

Beyond the Scalpel: The Role of Forensic Radiology in Mass Disaster Identification

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Abstract:

In cases of both natural and man-made mass disaster scenarios present profound challenges for the dignified, accurate identification of victims. Traditional means of identification may be slow, invasive, and hampered by the fragmented or commingled nature of remains. This paper highlights the critical and expanding role that forensic radiology plays as an indispensable tool in the modern DVI process. Forensic radiology, by employing modalities such as PMCT and PMMRI, offers a non-invasive, rapid, highly detailed method for documentation and analysis of human remains. The application of radiology in DVI is multifaceted. First and foremost, it is a potent tool for primary identification by comparing post-mortem radiographs against ante-mortem medical records, especially dental radiographs and unique skeletal features. It is also instrumental in disaster triage, enabling the virtual sorting and reconciliation of commingled remains. Radiology allows the documentation of identifying characteristics such as healed fractures, surgical implants, and unique anatomic variations. Beyond identification, it provides vital data for determining cause and manner of death through the visualization of traumatic injury, foreign objects, and disease pathologies while providing protection to the DVI personnel with the detection of hazardous materials embedded within the remains. In conclusion, the integration of forensic radiology into the standard DVI protocol is very important in increasing the efficiency, accuracy, and safety of the identification process. It does not only quicken victim repatriation with the creation of a permanent, objective, and detailed record, but it also maintains dignity in human identification amidst mass fatality incidents. Further development and standardization of the process are essential for the future in disaster response.

Keywords: *Multi-Slice Computed Tomography (MSCT), Ante-mortem/Post-mortem Image Reconciliation, Virtual Anthropology, Radiographic Identification, Commingled Remains Analysis, Post-mortem Imaging (PMI)*

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Introduction

In any fatality case, regardless of the cause or number of victims, identifying the victims is crucial for both humanitarian and legal reasons (Brough *et al.*, 2015). Everyone has the right to be recognized after death and to be returned to their families for a respectful burial. This principle is accepted in all cultures and legal systems. Besides the emotional importance for the victims' families, identification is also vital for legal purposes. Without identifying the victims, we cannot issue death certificates, settle estates, or start criminal procedures (Prokopowicz & Borowska-Solonyko, 2025).

Mass fatality incidents (MFIs) can result from environmental disasters (like earthquakes, tsunamis, or wildfires), transportation accidents (such as plane crashes or train derailments), industrial events (like explosions or structural collapses), or acts of terrorism. These incidents often lead to many victims who die suddenly, presenting unique challenges for identification teams (Santunione *et al.*, 2026). MFIs can be categorized into two types:

- Closed incidents: The victims' identities are known from records like passenger lists.
- Open incidents: The identity and number of victims are initially unclear (as seen in the 2004 Asian tsunami and public terrorist attacks).

The complexity of identifying victims varies significantly based on several factors. These include the number of victims, how badly the human remains are fragmented, whether there was thermal damage from fires, how much decay occurs during recovery, and the availability of ante-mortem material for comparison (Brough *et al.*, 2015).

Traditional identification methods like visual identification by family members, fingerprint analysis, dental analysis, and DNA testing can encounter problems when remains are fragmented, burned, decomposed, or mixed (Hofman *et al.*, 2019). Visual identification is not only unreliable but also very distressing for survivors. Fingerprint analysis works only if the skin is intact. Dental analysis is dependable only if there are enough remains and

thorough ante-mortem records. DNA analysis is often the best option, but it takes time and is expensive. The first use of radiography for identification occurred in 1927 when Culbert and Law compared ante-mortem and post-mortem radiographs in a homicide case (Prokopowicz & Borowska-Solonyko, 2025). The application of radiography in mass fatality cases began in 1949 after the Noronic disaster (Rainio *et al.*, 2001). Over the last century, conventional radiography has gained popularity in forensic pathology.

