ORIGINAL ARTICLE

The Gender Based Hyoid Silhouette-A Metric Study in North Indians.

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ABSTRACT

Background: The human hyoid bone is a part of viscerocranium and is susceptible to fracture during manual strangulation. A hyoid bone's shape may influence its susceptibility to fracture. The present study aims to create a metric gender based profile for the hyoid in North Indians. It is envisaged that the silhouette created will provide inputs vital in comprehending bone morphology patterns for males and females. **Methods:** Paucity of comprehensive gender based hyoid morphometric studies in local population prompted the authors to format the present study. The measurements were taken on 500 hyoid bones of North Indian subjects with a special emphasis on sexual dimorphism (Male Female ratio 1:1). **Results:** Most hyoid dimensions are significantly larger in men with some measurements more sexually dimorphic than others, there exists 100% dimorphism for hyoid lengths and selective dimorphism as far as hyoid widths are concerned in North Indian population. When the greater cornua dimensions as measured for right and left side in same sex were compared they came out to be statistically insignificant ($p>0.05$). This reported insignificance for the same sex is an indirect pointer towards the dimorphic predisposition of hyoid bone. **Conclusion:** The study establishes the dimorphic silhouette for hyoid bone in North Indians. It also quantify the percentage sexual dimorphism for various morphometric parameters.

Keywords: *Dimorphism, Hyoid, Morphology.*

INTRODUCTION

The hyoid bone is a key bone in the neck because it connects the floor of the oral cavity in front with the pharynx behind and the larynx below. It is supported by the muscles of the neck and in turn supports the root of the tongue. It is neither free-floating nor contiguous to any bone. The hyoid has no bony connection with the rest of the skeleton. It is attached to the mandible, to the styloid processes of the temporal bone and to the tongue by muscles and ligaments. Its anatomical position is below the mandible, in an anterior position, at the level of the fourth cervical vertebra.[1]

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The human hyoid bone is a part of viscera-cranium placed between tongue root and thyroid cartilage. It is a part of both digestive and respiratory tracts. The bone is 'U' shaped bone and is suspended from the tips of the stylohyoid ligaments.[2] The hyoid bone is of considerable interest owing to its susceptibility to fracture during manual strangulation. A hyoid bone's shape may influence its susceptibility to fracture and these are frequently confused with normal variation in clinical and forensic settings.

In spite of the importance, few systemic studies of hyoid bone morphology have been conducted.

During the process of developing a biological profile for unidentified skeletal material, the importance of this small horseshoe-shaped bone positioned in the anterior, upper neck is often forgotten.[3]Although the hyoid has gained notoriety within forensic anthropology for possibly indicating hanging or strangulation[4], its usefulness in aiding the anthropologist in their estimation of sex and, in particular, ancestry has been somewhat neglected. Several studies[5-8] focusing on size and shape

differences between sexes have used a variety of statistical methods, primarily discriminant function analysis, to attempt to produce standards that can then be used to estimate sex of a recovered hyoid.

MATERIALS AND METHODS

The measurements were taken on 500 hyoid bones of North Indian subjects with a special emphasis on sexual dimorphism (Male Female ratio 1:1). The study was conducted in the department of Anatomy at Government Medical Colleges of Punjab, India. The hyoid bones were obtained from the Anatomy and Forensic departments at Government Medical College, Amritsar and Patiala, Punjab, India and also from the Anatomy department at Dr Harvansh Singh Judge Institute of Dental Sciences and Hospital, Punjab University, Chandigarh, India.

In each case, the hyoid was carefully dissected from the larynx and surrounding connective tissues. Care was taken to retain enough connective tissue so that the bone's overall shape was preserved. The sex in each case was confirmed as known. All bones included were of adult males and females in the age group of 40-70 years.

After the bone was dissected out:-

1. The hyoid bone was kept in a jar containing water for 2 days
2. Defatting was done by keeping in acetone for 3-4 days.
3. The bones were dried and numbered

A total of 17 parameters for the hyoid bone were measured to establish the morphometric profile of the hyoid bone in both sexes of the North Indian population. The parameters measured have previously been identified as quantifiable in the hyoid bone.[5] The parameters measured in male and female hyoids were [Figure 1]:

1	Distance from midpoint of distal end of left greater cornu to middle of the joint between left greater cornua and left side of the body.
2	Distance between middle of junction between body and greater cornu on both sides.
3	Distance from midpoint of distal end of right greater cornu to middle of the joint between left greater cornua and left side of the body.
4	Distance between distal ends of the right and left greater cornua.
5	Perpendicular distance from midpoint of parameter 4 to midpoint of posterior aspect.
6	Distance between points defined by change in curvature of the anterior surface of the body (corresponds to the lateral borders of area for insertion of geniohyoid muscle).
7	Maximum length of left greater cornua.
8	Maximum diameter of distal end of left greater cornua perpendicular to internal surface.
9	Minimum diameter of distal end of left greater cornua perpendicular to internal surface.
10	Width of left greater cornua perpendicular to internal surface at midpoint of maximum length of greater cornua.
11	Maximum width of proximal end of left greater cornua perpendicular to internal surface.
12	Width of body at midpoint perpendicular to surface.
13	Maximum length of right greater cornua.
14	Maximum width of proximal end of right greater cornua perpendicular to internal surface.
15	Width of right greater cornua perpendicular to internal surface at midpoint of maximum length of greater cornua.
16	Minimum diameter of the distal end of right greater cornua measured perpendicular to internal surfaces.
17	Maximum diameter of distal end of right greater cornua perpendicular to internal surface.

