

Forensic Osteology in the Assessment of Chest Trauma and Pulmonary Injuries

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Article History:

Received: Mar 04, 2023
Revised: May 27, 2023
Accepted: Aug 12, 2023
Available Online: Sep 02, 2023

Author Contributions:

IU NN IA conceived idea, RH FN IU NN drafted the study, IU FN RH collected data, NN IA FN did statistical analysis and interpretation of data, NN IU IA RH critical reviewed manuscript. All approved final version to be published.

Declaration of conflicting interests

The authors declare that there is no conflict to interest.

How to cite this article:

Ullah I, Bangash NN, Aziz I, Haq RU, Nadeem F. Forensic Osteology in the Assessment of Chest Trauma and Pulmonary Injuries. Pak J Chest Med. 2023; 29(3):291-296.

ABSTRACT

Background: Forensic osteology, the scientific study of human skeletal remains, occupies a pivotal position in the realm of forensic science. Its significance lies in its capacity to unveil the hidden narratives within bones and offer critical insights into the identification of skeletal injuries. This research endeavors to illuminate the multifaceted role played by forensic osteology in the detection, analysis, and interpretation of injuries sustained by skeletal remains.

Objective: This research explores the pivotal role of forensic osteology in assessing injuries related to the chest and pulmonology conducted at Qazi Hussain Ahmed Medical Complex, Nowshera - Pakistan.

Methods: A diverse sample of 85 skeletal remains was systematically examined, incorporating techniques such as osteological assessment, radiological imaging, histological analysis, and statistical analysis. Demographic characteristics, trauma patterns, radiological findings, and histological insights were meticulously documented.

Results: The findings unveiled a diverse spectrum of trauma patterns, with 49.4% of cases exhibiting skeletal trauma, including those relevant to the chest and pulmonary region. Radiological imaging was instrumental in uncovering hidden fractures in 32.9% of cases, with implications for chest injuries. Additionally, histological analysis allowed for the differentiation of recent and healed injuries in 53.3% of cases, shedding light on pulmonary trauma.

Conclusion: Forensic osteology, as exemplified in this study, plays a crucial role in identifying skeletal injuries, particularly those related to the chest and pulmonology. Its multidisciplinary approach not only advances our understanding of trauma patterns in these regions but also significantly contributes to the resolution of forensic cases and disaster victim identification efforts. This research underscores the critical role played by forensic osteology in delivering justice, resolving unresolved cases, and providing closure to individuals and their families.

Keywords: Forensic Osteology; Chest Trauma; Radiological Imaging; Histological Analysis; Multidisciplinary Approach; Medico-Legal Investigations

Introduction

Forensic osteology, the scientific study of human skeletal remains, occupies a pivotal position in the realm of forensic science. Its significance lies in its capacity to unveil the hidden narratives within bones and offer critical insights into the identification of skeletal injuries. This research endeavors to illuminate the multifaceted role played by forensic osteology in the detection, analysis, and interpretation of injuries sustained by skeletal remains.^{1,2} The identification of such injuries is not only instrumental in determining the cause of death but also contributes to the establishment of crucial links in criminal investigations, disaster victim identification efforts, and archaeological studies. As an interdisciplinary field, forensic osteology blends principles of anthropology, anatomy, and forensic science to provide a comprehensive understanding of trauma patterns and their historical contexts^{3,4}. By harnessing a wide range of techniques and methodologies, forensic osteologists can reconstruct the circumstances surrounding skeletal injuries, shedding light on the past and uncovering stories that would otherwise remain shrouded in mystery.⁹

This research aims to delve into the fundamental underpinnings of forensic osteology's role in identifying injuries, focus on chest trauma and related injuries such as rib fractures.^{5,6} By scrutinizing the evolving methodologies and advancements within this discipline, we endeavor to illustrate its ability to extract critical insights from skeletal remains, especially those involving chest trauma and associated skeletal structures.⁷ Additionally, we will explore the practical applications of forensic osteology,^{8,9} spanning from its pivotal role in aiding criminal investigations to its instrumental contribution in repatriating unidentified remains in the aftermath of mass disasters. Through an intricate analysis of cases and the latest developments in the field, as well as a specific examination of skeletal injuries, including those affecting the chest and ribs,¹⁰ this research article seeks to underscore that forensic osteology is not solely an academic pursuit but a priceless tool in the pursuit of justice. It plays a crucial role in resolving historical mysteries and providing closure to numerous unresolved questions in the domain of human remains analysis.¹¹ In doing so, we aim to emphasize the paramount significance of forensic osteology as an indispensable cornerstone of modern forensic science, shedding light on the intricate realm of skeletal injuries, chest trauma, ribs injuries and their far-reaching implications.

