

CASE REPORT

Unravelling the Secrets of Age Estimation: A Look at the Science Behind the Bone Analysis

Roopam Mourya¹, Ramkrishna Mishra², Surendra Kumar Pandey³, Devashish Verma⁴

How to cite this article:

Roopam Mourya, Ramkrishna Mishra, Surendra Kumar Pandey, et al. Unravelling the Secrets of Age Estimation: A Look at the Science Behind the Bone Analysis. Indian J Forensic Med Pathol. 2025; 18(2): 131-136.

ABSTRACT

Determining the age of unidentified human skeletal remains is one of the objectives of forensic identification. Age is estimated using the articular surface of the ilium, pubic symphysis, acetabulum, clavicle, skull, and sternum. In November 2020, the body of an unknown 35-year-old man was found in a black plastic bag and transported to the Varanasi postmortem house for examination. Age can be inferred from changes in bone morphology as people age. The age had been estimated by the police. Bone morphology is the most accurate indicator of age, especially in a medicolegal setting. The deceased's age is determined to be between 40 and 45 years old after a postmortem. For this middle age group estimation of age, most reliable morphological changes occur in acetabulum, pubic symphysis and the 4th rib.

KEYWORDS

- Age estimation
- Skeletal remains
- Bone morphology
- Ossification
- Porosity
- Epiphysis

AUTHOR'S AFFILIATION:

¹ Assistant Professor, Department of Forensic Medicine and Toxicology, Santosh Medical College, Ghaziabad, Uttar Pradesh, India.

² Assistant Director, Directorate of Forensic Science and Laboratory, Ranchi, Jharkhand, India.

³ Professor, Department of Forensic Medicine, Institute of Medical Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, India.

⁴ Assistant Professor, Department of Forensic Medicine and Toxicology, Tezpur Medical College and Hospital, Tezpur, Assam, India.

CORRESPONDING AUTHOR:

Roopam Mourya, Assistant Professor, Department of Forensic Medicine and Toxicology, Santosh Medical College, Ghaziabad, Uttar Pradesh, India.

E-mail: Rupm.mbbs@gmail.com

➤ **Received:** 15-03-2025 ➤ **Accepted:** 30-05-2025



Creative Commons Non Commercial CC BY-NC: This article is distributed under the terms of the Creative Commons Attribution NonCommercial 4.0 License (<http://www.creativecommons.org/licenses/by-nc/4.0/>) which permits non-Commercial use, reproduction and distribution of the work without further permission provided the original work is attributed as specified on the Red Flower Publication and Open Access pages (<https://www.rfppl.co.in>)

INTRODUCTION

In cases involving both living and deceased people, identity loss and biological profiling are frequent concerns for both individuals and forensic practice authorities. Age can be estimated from a variety of factors, including clavicle morphology, bone degenerative changes, cranial sutural ossification, skeletal growth, phase analysis of the sternal end of the ribs, bone form, and porosity developed. The quantity and speed of developmental changes decline as a person reaches biological adulthood. Middle age is the most difficult stage to assess adult age because of transition and degenerative changes brought on by hormonal and metabolic changes. As an individual matures, specific morphological changes occur in their skeletal remains. Advanced decomposition hinders the ability to identify persons undergoing skeletonization changes. The best metric for estimating age is bone, particularly in medicolegal contexts.⁽¹⁻⁸⁾

Case background

On 2020 November, an unknown dead body of 35 years old male was found wrapped in a black coloured plastic bag send to modern postmortem house Varanasi for postmortem examination. The body was recovered from near to Banaras railway station Varanasi. On conducting postmortem examination, body was found in the advanced stage of decomposition, skull was detached, with adipocere formation on back portion of the body, right side of chest region was eaten up by animal along with most of the visceral and vital organs Immature to mature maggots were crawling on the body, external genitalia was spared (penis, so the sex of the body was identified). one black tshirt, one blue colour lower (soaked with decomposition fluid) and one pair of red coloured slipper found on the body The body was send to IMS BHU on November 2020 for second postmortem examination for expert opinion in respect to time since death, age of the body The body has been macerated and cleaned for further postmortem examination.

Postmortem Examination

After maceration Total number of 61 bones were recovered, which included 1 skull and 1 mandible with teeth, 1 left clavicle , 2 humerus In number, 2 Radius in number, 2 ulna in number, right side 10 ribs in number, left side

11 ribs in number, 1 left scapula in number.

