January - June 2022 Volume 31 Issue 1
PRINT ISSN: 2277-1867
ONLINE ISSN: 2277-8853

JOURNAL OF FORENSIC MEDICINE SCIENCE AND LAW

Official Publication of Medicolegal Association of Maharashtra

MULTISPECIALITY, MULTIDISCIPLINARY, NATIONAL
PEER REVIEWED, OPEN ACCESS, MLAM (SOCIETY) JOURNAL
Indexed with Scopus (Elsevier) & Index Copernicus (Poland)

Editorial Office Address
Department of Forensic Medicine & Toxicology, Third Floor, Library Building, Seth G S Medical College & KEM Hospital, Parel, Mumbai, Maharashtra, India. Pin-400 012. Email id: mlameditor@gmail.com Phone: 022-24107620 Mobile No. +91-9423016325.

JOURNAL OF FORENSIC MEDICINE SCIENCE AND LAW
(Official Publication of Medicolegal Association of Maharashtra)
Email.id: mlameditor@gmail.com

PRINT ISSN: 2277-1867
ONLINE ISSN: 2277-8853

Original Research Article

Estimation of age from hyoid bone – is it a viable option?

Ranjit Immanuel James[a], Shankar Bakkannavar[b*], Anita S[b]

[a]Assistant Professor, Department of Forensic Medicine & Toxicology, Christian Medical College Vellore, Tamil Nadu, India. [b]Associate Professor, Department of Forensic Medicine & Toxicology, Kasturba Medical College, Manipal Academy of Higher Education, Manipal, Karnataka, India.

Article Info

Received on: 19.09.2021
Accepted on: 20.04.2022

Key words:
Age estimation,
Hyoid bone,
Identification,
Ossification.

Abstract

Introduction: Identification of an individual is crucial from womb to tomb. It has always been a challenging task. Estimation of age after death from the adult skeleton is one of the most important objectives in medico-legal cases. Among the various parameters available, skeletal age determination is considered the best. This study attempts to assess the reliability of age estimation based on the ossification of hyoid bone as an indicator of chronological age. **Methodology:** This prospective observational study was conducted in the mortuary of the tertiary care Teaching Hospital in South India from October 2014 to September 2016. This study includes 100 hyoid bones from male and female cadavers of known age, brought for medico-legal autopsy. The hyoid bone was removed, cleaned and subjected to X-ray. For estimating the age of the person the categories such as non-fusion, initiation of fusion, partial fusion and complete fusion were used. **Results:** The mean age for bilateral complete fusion of greater cornua with the body of hyoid bone is 50.44 ± 10.28 years. The mean age for bilateral complete fusion of greater cornua with the body of hyoid bone in males is 52.77 ± 10.9 years. The mean age for bilateral complete fusion of greater cornua with the body of hyoid bone in females is 48.84 ± 9.82 years. **Conclusion:** The sample size was small for establishing a concrete conclusion. Future studies with a larger sample size need to be considered for more reliable results.

1. Introduction

Identification of an individual is crucial from womb to tomb. It has been defined as the "determination or establishment of the individuality of a person, whether living or dead, and it is exact fixation of the individuality".[1,2] Historically, identification of a person has always been a challenging task.[3] Investigating officers and forensic specialists are concerned with identifying a dead body. This is especially true in challenging cases like explosion, accidents, or other mishaps. The medico-legal importance of age is multi-faceted, for example, regarding criminal responsibility, judicial punishment, etc. Estimation of age after death from the adult skeleton is one of the primary objectives in medico-legal cases. Several techniques are used for estimating age in adult skeletons with varying accuracy. These include age estimation by cranial suture closure,

How to cite this article: James RI, Bakkannavar S, Anita S. Estimation of age from hyoid bone – is it a viable option? J For Med Sci Law 2022;31(1):33-38.

