

■ REVIEW ARTICLE

# Significance of Medical Imaging in Forensic Science

Amit Pratap Singh Chouhan

## ABSTRACT

**CONTEXT:** Forensic radiology is an area of expertise in medical imaging that uses radiological techniques to assist physicians and pathologists in matters related to the law. The forensic application of clinical medical radiology can be applied in many fields; The primary target of evaluation is the skeletal skeleton, but the soft tissues and abdominal and thoracic viscera may provide the predominant findings. Technological advances in clinical radiology offer many potential tools for forensic radiology, allowing a broader field of applications in this field. In the event of a massive disaster, the identity of the individual is of utmost importance. To do this, forensic investigators use different methods to identify the dead. They consider the skeletal remains of the dead to be the initial stage of identification. Radiographs have great evidence to serve as an ex-mortem record and also help to identify the individual, age, gender, caste, etc. Forensic dentistry is also emerging as a new branch of forensic medicine. Therefore, the forensic dentist must know the various techniques, developments and resources to incorporate technology to achieve success in human identification. Therefore, our aim of the present review is to focus on the various radiological techniques and new developments available for the successful identification of the dead. Since X-rays can capture their distinctive physical characteristics, they become an invaluable tool in forensic science. Radiographic identification has been used for a long time and the technique is efficient, comparatively easy, both living and dead records can be obtained, and it is inexpensive compared to DNA technology. Therefore, expert knowledge and proper application of maxillofacial radiological techniques play an important role in forensic identification and resolution of medico-legal cases.

**KEY MESSAGES:** Medical Radio-Imaging Techniques Shows a significant measure in forensic identification and Determination of MLCs.

**KEYWORDS** | forensic radiology, medical imaging, radiographs, dentistry, MLC

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## INTRODUCTION

**F**ORENSIC IS A WORD the word defining the term forum, public in other word forensic is the procedure of investigating and identifying the facts in crime criminal or civil court of law by utilizing science and technology. The forensic have been much helpful in today's world by successfully identifying small abuses, murders, to mass disasters.<sup>1</sup>

Similarly, "Forensic Science" description includes the behaviour which are perturbed

with the exercise of the power, law enforcement, and civil, legal and judicial areas in detecting illegal actions in Table 1.

The person who discovered the forensic science was Sir Bernard Spilsbury. This pioneer looked beyond the crime and to lead the science in a new way, which is very important in today's century.<sup>2</sup> The area included in forensic science are; Forensic Odontology (Dental), Forensic Radiology (X-Rays), Forensic Entomology

(Zoology), Forensic Toxicology (Poisons), and Forensic Psychiatry (Psychopathology), etc. (fig.1) So, the term forensic science is a vast subject including all these areas.<sup>3</sup>

Here, Forensic Radiology is the field of X-Rays where the rays are used to identify the suspected crime. The radiologist are fundamental part off forensic science.<sup>5</sup> The role of radiologist in forensic science involves identifying the corpse through the anatomical bones and x-ray images, during post-mortem, radiographs are taken which will help in assessing the foreign particles in the body.<sup>6</sup>

The two radiographs of same individual is taken one is ante-mortem (before dissection) and another is post-mortem, so that it is more specific in determining the person.<sup>7</sup> So, it is equally important in odontology as well as anthropology. When the case comes of claiming the death of a person through external force, then the radiographs of those injured area will be helpful in determining any fractures or internal trauma and the reason why the person died can also be evaluated.<sup>8</sup> This is essential in women and children in case of abuse like homicide. Therefore, following the court law is equally important in forensic radiology. Hence, the key role played by radiologist in forensic science has major advantages in future generations, as well.<sup>9</sup>

### History of Forensic Radiology

- In the year 1895, November 8, Sir Wilhelm Conrad Roentgen accidentally discovered X-Rays which increased its importance throughout the decades.<sup>10</sup>
- These X-Rays were then first used for investigating a murder case in North America. However, the errors were observed as it took around 70 min. in taking a single radiograph.<sup>11</sup>
- Finally, in the year 1919 (after 24 years of discover of x-rays) the government of North America accepted legal use of radiology for solving forensic crimes.
- In year 1940, W.Koenig took the radiographs of teeth which was used in the identification

of Adolf Hilter, this started the Forensic Odontology.

