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Research Paper: Sex Identification by Morphometric Study of Hyoid Bone

Arash Okasi[1], Mohammad Hossein Sadeghian[1*], Behnam Behnoush[1], Ali Shakori Rad[2]

1. Department of Forensic Medicine, School of Medicine, Tehran University of Medical Sciences, Tehran, Iran.
2. Department of Radiology, School of Medicine, Tehran University of Medical Sciences, Tehran, Iran.

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ABSTRACT

Background: Morphometric measurements are important for identification in forensic medicine. Gender is one of the important components of identity. Many studies have reported that hyoid bone can be used for sex estimation but this claim must be verified in different populations.

Methods: We evaluated 372 hyoid bones of 15 to 87 years old Iranian people who had a valid identity certification. Nine anthropometric indices of hyoid bone were measured and investigated in this regard. Computerized tomography scan was done after fixation of dissected tissue in formalin. Logistic regression analysis was performed. The cut-off point (ROC) and discriminative formula were determined.

Results: In this study, hyoid bones of Iranian bodies were studied, of which 217 were male and 155 were female cases. The length of the hyoid body, great left horn length, angle between right great horn and left great horn with body of hyoid are associated with sex determination.

Conclusion: Hyoid bone in male is generally larger than in females. The result indicate that the hyoid bone morphometry with a high degree of accuracy can determine the sex. Discriminant formula was determined for hyoid bone.

1. Introduction

Identification based on human body parts like the skeleton or mutilated bodies is an important and difficult task in forensic medicine. The first step in identification of a corpse is sex determination [1]. Undoubtedly, the gender is one of the most important components of identity [2-4]. Already, the gender of unknown bodies is recognized by physical examination, assessing the bones, genetic studies and so on. However in some cases, these could not solve the problem [1]. The morphometric study of hyoid bone could be another way to determine the sex [3, 5]. Hyoid bone and larynx area is covered with soft tissue which is located above the thyroid cartilage. Initially, it is a cartilaginous tissue and with increasing age it gradu-

*** Corresponding Author:**
Mohammad Hossein Sadeghian, MD.
Address: *Department of Forensic Medicine, School of Medicine, Tehran University of Medical Sciences, Tehran, Iran.*
Tel: *+98 (21) 66405588*
E-mail: *mhsadeghian@sina.tums.ac.ir*

ally turns to bone [6-9]. This bone consists of two large and two small horns and a body [4, 6-9].

The hyoid bone plays an important role in speaking, swallowing, preventing the reflux, and maintaining the airway [6]. It is noteworthy that the bones of males are larger than females, and dimensions were set for them in some texts [1, 4, 10-12]. In addition, many studies have reported that hyoid bone is valuable for sex estimation [11, 13-15]. According to Dr. Kim study, the hyoid bone morphometry can be used for sex estimation [2]. In addition, Ito study (was done on Japanese patient`s head and neck CT-Scan [Computed Tomography Scan]) that examined CT scan images of hyoid indicate that the sex estimation is possible by hyoid bone morphometric study [16]. This study was done for sex estimation by hyoid bone morphometric with larger sample size. The hyoid bone morphometric has been studied in CT images for identification in Iranian population.

2. Materials and Methods

This cross-sectional study was conducted on Iranian cadavers referred to the autopsy hall of the Forensic Medicine Center of Tehran during 2016-2018. The hyoid bone of the cases that had a reliable identity certificate in the age range of 15 to 87 years was carefully removed by a forensic medicine specialist. All cases with positive signs of trauma or pressure on the neck, hyoid bone fracture, or dislocation of the joint between the body and the horn were excluded from the study.

In this study, the following 6 anthropometric indices of the hyoid bone were measured consistent with the points specified in Figure 1 and 2:

1. The length of the greater horns (the maximum length of the greater horn, as the AB line on the right side and the A`B` line on the left); 2. The length of the body (the distance between the central points of the junctions of the right greater horns with the body depicted as the BB` line); 3. The diameter of the hyoid body (identified by a line perpendicular to the center of the BB` line, the distance between the tip of the greater horns (line AA`); 4. The angle between the greater horns and the hyoid body (the ABB` angle on the right side and A`B`B on left side); 5. The angle between the greater horns (the ABB`A` angle); and 6. The vertical length of the greater horn with the body of the hyoid bone (a vertical line from the center of AA` to the center of BB`) (Figure 1 and 2).

