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# A Review: Role of X-rays, CT-scan, and Photographic Analysis for the Identification of Traumatic Injuries on Skeletal Remains in Forensic Anthropology

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## Abstract

An essential component of forensic investigations is forensic anthropology. Forensic Anthropology deals with the study of skeletal remains. When it comes to determining the cause of death and traumatic injuries, forensic anthropology is quite helpful. The investigation of several techniques for identifying traumatic injuries like blunt force trauma, sharp force trauma and gunshot wounds is the major topic of this study. These traumatic injuries are examined using various techniques. This study focuses on the detection of traumatic injuries on skeletal remains by the using visual examination, x-rays analysis, radiography, CT scans, and photography. Among all of these techniques, visual analysis is of great importance in forensic Anthropology because it offers comprehensive data for the investigation of traumatic injuries.

**Keywords:** Forensic Anthropology, Forensic Investigation, Death investigation, Traumatic injuries

## Introduction

Forensic anthropology is very important in crime scene investigation, especially when skeletal remains are involved. A key component of forensic anthropology is identifying traumatic injuries on skeletal remains, which can reveal important details about the circumstances of a person's death. A key component of forensic anthropology is identifying traumatic injuries on skeletal remains, which can reveal important details about the circumstances of a person's death. Traumatic injuries can result from a variety of causes, including gunshot wounds, blunt force trauma, and sharp force injuries. Forensic anthropology is a field that supports forensic pathology in the investigation of skeletal remains [1]. One of the most frequent injuries that forensic pathologists see in a range of situations, including transportation fatalities, explosion injuries, falling or jumping from heights, and being struck by hard objects, is blunt force trauma. Examining blunt force injuries in the skull is crucial to the medicolegal analysis of death since these injuries are frequently linked to the cause of death [2]. A forensic anthropologist's responsibilities include examining, characterizing, and perhaps linking bone injuries to the cause of death. Depending on where they occur, skeletal injuries fall into two categories: cranial and postcranial. Depending on the kind of injury (ballistic trauma, sharp force, and blunt force), a separate classification scheme applies. There are several types of craniofacial injuries, including depression, penetration, crushing, slashing, cuts, and slicing [3, 4].

Even though a lot of research focuses on the characteristics of blunt force impact, there is still a great deal of confusion surrounding the evaluation of trauma. The deposition environment, internal and exterior taphonomy processes, scavenger disruption following death, and relocation to secondary deposition sites are some of the variables that complicate the interpretation of skeletal trauma. A skeletal examination must take into account the probability of trauma-related alterations, which are raised by each of these causes. The principles of bone biomechanics that underpin these assessments stay constant, despite variations in the factors influencing the perception of trauma across different cases and even within components of the same skeleton [5].

The analysis not only enhances the field of forensic anthropology but also sheds light on the particular case. Forensic anthropology, a subfield of biological anthropology, studies human skeletons, highly degraded bodies, or body parts in order to identify human remains. Forensic anthropologists' primary responsibility is to identify individuals. In a medicolegal setting, forensic anthropologists perform trauma analysis, facial reconstruction, photo superimposition, determining the amount of time elapsed since death, and evidence recovery from the crime scene. Furthermore, more contemporary techniques like forensic genetics and histology have been applied to reconstruct the human diaspora and ascertain individual identities. A variety of techniques are used in forensic anthropology to locate and examine these wounds, and each one offers a different perspective on the type, extent, and possible origin of trauma [2, 6].

