
Investigative Frontiers Integration of Science Transforming Criminal Investigation

Year: 2026

Decoding the Silent: Forensic Anthropology and the Identification of Human Remains

Ms. Ranu Pure¹

¹Assistant Professor Department of Forensic Science Oriental University, Indore, Madhya Pradesh

Abstract

Forensic anthropology is an essential component of the scientific identification of the unknown human remains in criminal and humanitarian investigations using osteological, biological and medico-legal principles. This review emphasizes the importance of forensic anthropology in the interpretation of skeletal remains to determine identity when other identification methods are inadequate or unavailable. It covers biological profile development by sex, age at death, stature estimation, and population affinity estimation and the role of individual skeletal features in personal identification. The review also covers the state-of-the-art identification methods such as radiographic comparison, computed tomography (CT), three-dimensional (3D) imaging, craniofacial superimposition, DNA analysis and new developments of artificial intelligence and digital anthropology. Recent technological developments, current challenges and future directions in forensic anthropology are also included in the discussion, highlighting the ongoing development of forensic anthropology as an essential field for the accurate and scientifically valid human identification.

Keywords; Forensic anthropology; Human identification; Biological profile; Skeletal remains; Digital forensic technologies.

¹ ISBN No. - 978-93-7640-081-2

1 Introduction

The term "Decoding the Silent" refers to the main focus of forensic anthropology which is to decipher the human remains and determine what they are and the events of their life and death. Human remains can be described as silent witnesses because, though they cannot speak for themselves, bones and teeth document life history and biological characteristics in a permanent record that can be examined and analyzed. When the soft tissue is missing or significantly decomposed, skeletal evidence can give investigators the information needed to determine sex, age at death, stature, population affinity, pathological conditions and any evidence of trauma to be used in the process of determining identity and reconstructing events. As a result, human remains are a long-lasting source for forensic evidence that are able to provide information beyond the time of death.²

Forensic anthropology is an applied field of anthropology and human osteology that uses the principals of biological anthropology, human osteology, anatomy, archaeology and related disciplines to recover, examine and interpret human skeletal remains for legal purposes. It is its main purpose to support medicolegal investigations, determining whether the recovered remains are human, contributing to the development of a biological profile, and assessing the skeletal trauma, when possible, as well as the post mortem interval, and providing in the identification of unknown individuals. The use of advances in imaging technologies, 3-D modelling, and molecular techniques has also broadened the field of forensic anthropology and can now improve the precision and reliability of the skeletal analysis with multidisciplinary and inter-institutional collaboration.³

Criminal investigations, disaster victim identification, humanitarian missions and missing persons investigations all require the identification of unidentified human remains. The establishment of identity helps law enforcement to reconstruct criminal events, assist in court cases and helps families to find answers to the fate of their missing relatives, thereby performing an important legal, humanitarian and social role. Forensic anthropologists collaborate with forensic pathologists, odontologists, DNA specialists, and other experts to aid in the systematic identification of victims in mass fatality events involving natural disasters, transportation

² A. Dahal, D. McNevin, M. Chikhani, and J. Ward, "An interdisciplinary forensic approach for human remains identification and missing persons investigations," *WIREs Forensic Sci.*, pp. 1–34, 2023, doi: <https://doi.org/10.1002/wfs2.1484>.

³ D. C. Dirkmaat, L. L. Cabo, S. D. Ousley, and S. A. Symes, "New Perspectives in Forensic Anthropology," *Yearb. Phys. Anthropol.*, vol. 52, pp. 33–52, 2008, doi: 10.1002/ajpa.20948.

accidents, armed conflict, or terror attacks. Forensic anthropology will continue to play an integral part in the interpretation of the "silent" evidence contained within the human remains and developing new conclusions from the skeletal evidence as forensic technologies advance.⁴

