

# Ethical Challenges in Forensic Imaging: A Systematic Review of Key Issues, Emerging Artificial Intelligence (AI) Implications and Future Directions

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## ABSTRACT

**Background:** Forensic imaging is a widely employed technique in the field of forensics yet it raises numerous ethical concerns. For radiographers, ethical issues can significantly impact the credibility and reliability of their work, especially as advancements in imaging technology introduce challenges related to data manipulation and the need to balance diagnostic objectives with patient privacy. Thus, a comprehensive study of these ethical challenges is essential. **Methods:** A thorough literature search was conducted using Google Scholar, ScienceDirect, PubMed, and GoPubMed, focusing on "ethical issues in forensic imaging" and related terms like "ethical issues in postmortem imaging." Boolean operators and keyword variations such as "ethical issues AND forensic imaging," "forensic AND ethical issues AND radiology," and "postmortem imaging AND ethics" enhanced relevance. The search covered publications from 2003 to 2024, specifying "human" and "ethics". Articles were selected based on predefined criteria for further data extraction, synthesis, and analysis. **Results:** The findings reveal key ethical concerns, including the validity of tests, informed consent, privacy, confidentiality, and professionalism issues commonly identified in forensic radiographic imaging. The integration of artificial intelligence (AI) into forensic processes adds further complexity to these ethical dilemmas. **Conclusion:** These findings highlight the urgent need for developing robust guidelines, raising awareness, fostering cooperative environments, establishing standards, and creating centres of excellence to address the ethical challenges in forensic imaging.

## Keywords:

forensic imaging; patient consent and privacy; ethical issues; future directions

## INTRODUCTION

Forensic imaging has revolutionized modern forensic investigations by providing non-invasive techniques to document and explain medico-legal findings. Techniques like X-ray, CT, MRI, and 3D scanning provide non-invasive alternatives to traditional autopsies, especially in cases where families object due to religious or personal reasons (Zhang, 2022; Murphy, 2016). These methods are crucial for identifying trauma, pathological changes, and human remains and are widely used in forensic anthropology, odontology, ballistics, and clinical forensic medicine (Franklin et al., 2015; Yadav 2017; Bjelopavlovic et al., 2023; Dahal et al., 2023; Ferreira & Caldas 2024).

Ethical concerns are vital in forensic imaging, with issues like postmortem imaging without consent, data misuse, and privacy violations (Heathfield et al., 2017; O'Donnell & Woodford, 2008). Bias or privacy mismanagement can lead to wrongful convictions, underlining the need for clear ethical guidelines. Radiographers face dilemmas and

require clear protocols and support from governing bodies, especially for sensitive topics like 3D-printed remains (Smith et al., 2022; Carew, 2023).

Virtopsy, using CT and MRI, offers virtual autopsies that are storable and infection-free, though it has limitations in detecting certain conditions (Ahmad et al., 2021). Ethical issues include ensuring informed consent from the deceased's next of kin and safeguarding digital data (Habburrahman et al., 2023). The deceased's confidentiality extends postmortem and requires careful data management (Silviu et al., 2008).

Forensic science combines ethical principles like autonomy, justice, and dignity with legal standards such as due process to ensure fairness (Carew & Errickson, 2019). Professional standards, particularly for technologies like SPECT, PET, and neuroimaging, are essential to maintain evidence integrity and ethical practices (Meltzer et al., 2014). Regulatory bodies like the International Association of Forensic Radiographers (IAFR) emphasize proper

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training and ethical evidence handling (Doyle et al., 2020; Professional Board for Radiography and Clinical Technology, 2023).

Technological advancements like artificial intelligence (AI) in dental age estimation raise privacy concerns, requiring proper data management and informed consent (Lygate, 2024). Ethical dilemmas also arise in handling human remains, with respect for cultural beliefs being crucial (Chamsi-Pasha & Albar, 2017). Managing digital data securely is essential to uphold ethical standards (Obertova et al., 2019; Belcastro et al., 2022).

In this study a review over three decades highlights the need for standardized guidelines and better training to address emerging forensic imaging challenges. As technology evolves, ethical and professional frameworks must adapt to ensure justice and fairness in its use.

## MATERIALS AND METHODS

### Search for Relevant Literature

A comprehensive literature search was conducted using databases like Google Scholar, ScienceDirect, PubMed, and GoPubMed. Keywords such as "ethical issues in forensic imaging" and "ethical issues in postmortem imaging" were used alongside Boolean operators (e.g., "Ethical issues AND forensic imaging," "forensic AND ethical issues AND radiology"). The search focused on human-related ethics from 2003 to 2024, using snowballing technique to thoroughly review key articles and subsequent papers.