***Corresponding author:** Dr. Shankar M Bakkannavar, Associate Professor, Department of Forensic Medicine and Toxicology, Kasturba Medical College, Manipal, Karnataka, India. 576104 Email id- shankar.mb@manipal.edu (M): +91 9110240992.

radiological assessment of ossification centers, eruption pattern of teeth, studying the metamorphosis in the pubic symphysis and scapula, rib phase analysis, and osteon counting in a segment of long bone. Among the various parameters available, skeletal age determination is considered the best as it provides near total accuracy. Some bones are cartilaginous, and others are membranous in origin. However, changes in all bones continue after complete ossification and even until death. Ossification and degenerative changes in bones are taken into consideration when estimating the age of a person, since their occurrences maintain a reasonable sequence and chronology.

Based on previously conducted studies, we can recognize the importance of using hyoid bone for age estimation. The following observations would highlight the importance of using hyoid bone in the estimation of age:

1. Hyoid bone can be used for anthropological studies due to its robustness and location, even making it possible to be examined as a fragmented or burnt bone.
2. Previous studies gave significant results demonstrating the use of hyoid bone in estimating the age.
3. Scarcity of national (Indian) studies for estimating age from hyoid bone

Hence, this study was conducted to estimate the reliability of age estimation based on the ossification of hyoid bone as an indicator of chronological age.

2. Aim & Objective:

To estimate the age based on the fusion of greater cornua with the body of hyoid bone. This aim will be achieved by observing the time of fusion between the greater cornua and body of the hyoid bone

3. Methodology:

This prospective observational study was conducted in the mortuary of the tertiary care Teaching Hospital in South India from October 2014 to September 2016. This study includes 100 hyoid bones from male and female cadavers of known age, brought for medico-legal autopsy. The dissection was performed in the mortuary. A layer-by-layer flap dissection was performed, and subcutaneous dissection was carried up to the lower border of the mandible, laterally on the sides of the clavicle and neck. The deep cervical fascia is incised and reflected from the cervical muscles and the submandibular gland.[4] The sternocleidomastoid muscle was freed from its attachments, separated from its fascia, and reflected on each side. The omohyoid, sternothyroid and thyrohyoid muscles were exposed, inspected, and reflected on each side.

The thyroid gland and the carotid sheaths were freed from their investing connective tissue. The larynx, trachea, pharynx, and oesophagus were mobilised and pulled away from the prevertebral tissue. The hyoid bone was removed and was examined for any signs of fracture. Further dissection was done to clear the soft tissue and maceration was then performed to remove all soft tissue. The sample size was calculated based on comparison proportion formula and was estimated to be of 90 (45 males and 45 females). A control group of five bones were taken from hanging cases involving each sex (total 10 bones). Total of 100 hyoid bones were studied. They were numbered at the time of retrieval from body and tagged to reduce the objective errors which may cause undue confusion. After maceration, they were cleaned, dried, and packed in polythene zip lock bags. They were then labelled with their corresponding post-mortem numbers and X-rays of these hyoid bones were taken.

Radiological examination:

Superior view and antero-posterior views of the bone were X-rayed to study the fusion between the body of the hyoid and greater cornua.[5] Nine hyoid bones were subjected to digital X-ray film of size 17 x 14 cm. The first 11 batch with nine bones each and a single bone in the 12th batch were X-rayed by placing it in a thermocoal sheet. The bones were labelled with lead numbers (1 to 9), and on each X-ray the corresponding batch (lead) number was placed for identification. The corresponding batch of hyoid bones was noted down for correlation with postmortem number with respect to the lead number to avoid unnecessary confusion while assessing the fusion. The X-ray specifications were set to 60 Kilo volt potential energy, X-ray tube strength is 200 mA, and the exposure time was 0.05 seconds.

Categories of fusion: [5] The fusion of the hyoid bones was then classified into following categories:

1 - Not fused

2 - Initiation of fusion: When the fusion has started either in middle or on one side, but the total area of fusion was less than 1/4th of the contact area.

3 - Partially fused: When the area of fusion advanced to include more than half of the contact area but did not exceed 3/4th of the contact area.