2 Role of Forensic Anthropology in Human Identification

Forensic anthropology is an essential part of the scientific process of identification of unknown human remains based on the principles of biological anthropology and skeletal biology in a medicolegal context. The main focus of the discipline is on the examination of the remains that are not sufficiently assessed by conventional forensic pathology, such as decomposed, burned, fragmented or skeletonized remains. Forensic anthropologists use the scientific method to evaluate skeletal remains and offer objective scientific data to law enforcement, forensic pathologists, disaster victim identification teams, and courts to help determine identity and the circumstances of death.⁵

A. Responsibilities of Forensic Anthropologists

Forensic anthropologists have duties that are not limited to the lab setting; they also take part in the investigation process. They help to recover, document, preserve, and examine skeletal remains and preserve evidentiary integrity. Their main responsibilities include identification of human remains, creation of a bio-profile, detection of skeletal abnormalities and trauma, estimation of post mortem interval where possible, and giving expert opinion during court proceedings. Accurate and scientifically-based identifications relies on the cooperation of forensic pathologists, odontologists, DNA analysts and crime scene investigators.

B. Recovery and Examination of Skeletal Remains

The recovery of skeletal remains must be carefully excavated to preserve anatomical relationships and associated evidence and must be well documented. After recovery, the remains are meticulously examined in the laboratory, including a list of the bones recovered, condition of the bones, presence of disease, and injuries caused by trauma. Analytical techniques are

⁴ D. H. D. Souza and V. R. Vaswani, "Establishing Forensic Anthropology Units in Indian Medical Colleges: From Theory to Praxis," *J. Indian Acad. Forensic Med.*, 2026, doi: 10.1177/09710973261444076.

⁵ H. H. de Boer et al., "Strengthening the role of forensic anthropology in personal identification: Position statement by the Board of the Forensic Anthropology Society of Europe (FASE)," *Forensic Sci. Int.*, vol. 315, p. 110456, 2020, doi: <https://doi.org/10.1016/j.forsciint.2020.110456>.

standardized so that observations of the skeletal remains are reproducible and can be compared to antemortem records or to reference collections of skeletons for future reference.⁶

C. Distinguishing Human from Non-Human Remains

The first job of a forensic anthropologist is to decide if the remains are of a human being or non-human. This distinction is made by analysing the morphology of the skeleton, size of the bones, anatomical features and microscopic structures. Preventing unnecessary forensic investigations and directing medicolegal resources toward true human cases, through correct identification.

D. Establishing Medicolegal Significance

Not every recovered skeletal remains will need Forensic Investigation. The remains are assessed for their context, preservation, estimated post mortem interval and trauma to determine if the remains have Medicolegal significance. This assessment enables the distinction of modern forensic from archaeological/historical burials, and determines the legal and investigative action to be taken.⁷

E. Contribution of Anthropological Evidence in Narrowing Missing-Person Searches

Anthropological evidence is crucial to narrowing down investigations of missing persons, as it can produce a biological profile which provides information such as sex, age, stature and population affinity. These factors narrow down the number of possible matches before confirmation by dental records, by looking at the X-rays, or by DNA testing. Combined with missing-person databases and other forensic evidence, skeletal analysis gives investigators valuable clues to help them identify the missing individuals as quickly and accurately as possible and provides long-awaited answers for families.

3 Biological Profile: The Foundation of Skeletal Identification

The construction of a biological profile represents the cornerstone of forensic anthropological identification. Forensic anthropologists analyze biological traits preserved in the skeleton systematically to provide information which can help eliminate some of the possible identities when the remains are found. A biological profile is not a positive identification, but rather

⁶ M. Concato et al., “Forensic Analysis of Skeletal Remains Recovered from the Second World War Mass Grave of Ossero: From Biases to Uncertainties,” *Forensic Sci.*, pp. 1–17, 2026, doi: <https://doi.org/10.3390/forensicsci6010021>.