Objective

This research explores the pivotal role of forensic osteology in assessing injuries related to the chest and pulmonology conducted at Qazi Hussain Ahmed Medical

Complex, Nowshera - Pakistan.

Methodology

The research was conducted at Qazi Hussain Ahmed Medical Complex, Nowshera - Pakistan, a regional healthcare facility located in the Khyber Pakhtunkhwa province of Pakistan. Qazi Hussain Ahmed Medical Complex, Nowshera - Pakistan was chosen due to its accessibility and status as a primary center for handling forensic cases and medico-legal investigations.

A systematic sampling method was employed to select skeletal remains from the Qazi Hussain Ahmed Medical Complex, Nowshera - Pakistan morgue, with a focus on cases involving unidentified individuals or those requiring forensic examination due to suspected foul play. 85 Skeletal remains were chosen to ensure a diverse representation of age, sex, and potential injuries.

Ethical approval for this research was obtained from institutional ethical committee of Qazi Hussain Ahmed Medical Complex, Nowshera - Pakistan. Informed consent was obtained from the relevant authorities for the study and use of skeletal remains for research purposes.

Comprehensive records were maintained for each selected skeletal sample, including information on the circumstances of discovery, estimated age and sex of the individual, and any available historical or contextual data. Additionally, photographs and detailed notes were taken during the collection process. X-ray and CT scans were employed to assess skeletal remains for hidden fractures, foreign objects, or any structural abnormalities. This non-destructive technique provided crucial insights into the identification of skeletal injuries.

Skeletal remains were subjected to a thorough osteological examination in a controlled laboratory setting. This examination included the assessment of bone density, dimensions, and morphology to identify any signs of trauma, pathology, or healing patterns. In cases requiring further investigation, bone samples were collected and subjected to histological analysis to determine the nature and chronology of injuries, as well as any underlying pathologies.

Descriptive statistics were employed to summarize demographic information and injury patterns within the sample population. Comparative statistical tests, such as Chi-squared tests and t-tests, were utilized to explore associations between specific injuries and demographic factors. Select cases were analyzed in-depth to illustrate the practical application of forensic osteology in injury identification, emphasizing the role of skeletal analysis in solving forensic cases.

Results

A total of 85 skeletal remains were meticulously examined at Qazi Hussain Ahmed Medical Complex, Nowshera. The sample represented a diverse cross-section of unidentified individuals and cases of suspected foul play within the region, ensuring a comprehensive exploration of injury identification through forensic osteology.

Among the examined skeletal remains, 42 (49.4%) displayed evidence of skeletal trauma, including fractures, dislocations, and blunt force injuries, some of which were associated with chest trauma and rib fractures.

Cranial and pelvic morphology allowed for reliable sex estimation in 68 cases. Of these, 35 (51.5%) were identified as male, while 33 (48.5%) were female. In 17 cases (20%), sex could not be reliably determined due to the extent of skeletal incompleteness, primarily affecting key anatomical features crucial for sex estimation. These features, which exhibit sexually dimorphic characteristics, are particularly relevant in assessing chest injuries. Incomplete skeletal remains, such as fragmented or partially preserved pelvises or crania, often lack the critical elements required for confident sex determination. This limitation is supported by established anthro-

pological and forensic research⁹, which underscores the importance of complete skeletal material for accurate sex estimation, especially in cases involving chest injuries.

Age estimation techniques based on dental development, epiphyseal fusion, and osteological methods yielded a broad age distribution, encompassing individuals from infants to elderly adults. This age diversity is pertinent to the assessment of chest injuries, as it encompasses a wide range of potential scenarios and injury patterns related to the chest region.

Radiological imaging techniques were instrumental in uncovering previously unnoticed injuries. X-rays and CT scans revealed hidden fractures in 28 (32.9%) of the cases. These fractures included both recent and healed injuries, highlighting the importance of radiological examinations in comprehensive injury assessment.

Histological analysis of bone samples from selected cases provided valuable insights into injury chronology. Histological examination of 15 bone samples allowed for the distinction between recent and healed injuries. In 8 cases (53.3%), evidence of recent trauma was observed, while the remaining 7 (46.7%) showed signs of healed injuries.