Recently, post-mortem computed tomography (PMCT) has emerged as a new technology for disaster victim identification (DVI). PMCT offers various advantages over conventional radiography, including faster processes, fewer personnel requirements, three-dimensional images, and the ability to review images after years (Sidler *et al.*, 2007).

This paper looks at the growing role of forensic radiology in identifying victims of mass disasters. It explores its historical development, current applications in various fields, documented benefits and drawbacks, and potential future directions within the multidisciplinary DVI framework. By reviewing evidence from peer-reviewed studies and documented disaster responses, this paper demonstrates how forensic radiology has significantly evolved to become a key component of modern disaster victim identification.

2. REVIEW OF LITERATURE

Sidler M, Jackowski C, Dirnhofer R, Vock P, Thali M (2007). This foundational research investigated how post-mortem multislice computed tomography could contribute to the Interpol DVI process, demonstrating that most post-mortem information required for identification could be gathered from CT data alone. The authors identified key advantages including observer-independent documentation, digital transmission capabilities, and reduced time requirements at disaster sites.

O'Donnell C, Iino M, Mansharan K, Leditscke J, Woodford N (2011). This study documented the contribution of post-mortem multidetector CT scanning to victim identification in the 2009

Victorian bushfires, demonstrating PMCT's particular value in cases of severe thermal damage. The authors showed that comprehensive imaging before autopsy allowed identification teams to prioritize cases and allocate resources efficiently in a mass disaster setting.

Brough AL, Morgan B, Ruty GN (2015). This comprehensive review examined the integration of post-mortem computed tomography into disaster victim identification protocols, detailing how PMCT enables virtual sorting of commingled remains and documentation of unique identifiers including surgical implants. The authors emphasized that PMCT provides permanent digital records that can be reinterpreted long after the initial examination.

Elliott D, Batty-Smith L (2016). This paper presented the experience of the United Kingdom Forensic Radiography Response Team during the London bombings investigation, one of the first deployments of a forensically trained radiography team as an integral part of emergency mortuary operations. The authors provided lessons learned and personal insights from working as part of the Metropolitan Police Operation Theseus investigation into this terrorist attack.

Borowska-Solonyko A, et al. (2018). This position statement from the Polish Society of Forensic Medicine and Criminology established national guidelines for radiological examination of mass disaster victims in Poland. The authors provided standardized protocols for image acquisition, interpretation, and documentation to ensure consistency in forensic radiology practice during disaster victim identification operations.

Hofman P, Alminyah A, Apostol M, et al. (2019). This updated positional statement from the International Society of Forensic Radiology and Imaging outlined the established role of post-mortem computed tomography in mass fatality investigations, including applications for hazardous material detection, victim identification, and cause of death determination. The authors emphasized that CT scanners can be mobile or fixed-site and must be integrated into appropriate body handling protocols.

Ruty GN, Biggs MJP, Brough A, Morgan B, Webster P, Heathcote A, Dolan J, Robinson C (2020). This paper documented the first use of remote post-mortem radiology reporting for disaster victim identification during the 2017 Grenfell Tower disaster, where 119 scans were undertaken over 16 days. The authors demonstrated that a team of four reporters could provide 96% of DVI forms and 86% of preliminary reports within one working day of image receipt using a remote reporting pathway.

Chauhan I (2020). This review paper examined the role of forensic anthropology in disaster victim identification, emphasizing the use of radiographic techniques to establish biological profiles and assist in reassociation of fragmented remains. The author highlighted how anthropological expertise combined with imaging can accelerate identification in mass disaster situations.

Morishita J, Ueda Y (2021). This paper outlined the history of biometrics for personal identification and explored automated image recognition techniques developed for clinical imaging that could be applied to victim identification in mass disasters. The authors noted that development of methods adaptive to recent imaging modalities in forensic pathology and odontology is still in early stages but will increase in importance.

Prajapati G, Sarode SC, Sarode GS, Shelke P, Awan KH, Patil S (2022). This systematic review examined the role of forensic odontology in identification of victims from major mass disasters across the world, confirming dental identification as one of three primary identifiers recognized by Interpol. The authors documented that scanning techniques including digital radiographs have an essential approval role in forensic dentistry for disaster victim identification.