### Methods of Identification

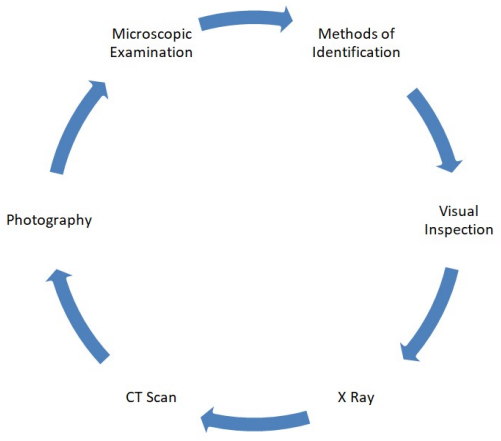


**Figure 1:** Graphical Representation

## Visual Inspection

Visual inspection is a foundational method for identifying traumatic injuries on skeletal remains in forensic anthropology. It involves a thorough examination of the skeletal elements for visible signs of trauma, such as fractures, dislocations, and penetrating injuries. This method relies on the expertise of the forensic anthropologist to recognize and interpret the various manifestations of trauma present on the bones. During visual inspection, the forensic anthropologist carefully examines the surface of each bone, looking for abnormalities, irregularities, or any deviations from the normal anatomical structure. This process may involve the use of magnification tools, such as magnifying lenses or microscopes, to enhance the visibility of subtle features [7, 8, 9].

Different types of traumatic injuries exhibit distinct characteristics that can be identified through visual inspection. For example:

**1. Blunt Force Trauma:** This type of trauma often results in fractures characterized by features such as irregular margins, comminution (broken bone fragments), and impacted or depressed regions of the bone surface. Visual inspection can reveal these fracture patterns, providing insights into the force and direction of the impact [2, 10].

**2. Sharp Force Injuries:** Sharp force injuries, caused by objects with sharp edges or points, produce distinctive incised or stab wounds on the bone surface. Visual inspection allows forensic anthropologists to identify these injuries based on their linear or punctate nature, as well as the presence of associated features such as cut marks or striations [11, 12].

**3. Gunshot Wounds:** Gunshot wounds leave characteristic entry and exit defects on the bones, which can be identified through visual inspection. Entry wounds typically exhibit a circular or ovoid shape with beveled margins, while exit wounds may appear more irregular and exhibit signs of bone fragmentation or radial fractures [13, 14].

## X-rays and Radiography

X-rays and radiography are very important methods used in forensic anthropology for identification of traumatic injuries on skeletal remains. In 1984, Radiology department and the chief medical examiner of Commonwealth of Massachusetts's office started a project to provide detailed histopathological as well as radiological analysis of skeletal injuries in the cases of abuse. Initial reports of their findings have been published previously [15]. The removed bone specimens were radiographed in different projections using direct exposure high-detail film in a specimen X-ray equipment. The samples underwent a series of procedures including formalin fixation, decalcification, radiographic sectioning in the proper planes, and hematoxylin and eosin staining. This imaging technique utilizes Xray radiation to penetrate the bone, producing detailed images that allow forensic anthropologists to visualize internal structures and detect abnormalities, including fractures, foreign objects, and other signs of trauma .X-rays and radiography offer several advantages in the analysis of skeletal remains and both blunt force and sharp force traumatic injuries. Traumatic injuries on the chest can be accurately analyzed by the help of x-rays and radiology [16-19].

**1. Detection of Fractures:** X-rays are highly effective in detecting fractures in bones, including both complete and incomplete fractures. Fracture lines appear as interruptions in the bone's density on the Xray images, providing precise information about the location, orientation, and severity of the fracture [20].

**2. Documentation of Trauma:** Radiography enables forensic anthropologists to document traumatic injuries systematically. By capturing Xray images from multiple angles, they can accurately assess the extent and distribution of trauma throughout the skeletal elements, aiding in the reconstruction of the events leading to an individual's death [20].

**3. Visualization of Foreign Objects:** In cases involving penetrating trauma, such as sharp force injuries or gunshot wounds, X-

rays can help identify and localize foreign objects embedded in the bone. This information is crucial for determining the nature of the trauma and may provide valuable evidence for forensic investigations [21-23].

**4. Assessment of Healing:** X-rays can also be used to evaluate the healing process of fractures, providing insights into the timing and progression of traumatic injuries. By comparing Xray images taken at different time points, forensic anthropologists can assess the stage of healing and determine whether the trauma occurred antemortem (before death) or perimortem (around the time of death) [24, 25].