Right & left femur - 2 in number, right and left tibia-2 in number, right and left fibula-2 in number, 2 pelvic bone in number , I sacrum in number, 4 cervical vertebra - C4, C5, C6, C7 in number, thoracic vertebra were 12 in number, lumbar vertebra 5 in number. The second autopsy was conducted on completely dried and cleaned off bone.

DISCUSSION

Clavicle

External inspection reveals that the medial end of the clavicular epiphysis covers the majority of the articular surface. This is likely to happen between the ages of 24-29 years. Individual porosity is present across the completed bone fusion of the medial epiphysis (which indicates 29+years of age). It is rare to observe complete epiphyseal fusion before the age of 22, and it is always finished by the age of 30. Therefore age of provided clavicle is more than 29 years of age⁽⁹⁻¹⁰⁾, Figure 1.

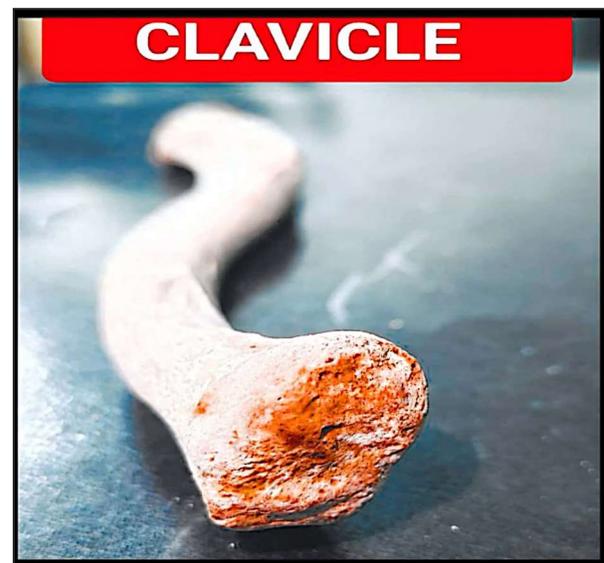


Figure 1: Medial end of clavicle-complete epiphyseal fusion

RIBS

Left right of 1st ribs – show epiphyseal fusion on tubercle approximately 17 years age, Epiphyses appears and fused with head at the age of 17-25 years of age. Epiphyseal fusion on articular and nonarticular surface of rib was present (21 years of age). The provide rib is fully adult i.e. age is more than >25 years.⁽¹¹⁾, Figure 2.1 and 2.2.

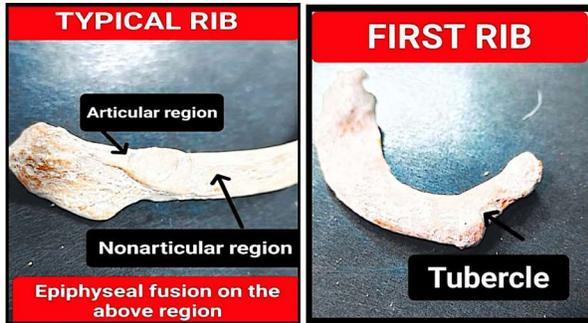


Figure 2.1: Typical Rib

Figure 2.2: First Rib

Symphysis PUBIS

On examination - Upper boundary of pubic symphysis has established outline and has thickened to clearly established borders, outline of lower boundary appears thick, V shaped and has established border. Outline present on inverted tear drop shape, surface texture with increased granularity, topography is broad, flat plateau inferior to superior symphyseal surface is flat. According to Todd's Classification of phase 8 of the morphological changes observed in the pubic symphysis, the ventral aspect of the pubic bone and the symphyseal face are both generally smooth and inactive, and the oval contour is complete. There is no apparent rim to the symphyseal face, and the extremities are well defined. The age range of 40 to 45 years is indicated by the lack of noticeable lipping of the ventral and dorsal margins. According to Suchey's Classification of the phases of morphological changes in the pubic symphysis, phase IV, the pubic tubercle is totally separated from the symphyseal face by definition of the upper extremity, and the oval outline is typically complete at this point. The age range for this stage is 23-57 years.

As per these classification, the given bone age is 40-45 years of age⁽¹³⁻¹⁴⁾, Figure 3.1 and 3.2.