Machado MPS, Silva JVE, Freitas PH, et al. (2024). This article presented three complex forensic cases including a mass dam disaster, burnt remains, and decomposed remains where positive identification was achieved using medical findings comparison with digital radiography and computed tomography. The authors demonstrated that technological advancements reveal additional skeletal details,

making medical data comparisons significantly more effective in anthropological identification.

Prokopowicz V, Borowska-Solonyanko A (2025). This systematic literature review examined the current state of using post-mortem computed tomography for personal identification beyond odontology, analyzing multiple anatomical structures including frontal sinuses, paranasal sinuses, mastoid air cells, and lumbar vertebrae. The authors provided a comprehensive reference list of studies validating various skeletal features as reliable identifiers in forensic contexts.

Engel I, et al. (2025). This study examined the role of forensic odontology in the October 7, 2023 Israel attack, where 970 victims were examined and 166 (17%) identified through dental methods. The authors demonstrated that CT-generated panoramic images provided effective alternatives to full mouth X-rays when direct oral access was restricted due to severe trauma or decomposition.

3. MATERIALS AND METHODOLOGY

3.1 RESEARCH DESIGN

For the purpose of the present study, the methodology of systematic literature review was used to investigate the role of forensic radiology in relation to mass disaster victim identification. The comparative methodology was used to compare different imaging modalities, identification techniques, and their applications in relation to different disaster situations. The research review attempts to synthesize information from peer-reviewed articles, technical resources, guidelines, and responses to disasters over the last nearly a century (1927-2025).

3.2 SEARCH STRATEGY

A comprehensive literature search was carried out using a variety of online sources to obtain relevant literature. The literature search strategy was intended to obtain both historical and current literature on the applications of forensic radiology in mass disaster situations.

Database/Source	Search Period	Search Terms	Limits Applied
MEDLINE/PubMed	1946–2025	“Forensic radiology”, “post-mortem computed tomography”, “disaster victim identification”, “mass fatality”, “radiographic identification”	English language, human studies
ScienceDirect	2000–2025	“PMCT DVI”, “forensic imaging mass disaster”, “virtual autopsy”	Peer-reviewed journals
Forensic Imaging	2013–2025	“Disaster victim identification”, “mass disaster radiology”	All article types
Forensic Science International	1990–2025	“Radiological identification”, “commingled remains”	Original research, reviews
Google Scholar	1927–2025	“Frontal sinus identification”, “mass disaster radiology history”	Books, articles, technical reports

Table 3.1: Database Search Parameters

Criterion Type	Inclusion	Exclusion
Publication type	Peer-reviewed original research, systematic reviews, meta-analyses, case studies, technical guidelines, position statements	Conference abstracts, editorials, opinion pieces, non-English publications
Study population	Human remains from mass fatality incidents, disaster victim identification operations	Single fatality cases, clinical radiology studies, animal studies
Intervention	Post-mortem radiology (PMCT, conventional radiography, fluoroscopy, dental radiography)	Ante-mortem imaging only, non-radiological identification methods
Outcome measures	Identification rates, accuracy, time efficiency, safety outcomes, cause of death determination	Technical imaging parameters without forensic application
Time period	1927–2025	Studies prior to 1927

Table 3.2: Inclusion and Exclusion Criteria

3.3 DATA EXTRACTION AND SYNTHESIS

- From the identified literature, data extraction was performed using a standardized form created for the purpose of this review. The data collected includes:
- Study characteristics: Authors, year, country, type of disaster, number of victims
- Imaging modalities: PMCT (multislice/multidetector), conventional radiography, fluoroscopy, dental radiography, CBCT

- Identification methods: Radiographic comparison, dental comparison, identification by implants, virtual anthropology
- Outcome measures: Identification rate, time to identification, comparison with traditional methods
- Operational factors: Deployment type (fixed/mobile), human resource requirements, safety issues
- Limitations: Technical difficulties, interpretative difficulties, resource issues.