**5. Nondestructive Examination**: Unlike some other methods for examining skeletal remains, such as histological analysis, X-rays are nondestructive and do not require invasive procedures that could compromise the integrity of the evidence. This makes radiography an invaluable tool for preserving skeletal specimens while still obtaining detailed information about traumatic injuries [26].

## CT scans (Computed Tomography)

Computed Tomography (CT) scans that are also known as CT imaging or CAT scans (Computerized Axial Tomography), are very advanced medical imaging techniques used to provide cross-sectional images of the internal parts of the body, including organs, soft tissues, and bones. A combination of X-rays and Computer technology is used in CT scans to create cross-sectional images of the body. Forensic anthropologists and pathologists use this technique to evaluate pattern of skeletal fractures for the assessment of the type of traumatic injuries (i.e blunt, sharp, or projectile). Apart from the assessment of the type, different aspects of trauma such as direction, magnitude and the timings of the event can also be evaluated by the help of CT scans. CT scans focused on the analysis of the pattern of fracture in bone including shape of the fragment [27-29].

**1. Xray Beams:** A CT scan involves placing the patient's body on a table that slides inside a device that resembles a doughnut. An X-ray tube inside the CT scanner spins around the patient to produce small X-ray beams.

**2. Detectors:** Detectors are present opposite to the X-rays that are used to measure the intensity of the rays that are passing through the body.

**3. Data Collection:** As the Xray tube rotates around the body, multiple Xray images are captured from various angles. The detectors record the intensity of the X-rays that passes through the body at each angle.

**4. Computer Reconstruction**: The collected data is sent to a computer attached to the CT scan machine, it processes the data by using specialized algorithms and reconstructs slices or the cross-sectional 3D photographs of the body. These cross-sectional photographs provide a detailed overview of the internal parts, including blood vessels, bones, organs as well as soft tissues [30].

**5. Image Interpretation:** The resulting CT images are typically displayed on a computer monitor, allowing radiologists and other healthcare professionals to examine them in detail. CT scans can reveal a wide range of conditions, including fractures, tumors, internal bleeding, infections, and other abnormalities. CT scans offer several advantages over traditional X-rays, including [30].

**6. Enhanced Resolution:** CT scans provide detailed, high-resolution images that offer greater clarity and precision compared to conventional X-rays.

**7. Cross-sectional Views:** CT scans provide detailed cross-sectional images of the body, which allows the healthcare professionals to observe internal structures from multiple angles.

**8. Versatility:** CT scans can be used to examine various parts of the body, making them valuable diagnostic tools in numerous medical specialties, including radiology, oncology, neurology, and orthopedics.

**9. Rapid Imaging:** CT scans are relatively quick to perform, with the entire process typically taking only a few minutes.

## Photography

Photography, in the context of identifying traumatic injuries on skeletal remains, involves capturing high-resolution images of the bones from various angles and perspectives. These images serve as visual documentation of any visible signs of trauma present on the skeletal remains. Photography is an essential tool in forensic anthropology and pathology because it allows for detailed examination and analysis of skeletal features without the need for direct physical manipulation of the remains. Here's how photography is typically utilized in this process [31, 32].

**1. Documentation**: Photographs provide a permanent record of the condition of the skeletal remains at the time of examination. They capture details that might be missed during initial observation and serve as a reference for further analysis [33].

**2. Visualization:** High-quality photographs enable forensic experts to zoom in on specific areas of interest and examine them in detail. This allows for the detection of subtle injuries or abnormalities that may not be immediately apparent during a cursory examination.

**3. Comparison:** Photographs allow for easy comparison between different skeletal elements or between the remains and reference materials, such as medical textbooks or databases of known trauma patterns. This comparison aids in the identification and classification of traumatic injuries.

**4. Communication:** Photographs facilitate communication among forensic experts, investigators, and other stakeholders involved in the investigation. They provide a visual means of conveying findings, interpretations, and conclusions regarding the nature and extent of traumatic injuries present on the skeletal remains.

