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## A Study On Sex Determination From The Osteometric Measurements Of The Hyoid Bone.

AH Suganchander<sup>1</sup>, R Julius<sup>2\*</sup>, and Saravanan DS<sup>3</sup>.

<sup>1</sup>Assistant Professor, Department of Forensic Medicine, Government Tiruvannamalai Medical College, Tiruvannamalai, Tamil Nadu, India.

<sup>2</sup>Senior Assistant Professor, Institute of Forensic Medicine, Madras Medical College, Tamil Nadu, India.

<sup>3</sup>Senior Assistant Professor, Institute of Forensic Medicine, Madras Medical College, Tamil Nadu, India.

### ABSTRACT

Identification of individual has greater significance in criminal investigations. Finding out age and sex from human skeletal remains is a routine procedure in the forensic medicine departments in India and plays a key role in solving the medico-legal disputes. Determination of sex from analysis of human skeletal remains has been an age-old problem. To establish a method of sex discrimination that could provide an accurate means of distinguishing between males and females and does so requiring the fewest osteometric measurements. The present study was carried out in the institute of forensic medicine, Madras medical college and Rajiv Gandhi Government General Hospital, Chennai-03 in the year April 2017-March 2018. During this period, the hyoid bones were collected from all the cases in the age group of 18-60 years which are subjected to medico legal autopsies. Before starting the autopsy, the general particulars about the deceased such as age and sex were collected and recorded. General details about the case were collected from the documents produced by the police at the time of autopsy. In our study we found that the average maximum cornual lengths were 3.22 cm for males and 2.69 cm for females. vertical height of the hyoid bone at its midpoint perpendicular to the bone surface was 1.11cm for males versus 0.96 cm for females. the transverse width of the body of the hyoid bone was 2.13 cm for males and 1.82 cm for females. Hence, it is possible to determine the sex of the hyoid bone using various parameters obtained in our study, given a situation where a hyoid bone of an unknown person is found. When more than one parameter is used, it is possible to determine the sex of the individual to a reasonable degree of accuracy.

**Keywords:** Hyoid bone, Cornu, Sex determination, Anthropometry.

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*\*Corresponding author*

## INTRODUCTION

Determination of sex is the first and foremost step in the process of identifying human remains in forensic casework. Identifying the unknown remains is a challenging and crucial task in the field of forensic medicine. In Cases such as major accidents, completely burnt bodies, mutilated bodies, decapitated bodies and in buried bodies, sex and age of the victims should be determined for the purpose of identification [1]. For this purpose, bones are sent for examination to determine age and sex of the body. Identification becomes easy for the forensic experts, if whole skeleton is available for examination [2]. According to Krogman, When both pelvis and skull are available accurate results may be obtained in 98% of the cases. Pelvis alone gives 95% accurate results, skull alone gives 92% accurate results and long bones give 80-85% results. But most experts do not claim 100% accuracy even when entire skeleton is available [3]. Apart from bones such as pelvis, skull, mandible, sternum, manubrium and femur which usually helps in identification of the sex, other bones such as scapula, tibia, vertebra, ribs and hyoid can also tell about the sex of the body. Sex determination from skeletal remains is a well studied and extensively documented subject. The hyoid bone too has its own uses and application in these types of studies [4]. Hyoid bone is a solitary bone that has no bony articulations but provides attachment for muscles, ligaments, and fascia of the pharynx, mandible, and cranium [5]. Though hyoid bone exhibit sexual dimorphism and morphometric variables, it has drawn less attention in studies of this nature [6]. Sex determination becomes challenging to forensic experts when the bodies are badly mutilated or in advance state of decomposition or even at times skeletonised. Sometimes only neck structures may be available for examination and further investigation. In such cases hyoid bone which can easily be secured for examination, forms a vital key in determination of sex [7]. Hyoid bones can also be used in identification of victims in mass disasters, where identification of dead bodies is a difficult task [8]. International authors have published many articles about sex determination from skeletal remains but, there are only few documented Indian articles exist till today about these studies. The shape of hyoid bone may influence its susceptibility to fracture and hyoid bone fractures are frequently confused with normal variation in both clinical and forensic settings [9]. Although the relationship between hyoid bone shape and fracture pattern figures prominently in criminal investigations of strangulation cases, the morphological variations of sex and age in the hyoid bone are yet to gain popularity in the forensic field. There are many osteometric measurements which can be used in the determination of sex of the hyoid bone. Hence, the present study was conducted to distinguish between male and female hyoid bones using fewer and reliable osteometric measurements [10].