Category	Variables Extracted
Publication metadata	Authors, year, journal, study type, citation count
Disaster characteristics	Type (natural/terrorism/transport/industrial), location, year, total fatalities, number examined radiologically
Technical specifications	Scanner type, protocol parameters, modalities used, deployment setting
Identification outcomes	Primary identifications via radiology, secondary contributions, comparison with other modalities
Temporal factors	Time from incident to identification, imaging throughput rate, reporting time
Safety applications	Hazardous material detection, personnel protection measures, documented incidents
Limitations reported	Technical failures, interpretive errors, resource limitations

Table 3.3: Data Extraction Categories

3.4 DATA ANALYSIS

Quantitative analysis: Descriptive statistical analysis was carried out for:

- Identification rate for different modalities and types of disasters
- Time efficiency metrics
- Frequency of certain identification features, such as implants, sinuses, dental work, etc.
- Rate of detection of hazardous materials

Qualitative synthesis: Thematic analysis was carried out for:

- Frequent challenges faced in radiological identification
- Best practices and lessons learned
- Knowledge gaps
- Future innovations

Comparative analysis: The results were compared for:

- Disaster types: natural and human-made
- Pre-2000- and 2000–2025-time frames
- PMCT and conventional modalities
- Fixed site and mobile deployment

3.5 ETHICAL CONSIDERATIONS

Since the study was based only on the analysis of literature, there was no need to seek any kind of clearance for the research. All the studies have been cited appropriately, and the results have been presented in an objective manner without any kind of modification or alteration. An extensive literature search was done, and the results showed that there were 1,450 articles in the literature. After eliminating 290 duplicates, the remaining articles totaled 1,160. After the title and abstract screening of the articles,

the full-text articles totaled 310. Finally, the articles that met the criteria for synthesis totaled 150.

Database-Specific Contributions:

MEDLINE/PubMed (410 hits, 42 included), ScienceDirect (520 hits, 34 included), Forensic Imaging (180 hits, 27 included), Forensic Science International (240 hits, 25 included), and others (100, 22 included)

4. RESULTS AND DISCUSSION

4.1 IDENTIFICATION EFFICACY OF FORENSIC RADIOLOGY

From the analysis of documented mass disasters, it has been established that Forensic Radiology, in the form of Post Mortem Computed Tomography (PMCT), has shown considerable efficacy in the identification of victims in various disasters. The findings have consistently demonstrated that PMCT can function both independently and in conjunction with other identification techniques.

Primary Identification Capabilities:

- Comparative radiography remains the basis of identification, with unique anatomical features that are compared, including the shape of the frontal sinuses, configurations of the paranasal sinuses, mastoid air cell patterns, and vertebral body patterns. The frontal sinuses, first used for identification in 1927, continue to be useful for identification today, owing to their unique shape and constancy of size in adults.
- Surgical implants and prostheses are useful tools for identification, with orthopedic implants, cardiac pacemakers, and other medical devices having manufacturer identification and serial numbers that can be visualized on CT scans, as shown by *Chatzaraki et al.*, who demonstrated that cardiac conduction devices can be used for reliable radiologic comparative identification.
- Changes due to disease, including healed fractures, degenerative joint diseases, and

metabolic bone diseases, can be useful distinctive identifiers, especially when ante-mortem records are available for comparison, as shown by *Martrille et al.*, who demonstrated that bone diseases like tuberculosis can be useful for personal identification.

Dental Identification Contributions:

The attack in Israel in 2023 served as compelling evidence of the effectiveness of dental identification. In the investigation, dental identification was successful in 166 people (17%) out of the 970 victims examined. This proves that dental identification is one of the three major identification techniques accepted by Interpol, along with fingerprint and DNA analysis.

Another major breakthrough in dental identification techniques was the use of CT-generated panoramic images (CT-OPGs) as viable options instead of full mouth X-rays when access to the mouth was restricted due to trauma, burning, or decomposition. It was found that there was no significant difference in the efficiency of PM CT-OPGs and full mouth X-rays in detecting dental interventions and tooth morphology.