- The establishment of CT scan, MRI and other imaging tools set the 'Gold Standard' for comparing the post and pre-mortem radiographs.<sup>12</sup>

### Scope of the Forensic Radiology

- The forensic radiology have increased its advancement in imaging as well as identifying the crimes.<sup>13</sup> And it is expected to further improve the technology and techniques in future.<sup>14</sup>
- B.G. Brogdon, classified the scope of forensic radiology into four categories along with its sub types:
  - On the basis of service – Identify discovery, Assessment of injury and death (accidental injury/trauma, non-accidental injury/trauma, foreign bodies, criminal lawsuit –fatal, non-fatal, civil lawsuit, etc.); On the base of Edification; on the base of Investigation; on the base of organization cases.<sup>15</sup>According to the types;
  - Identify discovery includes; determining the age, sex, stature, whether animal or human remains and so on.
  - Assessment of death and injury covers the types, depth of injury, origin of fracture, internal bleeding or not, trauma relating to death, the type of device used to injure and shape and size of injury.
  - Criminal litigation- Fatal (murder, suicide, abuse and terrorism) and Non-Fatal cases (fraud, faking, kidnapping, smuggling, etc.)
  - Civil Litigation – Violation of civil rights, personal injury, wrongful death or birth, etc.)<sup>16</sup>

### Radiology in Forensic Dentistry

The forensic radiology involving dentistry deals with the evaluation of dental confirmation with the proper investigation of dental findings.<sup>17</sup> The field of forensic odontology is concerned with evaluation, indulgence of dental evidences, findings and so on.<sup>18</sup> This field have a basic role in forensic science and evidence because the teeth is the only art of the body which takes

certain time to decay even if the other parts of body are highly damaged due to accidents like trauma, burning, etc.<sup>19</sup> However, the dentition remains undamaged and will provide a solid evidence in determining the age, sex, and nationality of the deceased person.<sup>20</sup> (Fig. 2)

Through the stage of teeth eruption also we can identify the victim. In case of bite marks, through the shape of teeth it can be analyzed. The error in charting of teeth of dead victim can be corrected by numbering teeth;<sup>21</sup> In case of adjacent tooth migrating into the space of extraction, this can be joined using other radiographs. During the post-mortem inspection, the X-ray image appearance of teeth and facial bones is a perpetual data of these tissues even if teeth's and bones are being detached from histopathologic examination.<sup>22</sup>

The forensic odontology is very essential in anthropology as well. Through the dentition the age and life span of the individual can be identified. Hence, the necessity of dentistry in forensic radiology is increasing. The advancement in modalities of identifying and solving the crime incident is also improving.<sup>23</sup>

#### Anatomical Identification of Suspect

For the identification of victim only the surface of dental evidence will be insufficient sometimes. So, the experts rely on recognising through the surface landmarks of the teeth and making comparison between pre-mortem and post-mortem images.<sup>24</sup> The surface landmarks of the teeth involved in assessing the characteristics like crown morphology, the size of tooth, pulp morphemes, etc. These features will provide some particular information on the individual. In case where this morphology's are damaged then spatial connection of posterior teeth can be analyzed. Still, the identification through facial bones are much tough as the bones are overlapped mainly in maxillofacial region.<sup>25</sup> So, for facial evaluation, the only landmark that can be used in comparing post-mortem ante-mortem radiographs is through frontal sinus which is present in underneath the forehead, reaching above the eye sockets and eye brows. The radiographs having various

sinus can be examined for further identification of individual and case solving. In some reports when the teeth's are already lost due to age or other incident, the anterior teeth can again be reconstructed so, that assessment and numbering will be possible.<sup>26</sup>