## METHODOLOGY

The present study was carried out in the institute of forensic medicine, Madras medical college and Rajiv Gandhi Government General Hospital, Chennai-03. in the year April 2017-March 2018. A prospective study, done to analyse the sexual dimorphism in the hyoid bones using various measurements, that were collected during the study period and to establish a method of sex determination from the above measurements. descriptive statistics of length of the hyoid, width of the hyoid, average maximum cornual length, height and width of the body of hyoid bone were analysed and recorded in terms of mean and standard deviation.

### Inclusion Criteria

All cases in the age group of 18-60 years, subjected for medico-legal autopsy.

### Exclusion Criteria

Cases where hyoid bones are fractured mainly of hanging and strangulation were excluded from the study. A Sample size of 200 cases, subjected to medicolegal autopsy were included in the study

### Dissection Technique

Dissection of hyoid bone was done by the following method suggested in the text book-Post Mortem Technique Handbook By Micheal T. Sheaff . A wooden block of 10-15 cm in height was kept under the shoulders, to allow the head to fall back and thus the neck was extended. A modified "Y" shaped incision was made in the midline, extending from the Suprasternal notch over the clavicle to its centre on both sides and then passes upwards over the neck behind the ear. The skin flap was raised upwards and

backwards, exposing the muscles of neck. All the muscles of the neck were carefully dissected in layers. Then, the trachea was identified in the midline and followed upward; Thyroid cartilage was identified from the upper end of the trachea. The hyoid bone was palpated immediately above the thyroid cartilage. The muscle attachments and the soft tissues were cut and separated from the hyoid bone. Care must be taken not to damage the greater cornua during dissection. Hyoid bones are then stored in 10% formalin solution for 72 hrs. This was followed by cleaning and wiping to make the bone dry and clean. The bones were kept on a flat surface in their respective anatomical position, while taking the measurements. Direct measurements were taken by a battery operated digital vernier caliper (Precision of one mm) and measurement scale. A total of three readings were taken and average of three reading were recorded.

**Statistical analysis**

Analysis of Variance (ANOVA) was used to prove that the differences between the age groups was statistically significant for each of the parameters. Independent “t” test would be used to compare the mean cornual length, the width of hyoid bone, the length of the hyoid bone, the height of the body of the hyoid bone and the transverse width of the body of the hyoid bone. Discriminant analysis was done to find the sexual dimorphism in each of five parameters. The ultimate purpose was to find out which of the five parameters show greatest sexual dimorphism.

**OBSERVATION AND RESULTS**

The data has been recorded systematically and various observations were made and tabulated.

**Figure 1: Distribution of sex among the study groups**

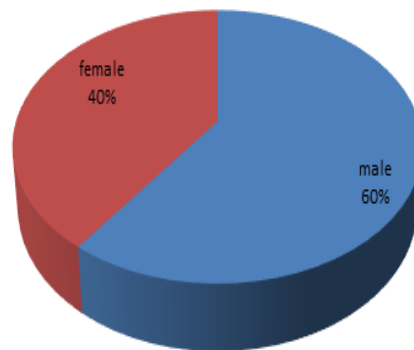


Figure 1 shows the distribution of sex among the study cases In our study sample of 200 cases, the total numbers of male( blue) cases were 120, which forms 60 percent of the sample and the total number of female(red) cases were 80, which forms forty percent of the study sample. There are more number of male cases recorded, as they are more prone to road traffic accidents and work place injuries.

