

## Review Article

# A Report on the Current Status of Radiology in Forensic Odontology in the Indian Scenario

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ABSTRACT

Forensic odontology deals with various forensics aspects of matters pertaining to dental and perioral tissues. As radiology entered the medical and dental fields for various applications, forensic scientists embraced radiological principles for identification and investigative purposes. Radiographic investigation is a reliable and a standard means by which prime procedures such as age estimation, sex-determination, individual identification and ascertaining the cause of death can be carried out. Radiographic interpretation can be impeded by various factors out of which artifacts and digital image manipulation are not uncommon these days. Any such factor is unnecessary and in the field of forensics, it poses threat to proper delivery of justice. As radiographs are highly credited as sound evidences in court, all attempts should be made to produce ideal and authentic images. The advancements in radiology with pertinence to forensics are so enormous in the recent years. The authors of this paper discuss the recent advancements of forensic radiology in India and its various implications in relation to forensic odontology.

**KEY WORDS:** *Artifacts, forensic odontology, radiology, teeth, X-rays*

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### INTRODUCTION

Radiography is a non-invasive, painless and non-destructive means of investigation of human hard and soft tissues, that is performed for a broad range of purposes.<sup>[1]</sup> They are consistent and reliable for every healthy individual. Forensic odontology is a vital branch of forensics as teeth are bestowed with qualities like resistance to high temperatures, nutritional deficiencies, mild to moderate mechanical forces, decomposition changes and dimensional stability.<sup>[2]</sup> Even the restorative materials in the teeth are resistant to high temperatures. In many cases the soft tissue health can also be assessed. Though there are more chances of lethal consequences after exposure to higher dosages of radioactive substances, there seems to be no better means of investigation to replace X-rays. This is the reason why it is still being used in the field of medicine under stipulated protocols.<sup>[3]</sup>

### HOW RADIOLOGY INVADED FORENSICS?

X-rays were discovered by Wilhelm Conrad Roentgen, a German physicist on November 8<sup>th</sup> 1895.<sup>[4]</sup> In 1896, X-ray was first used in forensics soon after its discovery for detecting the presence of lead bullets in the body of the victim to convict a criminal in America for attempting murder. This was reported by the newspaper 'New York Sun' on 6<sup>th</sup> January, 1896. The major problem encountered was that it took 70 minutes to produce images and it had a relatively higher dose then.<sup>[5,6]</sup> This was a major limitation as higher doses would lead to deterioration of the individual's health, even death. This was

the reason why radiations were not used either for diagnostic and investigative purposes in those days. As technology gradually improved, X-rays gained its importance in the field of medicine and dentistry after the availability of high vacuum X-ray tubes for production of X-rays.

### APPLICATIONS OF RADIOGRAPHY IN FORENSIC ODONTOLOGY

The uses of radiography in the field of forensic odontology are increasing day by day. The applications that are more vital and those that are being practiced currently are briefly discussed.

#### AGE ESTIMATION

In forensic odontology, age estimation is required in cases where the age of the person has to be proved in legal cases. Dental age estimation is considered to be the most reliable means of age estimation as it is not much affected by environmental factors. In adults, the age estimated with age-related traits such as attrition, the amount of dentin deposited in proportion to the pulp size and the bulk of cementum deposited around the roots of the teeth.<sup>[1,7,8]</sup> Age can also be estimated based on the presence of teeth that are contained within the bone in cases of mixed dentition and deciduous dentition. Based on the type of the teeth present and the stage of eruption, the age of the individual, including the prenatal

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age can be assessed.<sup>[9-14]</sup> However, the general health of the individual should be taken into consideration as they affect the eruption process of the teeth and deviate from the standard norms. It is prudent to also consider the nutritional status of the individual as malnutrition may cause delay in eruption and give a false conclusion that the person is younger than the actual chronological age.<sup>[15]</sup>

### SEX DETERMINATION

The skeletal features of the craniofacial complex exhibit a wide range of dimorphic features that help the anthropologist, anatomist or an odontologist to determine the sex of the individual. According to Krogman, the reliability percentage of determining the sex of an individual is ninety with skull and ninety eight if pelvis is also included.<sup>[16]</sup> The anatomical structures which are distinctly visible in the radiographs such as the mandibular ramus and frontal sinus stand as trustworthy sex predictors.<sup>[17,18]</sup> The radiographs vary in the nature of projection as per the need and the region of interest. Each projection has its precedence based on the indications. The projections such as panoramic view, occlusal view, and lateral cephalometric view possess the capacity to differentiate men from women based on the anthropometric values.<sup>[19,20]</sup>