## Comparison of methods of identification of traumatic injuries

### 1. Visualization

### Advantages

With this method one can easily visualize the injuries at the crime scene.

### Disadvantages

Detailed observation and extent of the traumatic injuries cannot be done with this method.

### 2. X-rays and Radiography

### Advantages

By capturing X-rays images from multiple angles, they can accurately assess the extent and distribution of trauma throughout the skeletal elements, aiding in the reconstruction of the events leading to an individual's death.

X-rays can help identify and localize foreign objects embedded in the bone.

Healing process can also be observed through X-rays analysis.

### Disadvantages

### Limited details of soft tissues

Conventional radiographs are very useful in identifying campaigns and other bony structures in the body but lack sensitivity in diagnosis of soft tissue structures such as muscles, ligaments, and organs [34].

### Radiation exposure

Although the amount of radiation used in a single X-ray is small, if the images are accumulated or if high dose examinations are employed, the risk of radiation induced diseases including cancers will be higher [35, 36].

### Lack of assessment of joint injuries

Injuries of the joint or ligament can also not be diagnosing using X-rays. These types of injuries, especially if complicated, may require MRI or CT scans to give a better picture [37].

### Lack of evaluation of functional impact

X-rays are still images and do not look at how the area of the trauma may function or the dynamic changes that occur in that area.

## 3. CT scans

### Advantages

CT scans offer detailed skeletal views, which are essential in diagnostics with regards to fractures, injuries, and disease. They can help to identify cracks and other bone injuries which may not be seen on an X-ray picture [38].

CT scans provide 3D images of the injuries which can be observed from different angles [39].

Especially, it is very useful in the analysis of injuries where complex structures are involved [40].

### Disadvantages

It is very expensive and it requires special instrumentation for the analysis.

This method of analysis is time consuming and not readily available in all forensic analysis.

Higher radiation penetration compared to regular X-rays.

## Photography

### Advantages

Photographic analysis is easily available in every traumatic analysis.

Photographs can be presented in the court for the visual references.

Proves useful in explaining the circumstances prevailing at the time of the injuries as well as the general state of the skeletal system (Shamata and Thompson 2018).

### Disadvantages

Photographic analysis provides surface documentations as it cannot capture the internal parts of injuries

The quality of the photographic analysis depends upon the quality of camera used and the lightening source available at the scene.

Interpretation and analysis of the photographs depends upon their quality and resolution

## Selection of methods based on injury, state of remains and Resources

The type of method for the analysis of traumatic injuries depends upon various factors including the type of injury, state of remains and available resources.

### I. Type of Injury and method of analysis

In severe cases of fracture or dislocation simple visualization method in addition to plain X-ray radiograph may be adequate [42]

Microscopic changes in the bone tissue or other concealed damage can only be revealed with the help of a CT scan [42, 43]

Surface injuries can be analyzed by the help of photography.

### II. State of remains and method of analysis

For cases involving decomposed and fragmented remains, CT scans may be more advantageous than conventional x-rays since they make it possible to reconstruct and study the bones in a three-dimensional manner [44].

Remains which are well preserved can easily be analyzed by the help of visualization and X-rays analysis.

### III. Resources and methods of analysis

If the high resources are available then CT scans are preferred for the detailed analysis.

If the resources are limited then Visual inspection and X-rays analysis is used.

## Limitations of Methods

There are the following limitations of each method.

- Visual inspection and photography are limited to the surface and due the observer's eyesight, microscopic details can be missed
- The resolution of X-rays is lower than CT scans and fine details can remain unnoticed.
- CT scan analysis is the costliest and requires specialized techniques and persons for the interpretation of results.

- Effectiveness of Photographic analysis is highly subjected to the quality and resolution of photographs
- In X-rays and CT scan analysis, radiations are involved which can be dangerous for the human being.
- All these methods used for the analysis of traumatic injuries require experts for their use and interpretation.