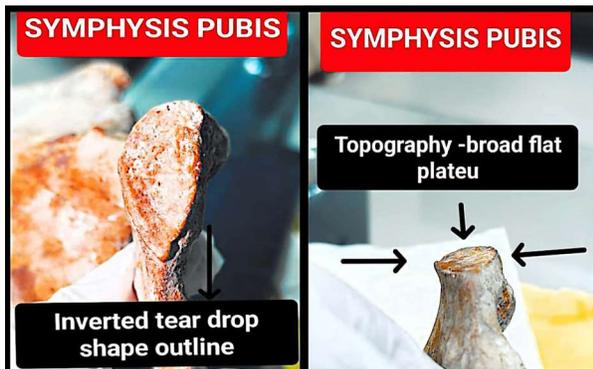


Figure 3.1: Symphysis Pubis – Inverted Tear Drop Shape

Figure 3.2: Symphysis Pubis – Topography (Broad Flat)

AURICULAR SURFACE OF ILIUM

Auricular surface shows coarse granularity with partial densification with marked loss of transverse organization, slight to moderate activity present at retro auricular surface, slight changes in apical activity, macroporosity present with a very vague striations, billowing not present, it is from mid-adult phase with the age range of 40-44 years.⁽¹⁴⁾, Figure 4.

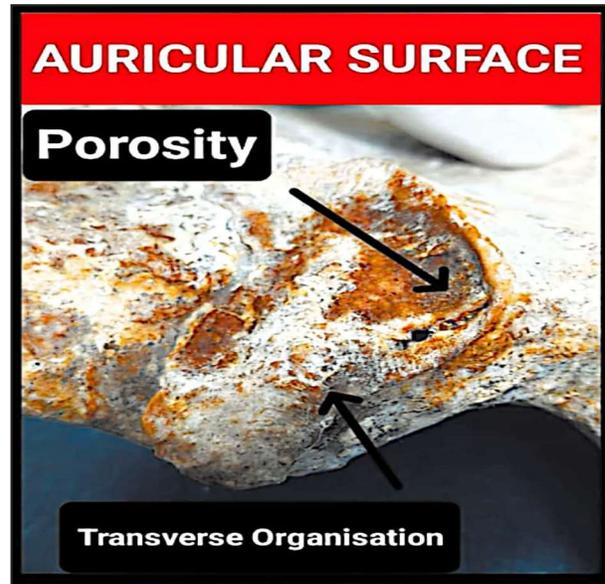


Figure 4: Auricular Surface

ACETABULUM

Rissech *et al.*'s male-specific approach for estimating age based on age-related acetabulum alterations using Bayesian inference. On examination of acetabulum (15) (Figure 5.1-Figure 5.5).