### ASSESSMENT OF PATHOLOGIES IN FACIAL TISSUES

Based on the radiographic evidences, it is possible to conclude the age of bone injuries depending on the density of the bones in relation to the other adjacent osseous tissues.<sup>[21,22]</sup> Any fracture of cranial bones and facial bones can also be discerned whether it was peri- or post-mortem by radiographic examinations.<sup>[23]</sup> Extraction sockets also give near to accurate idea about how many days back the extraction had been done and whether it was removed before the demise of the individual or afterward.<sup>[3]</sup> Any calcification of the soft tissues and presence of calculi in salivary glands, salivary gland ducts, tonsils, etc., can also be detected.<sup>[24]</sup> Age of the injuries in the soft tissues can also be vaguely assessed. In cases where individuals die due to gunshots, the bullets may be detected in the radiographs as distinct opaque masses. Furthermore in accident cases, there is a possibility of the flow of the metallic substances into the body's soft tissues which can be detected in radiographs.<sup>[2]</sup>

### IDENTIFICATION OF CRIMINALS AND VICTIMS

The objective of any forensic scientist is to establish identity, be it a criminal or a victim. Dental arches exhibit a large margin of uniqueness, varying distinctly from one another.<sup>[25]</sup> Usually, comparisons of ante-mortem and post-mortem radiographs are done and identity is established. It is always not necessary to have ante-mortem radiographs to identify the individual. Even written records of the person obtained from dental clinics can be used to compare with the post-mortem radiographs.<sup>[26]</sup> Radiographs are inevitable especially in cases of burns where no tissues are available for DNA analysis. The task of identification becomes easier if the person whose identification has to be established has any specific deformity such as a developmental anomaly. Certain manifestations are occupation specific. People working in certain industries, factories, mills have characteristic dental features which

simplify identification process. These deviations do not always require radiographic examination as these can be elicited by non-radiographic methods also.<sup>[24]</sup> It has been reported that some criminals alter their teeth after biting the victim to escape from showing similar patterns in bite mark analysis.<sup>[2]</sup> People of different races such as Mongoloids, Negroids, and Caucasians have differences in the morphology of teeth. All the findings can be corroborated with ante-mortem records and the person of interest can be identified. The records are highly beneficial in cases of mass disasters where the putative identity of all the victims belonging to different age groups, races, and both sexes need to be confirmed.

### DENTAL NEGLIGENCE AND MALPRACTICE

The transparency of the radiographic findings reveals the fact that even unethical treatments can be fairly judged with the radiographs. Dento-legal affairs are in the increasing trend day by day. To solve these issues, radiographs should be made on any patient if there is a need and it is mandatory that the dentist saves the radiographs in the patients' record for future references.<sup>[27]</sup> Failing to make a radiograph whenever necessary to establish diagnosis is also negligence unless patients themselves refuse. The patients' refusal should also be recorded in the written format for future clarifications. Dentists also ought to keep a patient's radiograph highly confidential.<sup>[28]</sup> These protocols can keep both the dentist and the patient away from dento-legal problems.

### MISHANDLING OF RADIOGRAPHIC IMAGES

Radiographs are prone to be mishandled very easily. Radiography is highly technique sensitive and requires good skills to produce images without any defects. Certain defects can be troublesome at times such as an artifact which can imitate any foreign bodies or pathologies and confuse the investigators or clinicians.

### DEFINITION OF ARTIFACT

In general artifact is defined as an object made by a human being. In radiology, it is described as the presence of foreign marks or foreign bodies on a radiograph that do not depict the anatomy or pathology of the patient who is being examined.<sup>[29]</sup> In other words, an artifact is any distortion or error in the image that is unrelated to the subject being studied. The word "artifact" is a combination of the words "arti" meaning artificial and "fact" meaning truth. Thus, a radiographic artifact is an artificial fact or a feature, which when introduced, can cause misinterpretation in the findings of a radiograph.

### CLASSIFICATION OF ARTIFACTS

Based on nature, artifacts are classified into handling artifacts, exposure artifacts, processing artifacts and packing and distribution artifacts. Based on purpose, artifacts can be classified into intentional artifacts and accidental artifacts. Intentional artifacts are developed by those who are directly or indirectly involved in any of the legal affairs that are possibly associated with those radiographs.