We used the following abbreviations to analyze the indicators mentioned above: B: the gap between the greater horns and the hyoid body; F: the diameter of the hyoid body; G: the length of the hyoid body; J: the vertical length of the greater horns of the hyoid bone); K: the length of the right greater horn); L: the length of the left greater horn; N: the angle between the right greater horn and the body; M: the angle between the left greater horn and the body; O: the angle between the greater horns of the hyoid bone.

The hyoid bones were fixed in 10% formalin for at least 15 days. After that, CT images were taken by a technician. Imaging was done by GE (General Electric) high speed FX1. A Horizontal cut was taken including the center of the hyoid body (parameters: 170 mA, 120 kV, image background: 15*5 cm, and imaging time lapse: 2 seconds). During the research, none of the researchers involved in the project were aware of the gender and age of the samples. It should be mentioned that out of 400 hyoid samples, 372 samples were included in study and others were excluded because of the above-mentioned reasons (fracture, damage to the bone during dissection of soft tissue, etc.).

SPSS V. 22 was used for data analysis. Because of ethical considerations, hyoid bones were collected from dissected bodies whose dissection line was expanded to the neck and the researchers did not create any unessential cuts during autopsies. After obtaining images, the bones were returned to the autopsy room and transferred to the assigned dishes. Moreover, data anonymity and confidentiality were maintained during the study. The long distance between the autopsy hall and the site of scanning was the main limitation of the study, for which a carrier box with a special bone template was designed to transfer hyoid bones.

3. Results

In the current study, 217 (58.3%) males and 155 (41.7%) female cases were included. The sample size was divided into 8 age groups (Table 1). The average age was 44 years in the male group and 43 years in female group. No significant difference was observed between the two groups in terms of age (P=0.448).

The indexes measured in this study were compared between male and female genders. We found a significant difference between male and female cadavers in F, G, J, K, L, M, and N indices (Table 2). Based on the results of logistic regression analysis, B, F, G, J, K,

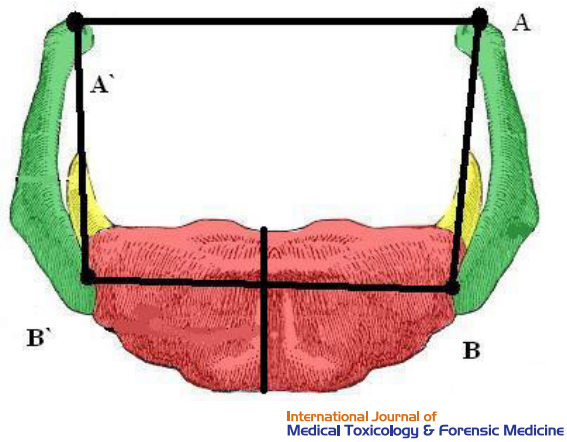

Figure 1. Hypothetical points of hyoid bone

L, M, and N variables can predict the changes of sex-dependent variables.

Based on regression analysis, G, L, M, and N could predict the sex (Table 3). A cut-off point was determined for the variables G, L, M, and N, which could predict sex. The ROC curve(Receiver Operating Characteristic Curve) is shown in Figure 3. As for G (the length of the hyoid body), the cut-off point was about 14.71 mm with a sensitivity of 64.2% and a specificity of 64.5% (P<0.05).The cut-off point of L was 35.4 mm with a sensitivity of 76.3% and a specificity of 74.3% (P<0.05). The cut-off point of M was about 115˚ with a sensitivity of 40% and a specificity of 39.5% (P<0.05). As for N, the cut-off point was 114˚ with a sensitivity of 46.5% and a specificity of 44.7% (P<0.05). Analysis of K, L, and F variables showed significant results (P<0.05).