4 - Completely fused: When the area of fusion involves more than 3/4th of the contact area.

Inclusion criteria: Hyoid bones of individuals between the age of 20 to 70 years were included in this study.

Exclusion criteria: Hyoid bones that were fractured by strangulation, hanging, trauma, etc or any artefacts; were excluded from the study.

Statistical analysis: For statistical analysis, the samples were classified in to five groups of 10 years' interval. This data was analysed using Statistical Package for the Social Sciences (SPSS) version 15.

4. Results:

In this study, a total of 100 subjects (50 males and 50 females) between the ages of 21 - 70 years were examined. It was observed that the maximum number of cases was belonging to the age group of 21 – 30 years (34%). Frequency of cases with respect to degree of fusion of greater cornua and the side of the cornua is as depicted in **Table 1.** Frequency of male cases with respect to degree of fusion of greater cornua and the side of the cornua is as depicted in **Table 2**. Frequency of female cases with respect to degree of fusion of greater cornua and the side of the cornua is as depicted in **Table 3**. The association between the right and left greater cornua fusion with respect to degree of fusion is depicted in **Table 4**. According to Pearson Chi-square test, there is a strong association between the fusion of right and left greater cornua with the body of the hyoid bone ('p' value < 0.05). The mean age of degree of fusion with respect to gender is depicted in **Table 5**.

Table 1: Frequency and degree of fusion with respect to the side of greater cornua in age group

Age group	Degree of fusion - Greater cornua							
	Not fused		Initiation of fusion		Partially fused		Completely fused	
	Right	Left	Right	Left	Right	Left	Right	Left
21 - 30	34	34	0	0	0	0	0	0
31 - 40	12	11	0	0	0	0	10	11
41 - 50	2	3	0	2	2	2	17	14
51 - 60	4	3	1	4	1	0	7	6
61 - 70	1	0	1	1	1	0	7	9
Total No. of cases	53	51	2	7	4	2	41	40

Table 2: Frequency of male cases and degree of fusion with respect to age group

Age group In years	Degree of fusion - Greater cornua in males							
	Not fused		Initiation of fusion		Partially fused		Completely fused	
	Right	Left	Right	Left	Right	Left	Right	Left
21 - 30	17	17	0	0	0	0	0	0
31 - 40	7	8	0	0	0	0	4	3
41 - 50	2	3	0	2	1	0	8	6
51 - 60	2	2	0	2	1	0	3	2
61 - 70	0	0	1	1	0	0	4	4
Total No. of cases	28	30	1	5	2	0	19	15

Table 3: Frequency of female cases and degree of fusion with respect to age group

Age group In years	Degree of fusion - Greater cornua in females							
	Not fused		Initiation of fusion		Partially fused		Completely fused	
	Right	Left	Right	Left	Right	Left	Right	Left
21 - 30	17	17	0	0	0	0	0	0
31 - 40	5	3	0	0	0	0	6	8
41 - 50	0	0	0	0	1	2	9	8
51 - 60	2	1	1	2	0	0	4	4
61 - 70	1	0	0	0	1	0	3	5
Total No. of cases	25	21	1	2	2	2	22	25

Table 4: Right and left greater cornua association with respect to degree of fusion

		Right side				Total no. of cases
		Not fused	Initiation of fusion	Partially fused	Completely fused	
Left side	Not fused	45	0	1	5	51
	Initiation of fusion	3	1	0	3	7
	Partially fused	0	0	1	1	2
	Completely fused	5	1	2	32	40
Total no. of cases		53	2	4	41	100

Table 5: Mean age of degree of fusion in relation to gender

Degree of fusion	Male				Female			
	Right		Left		Right		Left	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Not fused	31.61	8.9	32.7	9.48	32.04	11.3	28.86	7.63
Initiation of fusion	65	0	53.6	7.73	58	0	55	0
Partially fused	53	4.24	0	0	55	14.14	43	2.83
Completely fused	50.74	9.88	51.4	11.08	48	10.01	48.92	10.98