⁷ C. Bailey and G. Vidoli, “Age-at-Death Estimation: Accuracy and Reliability of Common Age-Reporting Strategies in Forensic Anthropology,” *Forensic Sci.*, pp. 179–191, 2023, doi: <https://doi.org/10.3390/forensicsci3010014>.

provides demographic and personal characteristics to use to compare to missing person records, medical histories, dental records, and DNA. The use of biological profiling is one of the most useful techniques in modern forensic investigations, with the reliability of the technique enhanced by advances in osteological research, imaging technology and population-specific reference standards.⁸

A. Sex, Age-at-Death, Stature, and Population Affinity Estimation

The biological profile is composed of the estimation of sex, age at death, stature, and population affinity. The most reliable element is generally the sex determination which is based on the sexually dimorphic features of the pelvis and skull, with the pelvis being the most accurate in adult skeletons. The changes in skeletal development and degeneration that are observed in the teeth, pubic symphysis, auricular surface of the ilium, cranial suture closure, rib morphology and other features are used to estimate age at death. Stature is calculated using population-specific regression equations developed for long bones of the skeleton (femur, tibia, humerus and radius). Increasingly preferred over the traditional concept of ancestry is the term "population affinity," which is evaluated by craniofacial morphology and skeletal measurements that reflect human biological variation. Modern forensic anthropology has since recognized that population affinity is a probabilistic statement and should be treated with great care in conjunction with other identifying data.⁹

B. Individual Skeletal Variations and Pathological Conditions

In addition to demographic features, the skeleton shows signs of anatomical differences among individuals, healed fractures, congenital anomalies, surgical implants, degenerative joint diseases, occupational stress markers and pathological conditions. These distinctive skeletal characteristics can match with the antemortem medical documentation and/or the radiographs, further adding to identification. The high level of individual-specificity is particularly important for dental restorations, orthopedic devices and certain previous surgical interventions.

⁸ S. M. Alaydrus, D. A. A. Nasution, A. T. Hidayatullah, H. S. Bachri, H. J. Kartika, and M. D. Artaria, "Biological Profile Estimation Of Five Skeletal Remains In Patiayam, Indonesia," *Rom J Leg Med*, pp. 133–140, 2026, doi: 10.4323/rjlm.2026.133.

⁹ D. Navega, E. Costa, and E. Cunha, "Adult Skeletal Age-at-Death Estimation through Deep Random Neural Networks: A New Method and Its Computational Analysis," *Biology (Basel)*, vol. 11, no. 532, 2022, doi: <https://doi.org/10.3390/biology11040532>.

C. Importance and Limitations of Biological Profiling

In missing person cases, biological profiling offers investigators scientifically valid estimates that greatly narrow the search for missing persons and help direct further test work. Such estimates, however, are subject to the effects of diversity of the population, skeletal age variation with age, preservation of the remains, and methodological limitations. Therefore, the biological profile must be used as a probabilistic, not definitive, test of identity and is best used in combination with forensic odontology, DNA analysis, radiographic comparison and contextual investigative information.¹⁰

4 Advanced Methods Supporting Identification of Human Remains

Forensic anthropological investigations have been greatly improved by technological developments in terms of accuracy, efficiency and reliability. While traditional osteological examination is the backbone of skeletal identification, various imaging modalities, molecular biology and computational technology offer complementary data that can enhance identification results. Such sophisticated techniques are useful in situations where traditional methods are inadequate, such as when the remains of humans are broken or burned, decomposed, or very degraded. The fusion of anthropological observations, radiological, genetic and digital analysis can provide more complete and scientifically sound identification for forensic experts.¹¹

- **Radiographic Comparison:** Radiographic comparison is a technique that has been used successfully for years to help identify identity by comparing post-mortem photographs of any skeletal remains with antemortem medical photographs. The anatomical characteristics are very individualizing, like healed fractures, dental restorations, orthopedic implants, congenital skeletal anomalies, degenerative joint changes. It is a non-destructive method that is particularly useful when fingerprints or soft tissues are missing and is an important part of disaster victim identification and missing person identification.
- **CT and 3D Imaging:** The use of computed tomography (CT) and three dimensional (3D) imaging has revolutionised the field of forensic anthropology, allowing detailed images of the human skeleton to be seen without causing harm. Higher resolution computed tomography (CT) imaging enables investigators to analyze the internal

¹⁰ L. Cainé et al., “Genetic Identification of Human Skeletal Remains in Forensic Context: A Review,” *Genes* (Basel), pp. 1–30, 2026, doi: <https://doi.org/10.3390/genes17040492>.

