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Original Article

Radiology Section

Gender-based Variations in Hyoid Bone Dimensions Measured using Computed Tomography: A Cross-sectional Study

A JENAL MONTEIRO[1], MM JASEEMUDHEEN[2]

ABSTRACT

Introduction: Identifying the age and sex of an unknown skull is challenging and crucial. Although forensic anthropology frequently receives fragmentary remains, certain parts are often obtained in great condition. In such conditions, the hyoid bone, which differs in shape and size between both genders, can be utilised to determine gender.

Aim: To assess gender-based variations in hyoid bone dimensions using Computed Tomography (CT).

Materials and Methods: A cross-sectional analytical time-bound study was conducted from April 2021 to March 2023 in the Department of Radiodiagnosis at KS Hegde Hospital, Mangaluru, Karnataka, India, consisting of 68 patients, including 34 males and 34 females referred for CT neck within the age range of 20-55 years. From the acquired data, different dimensions such as Hyoid Width (HW), Hyoid Length (HL), and Body Length (BL) of the hyoid bone were measured on 3D images to evaluate gender-related variations. The data were analysed using Statistical Package for Social Sciences (SPSS) version 20. The Independent sample t-test was used to compare HL, HW, and BL according to gender.

Results: The mean HL in males was found to be 36.3±3.3 mm, whereas in females, it measured 30.6±1.9 mm. The mean HW in males was determined to be 41.75±5.1 mm, while in females, it was 35.2±4.5 mm. Furthermore, the mean BL in males was 19.3±2.0 mm, whereas in females, it measured 16.4±1.7 mm.

Conclusion: CT measurements of the hyoid bone using 3D images can be a vital tool for gender determination in forensic medicine.

Keywords: Forensic medicine, Hyoid length, Volume rendering techniques

INTRODUCTION

Forensic medicine is a field of science that deals with medicolegal issues, as well as the identification of human bodies and their remains. Due to rising crime rates, unknown dead bodies or skeletons with unclear causes of death are often encountered; some may be recognisable, while others may have deformities or fractures. These medicolegal situations are significant concerns and are addressed by forensic medicine. Forensic anthropology focuses on the legal identification of human remains. By examining bones and their anatomical measurements, researchers can determine their origin, lineage, sex, stature, and age at death, assisting in determining an individual's identity [1].

Identifying a whole body or skeleton is a common problem in forensic legal medicine, and the solution requires techniques and experience in various areas [2]. Establishing the identity of unknown human remains is a crucial aspect of forensic examinations [3]. Sex can be determined by observing the shape of the skeleton [4]. While the pelvis and skull are the most reliable skeletal regions for determining sex, these bones can be damaged, fragmented, or incomplete, particularly in mass disasters [3]. Determination of sex can be achieved using non metric or metric methods. Non metric methods are based on morphological features that cannot be analysed statistically, whereas metric methods use measurements and statistical analyses [5].

The hyoid bone holds greater significance in forensic medicine as its fractures are considered evidence of strangulation or hanging. In archaeological and forensic investigations, the corpus of the hyoid bone is regarded as a valuable tool for gender determination [2].

The hyoid bone is a horseshoe-shaped, free-floating bone in the human body that does not directly articulate with other bones [6]. It is positioned between the base of the tongue and the thyroid cartilage, attached to various neck muscles and ligaments, and is part of both the digestive and respiratory systems [7,8]. The hyoid bone is instrumental in the functions of swallowing, tongue movements, and maintaining the airway. In early life, the hyoid bone is positioned anteriorly to the second and third cervical vertebrae, but with aging, it gradually descends to the fourth and fifth cervical vertebrae levels [9]. Different dimensions of the hyoid bone, such as HW, BL, and HL dimensions, can be measured to differentiate between males and females as they show significant variations in certain populations [3].