Comparative Accuracy:

A systematic literature review by (2018) evaluated the accuracy of dental PMCT compared to conventional post-mortem dental radiographs. The review concluded that:

Modality Comparison	Accuracy Finding	Key Advantages / Limitations
Dental PMCT vs. Conventional Dental X-rays	Accuracy is comparable or similar	3D capability enables reconstruction to match any AM radiograph; non-destructive approach preserves fragile remains
PMCT with metal artefact reduction	Improved image quality	Recent protocols reduce streak artefacts from amalgam restorations

Cone-beam CT (CBCT)	High-resolution dental imaging	Less metal artefact than MSCT; shorter scan times; portable units available; limited soft tissue information
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Table 4.1: Comparison of Imaging Modalities Used in Forensic Identification

The review emphasized that further research is required to establish an international standard protocol for dental PMCT before it can be adopted as new standard practice.

4.2 OPERATIONAL EFFICIENCY AND WORKFLOW INTEGRATION

The integration of PMCT into DVI operations has demonstrated substantial improvements in efficiency, throughput, and resource utilization across multiple mass disaster responses.

Throughput and Time Efficiency:

The first documented use of remote post-mortem radiology reporting for DVI occurred in the 2017 Grenfell Tower tragedy in London. Within an 11-week period, a total of 119 scans took place over 16 days, with up to 18 scans per day. A team of 4 reporters and 3 support staff used a process pathway to achieve remarkable results in efficiency within that timeframe. They successfully completed:

- 96% of prototype INTERPOL DVI radiology reporting forms within one working day
- 99% of image datasets delivered to DVI teams within one working day
- 86% of preliminary radiology reports delivered within one working day

The remote post-mortem radiology reporting process proves that PMCT can facilitate workforce participation, where experts can make contributions without having to physically attend the site of the tragedy. This was also seen to be beneficial in the face of the COVID-19 pandemic, where travel was restricted to deploy international DVI teams.

Consolidation of Imaging Functions:

Traditional mass fatality responses required moving victims through three separate radiological stations:

Traditional Approach	PMCT Consolidated Approach
Fluoroscopy (contaminant screening)	Single PMCT examination
Standard radiography (skeletal documentation)	Multi-purpose imaging
Dental radiography (odontological comparison)	Reconstructed dental images
Multiple handling of remains	Minimal physical manipulation
Multiple imaging personnel	Reduced on-site team

Table 4.2: Comparison Between Traditional Radiological Methods and PMCT Consolidated Approach

PMCT consolidates these functions into a single examination, typically completed in 2-5 minutes per body. This consolidation reduces on-site personnel requirements, minimizes body handling, and preserves fragile remains particularly valuable in cases of severe thermal damage as experienced in the Victorian bushfires.

The November 2015 Paris Attacks:

The analysis of the Paris terrorist attacks exemplified the capabilities and challenges in the implementation of PMCT in open disasters. In the 6-day period following the terrorist attacks, 49 corpses were scanned at two hospital centers. The operational findings of the Paris case include:

- Selection criteria: Multiple limb injuries or unclear fatal injuries were selected for PMCT, while corpses with clear fatal singular injuries in the head/neck area, visible to the naked eye, were not scanned

- Interdisciplinary coordination: 15 pathologists, 4 odontologists, 4 radiographers, 6 radiologists, 1 anthropologist, and 3 ballistics experts were included in the analysis
- Standardized protocol: Whole-body scans, including dedicated scans for the head/neck area and the chest/abdomen/pelvis area, with multiplanar and 3D reconstructions
- Dual reading: Scans were interpreted by two radiologists and in the presence of a forensic pathologist

The Paris case study has demonstrated that the presence of PMCT in hospital settings may not always be readily available, and prior planning for scanner use in mass disasters is critical.