### CAUSES OF ARTIFACTS

During handling, folding or bending the film, external high temperature, external low humidity, opening the unexposed film packet in visible light, water or saliva contamination can lead to development of artifacts on the film. Development of artifacts during processing can be due to films sticking to each other, hyporetention, static, roller marks, crimping, water stain, emulsion peel, etc. The artifacts that develop when exposing the individual to X-rays are patient motion, poor film screen contrast, fog, electrical/electronic defects, tissue of interest not shown, double exposure, wrong placement of cassette, light leakage into cassette, foreign bodies, and anatomical tissues.<sup>[30]</sup> In digital imaging, intentional manipulations of the images are being done to taint the veracity of radiographs by tweaking them to mimic a trauma or any pathology.

### RADIOGRAPHS AS EVIDENCES IN THE COURT

Radiographic evidences are given prime importance and considered highly valuable as they may be the sole evidences in some cases. Radiographic evidences are confirmatory evidences. Without radiographic evidences, the individuals' age, sex and other pertinent details are not accepted in the legal forums.<sup>[31]</sup> It is classical in burn cases, due to murder or any disasters, where only radiographs help in identifying the victims. A radiologist can be called to the court to give testimony by displaying the pictures or by giving oral witness to the juries when radiographic evidences are involved. It is always not necessary, as they are summoned by a lawyer only if need arises.<sup>[32]</sup> All the evidences produced in the court should be authentic. Radiographs that do not exhibit authenticity due to compromise on the quality are not considered as valuable evidences in the court. Besides going waste, it indicates the lack of expertise of the professional who made the radiograph.<sup>[33]</sup>

### RECENT ADVANCEMENTS OF RADIOLOGY IN FORENSICS

In the past, it was difficult to make radiographs in crime scene due to the lack of technology. Of late, with technical advancements, it is possible to make radiographs in the crime scene itself. Modalities such as transportable multislice computed tomography (CT) scanners and magnetic resonance imaging (MRI) scanners (limited usage) have become cheaper these days and these devices perform post-mortem dental scans in a short span of time.<sup>[34-36]</sup> These scanners can scan areas that are difficult to access, find hidden injuries and pathologies so that autopsy can be focused on that particular region, sometimes even eliminating the need for autopsy.<sup>[37]</sup> An added advantage is that the processing software allows comparison of every possible ante-mortem dental radiograph for the purpose of identification.<sup>[6]</sup> Using CT and MRI, along with digital three-dimensional scanners, the crime scene can be reconstructed, and this can be done with the support of forensic experts, engineers, and police.<sup>[38]</sup> Technical advancements in radiography allow identification of the body parts including dental fragments that are located far from each other in conditions like mass disasters.<sup>[39]</sup> The same technical advancement may also create opportunities for

unacceptable practices like image manipulation in cases of digital radiography which has to be kept in mind as well.

### CONCLUSION

Forensic odontology plays a lead role in most of the cases and almost all the problems are solved with radiographic evidences. The vulnerable fact is that, the evidences in some cases are not always available as the bodies go for cremation and there is no possibility for redoing the radiographic investigation. Most of the artifacts are seen where conventional radiographs are involved. Although artifacts are also seen in digital radiographic images, they are negligible when compared to conventional radiographs. If the artifacts are wrongly detected, it can lead to misinterpretation that may potentially lead to wrong convictions.

Almost all the nonintentional artifacts have been overcome by digital radiography which is not extensively being used in most of the centers in India. In conventional radiographic methods, there is also a problem increased radiation hazards and handling of radioactive materials. In the future, if all the centers that are authorized to use the radiographic units start using digitalized radiography, the problems about artifacts can be drastically reduced. The data in the form of images can be saved and can be reproduced at any time, even after so many years. Yet, the possibility of image manipulation should be ruled out by a forensic odontologist during investigations.

If these things are being taken into consideration, digital radiography must be conclusively considered the best technique, if maintained under strict conditions, giving no scope for image manipulation. Further in the days to come, it is also possible that the surgical means of autopsy can be replaced by virtual autopsy in many cases, thus making the fullest use of radiology in forensics.

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### CONFLICTS OF INTEREST

There are no conflicts of interest.

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