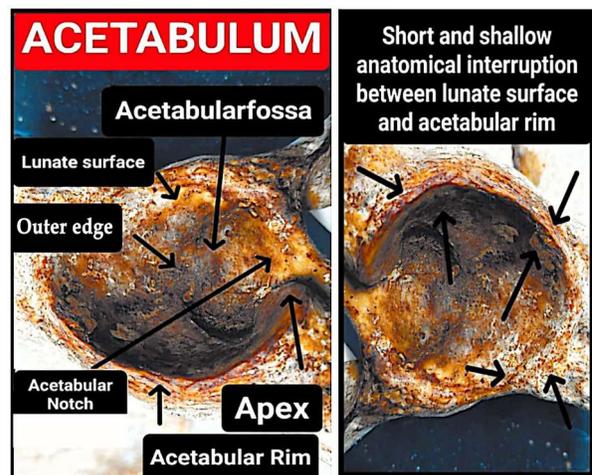


Figure 5.1: Acetabulum

Figure 5.2: Outer Edge activity on Acetabular Fossa

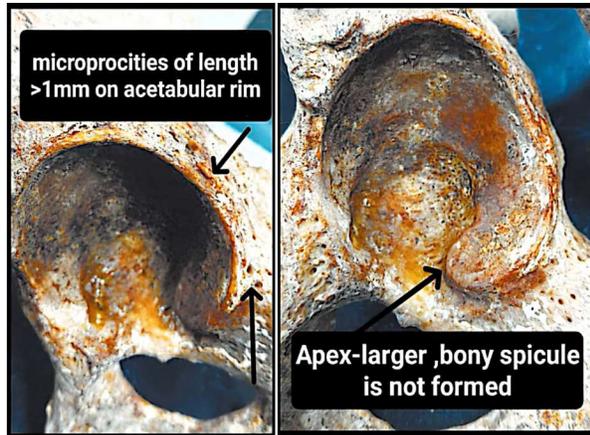


Figure 5.3: Acetabular Rim Porosity



Figure 5.4 Apex Activity



Figure 5.5: Foam Acetabular Fossa

1. Acetabular groove - Anatomical break between the acetabular rim and lunate surface are short and shallow (stage of variable-2) mean age - 48.04
2. Acetabular rim shape - It loose its smoothness, rough acetabular surface due to presence of little groove (stage of variable-2), mean age -45.15
3. Acetabular rim porosity – Some microporosities of length >1mm, on the acetabular rim with no bony destruction, rim is round and dense in appearance, (stage of variable - 2), mean age -37.84
4. Apex activity – Larger, bony spicules is is not formed, rough on touch due to presence of little grooves (Stage of variable-I), mean age - 39.09

5. There isn't any osteophytic growth extending from the acetabular fossa's outer edge toward or parallel to it, indicating activity on that area. (Stage of variable - 0) mean age - 45.15
6. Texture and bone density in the centre of the acetabular fossa - Shallow porosity, centre of acetabular fossa still remains dense and smooth, porosity is shallow (stage of variable - 1), mean age - 42.85
7. Activity in acetabular fossa - Swollen porosity is found, located at the periphery surrounding its outer edge on the lunate surface porotic, bulky shiny, it looks like a foam acetabular fossa display a predominance of micropores. (Stage of variable - 1), mean age - 40.91

SCAPULA

On examination, Left scapula, acromium process appeared and fused (more than 20 years), coracoid process appeared and fused (15 years age), fusion at acromium and coracoids epiphysis complete (age of 20 years) and medial border of epiphysis is also complete. Medial border unites with inferior angle (complete at 20-23 years of age). Therefore age is more than 23 years.⁽¹²⁾

The last scapular epiphysis union are associated with medial border and inferior angle, this appear at 15-17 years, fusion completed by (23 years) average age (20-23 years), therefore all scapular epiphysis fused and full adult form achieved by the age of 23 years⁽¹²⁾, Figure 6.



Figure 6: Scapula

FOURTH RIB

On examination, medial end of 4th rib showing U shaped pit, fairly thin wall (stage 3-mean age - 39.22 years), pit depth is 3.8mm (stage 3 mean age - 38.00 years), rim and wall configuration characteristics are definite visible thick walls which is smooth with a scalloped or slightly wavy form. (stage - 3 mean age - 36.81 years), total component score - 3+3+3=9, mean age group of 40.73 years. As per iscan and colleagues component analysis in 1984.

As per age of 4th rib was 40.73 years of age.⁽¹⁶⁾, Figure 7.



Figure 7: Medial end of 4th RIB (U Shaped PIT)

SKULL

Skull shows – posterior 1/3rd sagittal suture endocranially and ectocranially fused (30-40 years of age), middle 1/3rd sagittal suture is not fused, anterior 1/3rd is partially fused endocranially and not fused ectocranially (30-40 years), masto-occipital suture not fused, lambdoid suture partially fused and not completely fused (30 years of age), basiocciput fuse with basisphenoid sutures (22 years of age). Age of skull is more than 40 years of age⁽¹⁷⁾, Figure 8.1-8.2.



Figure 8.1: Skull



Figure 8.2: Skull

STERNUM

On observation, xiphisternum part is missing from sternum, xiphisternum to midsternal joint is not fuse, <45 years of age. Body of sternum has four sternebra, all sternebra fuse with each other 1st and 2nd sternebra fuse at the age of 25 years of age, Manubrium sterni not fuse with body of sternum <60 years of age, age of sternum – above >25 years of age but below 45 years of age.⁽¹²⁾, Figure 9.