5. Discussion:

Identification of the dead is an arduous task. But this task is mandatory according to the prevailing laws of the land. Availability of antemortem and postmortem information play an important role in easing this quandary. However, these identification features are ineffectual in cases involving advanced stages of decomposition.[6]

Aging is a continuous physiological and biological process which is inevitable and irreversible. Among parameters used to assess the age, skeletal remains are fairly accurate. Skeletal remains can even be used decades after death as it resists putrefaction. They are useful even if only fragments are recovered. This estimation of age from bones is most accurate in the first two decades of life, but variations increase as the age advances. To reduce this variation, numerous studies have been done on various skeletal indicators.

To estimate the age, X-ray of the hyoid bone was taken to look for the degree of fusion of the greater cornua with the body. It was observed that in the age group of 21-30 years (3rd decade of life), none of the hyoid bones were fused (0/34). In a similar study, Harjeet et al observed no fusion till the age of 25 years.[5] But from 26 to 30 years, bilateral non-fusion was noted in 58.54% cases, bilateral initiation of fusion in 9.76% cases, unilateral partial fusion in 7.32% cases, and bilateral complete fusion in 9.76% cases. However, Aysun Balseven-Odabasi et al[7] observed unilateral fusion in 20% of cases and bilateral fusion in 50% of cases. Deepak H D'Souza et al[8] found unilateral fusion in 24% cases and bilateral fusion in 6% cases. A. Gupta et al[9] discerned that only 10% of cases showed unilateral fusion.

Between the age of 31-40 years, 54.55% of cases (12/22) had not fused, whereas 45.45% of cases (10/22) exhibited complete fusion on the right side. On the left side, 50% of cases (11/22) showed non-fusion, and 50% of cases (11/22) showed complete fusion. For the same age group, Harjeet et al[5] noted bilateral non-fusion in 49.25% cases, bilateral initiation of fusion in 5.97% cases, bilateral partial fusion in 1.49% cases, and bilateral complete fusion was seen in 20.9% cases. Aysun Balseven-Odabasi et al[7] observed unilateral fusion, bilateral fusion and no fusion was seen in 45%, 40% and 15% of cases respectively. Deepak H D'Souza et al[8] noted unilateral fusion, bilateral fusion and no fusion was seen in 43%, 37% and 20% of cases respectively. A. Gupta et al[9] observed unilateral fusion, bilateral fusion and no fusion in 21.43%, 14.29% and 64.29% of cases respectively.

In the 5th decade of life, 9.52% of cases (2/21) showed no fusion, 9.52% of cases (2/21) showed partial fusion, and 80.95% of cases (17/21) showed complete fusion on the right side. However, 14.29% of cases (3/21), 9.52% of cases (2/21), 9.52% of cases (2/21), and 66.67% of cases (14/21) showed no fusion, initiation of fusion, partial fusion, and complete fusion on the left side respectively. Harjeet et al[5] noted bilateral non-fusion seen in 35.71% cases, unilateral initiation of fusion in 3.57% cases, bilateral partial fusion in 10.71% cases, and bilateral complete fusion in 35.71% cases. Aysun Balseven-Odabasi et al[7] discerned unilateral fusion, bilateral

fusion and no fusion in 38.89%, 50% and 11.11% of cases respectively. Deepak H D'Souza et al[8] detected unilateral fusion, bilateral fusion and no fusion in 37.5%, 31.25% and 31.25% of cases respectively. For A. Gupta et al[9] unilateral fusion, bilateral fusion and no fusion was seen in 17.65%, 27.45% and 54.9% of cases respectively.