The hyoid bone has been used to estimate sex in various investigations involving cadavers, photographs, and radiographs. Radiological examination is one of these approaches critical for determining age and sex. It is a straightforward, non invasive procedure that can be applied to both living and deceased individuals [10]. Multidetector CT has shown encouraging results and is now used as a routine forensic procedure before autopsies in many locations. Therefore, when other techniques are inconclusive, CT measurements of hyoid bone dimensions can be used to ascertain age and gender [11].

The present study assessed the differences in hyoid bone dimensions between genders and examines how age correlates with those measurements.

MATERIALS AND METHODS

The present cross-sectional analytical time-bound study was conducted on 68 patients (34 males and 34 females) from April 2021 to March 2023 in the Department of Radiodiagnosis at KS Hegde Hospital in Mangaluru, Karnataka, India, after being approved by the Institutional Ethical Committee (INST.EC/EC/097/2021-22). All the patients who were referred for a CT neck scan were examined under a 128-slice CT scanner (GE EVO Revolution).

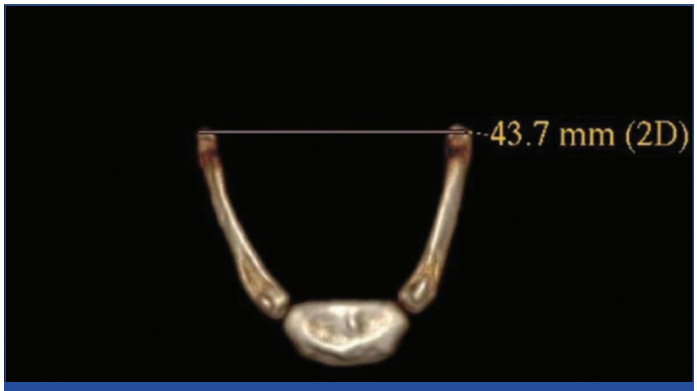
Inclusion and Exclusion criteria: All patients suggested for CT neck within the age group of 20-55 years were included in the study. Uncooperative patients and those who have trauma related to the hyoid bone were excluded from the study.

Study Procedure

Imaging technique: The CT neck scan was performed using a 128-slice multidetector CT scanner (GE EVO Revolution). Patients were placed supine with the head in a head holder, and centering was done on the chin. The parameters used in the study were 120 kVp and 200 mAs, with a slice thickness of 5 mm and reconstruction of 1.25 mm.

After obtaining the CT neck images, all data were directly collected from Digital Imaging and Communications in Medicine (DICOM) software. Patients were further categorised based on gender. Measurements of the different dimensions were done using an inbuilt electronic calliper in the DICOM viewer software. Measurements including HW, HL, and BL were obtained from the 3D image, which was reformatted using the Volume Rendering Technique (VRT). For the HW, BL, and HL measurements, the 3D VRT image of the hyoid bone was rotated superior to inferior from the AP position, and measurements were done simultaneously on 3D images.

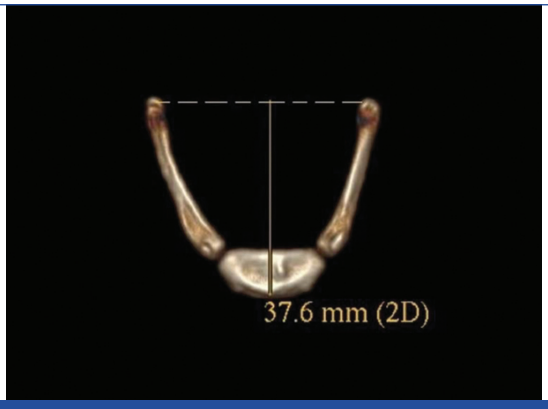
The HW was measured from the right greater cornu to the left greater cornu [Table/Fig-1].