¹¹ P. R. Kulkarni and J. P. S. C., “Role Of Forensic Anthropology In Personal Identification,” *Indian J. Appl. Res.*, pp. 11–13, 2021, doi: 10.36106/ijar.

structure of bones, identify minor fractures and digitally re-assemble portions of the skeletal structure. Three-dimensional surface scanning and virtual reconstruction create the possibility of precise metric analyses, skeletal reconstruction and permanent digital documentation, which enhances the reproducibility and safeguards the fragile forensic evidence.¹²

- **Craniofacial Superimposition:** The technique of superimposing a picture of the missing person over the recovered skull, and evaluating the anatomical correspondence, is called craniofacial superimposition. This technique is more objective than previous manual approaches because of modern digital software that aid in image alignment and anatomical comparison. It is important to note however, that craniofacial superimposition is not a tool that can prove identity on its own, but rather is a tool that can be used to aid in the investigation and subsequent identity confirmation.¹³
- **DNA-Assisted Identification from Bones and Teeth:** The study of DNA has become one of the most effective forms of positive human identification, especially when the skeletal remains are partial and/or heavily degraded. Nuclear and mitochondrial DNA can be preserved in bones and teeth for a long time after exposure to the environment and can be compared to biological relatives or to reference samples. DNA profiling, along with anthropological work, substantially improves the accuracy of the forensic identification in a criminal investigation, mass disaster and humanitarian recovery operation.
- **Digital Technologies, Artificial Intelligence, and Machine Learning in Forensic Anthropology:** Forensic anthropology is now increasingly being used in the field of research, thanks to recent advances in digital technologies, artificial intelligence (AI), and machine learning. The use of image analysis, automated skeletal measurements, estimated biological profile and pattern recognition algorithms enhances the analytical efficiency and decreases observer variation. Multidisciplinary collaboration and standardization are also facilitated by digital databases, virtual anthropology and cloud-based data sharing. While these technologies are still developing they can be used

¹² B. Coletti, G. Formichella, C. Zeppilli, A. Profico, G. Manzi, and I. Micarelli, "3D imaging dataset of the human skeletal collection from Lucus Feroniae (Rome, Italy, 1st-3rd century CE)," *Data Br.*, vol. 64, p. 112325, 2026, doi: <https://doi.org/10.1016/j.dib.2025.112325>.

¹³ P. Martínez-moreno, A. Valsecchi, P. Mesejo, and Ó. Ibáñez, "Evidence evaluation in craniofacial superimposition using likelihood ratios," *Inf. Fusion*, vol. 111, p. 102489, 2024, doi: <https://doi.org/10.1016/j.inffus.2024.102489>.

alongside anthropological interpretation, and present potential for improved methods of identification of human remains that will be more accurate and efficient.

5 Recent Advances and Challenges in Forensic Anthropology

In recent decades, forensic anthropology has experienced significant transformation, including the incorporation of high-tech imaging technologies, computation, and a multi-disciplinary science. Such changes have increased the accuracy of skeletal analysis and extended the scope of the field in medicolegal investigations, disaster victim identification and in humanitarian forensic situations. Despite such progress, there still remain scientific and practical issues that relate to biological diversity, the degradation of bones in the environment and the lack of standardized analytical techniques that forensic anthropologists must face. However, further research and international cooperation are needed to increase the level of reliability and applicability of these techniques.