In the age group of 51-60 years, no fusion was seen in 30.77% of cases (4/13), 7.69% of cases (1/13) showed initiation of fusion, 7.69% of cases (1/13) showed partial fusion, and 53.85% of cases (7/13) showed complete fusion on the right side. Regarding the left side, 23.08% of cases (3/13), 30.77% of cases (4/13), and 46.15% of cases (6/13) showed no fusion, initiation of fusion and complete fusion respectively. For the same age group, Harjeet et al[5] noted bilateral non-fusion in 22.22% cases, unilateral partial fusion in 22.22% cases, and bilateral complete fusion in 44.44% cases. Aysun Balseven-Odabasi et al[7] observed that bilateral fusion and no fusion was seen in 88.89% and 11.11% of cases respectively. In the study by Gupta et al,[9] unilateral fusion, bilateral fusion and no fusion was seen in 15.15%, 69.7% and 15.15% of cases respectively. Between the age of 61-70 years, it was observed that 10% of cases (1/10) had no fusion, 10% of cases (1/10) had initiation of fusion, 10% of cases (1/10) had partial fusion, and 70% of cases (7/10) had complete fusion on the right side. However, 10% (1/10) of cases showed initiation of fusion and 90% (9/10) of cases showed complete fusion on the left side. Harjeet et al[5] noticed bilateral non-fusion in 42.11% cases, unilateral initiation of fusion in 10.53% cases, bilateral partial fusion in 5.26% cases, and bilateral complete fusion in 21.05% cases. Aysun Balseven-Odabasi et al[7] noted bilateral fusion in 100% of cases. In the age group of 51-70 years, Deepak H D'Souza et al[8] observed that unilateral fusion, bilateral fusion and no fusion was seen in 60%, 30% and 10% of cases respectively. Between the age of 61-65 years, A. Gupta et al[9] observed bilateral fusion in 100% of cases. Only Harjeet et al. classified the degree of fusion of the greater cornua with the body of the hyoid.

In this study, 10 cases showed unilateral complete fusion (either right or left side completely fused, while the other side showed no fusion). Of cases which showed unilateral fusion, right-sided and left-sided unilateral complete fusion was seen in 50% of the cases each. The proportion of unilateral complete fusion of greater cornua with the body in each age group contributes to 70%, 20% and 10% of cases in 31-40 years, 41-50 years, and 61-70 years respectively. However, Harjeet et al observed that 3rd, 4th, 5th, 6th and 7th decade and above showed 26.92%, 34.62%, 7.69%, 11.54% and 19.23% of cases with unilateral complete fusion respectively.

The incidence of bilateral complete fusion among all the (100) cases studied was 32% and out of which the maximum number of cases were observed between the age group of 41 to 50 years that accounts for 40.63% cases. Bilateral complete fusion of greater cornua with the body of the hyoid bone was seen in 21.88%, 15.63% and 21.88% of cases in the age group of 31 to 40 years, 51 to 60 years and 61 to 70 years respectively. However, in a study by Harjeet et al, it is observed that 3rd, 4th, 5th, 6th and 7th decade showed 10%, 35%, 25%, 20% and 10% of cases with bilateral complete fusion respectively.

The earliest bilateral complete fusion of the greater cornua with the body was seen at the age of 32 years. On the contrary, even at 65 years the hyoid bone was found unfused bilaterally (initiation of fusion was seen on both the sides). There is no significant statistical difference between the fusion of right and left greater cornua with the body of the hyoid bone. This observation is supported by studies by Deepak H D'Souza et al, Achintya Biswas et al[10], Harjeet et al, Miller et al[11] where the authors found no statistically significant difference among the two sex groups. However, Gupta et al found the bilateral fusion occurs 5 years earlier in females when compared to males.

The mean age of complete fusion of greater cornua for males is 50.74 $\pm$ 9.88 years and 51.4 $\pm$ 11.08 years on the right and left side respectively. However, for females the mean age of complete fusion of greater cornua is 48 $\pm$10.01 years and 48.92 $\pm$ 10.98 years on the right and left side respectively. Mean age for all the cases with bilateral complete fusion is 50.44 $\pm$ 10.283 years, whereas the mean age for males and females with bilateral complete fusion were 52.77 $\pm$ 10.895 years and 48.84 $\pm$ 9.816 years respectively. However, Deepak H D'Souza et al[8] observed that the mean age of bilateral fusion for males and females were 41.77 years and 45 years respectively. Achintya Biswas et al[10] found the mean age of fusion for males and females to be 53.16 years and 48.5 years respectively.

