

Application of Endodontic Imaging Modalities in Forensic Personal Identification: A Review

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Abstract: Dental identification of a deceased individual is a core task in forensic odontology. The accurate recording of clinical dental procedures has become more important over time because of the increasing trend of lawsuits worldwide. Previous reports have discussed the practical usefulness of endodontic evidence for human identification. Advances in endodontic imaging, root and root canal anatomy, and biomaterials have been consistently emerging in endodontic research and practice. This article provides an update on the interrelationship between endodontics and forensic personal identification. Dental identification plays an important role in the identification of remains when there is a lack of a fingerprint record. Post-mortem radiograph taken in a way that it duplicates the ante-mortem radiograph are extremely useful in the comparison process for personal forensic identification. Even the status of a person's teeth changes throughout life and the combination of decayed, missing, and filled teeth is measurable and comparable at any fixed point in time. (1)

Key Words: forensic odontology, endodontics, post-mortem, ante-mortem, radiograph

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I. Introduction

Forensic dentistry involves the processing, review, evaluation and presentation of dental evidence with the purpose of contributing scientific and objective data in legal processes. (2)

Forensic dental identification depends mainly on the recognition of common concordant features by comparison of ante-mortem and post-mortem dental records with no irreconcilable differences demonstrated between the two sets of records. The vital role of forensic odontology in identification is based on the unique characteristics and arrangements of the teeth of different individuals. Although establishment of individual identity by the use of forensic odontology had been extremely useful and reliable, it is totally dependent on the presence of ante-mortem records. (3)

Dental identification can have three different applications:

- (a) Comparative identification, in which the postmortem dental records are compared with the ante-mortem records of an individual in order to establish whether both records correspond to the same person.
- (b) The obtainment of dental information to narrow the search for an individual when the ante-mortem records are not available and there are no possible data referred to the identity of the subject.
- (c) Identification of victims following mass disasters or catastrophes.

II. Knowledge On Root And Root Canal Anatomical Variations:

Human dentition shows a wide range of anatomical variations in each tooth type. Therefore, a forensic odontologist should be aware of such anatomical variations and their radiographic landmarks, which may facilitate postmortem personal identification when compared to ante-mortem records. (1)

The individual pulp chamber anatomy of a tooth can be described by its coronal pulp chamber morphology, and the number and location of canals, canal lengths and canal morphology. The number of root

canals within a root canal system is not always consistent; the mesiobuccal root of maxillary molars will usually have a second canal (4,5), the mandibular central incisor may have two root canals(6), the mandibular premolars may have multiple canals (7) as may the mandibular molars (8) and much variability exists in the root canal morphology of the maxillary premolars(9). In addition, variability in root canal lengths, curvatures and other root canal configurations such as the C-Shaped canals, add a plethora of features that may distinguish any given root canal system from all others. (10)

III. Use Of Periapical Radiographic Images :

The first recorded use of radiographic techniques in dental identification was by Schuller in 1921. (11) Postmortem radiographs should ideally be taken in a way that it duplicates ante-mortem image as closely as possible, and the similarity between the two images is confirmed by superimposition. The comparison of dental anatomical features in the absence of dental/endodontic restorations is more complex than when such evidence is present. Periapical radiographs also are useful to identify root canal filling materials such as gutta-percha, silver points, root canal sealers in addition to metallic and fiber posts, and post-endodontic coronal restorations. Radiographs are images displaying details of the physical features of the item recorded. In the forensic context, they form objective records of a person and derive directly from that person; they are not surrogate records in the way that written records are, they record morphological details of everything in their field of view, and are not prone to the potential errors inherent in a purely written document. Importantly, they can be accurately duplicated by a different operator at a different time on the same patient. They are therefore extremely useful in the comparison process for personal forensic identification. Dental treatment tends to leave radiographic evidence with detailed morphology that is likely to be unique, and therefore has high probative value in such a comparison. In this context, radiographs of endodontic treatments are an excellent source of individuating features based on their detailed distinctive morphology. (10)

Bitewings, periapical and OPG images are generally considered to be the most useful in forensic odontology because they show clear images of the teeth and morphological detail of artefacts resulting from trauma and dental treatment. Frontal sinus radiographs have also been used to establish identity. (12)

Visual comparison of pairs of corresponding radiographs may be thought of as a pattern-matching exercise. The accuracy of comparison of dental bitewing radiographs of individuals with unrestored dentitions has been investigated recently in adults by Wenzel et al., and in children by Fridell and Ahlqvist.(12)

IV. Use Of Three-Dimensional Imaging Techniques For Pulp Canal Space And Age Determination:

Age estimation of living or deceased individuals is an important aspect of forensic sciences. The pulpodentinal complex (PDC), which includes dentin, cementum and the dental pulp, do show age-related physiological and pathological changes. Quantification of these morphological changes nearly always requires extraction and sectioning of teeth, which is unethical and impossible in living individuals. Therefore techniques those have been or are being developed for age estimation in living individuals mostly rely on radiological imaging of teeth. Cone-beam CT scanning provides us a new method to acquire the 3D images of teeth in living individuals. Using their 3D images the ratio of pulp/tooth volume can be calculated. The newest cone-beam CT modalities and optimization of the ratio measurement software as well as increased numbers of samples can therefore make the technique mature in forensic odontology research. (13) The assessment of PTR (pulp to tooth area ratio) is an indirect quantification of secondary dentine deposition and generally correlates well with the chronological age of the subject. Secondary dentine—which is encased by harder tissue such as enamel and cementum and in addition, by primary dentine—is preferred for age estimation. Better correlation with chronologic age by the assessment of secondary dentine is thought to result since it may be more insulated from the effect of environmental factors on human remains. (11)