## Conclusion

All of the above discussed methods for the identification of traumatic injuries are of great importance but visual examination is a critical method used in forensic anthropology and forensic pathology to visually inspect skeletal remains for signs of trauma, pathology, and other relevant features. Through careful observation of bone surfaces, forensic experts can identify fractures, dislocations, lesions, wear patterns, and postmortem alterations that provide valuable insights into the individual's life history and circumstances surrounding their death. This initial examination serves as a foundation for further analysis and interpretation, guiding subsequent investigations using techniques such as radiography, microscopy, comparative analysis, and chemical testing. By integrating visual examination with other forensic methods, professionals can effectively reconstruct events leading to death and contribute to the resolution of legal inquiries and criminal investigations.

## References

1. Love JC, JM Wiersema (2016) Skeletal trauma: an anthropological review." Academic forensic pathology, 6: 463-77.

2. Kranioti EF (2015) Forensic investigation of cranial injuries due to blunt force trauma: current best practice. Research and Reports in Forensic Medical Science, 25-37.

3. Passalacqua NV, TW Fenton (2012) Developments in skeletal trauma: blunt-force trauma. A companion to forensic anthropology: 400-11.

4. Blau S (2017) How traumatic: a review of the role of the forensic anthropologist in the examination and interpretation of skeletal trauma. Australian journal of forensic sciences, 49: 261-80.

5. Thompson TJ (2005) Heat-induced dimensional changes in bone and their consequences for forensic anthropology. Journal of Forensic Sciences, 50: JFS2004297-2004298.

6. Zeiderman MR, LL Pu (2020) Contemporary reconstruction after complex facial trauma. Burns & Trauma 8: tkaa003.

7. Dedouit F et al. (2007) Virtual anthropology and forensic identification: report of one case. Forensic science international, 173: 182-7.

8. Symes SA et al. (2012) Interpreting traumatic injury to bone in medicolegal investigations." A companion to forensic anthropology: 340-89.

9. Franklin D et al. (2016) Virtual anthropology'and radiographic imaging in the Forensic Medical Sciences. Egyptian Journal of Forensic Sciences, 6: 31-43.

10. Wedel VL, A Galloway (2013) Broken bones: anthropological analysis of blunt force trauma, Charles C Thomas Publisher.

11. Symes SA et al. (2001) Taphonomic context of sharp-force trauma in suspected cases of human mutilation and dismemberment. Advances in forensic taphonomy, CRC Press: 403-4.

12. Smith AC (2014) The effects of sharp-force thoracic trauma on the rate and pattern of decomposition. Journal of Forensic Sciences, 59: 319-26.

13. Langley NR (2007) An anthropological analysis of gunshot wounds to the chest." Journal of Forensic Sciences, 52: 532-7.

14. Berryman HE et al. (2013) Basic gunshot trauma interpretation in forensic anthropology. Forensic anthropology: An introduction, 291-306.

15. Michael S et al. (2009) The Commonwealth of Massachusetts.

16. Hardy M, C Barrett (2003) Interpreting trauma radiographs. Journal of Advanced Nursing, 44: 81-7.

17. Martín JA et al. (2015) Radiology and imaging techniques in severe trauma. Medicina Intensiva (English Edition), 39: 49-59.

18. Agladioglu K et al. (2016) Chest X-rays in detecting injuries caused by blunt trauma." World journal of emergency

medicine, 7: 55.

19. Tataroglu O, et al. (2018) Diagnostic accuracy of initiai chest x-rays in thorax trauma. J Coll Physicians Surg Pak, 28: 546-8.

20. Myint WW et al. (2018) Analysis on leg bone fracture detection and classification using X-ray images." Machine Learning Research, 3: 49-59.

21. Russell RC et al. (1991) Detection of foreign bodies in the hand. The Journal of hand surgery, 16: 2-11.

22. Faguy K (2014) Imaging foreign bodies. Radiologic Technology, 85: 655-82.

23. Roy S, K Santosh (2023) Analyzing overlaid foreign objects in chest X-rays—clinical significance and artificial intelligence tools. Healthcare, MDPI.