### Reviewing and Selection of Articles

After an initial literature search and framework development, key points were identified to guide the research. These were used to form the inclusion and exclusion criteria outlined in Table 1. Titles and abstracts of retrieved articles were screened for relevance, followed by a full-text review of selected studies to confirm their suitability.

## Data Extraction

During article selection, it's essential to document the inclusion and exclusion process for transparency and reproducibility. We record details and objectives of reviewed articles in Excel, streamlining data summary, analysis, and discussion.

## Results Compilation, Data Analysis and Discussion

The data were gathered to meet the review objectives, analyzed to identify themes, and discussed to interpret and contextualize the findings. This process of data collection, synthesis, analysis, and discussion enhances the robustness and validity of the research outcomes.

## RESULTS

An initial search in academic databases yielded 1192 articles. After screening titles and abstracts, 46 were identified as potentially relevant. Following full-text review and applying inclusion/exclusion criteria, 36 were rejected, leaving 10 articles for detailed evaluation. Figure 1 illustrates the article selection process following Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

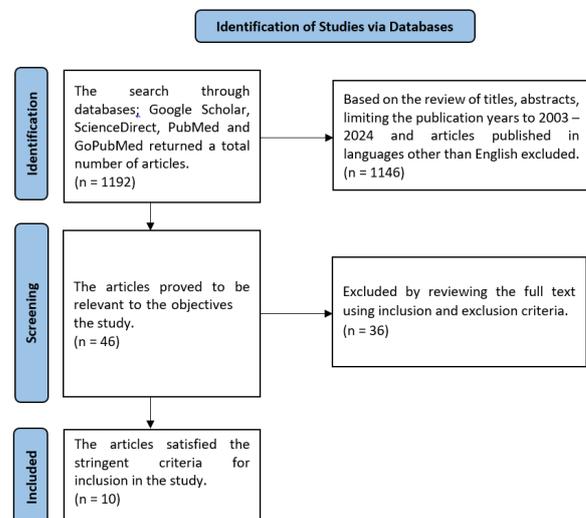


Figure 1: PRISMA flow diagram

Table 1: Table of inclusion and exclusion criteria

Inclusion Criteria	Exclusion Criteria
Articles in English.	Articles on forensic imaging of animals.
Articles spanning from 2003 – 2024.	Articles on psychological forensics.
Articles related to ethical issues in forensic imaging.	Articles published in languages other than English.

## Significant Ethical Problems in Forensic Imaging

articles related to test validity, consent, privacy, confidentiality, and professionalism, as shown in Table 2.

Data analysis identified ethical issues in forensic imaging. Ethical issues are categorized into privacy and data

**Table 2:** Description of articles on ethical issues and methods of overcoming ethical issues in forensic imaging

Author(s) and Publication Year	Title	Theme(s)
O'Donnell & Woodford, 2008	Post-mortem radiology - a new sub-speciality?	Highlights the need of radiological specialists working in a co-operative environment with pathologists.
Lygate, 2024	Testing the Use of Artificial Intelligence for Dental Age Estimation.	Concerns on the validity of examination, patient's data privacy and confidentiality, patient safety (radiation risk).
Lewis et al., 2018	Health professionals' and coroners' views on less invasive perinatal and paediatric autopsy: a qualitative study	Questions regarding storage and management of digital images related to human remains. Highlights the issue of uptaking non-invasive autopsy as main method which includes inappropriate uptake of examination and importance of validation and guidance.
Smith et al., 2022	Radiographers' experiences and perspectives of forensic imaging in Australia: A qualitative study.	Issues on consent taking.
Aghayev et al., 2008	Virtopsy – The concept of a centralized database in forensic medicine for analysis and comparison of radiological and autopsy data.	Concerning matters of data privacy.
Obertová et al., 2019	Postmortem imaging of perimortem skeletal trauma.	Having a center of excellence. Requirement of establishment of standards, guidelines and protocols. Forensic expertise in skeletal trauma assessment requires good understanding and is warranted to maintain high-quality expertise.
Aynsley-Green, 2009	Unethical age assessment.	Usage of forensic imaging as an administration method. Consent improperly obtained.
Alshamrani, 2022	Ethical aspects of age estimation for forensic purposes in Saudi Arabia.	Concerns issues such as consent, privacy, patient safety (radiation risk), and validity of patient.
Jeong et al., 2024	Korean radiographers' awareness, experiences, and education needs in forensic medicine and forensic radiology.	Lack of awareness and knowledge on forensic imaging.
Sonnemans et al., 2018	Dutch guideline for clinical foetal-neonatal and paediatric post-mortem radiology, including a review of literature.	By developing evidence-based guidelines and usage of evaluation by experts.

management, consent and ethical practices, and safety and validation to clarify differences in concerns. requirements, education, awareness, and collaboration.