**Figure 2: Summary for Mean cornual length in male cases**

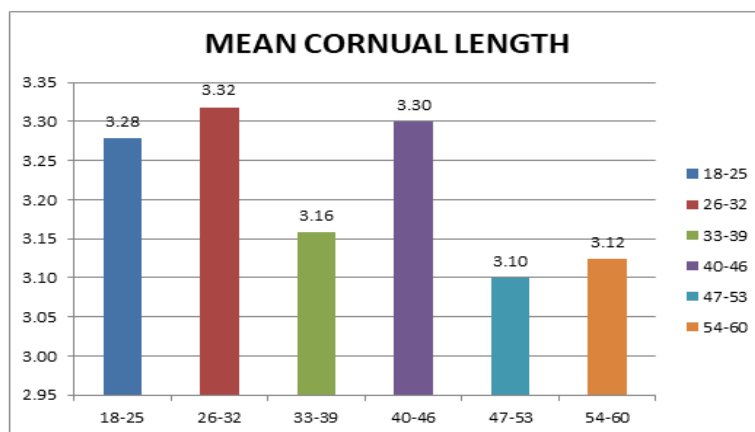


Figure 2 represents the summary of mean cornual length along with standard deviation of the hyoid bone for various age groups in the male cases. Mean cornual length with standard deviation for all the age groups in male cases were calculated and entered. Finally, the mean cornual length of entire male cases were calculated from all the age groups. The mean cornual length of the age group 18-25 years was found to be 3.28+/-0.23 cm, the mean cornual length of the age group 26-32 years was 3.32+/-0.28 cm, the mean cornual length of the age group 33 to 39 years was 3.16+/-0.21 cm, the mean cornual length of the age group 40-46 years was 3.30+/-0.29 cm, the mean cornual length of the age group 47-53 years was 3.10+/-0.19 cm, the mean cornual length of the age group 54-60 years was 3.12+/-0.21 cm. The mean cornual length of the entire male cases was 3.22+/-0.25 cm.

**Figure 3: Summary for Average maximal Cornual length in female cases**

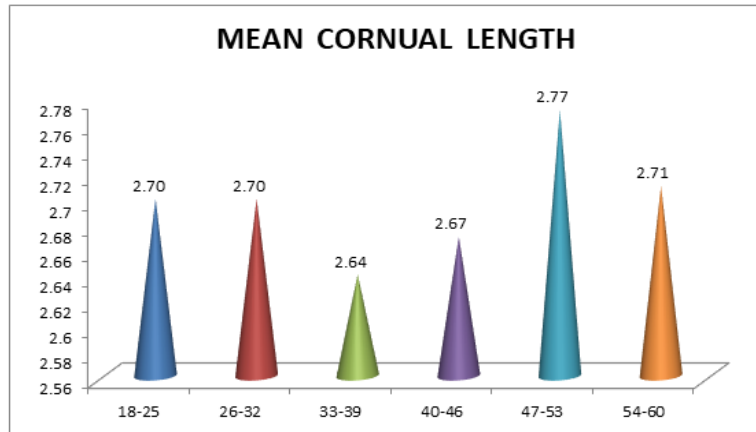


Figure 3 represents the summary of mean cornual length along with standard deviation of the hyoid bone for various age groups in the female cases. Mean cornual length with standard deviation for all the age groups in female cases were calculated and entered. Finally, the mean cornual length of entire female cases was calculated from all the age groups. The mean cornual length of the age group 18-25 years was found to be 2.70+/-0.30 cm, the mean cornual length of the age group 26-32 years was 2.70+/-0.30 cm, the mean cornual length of the age group 33 to 39 years was 2.64+/-0.15 cm, the mean cornual length of the age group 40-46 years was 2.67 +/-0.23cm, the mean cornual length of the age group 47-53 years was 2.77 +/-0.27cm, the mean cornual length of the age group 54-60 years was 2.71+/-0.32 cm The mean cornual length of the entire female cases was 2.69+/-0.27 cm.