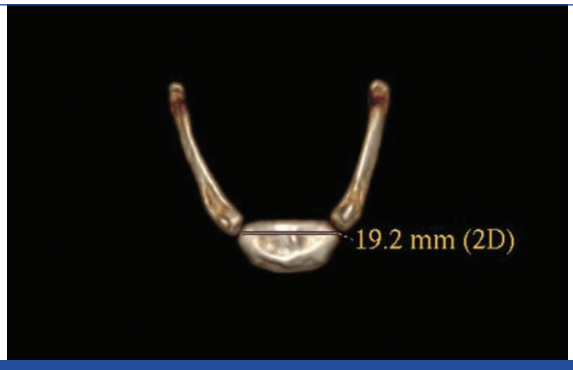
[Table/Fig-1]: Measurement of Hyoid Width (HW).

The HL was measured by drawing a line perpendicular to the midpoint between the HW and the body of the hyoid bone [Table/Fig-2].

The BL was measured by drawing a line from the right lesser horn to the left lesser horn [Table/Fig-3].



[Table/Fig-2]: Measurement of Hyoid Length (HL).



[Table/Fig-3]: Measurement of Body Length (BL).

STATISTICAL ANALYSIS

The statistical analysis was conducted using SPSS software version 2.0. The independent sample's t-test was used to compare HL, HW, and BL according to gender. The data were expressed as mean±Standard Deviation (SD). A p-value <0.05 was considered statistically significant. The Pearson's correlation coefficient was used to assess the correlation between age and HL, HW, and BL diameters.

RESULTS

The mean HL, HW, and BL for the total population were 33.44±3.91, 38.56±5.78, and 17.82±2.35, respectively. There was a difference (p<0.05) in mean HL, HW, and BL according to gender [Table/Fig-4].

Parameters	Gender	Mean±SD (mm)	"t"	p-value
Hyoid Length (HL)	Male	36.3±3.3	8.651	<0.001*
	Female	30.6±1.9		
Hyoid Width (HW)	Male	41.7±5.1	5.556	<0.001*
	Female	35.2±4.5		
Body Length (BL)	Male	19.3±2.0	6.539	<0.001*
	Female	16.4±1.7		

[Table/Fig-4]: Comparison of Hyoid Length (HL), Hyoid Width (HW), and Body Length (BL) according to gender (*significant).

The Pearson's correlation coefficient was used to find the relation between age and HL, HW, and BL in the overall sample. There was no statistically significant correlation (p>0.005) between age and hyoid dimensions [Table/Fig-5].

Parameters N=68	Pearson's correlation	p-value
Age and Hyoid Length (HL)	0.019	0.875
Age and Hyoid Width (HW)	-0.147	0.232
Age and Body Length (BL)	-0.125	0.310

[Table/Fig-5]: Relation between age and HL, HW, as well as BL in the total population.

DISCUSSION

In forensic casework, determining sex is the first and most important stage in identifying human remains [12]. Comparing antemortem and postmortem records and studying bones is critical for determining identity. For sex estimation, measures of the pelvis, skull, and long bones are commonly employed. However, tragedies may cause these bones to be destroyed, such as being burned and shattered. If the skull, pelvic bones, or long bones are missing, another approach based on additional bones (hyoid bone) should be developed [10].

The mean HW diameter in the present study in males was 41.7±5.1 mm, whereas, in the study performed by Leksan I et al., 70 individuals, including 35 males and 35 females with 15-90 years of age from the osteological collection in Osijek of Croatia, it was 45.8±6.7 in males [8]. Females in the present study had a mean value of 35.2±4.5, while the Croatian population had a mean value of 40.5±6.4. The Croatian population had significantly higher HW values for both genders. The difference might be due to racial and ethnic factors.

Kumar TN and Rudra A conducted a similar study where 116 cases of the Indian population had an equal distribution of both genders [12]. The mean HW in males was 44.5±3.99, while in females it was 37.89±2.70. From these findings, we can notice that the current study had a slightly lower mean value for both genders. The Indian population may have distinct skeletal characteristics compared to other populations due to their genetic ancestry and evolutionary history [12]. When comparing present study with Torimitsu S et al., performed on the Japanese population, a wide variation was noted in the Indian and Japanese populations, suggesting that Japanese people possess a larger HW dimension than the Indian people [3].