In recent years, micro-computed tomography (micro-CT) has gained increasing significance in the study of root canal morphology in endodontics. Micro-CT studies continue to demonstrate high levels of complexity of the root canal system, and many root canal configurations, encased in roots such as mesiobuccal roots of maxillary molars, distal roots of mandibular molars and single-rooted mandibular anteriors that are described as “nonclassifiable. (14)

V. Identification And Characterization Of Endodontic Materials:

An endodontically treated tooth potentially contains more individuating information than a non-endodontically treated tooth, and as a result is a richer source of comparative image data. The basic root filling consists of a cement sealer and a core filling material, most commonly gutta-percha. Other root fillings are silver points and most recently resin-based core filling materials. Zinc-oxide eugenol, resin, glass ionomer, silicone and calcium hydroxide are group classifications for endodontic sealers. The obturation of root canals, and hence post-preparation anatomy, will be demonstrated by the radio-opacity of these materials in a post-treatment

radiograph. Endodontic posts may be indicated in some circumstances. These posts may be active or passive, tapered or parallel, and prefabricated or custom cast. Nickel-Chromium alloy, stainless steel, titanium alloy, ceramic, zirconium and carbon fibre are materials commonly used in post fabrication. (10)

Also, one of the study demonstrates that the morphology of an obturated single root canal is easily identifiable by comparison of ante and post-mortem radiographs. Obturation of single-rooted teeth using gutta-percha creates a unique pattern that can be easily recognised using radiographs. This study also suggests that it is highly unlikely for two obturated single-root canals to have exactly the same radiographic appearance. (3)

The following table shows the radiographic appearances of various restorative and endodontic filling materials:

RADIOPAQUE	SLIGHTLY RADIOPAQUE	RADIOLUCENT
Metallic Restorations (amalgam and gold), Stainless Steel and Chrome Crowns, Base Materials, Metallic Pins, Gutta Percha, Silver Points	Porcelain Restorations, Composite Restorations	Composite Restorations, Acrylic Restorations

(15)

VI. Forensic Considerations When Dealing With Incinerated Human Dental Remains:

The identification of victims of incineration events is a daunting and intensive task that requires the coordination of professionals of different disciplines. Victims of incineration events result from airline accidents, automobile accidents, bombings, or wrongful cremation. (1)

Bonavilla et al, 2008, confirmed the preservation of microscopic structural patterns of root sealers and gutta percha exposed to high temperatures. (16)

A thorough review of past literature demonstrated that the charred dental remains could be analysed using stereomicroscopy, histology, radiography, scanning electron microscopy (SEM) and Energy dispersive X-ray spectroscopy (EDS). (17)

The results of a questionnaire sent to forensic anthropologists and forensic odontologists by Mincer et al. (1990) disclosed that the most popular methods used for physical stabilization of ashed teeth in incinerated remains were impregnation with a solution of polyvinyl acetate or application of cyanoacrylate glue.

SEM has been used in forensic dentistry to analyse severely burnt and fragmented teeth as it allows sufficient magnification, distinct surface changes in the hard tissues. It also provides valuable information such as markings from a dental drill with very high resolution.

reference for forensic odontologists. A study examined the behavior of endodontically treated teeth under thermal stresses, and results showed that the obturation material can be recognizable till 1100°C; however, a “honeycomb” appearance (radiolucent areas within the endodontic treatments) was observed over 600°C as a result of the softening of the obturation material, which can even flow to fill the missing root canals. Changes in the shape and dimension of the obturation material, especially if defective, can also be observed at lower temperatures. Broken files can also be observed at such elevated temperatures. Intracoronary restorations, such as amalgam and resin composite fillings, can also maintain their integrity at elevated temperatures. (1)

Incinerated persons commonly undergo severe muscle contraction that bends limbs into severely flexed positions. Such bent limbs may restrict access for an X-ray tube. Further, incinerated teeth and jaws are frequently very fragile, and attempts to dissect jaws or teeth can cause loss of remaining tooth structure, compromising the identification outcome. One of the authors (ASF) has found that use of a hand-held X-ray generating device can make this process much simpler and may significantly enhance the quality of the outcome. Such devices are now commonly used by forensic odontologists in Australian mortuaries and in mass disaster scenarios. (10)

VII. Some Novel Developments In Forensic Odontology:

Dostalova et al. (2012) applied the use of CamScan 2 scanning electron microscope linked with a microanalyser of characteristic X-radiation EDAX 9900 in forensic dentistry. Also, the diversity of dental patterns in orthopantomography can serve as an important tool for dental identification and records of the dental hard tissues from a coded panoramic radiograph could serve as an ante-mortem and post-mortem comparative tool for forensic identification of an individual. (17)

VIII. Conclusion

Despite the constant enhancement of dental techniques, materials and facilities, the conventional radiographs, routinely performed in the clinical practice, are still the most common source of forensic ante-mortem data for the human identification process. In this context, endodontics becomes a valuable specialty in the forensic scope, once periapical radiographs are performed. Dentists have a major role to play in keeping accurate dental records and providing all necessary information so that legal authorities may recognize malpractice, negligence, fraud or abuse, and identify unknown humans. It is imperative that dental evidence

should not be destroyed through erroneous handling until appropriate radiographs, photographs, or impressions can be fabricated. Proper methods of physical stabilization of incinerated human dental remains should be followed. The maintenance of integrity of extremely fragile structures is crucial to the successful confirmation of identity.

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