**Figure 4: Summary for Mean width of the hyoid bone in male cases**

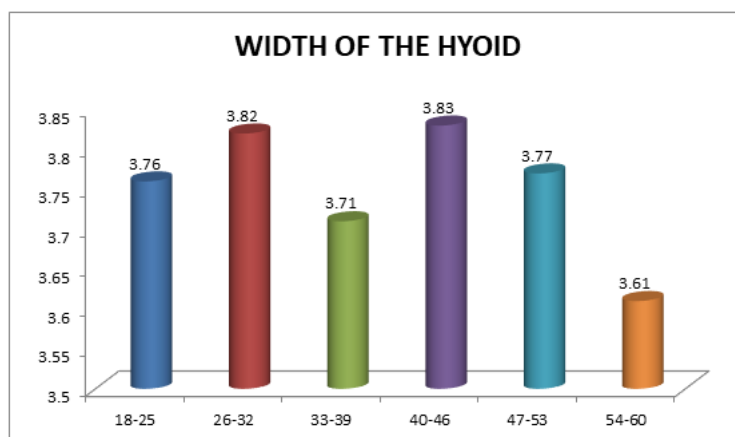


Figure 4 represents the summary of mean width of the hyoid bone along with standard deviation for various age groups in the male cases. The mean width of the hyoid bone along with standard deviation for all the age groups in male cases were calculated and entered. Finally, the mean width of the hyoid bone of entire male cases were calculated from all the age groups. The mean width of the hyoid bone of the age group 18-25 years was found to be 3.76+/-0.27 cm, the mean width of the hyoid bone of the age group 26-

32 years was 3.82+/-0.25 cm, the mean width of the hyoid bone of the age group 33 to 39 years was 3.71+/-0.25 cm, the mean width of the hyoid bone of the age group 40-46 years was 3.83+/-0.50 cm, the mean width of the hyoid bone of the age group 47-53 years was 3.77+/-0.40 cm, the mean width of the hyoid bone of the age group 54-60 years was 3.61+/-0.32 cm. The mean width of the hyoid bone of the entire male cases was 3.75+/-0.32 cm.

**Figure 5: Summary for Mean width of the hyoid bone in female cases**

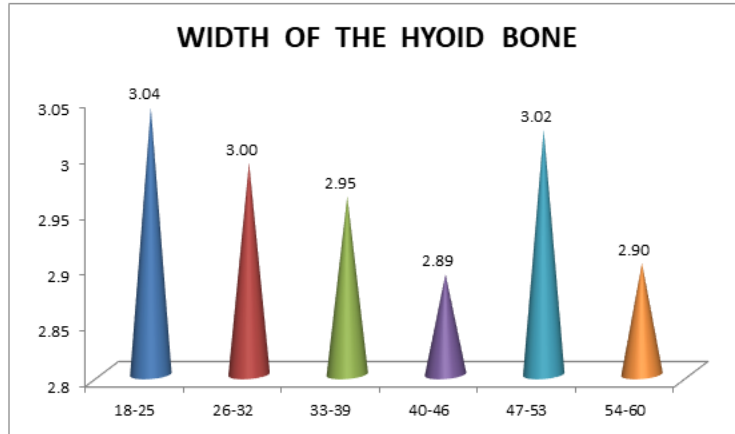


Figure 5 represents the summary of mean width of the hyoid bone along with standard deviation for various age groups in the female cases. The mean width of the hyoid bone along with standard deviation for all the age groups in female cases were calculated and entered. Finally, the mean width of the hyoid bone of entire female cases were calculated from all the age groups. The mean width of the hyoid bone of the age group 18-25 years was found to be 3.04+/-0.28 cm, the mean width of the hyoid bone of the age group 26-32 years was 3.00+/-0.20 cm, the mean width of the hyoid bone of the age group 33 to 39 years was 2.95+/-0.21+/-0.21 cm, the mean width of the hyoid bone of the age group 40-46 years was 2.89+/-0.31 cm, the mean width of the hyoid bone of the age group 47-53 years was 3.02+/-0.23 cm, the mean width of the hyoid bone of the age group 54-60 years was 2.90+/-0.44 cm. The mean width of the hyoid bone of the entire female cases was 2.97+/-0.29 cm.