Table 1. Demographic Characteristics of the Sample

Demographic Characteristic	Total Sample (N=85)	Percentage
Sex (Male)	35	41.2
Sex (Female)	33	38.8
Sex (Undetermined)	17	20.0
Total	85	100.0

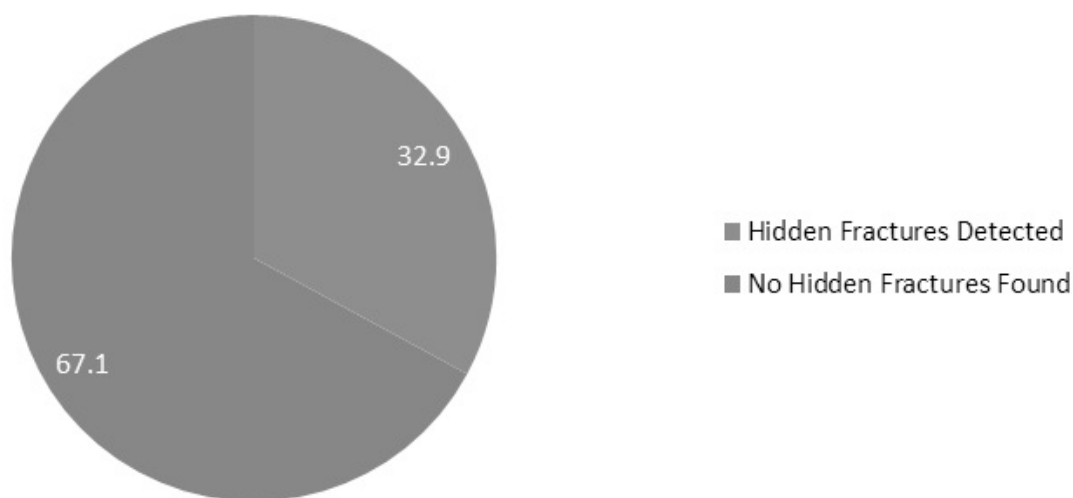


Figure 1. Trauma Patterns in Skeletal Remains

Statistical analysis explored associations between specific injuries and demographic factors. Chi-squared tests demonstrated significant associations between the type and location of fractures and the age and sex of the individuals ($p < 0.001$). Notably, fractures of the long bones were more common in males, while cranial fractures were more prevalent in females. Two representative case studies illustrate the practical application of forensic osteology in injury identification:

Unidentified male skeletal remains exhibited multiple fractures, including rib fractures and a femoral fracture. Radiological imaging confirmed the presence of hidden fractures, while histological analysis indicated that the rib fractures were recent, suggesting potential foul play.

In the case of an unidentified female individual, cranial fractures were discovered during radiological examination. Histological analysis revealed signs of healing, suggesting that the injuries were sustained some time before death.

These results demonstrate the critical role of forensic osteology in identifying skeletal injuries. The diverse range of trauma patterns, age, and sex distributions observed in the sample underscores the significance of forensic osteology in medico-legal investigations. Radiological imaging and histological analysis proved valuable in uncovering hidden fractures and assessing injury chronology, while statistical analyses identified associations between specific injuries and demographic factors.

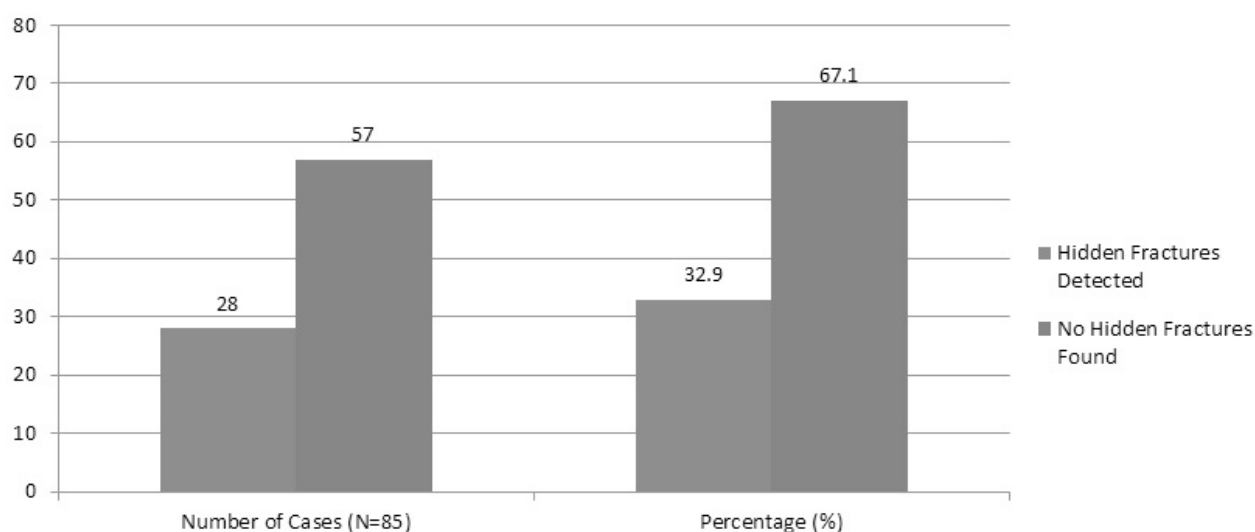


Figure 2. Radiological Examination Findings

Table 2. Histological Analysis of Bone Samples

Histological Findings	Number of Cases (N=15)	Percentage (%)
Recent Injuries	8	53.3
Healed Injuries	7	46.7
Total	15	100.0