The parameters measured are depicted in [Figure 1] and [Figure 2]. All measurements were taken with the help of vernier calipers with least count of 0.02. The collected data was subjected to extensive statistical analysis. Unpaired 't' test was utilized to compare the parameters as measured for males and females and the 't' distribution table was consulted.

The percentage sexual dimorphism was calculated for each parameter using the formula:

$$\text{Percentage Sexual Dimorphism} = \frac{\text{Mean value in males}}{\text{Mean value in females}} \times 100$$

The parameters were ranked according to percentage

sexual dimorphism to establish the chronological dimorphic order for hyoid bone in the North Indian population.

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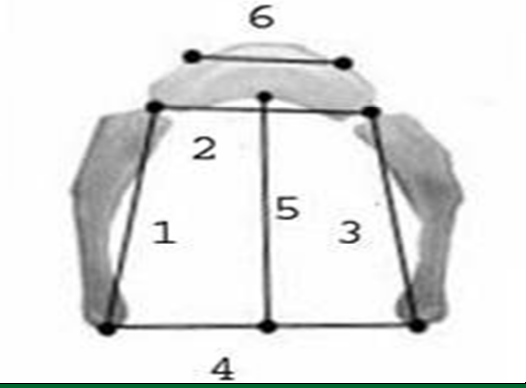

Figure 1: Hyoid bone dimensions 1-6.

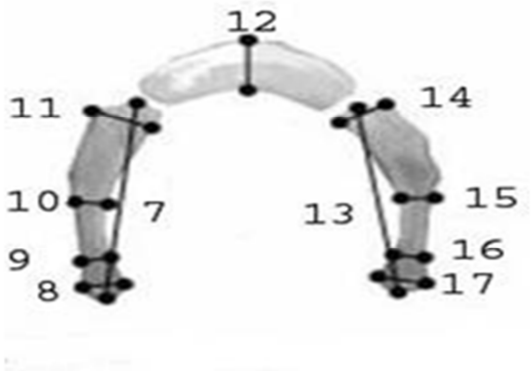

Figure 2: Hyoid bone dimensions 7-17.

RESULTS

When the hyoid lengths as measured for males and females were compared they came out to be statistically significant ($p<0.01$).So as far as lengths are concerned, there exists absolute (100%) dichotomy for gender in the North Indian hyoid bones [Table 1].

Table 1: Hyoid lengths and their statistical significance in sexes

Variable	Mean ± Standard deviation in Males	Mean ± Standard deviation in Females	Significance
1	33.6+4.5	30.2+3.4	p<0.01
2	25.4+3.2	23.2+4.4	p<0.01
3	33.4+0.8	30+2.4	p<0.01
5	32.2+3.8	28+4.1	p<0.01
6	22.8+2.3	20.4+3.4	p<0.01
7	33.1+4.5	29.8+4.4	p<0.01
13	33+4.8	29.6+4.6	p<0.01

Table 2: Hyoid widths and their statistical significance in sexes

Variable	Mean ± Standard deviation in Males	Mean ± Standard deviation in Females	Significance
4	49.6+2.2	45.4+3.6	p<0.01
8	4.3+1.0	4.3+1.4	p>0.05
9	3+0.5	3.02+0.4	p>0.05
10	4+0.8	3.8+0.6	p>0.05
11	6+1.4	5.7+0.7	p>0.05
12	9+1.6	8.5+1.7	p<0.01
14	5.8+1.5	5.7+0.9	p>0.05
15	3.8+0.7	3.7+0.7	P>0.05
16	2.9+0.6	2.92+0.7	p>0.05
17	4.4+0.8	4.42+0.8	p>0.05

When the hyoid widths as measured for males and females were compared they came out to be statistically insignificant ($p>0.05$). Only two widths, parameters 4 and 8 were statistically significant ($p<0.01$) for the sexes. This is in contrast to the results obtained for lengths where all male, female

comparisons were statistically significant. So,there exists 100% dimorphism for hyoid lengths and selective dimorphism as far as hyoid widths are concerned in North Indian population [Table 2].

Table 3: Statistical significance of Greater cornua parameters in males.

Parameters	Left Side	Right Side	Significance
1,3	33.6+4.5	33.4+0.8	p>0.05
7,13	33.1+4.5	33+4.8	p>0.05
11,14	6+1.4	5.8+1.5	p>0.05
10,15	4+0.8	3.8+0.7	p>0.05
9,16	3+0.5	2.9+0.6	p>0.05
8,17	4.3+1.0	4.4+0.8	p>0.05

When the Greater cornua dimensions as measured for right and left sides were compared in males they came out to be statistically insignificant (p>0.05). This reported insignificance for the same sex is an indirect pointer towards the dimorphic predisposition of the hyoid bone [Table 3].