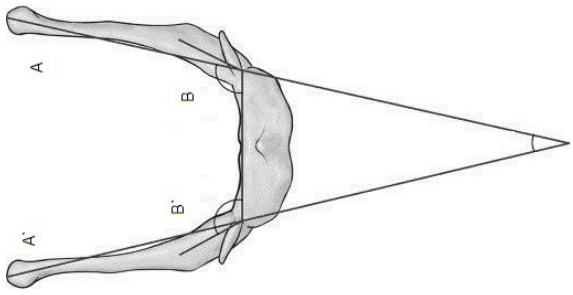

Figure 2. Hyoid bone angles

Discriminant formula was determined for hyoid:

Discriminant function (D)=F(0.508)+K(0.276)+L(0.241) -10.471

where F is the body diameter of hyoid bone, K refers to the great right horn length and L denotes the great left horn length.

4. Discussion

One of the most important dimensions of identification is sex [1, 4, 10, 11]. Generally, it is important to mention that most of the diameters of the bones are greater in males [1, 4, 10, 11, 17, 18].

Table 1. Sex and age groups

Age Group, y	Sex		Total
	Female	Male	
11-20	9	17	26
21-30	30	34	64
31-40	34	51	85
41-50	29	29	58
51-60	33	44	77
61-70	9	22	31
71-80	7	16	23
81-90	4	4	8
Total	155	217	372

Table 2. Study measures specified by sex

	Sex								P
	Female (n=155)				Male (n=217)				
Variables	Mean	SD	Min	Max	Mean	SD	Min	Max	
Age, y	43.09	16.53	15.00	87.00	44.45	17.43	13.00	87.00	0.0001
B	36.14	5.86	22.32	49.07	40.38	5.66	18.75	54.64	0.933
F	1.83	0.37	1.18	2.98	2.00	0.54	1.14	3.63	0.001
G	13.99	1.97	10.82	23.98	16.93	13.90	11.68	216.83	0.01
J	33.92	3.28	27.15	41.84	38.60	3.78	30.04	48.79	0.0001
K	33.08	3.38	25.20	40.82	37.68	3.93	14.20	47.65	0.0001
L	33.29	3.29	26.73	42.46	38.51	6.37	28.01	112.58	0.0001
M	115.82	5.37	104.39	126.96	114.16	4.88	94.73	125.51	0.002
N	115.33	5.62	99.52	126.58	113.35	6.92	45.75	125.92	0.004
O	48.63	8.16	15.00	68.90	65.77	15.81	8.00	47.89	0.229

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The results of regression analysis in the aforementioned study in comparison to the studies performed in the other countries were similar and indicate a significant difference in the above variables in terms of sex, so sex identification is possible using these indices [2, 19].

Polard, Kim and Ito, similar to our study used the discriminant formula. In a recent study, a cutoff point was defined by using the ROC statistical tool [2, 19]. Based on the achieved results from regression analysis in our study, G, L, N and M indices can predict the sex dependent variables.

Table 3. Logistic regression analysis to select variables ability to estimate the sex

Step 1[a]	B	S.E.	Wald	df	Sig.	Exp (B)	95% C.I.for EXP (B)	
							Lower	Upper
B	-0.116	0.096	1.451	1	0.228	0.891	0.738	1.075
F	-0.673	0.441	2.323	1	0.127	0.510	0.215	1.212
G	-0.353	0.104	11.560	1	0.001	0.703	0.573	0.861
J	0.131	0.158	0.688	1	0.407	1.140	0.836	1.556
K	-0.104	0.142	0.535	1	0.464	0.902	0.683	1.190
L	-0.296	0.146	4.107	1	0.043	0.743	0.558	0.990
M	0.145	0.065	4.964	1	0.026	1.156	1.018	1.314
N	0.153	0.063	5.976	1	0.014	1.165	1.031	1.318
O	-0.112	0.069	2.627	1	0.105	0.894	0.781	1.024
Constant	-11.383	11.467	0.985	1	0.321	0.000		

a: Variable(s) entered on step 1: A, F, G, J, K, L, M, N, O.