**figure 6: Summary for Mean length of the hyoid bone in male cases**

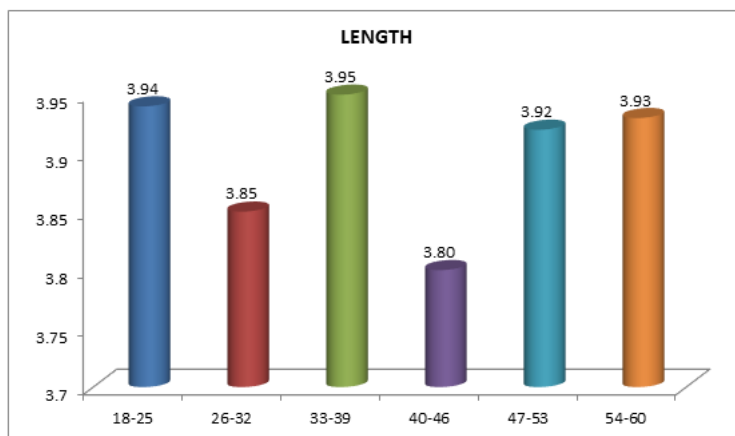


Figure :6The above represents the summary of mean length of the hyoid bone along with standard deviation for various age groups in the male cases. The mean length the hyoid bone along with standard deviation for all the age groups in male cases were calculated and entered. Finally, the mean length of the hyoid bone of entire male cases were calculated from all the age groups. The mean length of the hyoid bone of the age group 18-25 years was found to be 3.94+/-0.21 cm, the mean length of the hyoid bone of the age group 26-32 years was 3.85+/-0.20 cm, the mean length of the hyoid bone of the age group 33 to 39 years was 3.95+/-0.26 cm, the mean length of the hyoid bone of the age group 40-46 years was 3.80+/-0.22 cm, the mean length of the hyoid bone of the age group 47-53 years was 3.92+/-0.27 cm,

the mean length of the hyoid bone of the age group 54-60 years was 3.93+/-0.27 cm. The mean length of the hyoid bone of the entire male cases was 3.90+/-0.23 cm.

**Figure 7: Summary for Mean length of the hyoid bone in female cases**

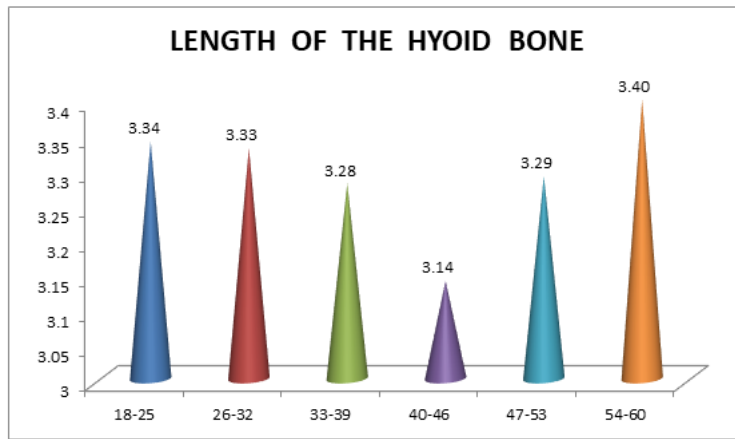
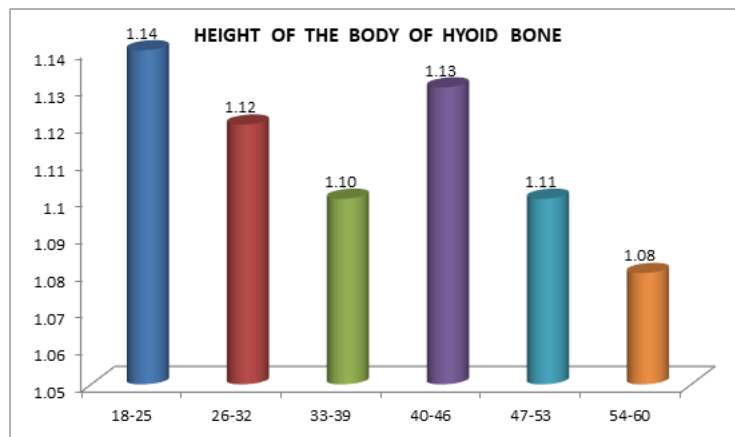