Table 4: Statistical significance of Greater cornua parameters in Females.

Parameters	Left Side	Right Side	Significance
1,3	30.2+3.4	30+2.4	p>0.05
7,13	29.8+4.4	29.6+4.6	p>0.05
11,14	5.7+0.7	5.7+0.9	p>0.05
10,15	3.8+0.6	3.7+0.7	p>0.05
9,16	3.02+0.4	2.92+0.7	p>0.05
8,17	4.3+1.4	4.42+0.8	p>0.05

As for males when the Greater cornua dimensions as measured for the right and left sides were compared in females, they came out to be statistically insignificant (p>0.05) [Table 4].

Table 5: Percentage Sexual Dimorphism based ranking for hyoid parameters.

Parameter	Percentage Sexual Dimorphism	Rank
1	111.3	4
2	109.5	7
3	111.3	4
4	109.3	8
5	115	1
6	111.8	2
7	111.1	6
8	100	14
9	99.3	16
10	105.3	10
11	105.3	10
12	105.9	9
13	111.5	3
14	101.8	13
15	102.7	12
16	99.3	16
17	99.5	15

The maximum sexual dimorphism was recorded for parameter 5. Parameters 9 and 16 came out to be least dimorphic among North Indian hyoids [Table 5].

DISCUSSION

The importance of modern forensic anthropology cannot be overemphasized. The hyoid bone is important due to its susceptibility to fracture during manual strangulation. Being a bone it is composed of tissues more resistant than any others to the effects of degradation, and therefore assumes significance in forensic identification.[12] Though a lot of work is being done nowadays utilizing soft tissues for gender identification, forensic anthropology often implies the identification and study of the human skeletal material a sub branch referred to as forensic osteology. So, special attention in forensic anthropology has been given to the development and understanding of bone analysis and osteometric standards.

The dictionary definition of dimorphism is “difference of form between members of the same species.” Sexual dimorphism, in general, refers to differences between males and females of the species in terms of size, appearance, and behavior.[13] Sex estimation from skeletal remains is crucial in the identification of human remains, as it halves the number of possible matches.[14] Furthermore, other biological reconstruction variables, such as age at death, rely on the knowledge of the sex of the individual. Sex estimation based on the morphological characteristics of skeletal elements is population specific and thus the establishment of regional criteria is one of the imperatives for modern forensic anthropology.[15] The present morphometric study on hyoid provides baseline regional data, which is vital for anthropometric estimations and comparisons.

Overall, seven hyoid lengths were quantified for the male and female hyoids. When the mean values as determined for males and females were compared they came out to be statistically significant (p<0.01). In contrast, when the mean values for the ten hyoid widths as measured for males and females were compared only two out of ten were statistically significant. This indicates that there exists a dimorphic predisposition in the morphometric profile for hyoid in North Indians. However, this predisposition is absolute for lengths and widths are comparatively less dimorphic. A similar result was obtained for Egyptian population.[16] It is evident that some measurements are much more gender dimorphic than others.[17] This dimorphism is further cemented obtaining the statistical significance of the parameters measured for right and left side of greater cornua in either

sex.($p>0.05$). Similar results which demonstrate the existence of a statistically significant sexual dimorphism for hyoid bone morphometry have been reported by Harjit and Inderjit for North West Indians[18], Santhi Priya and Ranzeetha[19] in Andhra Pradesh and Lekson et al[7] in their work on Croatian hyoids.

The maximum sexual dimorphism was recorded for parameter 5. Parameters 9 and 16 came out to be least dimorphic among North Indian hyoids. This is in contrast to the study in Americans by Miller et al[5] wherein parameter 2 came out to be most dimorphic and parameter 17 least dimorphic. This indicates that percentage sexual dimorphism for hyoid parameters is race specific. The length of the greater cornu was found to be the only variable not significantly different in the sexes in Bengali Indian population [20] ($p=0.116$) but in the present study, the length of the greater cornu was significantly different on both right and left side in sexes. Our results are in consonance with a study done in Bhopal[21] wherein the length of the greater cornu was significantly different for sexes.

Hyoid morphometry varies with sex and this variation is not uniform in all populations. Research shows that both traditional morphometric and molecular methods of sex estimation or determination are useful.[22] These methods also have numerous applications and furthermore, they complement each other. Ideally, when it is viable, in an attempt to reconstruct as much of the biological profile as possible, all of the available methods for sex determination should be used.

The study establishes the dimorphic silhouette for hyoid bone in North Indians. It also provides a metric gender based profile for the hyoid in North Indians. It is envisaged that the silhouette created will provide inputs vital in comprehending bone morphology patterns for males and females.

CONCLUSION

The study establishes the dimorphic silhouette for hyoid bone in North Indians. It also quantify the percentage sexual dimorphism for various morphometric parameters.

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