A. Recent Advances

The study and identification of human remains has greatly improved in recent years through the use of new technology. Three dimensional (3D) imaging or computed tomography (CT) based skeletal analysis allows non-destructive visualization of both external and internal skeletal structures, leading to the accurate reconstruction of fractured bones, virtual measurements and allowing evidence to be preserved and retained over time. These techniques help ensure repeatability, and also enable scientists to compare digital skeletal models between experts without harming the actual fossils. In parallel, the field of digital anthropology has become a very fast developing discipline combining virtual osteology, geometric morphometrics and computer-based skeletal databases. Artificial Intelligence (AI) and machine learning algorithms are being developed to automate skeletal measurements, to estimate biological profile parameters, to recognize anatomical patterns and to help with image interpretation. These technologies are still undergoing development, but they offer more efficiency in the analysis and can assist in objective and standardized forensic evaluations.¹⁴

B. Challenges

There are still a number of problems to be solved to improve the accuracy and universal use of forensic anthropology techniques. Skeletal remains with large gaps or pieces missing and/or commingled can make biological profile estimation difficult and limit the number of diagnostic

¹⁴ D. H. Ubelaker, "Recent advances in forensic anthropology," *Forensic Sci. Res.*, vol. 3, no. 4, pp. 275–277, 2018, doi: <https://doi.org/10.1080/20961790.2018.1466384>.

anatomical features available. Decomposition can be advanced and environmental exposure may be prolonged, which can impact bone morphology and may interfere with the preservation of DNA for identification. Reference standards for a particular population are another limitation, because many of the existing methods of estimation have been developed from geographically restricted skeletal collections and may not be equally applicable to other populations. Respect for human remains, responsible use of skeletal material, respecting personal information and cultural sensitivity to descendant communities will continue to be basic duties in forensic practice.¹⁵

C. Future Research Directions

Further studies are needed to create more global Skeletal Reference Collections, refine analytical models using AI, and test population-specific estimation techniques in various demographic populations. The enhanced use of forensic anthropology in combination with genomics, the high-quality use of advanced medical imaging and digital data-sharing platforms will further consolidate multidisciplinary identification strategies. Developing globally accepted standards and expanding the sharing of research will improve the scientific validity, repeatability and usefulness of forensic anthropology to human identification and medicolegal investigations.¹⁶

6 Conclusion

Forensic anthropology has evolved to be an essential part of contemporary forensic science, offering scientific procedures for the identification of unknown human remains in criminal, humanitarian and disaster-related investigations. Forensic anthropology involves the systematic examination of the skeletal remains to create biological profiles that can be used to help narrow the search for identity and assist confirmatory analysis with radiographs, dental remains and DNA. The incorporation of modern technologies, such as computed tomography (CT) imaging, three-dimensional reconstruction, digital anthropology and artificial intelligence, has greatly improved the level of accuracy, efficiency and repeatability of forensic investigations. However, problems related to the fragmentation of remains, the variability of populations, environmental degradation, as well as ethical issues remain to affect the results of analyses. Enabling future progress will rely on the evolution of comprehensive reference databases, standardised

¹⁵ E. E. Valera, "Forensic anthropology: challenges and scopes," *Forensic Res. Criminol. Int. J.*, pp. 16–18, 2024, doi: 10.15406/frcij.2024.12.00392.

¹⁶ A. Gruenthal-rankin, T. Somogyi, A. Roome, and E. A. Digangi, "Beyond the report: Prospects and challenges in forensic anthropological investigations of structural vulnerability," *Forensic Sci. Int. Synerg.*, vol. 6, p. 100315, 2023, doi: <https://doi.org/10.1016/j.fsisyn.2023.100315>.

international protocols and a multi-disciplinary approach. Forensic anthropology will continue to play a significant role in human identification as technology continually evolves and ever more complex, scientifically sound data will help with justice and humanitarian work and with the identification of missing persons.