Figure 7 represents the summary of mean length of the hyoid bone along with standard deviation for various age groups in the female cases. The mean length the hyoid bone along with standard deviation for all the age groups in female cases were calculated and entered. Finally, the mean length of the hyoid bone of entire female cases were calculated from all the age groups. The mean length of the hyoid bone of the age group 18-25 years was found to be 3.34+/-0.25 cm, the mean length of the hyoid bone of the age group 26-32 years was 3.33+/-0.16 cm, the mean length of the hyoid bone of the age group 33 to 39 years was 3.28+/-0.24 cm, the mean length of the hyoid bone of the age group 40-46 years was 3.14+/-0.23 cm, the mean length of the hyoid bone of the age group 47-53 years was 3.29+/-0.24 cm, the mean length of the hyoid bone of the age group 54-60 years was 3.40+/-0.32 cm. The mean length of the hyoid bone of the entire male cases was 3.30+/-0.25 cm.

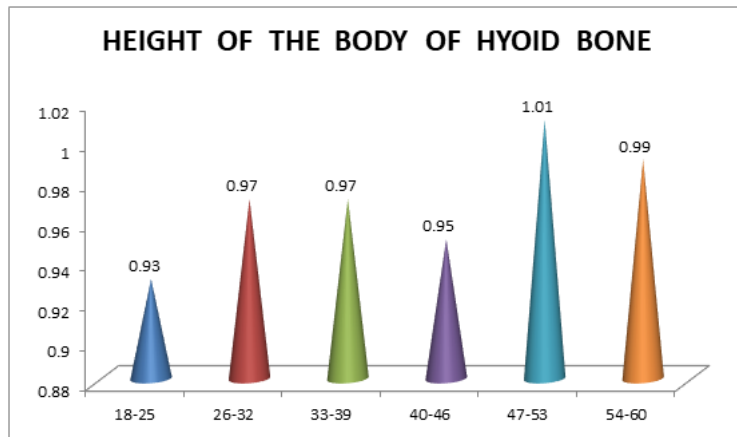
**Figure 8: Summary for Mean vertical height of the hyoid bone in male cases**



The above figure 8 represents the summary of mean height of the body of the hyoid bone along with standard deviation for various age groups in the male cases. The mean height of the body of the hyoid bone along with standard deviation for all the age groups in male cases were calculated and entered. Finally, the mean height of the body of the hyoid bone of entire male cases were calculated from all the age groups. The mean height of the body of the age group 18-25 years was found to be 1.14+/-0.09 cm, the mean height of the body of the age group 26-32 years was 1.12+/-0.11 cm, the mean height of the body of the age group 33 to 39 years was 1.10+/-0.11 cm, the mean height of the body of the age group 40-46 years was 1.13+/-0.10 cm, the mean height of the body of the age group 47-53 years was 1.10+/-0.10 cm, the mean height of the body of the age group 54-60 years was 1.08+/-0.10 cm. The mean height of the body of the entire male cases was 1.11+/-0.10 cm.

