discussion

The larynx, hyoid bone, and lower jaw bone move together and are interlocked via the muscles, while pulled into a vertical position from the cranium. This positional relationship was formed because humans stand upright on two legs, breathe through the diaphragm (particularly indrawn breath) stably and with efficiency, and masticate efficiently using the lower jaw, formed by membranous ossification [6]. The morphological features seen, is reflected by the attachment and the pull over the hyoid bone. This transverse ridge usually described as the ridge that divides the differently directed anterior surface into anterio-superior and anterio-inferior surface. Parson described it as a compact bar of bone, is not merely a plane feature, but can be related to the line of fusion between II and III arch bone [7]. Its continuity with lesser cornu, to our knowledge is secondary to complete fusion between greater cornu and lesser cornu as evident in our study. Therefore, there is no reason to believe that transverse ridge could be derived from II arch and rest of the body being derived from III visceral arch [7], in unossified hyoid the lesser cornu appear to arise from greater cornu as against from the body of hyoid in

ossified hyoid. Lesser cornu connected to the body by fibrous tissue and occasionally to the greater cornu by synovial joints. The joint may be obliterated by ossification in later decades [8]. Vertical median ridge as described in most textbook, found in 34% cases only, limited more commonly to anterio-superior aspect and rarely extend on anterio-inferior surface. From our study, it is clear that variation may exist pertaining to this ridge, which may be replaced by tubercle (38%), or 'V-shape ridge (12%) and no ridge (14%). Parson found the vertical median ridge in 72 of his 108 specimens, in nearly three quarters of specimen. In some it was a mere vestige, but in the greater number a knob projected some 3 mm. This ridge is described in some of our textbooks, but parson described it as the glosso-hyal process [7]. Above the transverse ridge in the middle line is the glosso-hyal or entoglossal process, well-marked in reptiles and in the horse among mammals [9]. The presence of transverse ridge and vertical ridge and its variation has led to wide range of morphological variations in anterio- superior surface of hyoid the anterio-inferior surface. This creates wide range of variation in the morphology of anterio-superior surface that in our view may lead to variations in muscular attachment on this surface. However, needs to prove by further study. Fossa on posterior surface of body of hyoid has been described as concavity in the literature but to our knowledge, it is not merely the concavity but a large fossa that is lodged with fibro fatty tissue. In the fetus this gap appears to occupy with thyroid cartilage superior border, where decent of larynx has not yet occurred with respect to hyoid. To margins of fossa on posterior surface of hyoid attachment of geniohyoid is described [8] but we did not find the attachment of geniohyoid and inferior longitudinal muscle of tongue [4,8]. Prominent projection on inferior border at the attachment of omo-hyoid and sterno-hyoid muscles, similar finding is observed in another case where author found to have the height of the body of the hyoid bone to be larger than normal and measured 15.9 mm. The inferior edge of the body of the bone was drawn out and presented with an unusual edge at the site of attachment of the omohyoid and sternohyoid muscles. However, the greater cornu and lesser cornu were found to be normal in size and orientation [9]. The average transverse width of adult male bones is 2.6 cm. and of adult female bones 2.2 cm. Through the hyoid bone the lower jaw exerts a pull on the larynx and move freely up and down as well as regulate exhalations. The morphological variations may cause difference in muscles attachment on hyoid leading to variation in its position in space with respect to the various structure it is attached to. Nicolas Fakhry has found correlation between muscle attachment that influence over the morphology of hyoid [10]. Mohammed Amayeri., *et al.* has studied lateral cephalometric measurements and successfully assessed the relationship between different skeletal patterns and the hyoid bone and allowed to correlate the hyoid bone position to other craniofacial parameters [11].

We measured various metrical parameters as in table 2 Parsons studied the 108 hyoid bone from cadavers from male adults (53), female adults (28), and children (27). His results showed an average height of 1.2 cm for males (range: 1.0 - 1.6 cm), and 1.0 cm for females (range: 0.9 - 1.2 cm) [6]. In 2012, a group of Japanese researchers analyzed 600 hyoid bones (310 males, 290 females) using three-dimensional computed tomography (CT) imaging. Their data closely matched that of the 1909 study showing a mean height of 9.4 mm in males (range: 6.3 - 16.0 mm), and 7.8 mm in females (range: 3.0 - 8.8 mm) [14]. Mukhopadhyay in his study on Determination of sex from hyoid found mean width of body of hyoid to be 10.96 mm. Length of cornu as 29.02mm and distance between lesser cornu as 26.12 mm [13]. However, the exact morphology of the hyoid bone in these cases was not reported.