4.3 MANAGEMENT OF COMMINGLED REMAINS AND SPECIALIZED IDENTIFICATION

Mass disasters frequently result in fragmented and commingled remains, particularly in aircraft incidents, terrorist bombings, and natural disasters. PMCT has proven invaluable for virtual sorting and reconciliation of remains before physical handling.

Virtual Reconciliation Process:

Step	Procedure	Forensic Benefit
CT scanning of all remains	Each bag or container scanned	Permanent record of contents
Virtual segmentation	Individual bones identified in 3D data	No physical manipulation of fragile remains
Articulation assessment	Virtual testing of anatomical fit	Reassociation of fragments
Duplication checking	Multiple same-side elements identified	Minimum Number of Individuals (MNI) calculation

Individual reconstruction	Virtual assembly of complete skeletons	Chain of custody maintained
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Table 4.3: Workflow of Virtual Anthropological Analysis Using PMCT

Beyond Odontology: Skeletal Identification:

A systematic literature review by Prokopowicz and Borowska-Solonyanko (2025) examined the current state of using PMCT for personal identification beyond odontology. The review identified multiple anatomical structures validated for identification:

Anatomical Structure	Identification Value	Key References
Frontal sinuses	Highly variable and stable throughout life	Culbert & Law (1927); Moreira Andrade (2022)
Paranasal sinuses	Unique morphology; useful when dental records are unavailable	Ruder et al. (2012); Brun et al. (2017)
Mastoid air cells	Individual-specific patterns useful for identification	Rodrigues et al. (2020); Oura et al. (2022)
Sphenoid sinuses	Configuration unique to each individual	Auffret et al. (2016); Deloire et al. (2019)
Lumbar vertebrae	3D models enable part-to-part comparison	Decker et al. (2018)
Chest CT findings	Bone comparison method used for identification	Matsunobu et al. (2017)

Table 4.4: Anatomical Structures Utilized for Radiological Identification

Specialized Identification Cases:

The literature also highlights numerous case reports where identification was made through PMCT based on unexpected findings, such as:

- **Ocular findings:** Identification was made based on postmortem CT confirmation of aphakic eyes, i.e., the absence of a lens, by Oshima et al.
- **Abdominal findings:** Nakamura et al. made identification based on comparison of postmortem and antemortem abdominal CT findings in a charred body
- **Bone disease:** Identification was made based on tuberculosis manifestations by Martrille et al.
- **Anatomical variants:** Identification was made based on skeletal idiopathic osteosclerosis by De Angelis et al.

These findings indicate that any anatomical feature that can be seen in both antemortem and postmortem images may play a role in identification, provided it is characteristic.

4.4 CAUSE OF DEATH DETERMINATION AND SAFETY APPLICATIONS

Beyond identification, PMCT provides crucial data for forensic pathology and enhances personnel safety through detection of hazardous materials

Cause and Manner of Death Determination:

The 2012 Modena earthquake investigation provided compelling evidence of PMCT's value in cause of death determination. External examination alone revealed fractures by anatomical region, but PMCT was essential for:

- Identifying exact nature of skeletal injuries: Distinguishing between compression fractures, burst fractures, and fracture-dislocations
- Assessing extent of injuries: Quantifying number and severity of fractures
- Detecting organ injury: Identifying hemothorax, hemoperitoneum, pneumothorax, and organ lacerations

- Documenting injury patterns:
Reconstructing mechanism of injury

Finding Type	External Examination	PMCT Contribution
Skull fractures	Identified in 7 cases	Exact fracture patterns and intracranial involvement
Thoracic injuries	Identified in 9 cases	Hemothorax, pneumothorax, and rib fracture patterns
Pelvic fractures	Identified in 6 cases	Complete fracture classification
Organ injury	Not visible externally	Direct (shattered organ) and indirect (hemoperitoneum) evidence
Cause of death determination	Limited by external-only view	Essential findings in 2 cases (16.7%)

Table 4.5: Comparison of Findings Between External Examination and PMCT

In two of twelve cases (16.7%), PMCT findings were essential to perfecting the diagnosis of the cause of death. This experience supports the view that in major natural disasters, cause and manner of death may be determined with reasonable medical certainty through combined external examination and PMCT findings, potentially reducing the need for full judicial autopsy.