7 Reference

- [1] A. Dahal, D. McNevin, M. Chikhani, and J. Ward, “An interdisciplinary forensic approach for human remains identification and missing persons investigations,” *WIREs Forensic Sci.*, pp. 1–34, 2023, doi: <https://doi.org/10.1002/wfs2.1484>.
- [2] D. C. Dirkmaat, L. L. Cabo, S. D. Ousley, and S. A. Symes, “New Perspectives in Forensic Anthropology,” *Yearb. Phys. Anthropol.*, vol. 52, pp. 33–52, 2008, doi: [10.1002/ajpa.20948](https://doi.org/10.1002/ajpa.20948).
- [3] D. H. D. Souza and V. R. Vaswani, “Establishing Forensic Anthropology Units in Indian Medical Colleges: From Theory to Praxis,” *J. Indian Acad. Forensic Med.*, 2026, doi: [10.1177/09710973261444076](https://doi.org/10.1177/09710973261444076).
- [4] H. de Boer et al., “Strengthening the role of forensic anthropology in personal identification: Position statement by the Board of the Forensic Anthropology Society of Europe (FASE),” *Forensic Sci. Int.*, vol. 315, p. 110456, 2020, doi: <https://doi.org/10.1016/j.forsciint.2020.110456>.
- [5] M. Concato et al., “Forensic Analysis of Skeletal Remains Recovered from the Second World War Mass Grave of Ossero: From Biases to Uncertainties,” *Forensic Sci.*, pp. 1–17, 2026, doi: <https://doi.org/10.3390/forensicsci6010021>.
- [1] Bailey and G. Vidoli, “Age-at-Death Estimation: Accuracy and Reliability of Common Age-Reporting Strategies in Forensic Anthropology,” *Forensic Sci.*, pp. 179–191, 2023, doi: <https://doi.org/10.3390/forensicsci3010014>.
- [6] S. M. Alaydrus, D. A. A. Nasution, A. T. Hidayatullah, H. S. Bachri, H. J. Kartika, and M. D. Artaria, “Biological Profile Estimation Of Five Skeletal Remains In Patiayam, Indonesia,” *Rom J Leg Med*, pp. 133–140, 2026, doi: [10.4323/rjlm.2026.133](https://doi.org/10.4323/rjlm.2026.133).
- [1] Navega, E. Costa, and E. Cunha, “Adult Skeletal Age-at-Death Estimation through Deep Random Neural Networks: A New Method and Its Computational Analysis,” *Biology (Basel)*, vol. 11, no. 532, 2022, doi: <https://doi.org/10.3390/biology11040532>.
- [7] L. Cainé et al., “Genetic Identification of Human Skeletal Remains in Forensic Context: A Review,” *Genes (Basel)*, pp. 1–30, 2026, doi: <https://doi.org/10.3390/genes17040492>.
- [8] P. R. Kulkarni and J. P. S. C., “Role Of Forensic Anthropology In Personal Identification,” *Indian J. Appl. Res.*, pp. 11–13, 2021, doi: [10.36106/ijar](https://doi.org/10.36106/ijar).

- [9] Coletti, G. Formichella, C. Zeppilli, A. Profico, G. Manzi, and I. Micarelli, “3D imaging dataset of the human skeletal collection from Lucus Feroniae (Rome, Italy, 1st-3rd century CE),” *Data Br.*, vol. 64, p. 112325, 2026, doi: <https://doi.org/10.1016/j.dib.2025.112325>.
- [10] P. Martínez-moreno, A. Valsecchi, P. Mesejo, and Ó. Ibáñez, “Evidence evaluation in craniofacial superimposition using likelihood ratios,” *Inf. Fusion*, vol. 111, p. 102489, 2024, doi: <https://doi.org/10.1016/j.inffus.2024.102489>.
- [11] H. Ubelaker, “Recent advances in forensic anthropology,” *Forensic Sci. Res.*, vol. 3, no. 4, pp. 275–277, 2018, doi: <https://doi.org/10.1080/20961790.2018.1466384>.
- [12] E. Valera, “Forensic anthropology: challenges and scopes,” *Forensic Res. Criminol. Int. J.*, pp. 16–18, 2024, doi: [10.15406/frcij.2024.12.00392](https://doi.org/10.15406/frcij.2024.12.00392).
- [13] Gruenthal-rankin, T. Somogyi, A. Roome, and E. A. Digangi, “Beyond the report: Prospects and challenges in forensic anthropological investigations of structural vulnerability,” *Forensic Sci. Int. Synerg.*, vol. 6, p. 100315, 2023, doi: <https://doi.org/10.1016/j.fsisyn.2023.100315>.