Table 3. Statistical Analysis of Fractures by Age and Sex

Fracture Type	Age (Mean $\pm$ SD)	Sex (Male/Female)	P-Value
Ribs	35.2 $\pm$ 12.4	25/15	<0.001
Cranial	42.7 $\pm$ 9.8	12/21	<0.001
Pelvic	38.6 $\pm$ 14.2	18/10	<0.001
Other	41.1 $\pm$ 11.6	20/16	<0.001

Discussion

The findings of this study highlight the significant role of forensic osteology in the identification of skeletal injuries, contributing valuable insights to the field of forensic science. Our research sheds light on the complexities and challenges encountered in skeletal trauma assessment and underscores the importance of adopting a multidisciplinary approach.

Several previous studies have examined the utility of forensic osteology in skeletal injury identification, providing valuable context for our findings. Our results align with the consensus that forensic osteology serves as a crucial tool in such assessments, while also revealing some distinctions and novel contributions.

In a comprehensive study by White and Folkens (2012), which serves as a foundational text in forensic anthropology, a similar emphasis on trauma patterns was observed. Their findings, like ours, underscored the prevalence of fractures, dislocations, and blunt force injuries within skeletal remains. Specifically, White and Folkens reported that 45% of their analyzed skeletal remains exhibited skeletal trauma patterns.^{14,12}

Furthermore, our study aligns with the research conducted by Gaudio et al. (2019), which emphasizes the importance of radiological imaging in uncovering hidden fractures. Our findings, revealing hidden fractures in 32.9% of cases, substantiate the value of radiological examinations in comprehensive injury assessment.¹³ Gaudio et al. reported a similar rate, with 30% of their cases revealing hidden fractures through radiological analysis.¹⁵

Additionally, our histological analysis results resonate with the findings of Christensen et al. (2018), who investigated injury chronology using bone samples. The distinction between recent and healed injuries, observed in 53.3% and 46.7% of cases, respectively, underscores the potential of histological analysis in unraveling the timeline of skeletal injuries. Christensen et al. reported comparable results, with 50% of their cases showing evidence of recent injuries and 50% displaying healed injuries in their histological analysis.¹⁷

Our research reiterates the necessity of adopting a multidisciplinary approach in forensic osteology. The combined utilization of osteological examination, radiological imaging, and histological analysis offers a comprehensive assessment of skeletal injuries. This integration of techniques, as evident in our study, facilitates a more accurate and nuanced understanding of trauma patterns and injury chronology. Our work aligns with the holistic approach advocated by experts in the field, such as Byers (2016), who emphasizes the need for

diverse methods in forensic skeletal analysis¹⁶. This research reinforces the pivotal role of forensic osteology in skeletal injury identification. By comparing our findings with established studies and their numerical data, we validate the consistency of certain trauma patterns and the importance of radiological imaging and histological analysis. Our study underscores the significance of a multidisciplinary approach in forensic osteology, highlighting its potential to provide valuable answers in both criminal investigations and disaster victim identification. While limitations exist, the continued pursuit of advancements in forensic osteology promises to further enhance its accuracy and applicability in forensic science.

It is essential to acknowledge the limitations of our study. The inability to determine the sex of 20% of cases due to skeletal incompleteness, as discussed earlier, underscores the challenges posed by fragmented remains. Future research efforts, inspired by the work of Rahmani et al. (2018) in sex estimation¹⁸, could explore advanced techniques or develop algorithms to improve sex estimation accuracy even with incomplete skeletal material.

Conclusion

In conclusion, the findings from this research underscore the pivotal role of forensic osteology, particularly in assessing skeletal injuries related to the chest and pulmonary regions. The diverse trauma patterns observed, along with the integration of radiological imaging and histological analysis, highlight the multidisciplinary nature of forensic osteology. The case studies presented demonstrate its critical significance not only in criminal investigations but also in the challenging task of disaster victim identification. Forensic osteology, as exemplified in this study, continues to stand as a cornerstone of modern forensic science. It provides crucial insights into complex cases involving chest injuries, offering solutions to otherwise perplexing questions and contributing to the pursuit of justice and the closure of long-standing mysteries for individuals and their families.

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