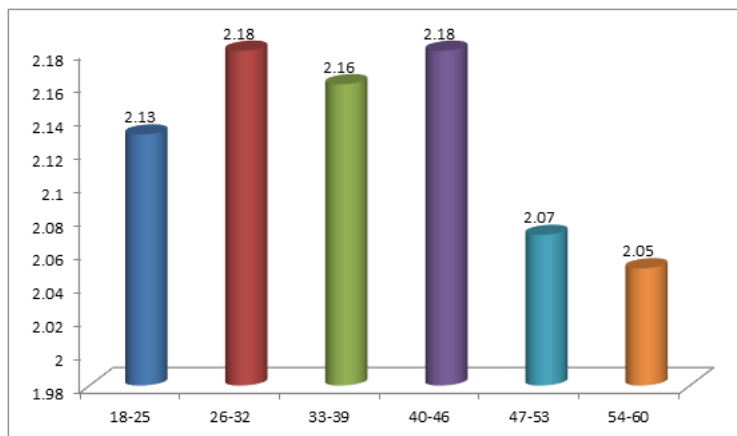


**Figure 9: Summary for Mean vertical height of the body of hyoid bone in female cases**



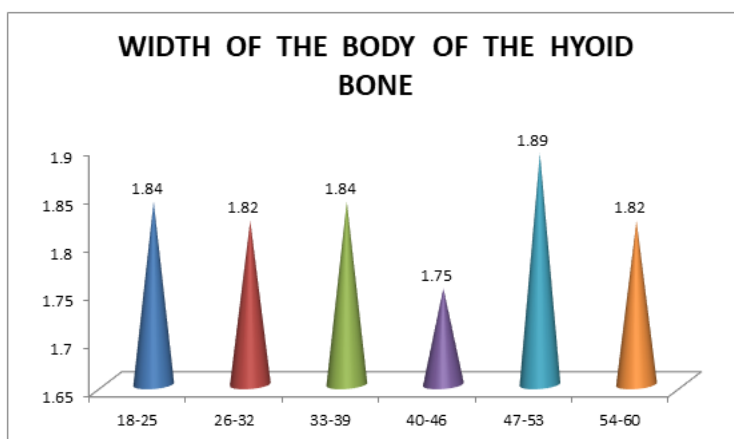
The above figure 9 represents the summary of mean height of the body of the hyoid bone along with standard deviation for various age groups in the female cases. The mean height of the body of the hyoid bone along with standard deviation for all the age groups in female cases were calculated and entered. Finally, the mean height of the body of the hyoid bone of entire female cases were calculated from all the age groups. The mean height of the body of the age group 18-25 years was found to be 0.93+/-0.19 cm, the mean height of the body of the age group 26-32 years was 0.97+/-0.08 cm, the mean height of the body of the age group 33 to 39 years was 0.97+/-0.08 cm, the mean height of the body of the age group 40-46 years was 0.95+/-0.06 cm, the mean height of the body of the age group 47-53 years was 1.01+/-0.09 cm, the mean height of the body of the age group 54-60 years was 0.99+/-0.06 cm. The mean height of the body of hyoid bone of the entire female cases was 0.96+/-0.13 cm.

**Figure 10: Summary for Mean transverse width of the body of the hyoid bone in male cases**



The above figure 10 represents the summary of mean width of the body of the hyoid bone along with standard deviation for various age groups in the male cases. The mean width of the body of the hyoid bone along with standard deviation for all the age groups in male cases were calculated and entered. Finally, the mean width of the body of the hyoid bone of entire male cases were calculated from all the age groups. The mean width of the body of the age group 18-25 years was found to be 2.13+/-0.30 cm, the mean width of the body of the age group 26-32 years was 2.18+/-0.34 cm, the mean width of the body of the age group 33 to 39 years was 2.16+/-0.20 cm, the mean width of the body of the age group 40-46 years was 2.18+/-0.23 cm, the mean width of the body of the age group 47-53 years was 2.07+/-0.12 cm, the mean width of the body of the age group 54-60 years was 2.05+/-0.32 cm. The mean width of the body of hyoid bone of the entire male cases was 2.13+/-0.28 cm.

**Figure 11: Summary for Mean transverse width of the body of the hyoid bone in female cases**



The above figure 11 represents the summary of mean width of the body of the hyoid bone along with standard deviation for various age groups in the female cases. The mean width of the body of the hyoid bone along with standard deviation for all the age groups in female cases were calculated and entered. The mean width of the body of the age group 18-25 years was found to be 1.84+/-0.17 cm, the mean width of the body of the age group 26-32 years was 1.82+/-0.15 cm, the mean width of the body of the age group 33 to 39 years was 1.84+/-0.13 cm, the mean width of the body of the age group 40-46 years was 1.75+/-0.16 cm, the mean width of the body of the age group 47-53 years was 1.89+/-0.07 cm, the mean width of the body of the age group 54-60 years was 1.82+/-0.17 cm. The mean width of the body of hyoid bone of the entire female cases was 1.82+/-0.15 cm.