24. Whelan DB et al (2010) Development of the radiographic union score for tibial fractures for the assessment of tibial fracture healing after intramedullary fixation. Journal of Trauma and Acute Care Surgery, 68: 629-32.

25. Farracho LC et al. (2020) Determining diagnosis of scaphoid healing: comparison of cone beam CT and X-ray after six weeks of immobilization. European journal of radiology open, 7: 100251.

26. Hardy WN et al. (2001) Investigation of head injury mechanisms using neutral density technology and high-speed biplanar X-ray, SAE Technical Paper.

27. Dedouit F et al. (2014) Virtual anthropology and forensic identification using multidetector CT. The British journal of radiology, 87: 20130468.

28. Garvin HM, MK Stock (2016) The utility of advanced imaging in forensic anthropology. Academic forensic pathology, 6: 499-516.

29. Colman KL et al. (2019) Virtual forensic anthropology: the accuracy of osteometric analysis of 3D bone models derived from clinical computed tomography (CT) scans. Forensic science international, 304: 109963.

30. Patel PR, O De Jesus (2021) CT scan.

31. Zephro L, A Galloway (2019) Skull shots: Forensic photography for anthropologists." Forensic anthropology and the United States judicial system, 109-21.

32. Bulut Ö, A Wedge (2022) Forensic Anthropology and Photography: Forensic Facial Analysis. Handbook of Forensic Photography, CRC Press, 611-8.

33. Thompson T (2008) The role of the photograph in the application of forensic anthropology and the interpretation of clandestine scenes of crime." Photography and Culture, 1: 165-84.

34. Izadifar Z et al. (2016) Low-dose phase-based X-ray imaging techniques for in situ soft tissue engineering assessments." Biomaterials, 82: 151-67.

35. Hendee WR, MK O'Connor (2012) Radiation risks of medical imaging: separating fact from fantasy. Radiology, 264: 312-21.

36. Linet MS et al. (2012) Cancer risks associated with external radiation from diagnostic imaging procedures. CA: a cancer journal for clinicians, 62: 75-100.

37. Pogorzelski J et al. (2017) The acutely injured acromioclavicular joint–which imaging modalities should be used for accurate diagnosis? A systematic review." BMC musculoskeletal disorders, 18: 1-11.

38. Schubl S et al. (2016) Temporal bone fracture: Evaluation in the era of modern computed tomography. Injury, 47: 1893-7.

39. Goodman D et al. (1995) 3D CT reconstruction in the surgical management of hepatic injuries." Annals of the Royal College of Surgeons of England, 77: 7.

40. Bagaria V et al. (2011) Use of rapid prototyping and three-dimensional reconstruction modeling in the management of complex fractures. European journal of radiology, 80: 814-20.

41. Aguilar III EA et al. (1987) High resolution CT scan of temporal bone fractures: association of facial nerve paralysis with temporal bone fractures. Head & Neck Surgery, 9: 162-6.

42. Moore TM (1981) Fracture-dislocation of the knee. Clinical Orthopaedics and Related Research®, 156: 128-140.

43. Kopperdahl DL et al. (2014) Assessment of incident spine and hip fractures in women and men using finite element analysis of CT scans. Journal of Bone and Mineral Research, 29: 570-80.

44. De Angelis D et al. (2016) Skeletal idiopathic osteosclerosis helps to perform personal identification of unknown decedents: a novel contribution from anatomical variants through CT scan. Science & Justice, 56: 260-3.

45. Scheirs S et al. (2017) New insights in the analysis of blunt force trauma in human bones. Preliminary results. International journal of legal medicine, 131: 867-75.

46. Scianò F et al. (2020) An investigative strategy for assessment of injuries in forensic anthropology." Legal Medicine, 42: 101632.

47. Shamata A, T Thompson (2018) Documentation and analysis of traumatic injuries in clinical forensic medicine involving structured light three-dimensional surface scanning versus photography. Journal of forensic and legal medicine, 58: 93-100.