#### Medicolegal Cases

The Medicolegal Cases (MLC) is defined as a case involving injury or illness where the investigation is carried out legally through law enforcement.<sup>26</sup> In Forensic Radiology, the identification of MLC cases can be done through Forensic Maxillofacial Radiology.<sup>28</sup> This is done in case, where the dental radiology fails to attend the mass casualty cases. For example, when the victim comes with external injury like swelling of face, bruises claiming of being attacked then this will be Medicolegal case where forensic radiology will be helpful in investigating whether the injury is intentional or accidental (Fig. 3).<sup>29</sup> The injuries in the head can be assessed by looking through the direction of injury and point or origin of impact. If any kind of metal objects or other tools is used to harm the victim then it can also be identified. These things can be analyzed through advanced modalities of imaging like CAT scan, Micro-Computed Tomography, etc. When the person is strangulated then the evidence can be collected looking through radiographs of hyoid bone fractures or cornu of thyroid cartilage.<sup>30</sup>

In determining the age, the profile of victim can also be created. The soft tissue of face can be reconstructed through CT scan and the image of person can be created in case of burning incident. The use of radiology is boundless in forensic dentistry, evaluated through anatomy morphology of the teeth as well as major landmarks of maxillofacial bones. So, the difference in ante-mortem and post-mortem radiology will help in finding the identity of the individual.<sup>31</sup>

#### Utilization of DTI of Brain for investigation in Forensics

The MRI have also major role in forensic field. The Diffusion Tensor Imaging (DTI) in MRI

S.NO	STUDY	YEAR	REFERENCE
1.	Forensic radiology as an instantaneous branch of science.	2017	Tarani et al., 2017
2.	Problems, dispute and advancement in forensic radiology as well as MLR	2015	Guglielmi et al., 2015
3.	Role and importance of forensic radiology in odontology (dentistry).	2015	Manigandan et al., 2015
4.	Issues of forensic radiology; case of Computed Tomography of patient having gunshot injury in Head.	2018	Giffen et al., 2018
5.	Importance of Computed Tomography imaging in cross-sectional digital examination in post-mortem case.	2014	Higginbotham et al., 2014
6.	Correlation of forensic radiology with forensic odontology.	2013	Silva et al., 2013
7.	Characteristic features of Imaging radiation in forensic odontology.	2011	Chandrasekhar et al., 2011
8.	Examination of ancient child mummies having head trauma by utilizing forensic radiology.	2016	Davey et al., 2016
9.	MRI Diffusion Tensor Imaging (DTI) of Brain playing an essential role in Forensic radiology.	2015	Berkovitz et al., 2015
10.	Character of MRI imaging in post mortem of an adult.	2014	Ruder et al., 2014
11.	Application of AI in clinical Forensic Medical Imaging.	2020	Pena-Solorzano et al., 2020
12.	Utilization of forensic radiology in veterinary.	2017	Watson et al., 2017
13.	Employment of computed tomography (cone beam) in field of forensic radiology.	2014	Sarment et al., 2014

Table 1: Case studies on applications of radiology in forensic investigation.

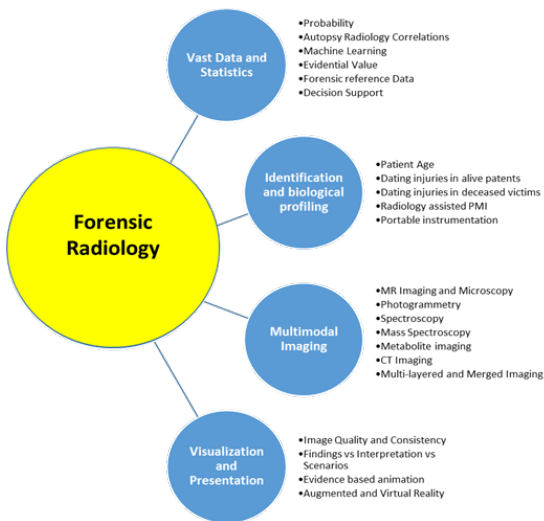


Figure 1: Showing Forensic Radiology and Medical Imaging Research outline.