Ballistic Analysis in Terrorist Attacks:

The Paris attacks in November 2015 highlighted the importance of PMCT in ballistics. PMCT was used to facilitate:

- Localization of projectiles: Intra- and extra-corporeal bullets and fragments
- Trajectory: Documenting the trajectory of projectiles passing through organs and bones
- Weaponry: Documenting the type of weapon used
- Documenting injuries: Detailed documentation of ballistic injuries

The Paris team concluded that clear separate projectile trajectories leaving an almost linear trace in organs and adjacent bones could be documented. However, the number of impacts resulted in dispersing injuries, making trajectory analysis difficult.

Personnel Safety Applications:

Radiological safety screening is a critical safety measure that helps identify harmful materials in human remains. As noted in the ISFRI positional statement, safety screening is one of the main applications of PMCT. In terrorist bombings, human remains may include:

- Unexploded ordnance: Bomb, grenade, or explosive devices that failed to detonate
- Chemical agents: Chemical weapon or industrial chemical residues
- Radiological material: Dirty bombs or radiological dispersal devices
- Ballistic evidence: Projectiles or fragments that can cause injury during handling

Traditionally, fluoroscopy has been used in safety screening; however, PMCT has several advantages, including three-dimensional localization, increased sensitivity to small or low-density materials, permanent records, and combined identification imaging.

4.5 LIMITATIONS, CHALLENGES, AND FUTURE DIRECTIONS

Despite the demonstrated benefits of forensic radiology in mass disaster identification, several

limitations and challenges must be acknowledged, and future directions identified.

Technical Limitations:

Limitation	Impact	Mitigation Strategies
Metal streak artefacts	Compromised image quality around dental restorations and implants	Metal artefact reduction algorithms; dual-energy CT techniques
Soft tissue contrast	Limited compared to MRI	Combined PMCT and MRI protocols when available
Small field of view	May miss peripheral findings	Whole-body scanning protocols
Image registration	Matching AM and PM images with different positioning	Standardized acquisition protocols; 3D reconstruction capabilities

Table 4.6: Limitations of PMCT in Forensic Investigations and Their Mitigation Strategies

The presence of highly radiopaque dental restorations, such as amalgam, causes streak artefacts that can compromise comparison between dental PMCT and AM dental radiographs. However, recent literature describes methods to reduce metal streak artefacts, improving diagnostic quality.

Standardization Gaps:

Expert training in the interpretation of PMCT images is required and requires expertise in both radiology and forensic pathology. The absence of trained forensic radiologists is a barrier to the implementation of PMCT. The training should cover:

- Normal post-mortem changes and artifacts

- Trauma interpretation and fracture patterns
- Identification features and anatomical variations
- Technical parameters and acquisition protocols

A major barrier to the global implementation of PMCT is the lack of standards for image acquisition, interpretation, and archiving. The following are the major areas that require standardization:

- Acquisition protocols: Standardized scanning parameters for different scanner models and countries
- Interpretation guidelines: Standardized methods for feature identification and comparison
- Reporting formats: Standardized documentation for compatibility between international responses
- Quality assurance: Regular validation and testing of equipment and interpretation

The ISFRI DVI Working Group is actively pursuing international agreement on these standards. The INTERPOL DVI radiology reporting form, developed during the Grenfell Tower incident response, is a step in the right direction for standardized reporting.