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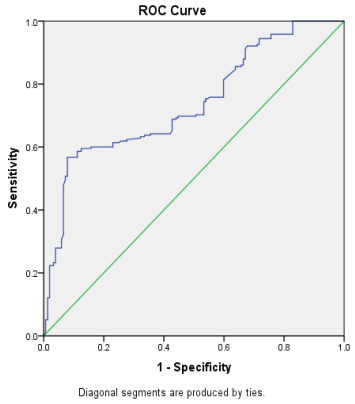
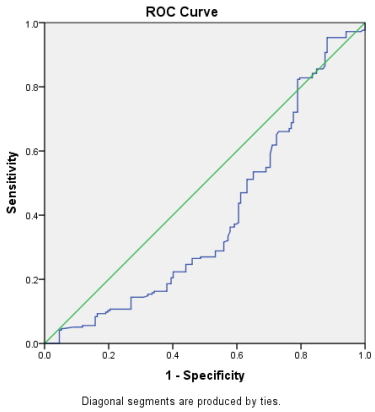
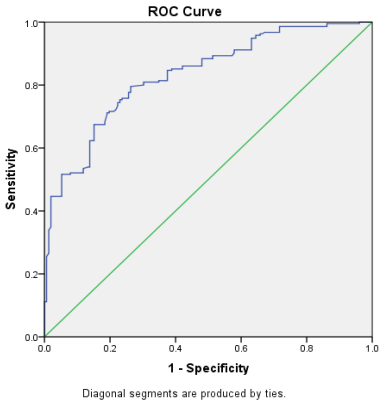


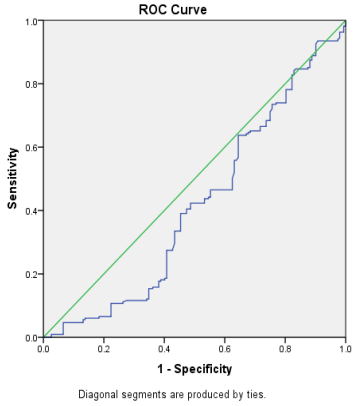
Index G (Length of the hyoid body)



Index M (Angle between the left greater horn and the body)



Index L (Length of the left greater horn)



Index N (Angle between the right greater horn and the body)

Figure 3. ROC Curve of Index G, L, M, N

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In the research of Ito, based on the regression analytical test, three variables were able to estimate the sex that include body length of hyoid bone and hyoid bone horn lengths [18]. In the research performed by Ito on hyoid bone, the great horns lengths, width and length and finally the distance of central part of great horns of hyoid bone were measured and investigated in terms of sex and age [18].

The variables F, G, K and L in our study were similar to the Ito study and can estimate the sex [18]. The age was not investigated in this study [18]. Similar to our study, Mukhopadhyay found that the great right and left horn length (K, L) could estimate the sex. In the study of Kim, the photographic images of hyoid bone were investigated. Similar to our study, B, F, K, L, J, M, N, O variables were investigated in both research studies that statistically showed a significant difference in sex estimation [2].

5. Conclusion

According to this research, hyoid bone is generally larger in men. Among the various horns of hyoid bone anthropometry, the length of left great horn is the best indicator for sex identification. According to the mentioned formula with 81.7% accuracy, we are able to estimate the sex. It is suggested that pathologic and microscopic investigation of hyoid bone be performed between two sexes in various communities and with larger sample size.

Ethical Considerations

Compliance with ethical guidelines

No particular moral considerations were contemplated. This is because the study was done on samples that were taken out of the body for further action.

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Authors contributions

The authors contributions is as follows: Arash Okazi carried out Sample taking and contributed in writing this paper. Mohammad Hossein Sadeghian carried out sample taking and also participated in the design of the study and performed the statistical analysis. Behnam Behnoush carried out sample taking and contributed in writing this paper. Ali Shakoori Rad took and prepared images. All authors read and approved the final manuscript.

Conflict of interest

The authors declared no conflict of interest.

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