In shapes of hyoid, the proportion of Horseshoe shaped bone was maximum in the study subjects 24 (50%) whereas V shaped accounted at four (8%). While horseshoe shaped is present almost in 50%. No other study shows the higher percentage of horseshoe shaped of hyoid as ours, cause of which not be judged. It must be noted that 'U' has straight limbs. Horseshoe bones described as base wider than the distance between the two tubercles. In' V' shaped where the great horns greatly flanked apart. Boat shaped has wider base with two greatly flanked greater cornu. According to N. Papadopoulos and et.al U-types and horse shoe type of the classical description together cover only 40% of the population. D, B and V type account for 60% of population [7], while in our study horseshoe type alone constitutes 54% while B and V shaped account for only 14% that is low in percentage even though we have not included D-(deviated) shaped in our study. Koebke and Saternus (1979), after an X-ray investigation of 504 human hyoid bones (337 male and 167 female), derived from autopsies and anatomical specimens, showed that there exist three main types of shape, covering 89% of the population: the parabolic coincides to N. Papadopoulos V and boat shaped (40.9%), the hyperbolic coincides to N. Papadopoulos U type (35%) horseshoe type (13.1%) asymmetric type (11%). The horse shoe type of hyoid bone is quite high in our case as compared to other previous studies. U shaped type is comparatively low may be because of the less number of female bones in our study, as U shaped type is more common in female (43.7%) as compared to male (30.6%) [3]. As male bones were predominant still V and B combined together (14%) was not common [15]. An asymmetric type, formed by a combination of the main types, represents the remaining 14%. Asymmetry of bone found more with respect to two horns then that of the body. Asymmetry in bone length is greater than asymmetry in bone width and this increases with increasing age [14] though

incidence not mentioned. In the present study also the percentage is slightly higher may be because all the cadavers studied were adult and above 11% [3] and 47.4% [2]. According to the author the occurrence of the main types is, to a certain degree, sex-related, which we could not compare in the present study as almost all the bone studied are belonging to male. According to Prashant Kumar., *et al.* it is observed that the most commons pattern of hyoid is of the Hyperbola type in either sex and the boat type being the least common. The second leading form is the Parabola type in males and the Horseshoe type in females. Of the 50 hyoid bones studied 33 were symmetrical and 17 were asymmetrical. It is further seen that most of the hyperbola types are symmetrical in nature. The Horse-shoe type of hyoid is the most commonly seen symmetrical type in females [16]. In one of the study, the cut-off point of M was about 115° with a sensitivity of 40% and a specificity of 39.5% ($P < 0.05$) for determining sex. As for N, the cut-off point was 114° with a sensitivity of 46.5% and a specificity of 44.7% ($P < 0.05$), where M, is angle between right greater horn and body and N, is angle between left horn and body [17].

Conclusion

Hyoid bone found to have wide range of morphological variations on to its anterior surface which is the prominent finding of the present study. Horseshoe shaped bone is maximum in this study followed by V shaped bone. We could not compare sexual differences because of few number of female hyoid. This study may prove to be helpful for morphologist, anthropologist otolaryngologist radiologist.

Acknowledgement

Author is thankful to all non-teaching staff that has helped a lot to carry out this work until completion and Mr. S. Sarangdhar for his help in artistic work.

Conflict of Interest

No any conflict of interest.

Bibliography

1. Miller K., *et al*. "Age and Sex-Related Variation in Hyoid Bone Morphology". *Journal of Forensic Sciences* 43.6 (1998): 1138-1143.
2. Koebke J and Saturnus KS. "The Morphologia of the Adult Human Tongue". *Chronology* 84 (1979): 7-18.
3. Papadopoulos N., *et al*. "The shape and size of the human hyoid bone and a proposal for an alternative classification". *Journal of Anatomy* 163 (1989): 249-260.
4. Harjeet Jit I. "Shape, Size and Sexual dimorphism of the hyoid bone in Northwest Indians". *Journal of the Anatomical Society of India* 45.1 (1996): 4-22.
5. Rangith C and Pillai S. "A Post mortem study of one hundred hyoid bone using weight as parameter". *Journal of Indian Academy of Forensic Medicine* 10 (1988): 31-33.
6. Hideto Saigusa. "Comparative Anatomy of the Larynx and Related Structures". *Japan Medical Association Journal* 54.4 (2011): 241-247.
7. Parsons FG. "The Topography and Morphology of the Human Hyoid Bone". *Journal of Anatomy and Physiology* 43.4 (1909): 279-290.
8. Susan Standring., *et al*. "Anatomy: In Neck". 36th edition: PubChurchill Living Stone.
9. Nishimura T. "Primates Comparative morphology of the hypo-laryngeal complex in anthropoids: two steps in the evolution of the descent of larynx". *Primates* 44 (2003): 41-49.
10. Nicolas Fakhry., *et al*. "Analysis of Hyoid Bone Using 3D Geometric Morphometrics: An Anatomical Study and Discussion of Potential Clinical Implications". *Dysphagia* 28.3 (2013): 435-445.
11. Mohammed Amayeri., *et al*. "The position of hyoid bone in different facial patterns: a lateral cephalometric study". *European Scientific Journal* 10.15 (2014).

12. Gnanadev Raja., *et al*. "An Unusual Finding of the Hyoid Bone". *Cureus* 10.9 (2018): e3365.

13. Mukhopadhyay., *et al*. "Determination of sex from an autopsy sample of adult hyoid bones". *Medicine, Science and the Law* 52.3 (2012): 152-155.

14. Skandalakis Johns E. "Surgical anatomy in Larynx". Paschalidis medical publication (edition) pp. 237-238.

15. Ito K., *et al*. "Morphological study of the human hyoid bone with three-dimensional CT images - gender difference and age-related changes". *Okajimas Folia Anatomica Japonica* 89 (2012): 83-92.

16. Prashant Kumar., *et al*. "Morphology of Hyoid Bone with its Forensic Implication". *Journal of Contemporary Medicine and Dentistry* 2.2 (2014).

17. Okasi A., *et al*. "Sex Identification by Morphometric Study of Hyoid Bone". *International Journal of Medical Toxicology and Forensic Medicine* 8.4 (2018): 145-150.

Volume 2 Issue 3 May 2019