### **Privacy and Data Management**

One of the ethical issues in forensic imaging is privacy and data management. Aghayev et al., (2008) highlighted challenges in protecting medical data when exchanged across state borders. Similarly, Lewis et al., (2019) questioned the security and ethical handling of digital image data related to human remains. Lygate (2024) raised concerns about AI development relying on confidential medical data, which compromises patient confidentiality and privacy.

### **Consent and Ethical Practices**

In forensic imaging, ethical practices and consent are vital, especially in sensitive contexts like age assessments and non-accidental injury (NAI) cases. Aynsley-Green (2009) highlighted challenges in obtaining consent for imaging in age assessments, raising ethical dilemmas. Smith et al. (2022) noted difficulties in securing consent for forensic imaging in suspected NAI cases due to legal and protective concerns. Alshamrani (2022) also emphasized the challenges in obtaining consent for age estimation forensic imaging.

### **Safety and Validation**

Ethical concerns in forensic imaging include consent, safety, and validation. Aynsley-Green (2009) questioned the ethical use of dental radiology for identification without therapeutic benefit. The reliability of procedures like Minimally Invasive Autopsy (MIA) is also problematic, with Lewis et al. (2019) highlighting that parents may give improper consent due to misunderstandings. Alshamrani (2022) raised concerns about radiation in age estimation, especially for minors, while Lygate (2024) warned that improper use of dental radiographs for age estimation could harm vulnerable children. These issues stress the need for clear, validated practices and transparent consent processes.

### **Strategy to Address the Prevalence of Ethical Concerns in Forensic Imaging**

Data analysis identified five approaches to address ethical issues in forensic imaging: developing evidence-based guidelines, enhancing existing guidelines, promoting cooperative environments, establishing standardized training programs, and creating centers of excellence. These solutions emphasize the need for proper

### **Developing Evidence-Based Guidelines**

Developing evidence-based guidelines is crucial, as highlighted by Sonnemans et al., (2018), who stress the importance of expert evaluation to ensure ethical practices and high standards in clinical fetal, neonatal, and pediatric postmortem radiology.

### **Enhancing Education and Awareness**

Jeong et al., (2024) highlight the importance of university education in forensic medicine and radiology to enhance radiographers' awareness and knowledge, addressing ethical issues from inadequate training.

### **Promoting Cooperative Environments**

O'Donnell & Woodford (2008) emphasize the importance of radiological specialists fostering cooperation with pathologists to enhance ethical practices and outcomes in post-mortem radiology.

### **Establishing Standards and Training Programs**

Lewis et al., (2019) recommend clear standards and training for health professionals and coroners involved in less invasive perinatal and pediatric autopsies to ensure ethical and effective procedures.

### **Creating Centers of Excellence**

Obertová et al., (2019) propose establishing Centers of Excellence led by experts to implement standards, guidelines, and protocols, ensuring high-quality expertise and ethical practices in post-mortem imaging of perimortem skeletal trauma.

## **DISCUSSION**

### **Significant Ethical Dilemmas in Forensic Imaging**

#### **Privacy and Data Management**

Privacy and confidentiality are major ethical concerns in forensic imaging, especially with the digitalization and global exchange of sensitive medical data. The movement of medical datasets across international borders introduces vulnerabilities, increasing the risk of unauthorized access and breaches of patient confidentiality (Aghayev et al., 2008). These risks are compounded by digital storage and online sharing systems (Lygate, 2024). The integration of AI in forensic imaging further complicates privacy issues, as AI systems rely on vast amounts of confidential data. Additionally, the secure

storage and management of digital images, particularly regarding human remains, raises ethical dilemmas about respectful handling and unauthorized access (Lewis et al., 2018). The issue of 'elevation of privilege', where unauthorized personnel gain access to sensitive data, emphasizes the need for robust security measures and ethical guidelines to protect patient privacy in forensic imaging (Benzie & Montasari, 2023).

### **Consent and Ethical Practices**

Consent and ethical practices are essential in forensic imaging, presenting challenges across various contexts (Budowle & Sajantila 2023). Aynsley-Green (2009) highlights the complexity of obtaining informed consent, particularly in age estimation cases, where vulnerable populations, such as asylum seekers, face barriers like language and trauma. This emphasizes the need for informed and voluntary consent, respecting individual autonomy. Challenges also arise in cases of Non-Accidental Injury, where emotional and intellectual barriers complicate the process, especially with minors or abuse victims (Smith et al., 2022; Aynsley-Green, 2009). Alshamrani (2022) stresses the importance of ethical practices, noting that failure to obtain proper consent can lead to breaches of trust and misconduct, making rigorous ethical standards crucial in forensic imaging.