In a study by Soltani S et al., on the Iranian population, the mean HL was very close to present values, and the mean HW showed a higher value in the present study in both males and females [13]. Conversely, the mean BL was lesser in the current population.

The mean HL dimension significantly differed in all the comparison articles, including the current study. Every literature showed a statistically significant difference between males and females in all populations.

The current study had the lowest mean BL of the hyoid compared to previous research. It showed a mean of 19.3±2.0 mm in males and 16.4±1.7 mm in females. The mean BL value in the Croatian study was the largest compared to all other studies.

Most of the literature reveals that the hyoid bone might be used to determine gender due to its notable difference in measures among males and females. The variations in dimensions among different populations could depend on geographical, racial, ethnic, and morphometric factors. The hyoid bone's HW, HL, and BL were the standard discriminative parameters. All the investigations, including the present study, found the mean values of all parameters to be more prominent in males and smaller in females [Table/Fig-6] [3,8,12,13].

Author's name	Place of the study	No. of subjects	HW (mm)	HL (mm)	BL (mm)
Leksan I et al., 2005 [8]	Osijek	Male-35	45.8±6.7	41.4±4.1	33.1±4.3
		Female-35	40.5±6.4	35.8±3.9	29.0±3.9
Soltani S et al., 2017 [13]	Tehran, Iran	Male-173	38.71±1.92	38.97±1.43	24.69±2.46
		Female-176	30.26±2.18	30.33±2.01	20.77±1.41
Kumar TN and Rudra A 2018 [12]	Pune, India	Male-58	44.45±3.99	39.68±4.36	21.67±1.50
		Female-58	37.89±2.70	32.27±1.93	17.64±1.00
Torimitsu S et al., 2018 [3]	Japan	Male-140	52.3±5.5	38.3±2.9	28.1±2.8
		Female-140	46.2±5.3	31.7±2.2	22.8±2.4
Present study 2022	Mangaluru, India	Male-34	41.7±5.1	36.3±3.3	19.3±2.0
		Female-34	35.2±4.5	30.6±1.9	16.4±1.7

[Table/Fig-6]: Comparison of hyoid bone dimensions from different studies [3,8,12,13]. Values are presented as mean±SD

Furthermore, authors tried to correlate age and hyoid dimensions using the Pearson's correlation coefficient. As a result, they identified no relation between age and hyoid dimensions.

Similarly, in a study by Cotter MM et al., there was a swift phase of growth across all variables in the initial years of life, followed by distinct variations in growth patterns around ages 6 to 8. Additionally, differences in growth trajectories between males and females were evident [14]. Any investigations that included adult subjects showed no relation with age or hyoid dimensions.

Limitation(s)

The present study did not consider the shape of the hyoid bone and the fusion of the greater cornua with the body of the hyoid bone. Due to the limited number of samples in present time-bound study, there was an absence of a predetermined cut-off value for measurements, which may have introduced ambiguity and subjectivity into the data interpretation process.

CONCLUSION(S)

The comparison of the hyoid bone dimensions showed a significant difference in both males and females. Males exhibited higher mean values compared to females. Therefore, these three hyoid dimensions, as measured using 3D CT images, may serve as a valuable tool for gender determination.

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PARTICULARS OF CONTRIBUTORS:
1. Lecturer, Department of Radiodiagnosis and Imaging, Father Muller College of Allied Health Sciences, Kankanady, Mangaluru, Karnataka, India.
2. Assistant Professor, Department of Radiodiagnosis and Imaging, KS Hegde Medical Academy (KSHEMA), NITTE (Deemed to be University), Mangaluru, Karnataka, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. MM Jaseemudheen,
Assistant Professor, Department of Radiodiagnosis and Imaging, KS Hegde Hospital, Deralakatte, Mangaluru-575018, Karnataka, India.
E-mail: Jaseemudheen12@gmail.com

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