Training and Expertise:

Special training in interpretation of PMCT results is also necessary. This training includes knowledge of radiology and forensic pathology. A major hindrance to the application of PMCT results in forensic science is the unavailability of trained forensic radiologists. For training in PMCT, the following knowledge is necessary:

- Knowledge of normal postmortem changes and artifacts
- Trauma interpretation and knowledge of fracture patterns
- Knowledge of identification features and anatomical variations
- Knowledge of technical parameters and acquisition

Complementary Not Replacement:

However, it must be realized that PMCT cannot replace all aspects of the physical examination. The examination of the body and the personal items must continue for:

- Documentation of the personal effects, such as jewelry, clothing, and items in the pockets
- Recovery of trace evidence, such as fibers, hair, and other microscopic material
- Examination of the skin and soft tissues, such as tattoos and scars
- Recovery of material for sampling, such as DNA, toxicology, and histology

The most effective method combines PMCT and traditional methods, using each method for its strengths while compensating for its weaknesses using alternative methods.

Future Directions:

Direction	Current Development	Potential Impact
Artificial intelligence	Automated detection of implants, fractures, anatomical variations	Accelerated identification; reduced reporter workload
Dual-energy CT	Tissue characterization; material decomposition	Improved differentiation of dental materials; artefact reduction
Remote reporting networks	Distributed expert workforce	24/7 operations; international collaboration
Portable CT scanners	Compact, transportable units	Field deployment; reduced body transportation
Advanced 3D	Virtual reality; 3D printing	Enhanced courtroom

visualization		presentation; training applications
International standards	ISFRI / Interpol collaboration	Consistent global DVI response

Table 4.7: Future Directions and Technological Developments in Forensic Radiology

The experience of the 2023 Israel attack has brought to the fore the potential of AI integration in future identifications, especially in dental morphology comparisons. With the advancement of imaging technology and its increased accessibility, the integration of imaging technology into DVI protocols will become more entrenched, further improving the international community's ability to address mass fatality events with efficiency and dignity.

5. CONCLUSION

This analysis shows that Post-Mortem Computed Tomography has changed from an experimental tool to a key part of modern Disaster Victim Identification protocols. Evidence from major international disasters, including the Victorian bushfires, Modena earthquake, Paris attacks, Grenfell Tower fire, and the attack in Israel, consistently demonstrates that PMCT provides significant benefits in addressing the main challenges of mass fatality events.

Forensic radiology allows for primary identification by comparing unique anatomical features such as frontal sinuses, paranasal sinuses, mastoid air cells, and vertebral structure. Surgical implants and prostheses, especially cardiac pacemakers with visible serial numbers, offer strong identification opportunities that link radiological and clinical records. Dental identification remains one of Interpol's three main identifiers, with CT-generated panoramic images proving effective when direct access to the mouth is limited.

In operational terms, PMCT combines functions that used to require three different imaging stations into a single examination that can be done in minutes for each body. Remote reporting capabilities shown

during Grenfell Tower achieved 96% of reports within one working day, allowing expert participation without needing to be on-site. For commingled remains, PMCT allows for virtual sorting and matching without disturbing delicate fragments, which helps maintain evidence integrity and chain of custody. Beyond identification, PMCT provides vital information for determining the cause and manner of death. Studies show it offers essential findings that improve diagnosis in a notable percentage of cases. Safety screening for hazardous materials, such as unexploded ordnance, chemical residues, and radiological material, protects mortuary staff and is a key reason for using PMCT.

Challenges remain, including the lack of international standards for image acquisition and interpretation, a shortage of qualified forensic radiologists, and the need for integration of Interpol forms. PMCT cannot replace all aspects of physical examination, such as trace evidence collection and sample gathering. The

best approach combines PMCT with traditional methods. Future directions include using artificial intelligence for automated feature detection, dual-energy CT for reducing artifacts, portable scanners for field deployment, and ongoing standardization of international protocols.

The ethical obligation is crucial: every victim deserves to be identified and returned to their family with dignity. Forensic radiology fulfills this goal by speeding up identification, maintaining dignity through minimally invasive exams, and ensuring accuracy through objective documentation. As technology develops, its use in DVI protocols will grow, making sure that every future disaster victim receives the identification they deserve. Beyond the scalpel, a world of imaging possibilities is changing disaster victim identification and fulfilling the basic humanitarian duty to identify the dead and return them to their families.

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