### DISCUSSION

In this study we analysed the sexual dimorphism in the hyoid bone using five parameters namely- the mean cornual length, the width of the hyoid bone, the length of the hyoid bone, the height of the body of the hyoid bone and the transverse width of the body of the hyoid bone [11]. The mean cornual length of the hyoid bone for the males was found to be 3.22+/-0.25 cm. The mean cornual length of the hyoid bone for female bone was found to be 2.69+/-0.27 cm. For the male bones, the average cornual length was found to range from 2.76 cm to 4.11 cm, additionally 98% of the male bones were found to be greater than 2.79 cm in length [12]. For female bones, the average cornual length was found to range from 2.23 cm to 3.34 cm, additionally in 98% of female bones it was found to be less than 3.19 cm in length. It could thus be inferred that bones with length greater than 3.34 cm could only be male, while bones with length lesser than 2.76cm could only be female. The mean width of the hyoid bone for males was found to be 3.75+/-0.32 cm [13]. The mean width of the hyoid bone for females was found to be 2.97+/-0.29 cm. For male bones the average width was found to range from 2.18 cm to 4.42 cm, additionally in 98% of the male bone's width was found to be greater than 3.15 cm in width. For female bones, the average width was found to range from 2.10 cm to 3.47 cm, additionally in 98% of female bones width was found to be less than 3.34 cm. Thus, it could be inferred that bones with width greater than 3.47 cm could only be male, while bones with width lesser than 2.18cm could only be females. The mean length of the hyoid bone for males was found to be 3.90+/-0.23 cm. The mean length of the hyoid bone for females was found to be 3.30+/-0.25 cm [14]. For male bones the average length was found to range from 3.40 cm to 4.55 cm, additionally in 98% of the male bones length was found to be greater than 3.50 cm in length. For female bones, the average length was found to range from 2.85 cm to 3.77 cm; additionally in 98% of female bones length was found to be less than 3.72 cm [15]. Thus, it could be inferred that bones with length greater than 3.77 cm could only be male, while bones with length lesser than 3.40 cm could only be females [16]. The mean height of the body of the hyoid bone for males was found to be 1.11+/-0.10 cm. The mean height of the body of the hyoid bone for females was found to be 0.96+/-0.13 cm [17]. For male hyoid bones, the average height was found to range from 0.89 cm to 1.38 cm, additionally in 98% of the male bones it was found to be greater than 0.96 in height. For female bones, the average height was found to range from 0.81 cm to 1.12 cm, additionally in 98% of the female bones it was found to be less than 1.08 cm in height. It could thus be inferred that bones with height greater than 1.12 cm could only be male, while bones with height less than 0.89cm could only be females [18]. The mean transverse width of the body of the hyoid bone for males was 2.13+/-0.28 cm. The mean transverse width of the body of the hyoid



bone for females was 1.82+/-0.15 cm. For male bones, the width of the body of the hyoid bone was found to range from 1.20 cm to 3.03 cm; additionally in 98% of male bones, the width was found to be greater than 1.81 cm. For female bones, the width of the body of the hyoid bone was found to range from 1.55 cm to 2.21 cm, additionally in 98% of female bones width was found to be less than 2.10 cm [19]. It could thus be inferred that bones with width greater than 2.21 cm could only be male, but bones with width less than 1.55 cm could also be male, since the lowest measurement value for the width of the body of the male hyoid bone (1.20 cm) is lesser than the female bone (1.55 cm) Thus we were able to demonstrate a significant sexual dimorphism in the hyoid bone with regard to all the five parameters. From the above analysis models, it was determined that sexual dimorphism is most marked in the width of the hyoid bone, followed by the length of the hyoid bone, followed by the average maximal cornual length, next the vertical height of the body of the hyoid bone and finally in the transverse width of the body of the hyoid bone [20].

### CONCLUSION

There is a definite sexual dimorphism in the hyoid bone and it was demonstrated in this study using the five parameters. There is a clear-cut demarcation between the values of male and female bone. The sexual dimorphism is most marked in the width of the hyoid bone, followed by the length of the hyoid bone, next in the average mean cornual length, followed by height of the body of the hyoid bone and finally in the transverse width of the body of hyoid bone. The dimorphism is constant across the age spectrum for all the parameters, except the Average maximal cornual length in male cases where there is significant difference seen among various age groups. Hence, it is possible to determine the sex of the hyoid bone using various parameters obtained in our study, given a situation where a hyoid bone of an unknown person is found. When more than one parameter is used, it is possible to determine the sex of the individual to a reasonable degree of accuracy. In such cases, the width of the hyoid bone should be used as one of the parameters along with other measurements as the sexual dimorphism is more marked in this parameter.

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