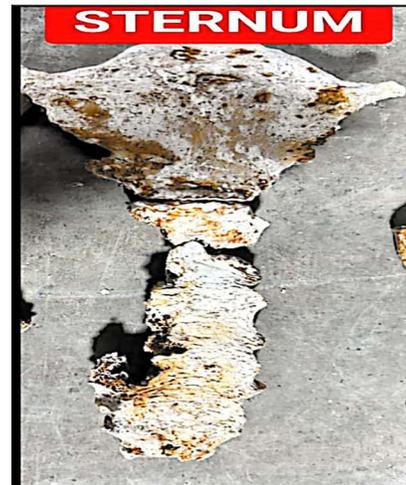


Figure 9: Classification, Manubrium Sterni not Fuse with body of Sternum

CONCLUSION

The morphological changes in the set of bones mentioned above are thought to be a more accurate way to estimate age. According to sternum bone, people are 25–45 years old. According to the clavicle, full epiphyseal fusion happens at age thirty. According to the fourth rib, the mean age group is approximately 40 years old. In this instance, a skull scan reveals an age of above 40. The ilium's articular surface falls within the mid-age range, which is roughly 40–44 years old. According to this case study, acetabulum age ranges from 40 to 45 years. Based on the post-mortem study of the aforementioned collection of bones, we determined that the deceased's age should have been between 40 and 45 years old. The acetabulum, pubic symphysis, and fourth rib exhibit the most consistent alterations for this age group.

Ethical approval: Ethically approved by institutional ethical committee

Conflict of interest: No

Funding body: None

REFERENCES

1. Moraitis K., Zorba E., Eliopoulos C., *et al.* A Test of the Revised Auricular Surface Aging Method on a Modern European Population. *J Forensic Sci.* 2014; 59(1): 2014, 188-194.
2. Cerezo R.J.I., Hernández E.P.O. Estimating age at death using the sternal end of the fourth ribs from Mexican males. *Forensic Sci Int.* 2014; 236: 196.1-196.
3. Loth S.R., Iscan M.Y. Morphological age estimation. In: Seigal J., Knupfer G., Editors. *Encyclopedia of forensic sciences.* 2010.
4. Pickering R., Bachman D. The use of forensic anthropology. 2009: 1.
5. Anderson M.F., Anderson D.T., Wescott D.J. Estimation of Adult Skeletal Age-at-Death Using the Sugeno Fuzzy Integral. *Am J Physical Anthropol.* 2010; 142(1): 30-41.
6. Passalacqua N.V. Forensic age-at-death estimation from the human sacrum *J Forensic Sci.* 54 (2) (2009), pp. 255-262.
7. Black S., Scheuer B. Age changes in the clavicle: from the early neonatal period to skeletal maturity *Int J Osteoarchaeol*, 6 (1996), pp. 425-43.
8. Meijerman L., Maat G.J.R., Schulz R., Schmeling A. Variables affecting the probability of complete fusion of the medial clavicular epiphysis *Int J Leg Med*, 121 (2007), pp. 463-468.
9. Scheuer L. and Black S. Illustrations by Angela Christie, *Developmental Juvenile Osteology*, elsevier academic press, copyright 2000, the pectoral girdle, the clavicle p. 251.
10. Singh J., Chavali K.H. Age estimation from clavicular epiphyseal union sequencing in a Northwest Indian population of the Chandigarh region, *Journal of Forensic and legal medicine*; 18(2011).
11. Scheuer L. and Black S. Illustrations by Angela Christie, *Developmental Juvenile Osteology*, elsevier academic press, copyright 2000. The Thorax, The Ribs and Costal Catilages pp. 231-242.
12. Aggrawal A. *Textbook Of Forensic Medicine and Toxicology*, 2nd edition, Avichal publication 2021; Identification, sternum; pp. 81-82.
13. Truesdell J., *The Composite Method: A Novel, Continuum-Based Approach to Estimating Age from the Female Pubic Symphysis with Particular Relevance to Mature Adults*; *Forensic Sci.* 2023, 3(1), 94-119; <https://doi.org/10.3390/forensicsci3010009>
14. Priya E. Methods of skeletal age estimation used by forensic anthropologists in adults: a review. *Forensic Res Criminol Int J.* 2017; 4(2): 41-51. DOI: 10.15406/frcij.2017.04.00104
15. Martha San Millan, Carme Rissech, *et al*, New approach to age estimation of male and female adult skeletons based on the morphological characteristics of the acetabulum; *Int J Legal Med.* 2017 Mar; 131(2): 501-525. doi: 10.1007/00414-016-1406-4. Epub 2016 Jun 30.
16. Meena M.C., Rani Y. Age estimation from the IV rib by the components method in Indian males, *Australian Journal of Forensic Sciences* Received 02 Feb 2014, Accepted 02 Feb 2014, Published online: 20 Mar 2014: Pages 463-470.
17. Aggrawal A. *Textbook of Forensic Medicine and Toxicology*, 2nd edition, Avichal publication 2021; Identification, Ossification center during IU life; p. 89.