### **Safety and Validation**

Ethical issues in forensic imaging, particularly safety and validation, focus on the accuracy and appropriateness of imaging techniques. Aynsley-Green (2009) highlights the ethical dilemma of using dental radiographs for age estimation without therapeutic benefit, exposing individuals, especially minors, to ionizing radiation without medical justification. Lewis et al., (2018) raise concerns about procedures like Minimally Invasive Autopsy (MIA), emphasizing the risks of inadequate parental consent.

The validity of forensic imaging tests is critical for fairness and justice. Alshamrani (2022) notes that age estimation techniques may lack reliability across diverse ethnic groups, potentially impacting legal outcomes. Lygate (2024) critiques the inaccuracy of third molar radiographs for age estimation, especially for asylum seekers and trafficking victims, highlighting risks of misclassification affecting legal and social status.

### **Strategies to Address Ethical Concerns in Forensic Imaging**

#### **Developing Evidence-Based Guidelines**

Developing evidence-based guidelines is essential for addressing ethical issues in forensic imaging. Sonnemans et al., (2018) highlighted the importance of rigorous evidence and expert evaluation, as demonstrated by Dutch guidelines for clinical fetal-neonatal and pediatric postmortem radiology, which ensure ethical practices and high standards. These can serve as a model for forensic imaging.

Uniform national guidelines for data storage, consent, and AI usage are crucial (Lygate 2024; Obertová et al., 2019; Alshamrani 2022). Ambiguities in legal regulations on data privacy and secure storage (Habiburrahman et al., 2023) necessitate enhanced measures to prevent hacking risks (Bourla et al., 2018).

With AI integration into forensic imaging, clear regulations are vital. The EU's AI Act (Regulation (EU) 2023/1874) addresses AI oversight, and updating forensic imaging standards will promote ethical practices, patient safety, and risk mitigation. Adherence to these regulations will enhance trust and outcomes in forensic imaging (Martin et al., 2022).

#### **Enhancing Education and Awareness**

University education in forensic medicine and radiology is essential for the awareness and competence of radiographers and professionals in this field (Jeong et al., 2024). It helps address ethical issues stemming from inadequate training. Jeong et al. (2024) emphasize the need for policies in forensic education and courses on forensic imaging, alongside continuing education for radiographers in the forensic field. This ensures high-quality imaging for victims and deceased patients, aiding in the accurate identification of causes of death or injury mechanisms while preserving evidence for court use. This supports human rights and justice for the deceased. Similarly, Obertová et al. (2019) stress the importance of continuous education and expertise sharing to keep up with advancements in imaging techniques for detecting and interpreting traumatic injuries in postmortem imaging.

#### **Promoting Cooperative Environments**

Promoting cooperation between radiological specialists and pathologists is essential to reduce the risk of misinterpreting findings (O'Donnell & Woodford, 2008). Sharing expertise among radiologists, forensic pathologists, engineers, and other specialists helps maintain high-quality skills in detecting traumatic injuries on postmortem imaging (Obertová et al., 2019). Collaboration fosters ethical practices and improves

outcomes in post-mortem radiology by leveraging collective expertise. Sonnemans et al. (2018) emphasize that images should be evaluated by experienced radiologists to prevent misdiagnosis, recommending the assistance of specialists in non-specialized centers to address ethical concerns in forensic imaging.

### Establishing Standards and Training Programmes

Implementing training programs and standards of practice is vital for ethical conduct in forensic imaging. Lewis et al., (2019) emphasize training radiologists, pathologists, and health professionals to ensure ethical procedures and informed consent standards, aiding parents in decision-making. O'Donnell & Woodford (2008) highlight the need for training clinical radiologists with limited experience in postmortem imaging to reduce false positives.

Enhancing consent procedures, such as those in Saudi regulations, ensures transparency and uniformity (Alshamrani, 2022). While some argue consent may hinder investigations, it is crucial to safeguard individual rights (García-Garduza, 2019).

### Creating Centers of Excellence

The establishment of centers of excellence, as proposed by Obertová et al., (2019), is essential for ensuring high-quality expertise and ethical practices in postmortem imaging, particularly in cases of perimortem skeletal trauma. These centers, located strategically in various countries, would support close cooperation among experts such as engineers, computer scientists, forensic pathologists, anthropologists, and radiologists in both research and casework (Obertová et al., 2019).

### CONCLUSION

Ethical issues in forensic imaging remain significant across decades, with persistent challenges in privacy, consent, safety, and technological advancements. These issues continue to be raised by various authors. Potential solutions include developing evidence-based guidelines, enhancing education and awareness, fostering cooperation, establishing standards and training programmes, and creating centers of excellence to address these concerns.

### Limitations of the Study

One significant limitation of this study is the restricted access to numerous pertinent articles due to subscription barriers. This limitation may have led to the omission of

critical perspectives and findings that could have enriched the analysis, thus potentially limiting the study's comprehensiveness. Consequently, the study primarily reflects the data available through open-access resources, which may not fully encompass the current state of research in the field.

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