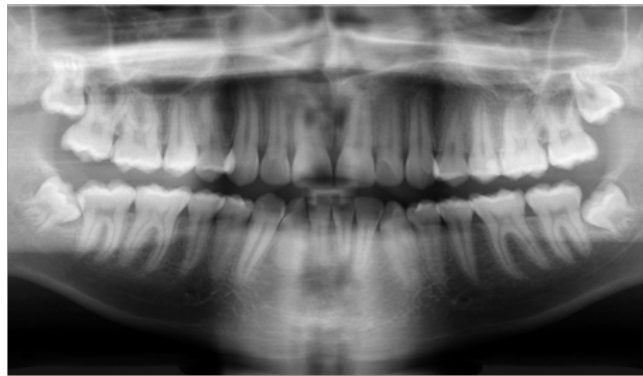


Figure 2: Showing images of Cone Beam CT

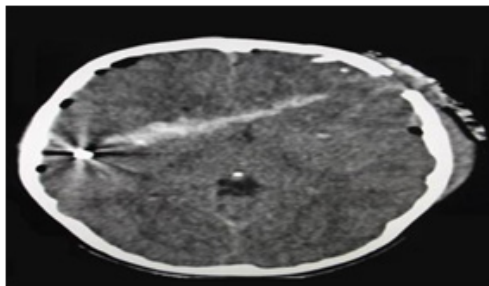


Figure 3: Showing CT images of gunshot wound

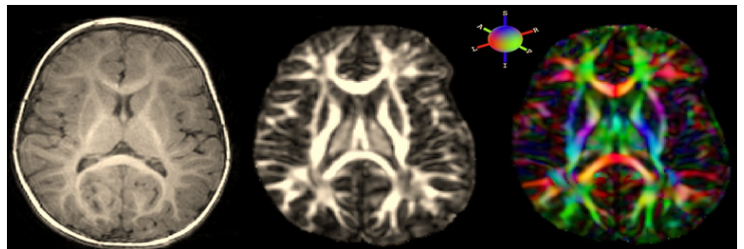


Figure 4: Showing MRI images of brain DTI

is elucidated as the sequence of MRI which gives knowledge or biological activity of tissue at microstructural level.<sup>32</sup> This is done by evaluating diffused water in various tissue. The DTI will provide information on neurological tissue either damaged or normal by computing the magnitude and direction of diffusion.<sup>33</sup> Where there is a case of cell death in stroke this is identified by decreased diffusivity.<sup>34</sup> The PM (post-mortem) DTI assessment is essential in differentiating MRI derived records with histological and forensic examination. (Fig. 4)

Hence, by reading the magnitude of diffusion and direction the forensic evidence in an individual can be found.<sup>35</sup>

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#### CONCLUSION

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Hence, the forensic radiology have played a significant role in the forensic science field. The radiographs are much more helpful in identifying and investing the cases and evidence.<sup>36</sup> The human identification can be relayed through radiographs of different parts.<sup>37</sup> The age, sex, race, and stature of an individual can be easily identified. Along with human identity the weapons of murder, injury can also be examined through Forensic Radiology.<sup>38</sup> The dentition is also valuable in providing information through bite-mark analysis and morphological analysis of teeth. The dental radiography should be given more importance by the forensic experts. These modalities, used along with other forensic methods will be able to provide most accurate reading in short time. In

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the developing countries like India, the forensic radiology and odontology are regarded as the important aspect for investigation.<sup>39</sup> However, the advancement in protocols are still lacking. As, the country have raising case of murders, illegal doings, the experts are focusing on all methods for solving the cases.<sup>40</sup> In future it will have more bright way. The value of maxillofacial radiology will also increase in coming decades.

So, in the upcoming decades Forensic Radiology will be an ideal contrivance for the investigations and it is also regarded as an integral part of forensic sciences. And with the advancements in the imaging modalities the role of radiology will also increase in the field of Forensic Science.<sup>41</sup> **IJFMP**

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