This study showed that as the age advances, the incidence of degree of fusion of greater cornua with the body of hyoid bone increases. In our study, 7 out of 10 cases in the age group of 61-70 years showed complete bilateral fusion of the greater cornua with the body of the hyoid bone, which accounts for 70% of cases (maximum). This observation was reinforced by Gupta et al, with 100% bilateral fusion of hyoid bones after the age of 60 years. On the contrary, Harjeet et al concluded that only 21.05% cases above the age of 60 years showed bilateral complete fusion.

6. Conclusion:

Based on the observations of our study, we were able to conclude that:

1. The mean age for bilateral complete fusion of greater cornua with the body of hyoid bone is **50.44 ± 10.283** years.
2. The mean age for bilateral complete fusion of greater cornua with the body of hyoid bone in males is **52.77 ± 10.9** years.
3. The mean age for bilateral complete fusion of greater cornua with the body of hyoid bone in females is **48.84 ± 9.82** years.

Limitations: The sample size was small for establishing a concrete conclusion. Future studies with a larger sample size need to be considered for more reliable results.

Acknowledgement: The authors would like to thank the members of Department of Forensic Medicine & Toxicology, Faculties of Department of Biostatistics, Kasturba Medical College, Manipal & Dr. Daniel Manoj for their valuable insights and critical inputs.

Contributor ship of Author: All authors have equally Contributed.

Ethical Clearance: Yes.

Conflict of interest: None declared.

Source of Funding: Post-Graduate (PG) Grant, Kasturba Medical College, Manipal Academy of Higher Education, Manipal, Karnataka, India.

References:

1. Karmakar RN. Identification. In: JB Mukherjee's Forensic Medicine and Toxicology. 3rd ed. Kolkata: Academic Publishers; 2007. p96.
2. Reddy KSN. Identification. In: The Essentials of Forensic Medicine and Toxicology. 32nd ed. Hyderabad: Suguna Devi; 2013. p56.
3. Vij K. Identification. In: The Textbook of Forensic Medicine and Toxicology Principles and Practice, 5th ed. New Delhi: Elsevier India (P) Limited: 2011; 28–41.
4. Reddy KSN. Identification. In: The Essentials of Forensic Medicine and Toxicology. 32nd ed. Hyderabad: Suguna Devi; 2013. p103.
5. Harjeet K, Synghal S, Kaur G, Aggarwal A, Wahee P. Time of fusion of greater cornu with body of hyoid bone in Northwest Indians. Leg Med (Tokyo). 2010;12(5):223–7.
6. Williams PL, Bannister LH, Berry MM, Collins P, Dyson M, Dussek JE, et al, Gray's anatomy, 38th ed. Edinburgh, Churchill Livingstone, 1995. p1637 [Internet]. Sciepub.com. [cited 2021 Nov 24]. Available from: http://www.sciepub.com/reference/266196
7. Balseven-Odabasi A, Yalcinozan E, Keten A, Akçan R, Tumer AR, Onan A, et al. Age and sex estimation by metric measurements and fusion of hyoid bone in a Turkish population. J Forensic Leg Med. 2013;20(5):496–501.
8. Deepak HD, Setty SH, Jayaramaiah K. Fusion in the hyoid bone: usefulness and implications. Med Sci Law. 2010;50(4):197–9.
9. Gupta A, Kohli A, Aggarwal NK, Banerjee KK. Study of age of fusion of hyoid bone. Leg Med (Tokyo). 2008;10(5):253–6.
10. Biswas A, Mazumdar S, Sardar T. Fusion of hyoid bone: a preliminary study in Indian Bengali. J Indian Acad Forensic Med. 2013; 35(1):14-6.
11. Miller KW, Walker PL, O'Halloran RL. Age and sex-related variation in hyoid bone morphology. J Forensic Sci. 1998;43(6):1138–43.