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Endodontics unveiled: The forensic frontier- A comprehensive review

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Abstract

In the intricate nexus of forensic odontology and endodontics, this comprehensive review elucidates the indispensable role of dental sciences in the pursuit of justice. Forensic odontology, predicated on meticulous dental evidence analysis, remains a cornerstone in identifying individuals amid mass fatality incidents, despite advancements in biometric techniques. Endodontics, with its profound grasp of dental anatomy and therapeutic precision, emerges as a pivotal tool for forensic specialists, enhancing identification accuracy through advanced technologies like Cone-Beam Computed Tomography (CBCT) and digital forensics. Illustrative case reports demonstrate the critical contributions of endodontic insights in bridging gaps in personal identification, providing closure to families, and crucial evidence to investigators. As technological advancements continue to refine forensic odontology's capabilities, the future heralds promising prospects for endodontics, solidifying its role as an indispensable ally in the relentless pursuit of truth and justice.

Keywords: Forensic odontology, endodontics, dental identification, root canal therapy, cone-beam computed tomography (CBCT), digital forensics, dental morphology, mass fatality incidents, radiographic analysis, dental restorative materials

Introduction

Forensic odontology, a specialized field within dentistry, is dedicated to the meticulous handling, examination, and interpretation of dental evidence to serve the cause of justice^[1]. The use of distinctive dental features and morphological variations for personal identification is well-established and widely accepted in both forensic investigations and legal proceedings^[2]. Despite significant advancements in primary identification techniques such as DNA profiling, fingerprint analysis, and facial reconstruction, the comparison of dental records remains a crucial component in the identification of deceased individuals in mass fatality incidents. These incidents may include airplane crashes, large-scale accidents, terrorist attacks, and natural disasters. In cases where ante-mortem dental records are unavailable for comparison, forensic anthropologists or odontologists can provide valuable insights into the age, race, and sex of the deceased based on dental evidence retrieved from the scene^[3].

Endodontics: Fundamentals and Applications

The overarching objective of any surgical procedure in dentistry is to restore the tooth to its natural form and function while also enhancing its aesthetic appeal when necessary. One of the principal aims of endodontic therapy is the thorough decontamination of the root canal system, eliminating pathogens, pulpal remnants, and other extraneous materials. Achieving this objective often necessitates compromising the tooth's biomechanical properties, which consequently diminishes the prognosis for restorative success. The integrity of the remaining dental structure and the quality of restorations play a pivotal role in the long-term viability of an endodontically treated tooth^[4]. A successful root canal procedure significantly enhances the likelihood of the tooth maintaining normal function within the oral cavity for an extended period^[5]. The longevity of a tooth post-endodontic treatment is contingent upon the amount of residual tissue and the healing process.

Several factors influence endodontic outcomes, including the quality of the root canal filling and the structural integrity of the tooth post-preparation. Current research in this domain is focused on understanding dentine behavior and configuration throughout aging and functional usage [6]. In contemporary practice, a more conservative approach is being advocated, facilitated by numerous innovative technologies and methodologies. The importance of preservation and a prudent therapeutic strategy cannot be overstated [7]. Endodontics has undergone significant advancements with the introduction of new technologies that enhance precision, efficacy, and patient experience. Noteworthy applications include the use of lasers [8], artificial intelligence [9], endoscopes [10], and cone-beam computed tomography (CBCT) [11].

Materials and Methods in Endodontics Pertinent to Forensic Odontology

Human dentition encompasses a vast array of anatomical variations across different tooth types. Forensic odontologists must possess an intimate understanding of these variations and their radiographic landmarks, as this expertise is invaluable for postmortem personal identification when compared to ante-mortem records. The distinctive pulp chamber anatomy of each tooth, delineated by its configuration, is a critical component in the identification process [12]. The specific anatomy of a tooth's pulp chamber includes the morphology of the coronal pulp chamber, the number and location of canals, canal lengths, and canal morphology. The number of root canals can vary significantly: for instance, maxillary molars often possess a second mesiobuccal canal, mandibular central incisors may exhibit two root canals, and mandibular premolars and molars frequently contain multiple canals. Maxillary premolars are particularly noted for their substantial variability in root canal morphology. Variations in root canal lengths, curvatures, and configurations, such as C-shaped canals, further contribute to the unique characteristics that can differentiate any given root

canal system from others [13]. An in-depth knowledge of the variations and transformations in human dentition, as well as the distinctive traces left by endodontically treated teeth, can significantly aid forensic experts in identifying fire victims [14].

Role of Endodontics in the Identification Process

Endodontics has emerged as a valuable specialty within the forensic domain. The expertise of endodontists transcends the realm of root canal treatments, extending to the establishment of a deceased individual's identity. Various tools and methodologies have been explored to assist endodontists in this critical function. Radiographs, for instance, serve as excellent instruments for identification [15]. Furthermore, comprehending dental hard and soft tissue measurements facilitates the determination of a victim's age and sex [16]. The diverse restorative and endodontic materials utilized during root canal treatments also provide significant clues for identifying deceased individuals [17].

Case Reports

Case 1: An examination of antemortem and postmortem dental panoramic radiographs revealed a transposition of the right maxillary canine (tooth 6) and the first premolar (tooth 5), a distinctive feature present in both sets of images. Despite the discrepancies regarding the mandibular third molars (teeth 17 and 32), which had been extracted, the identical treatment marks observed on teeth 14, 19, and 30 corroborated the positive identification. The inherent durability of dental structures against various forms of degradation and catastrophic events underscores their reliability for forensic identification. The utilization of postmortem computed tomography (CT), particularly maximum intensity projection (MIP) images, significantly augments the visualization of dental structures, facilitating the detection of anomalies such as root alignment, which are indispensable for accurate identification (fig.1, fig.2, fig.3, fig. 4) [18].

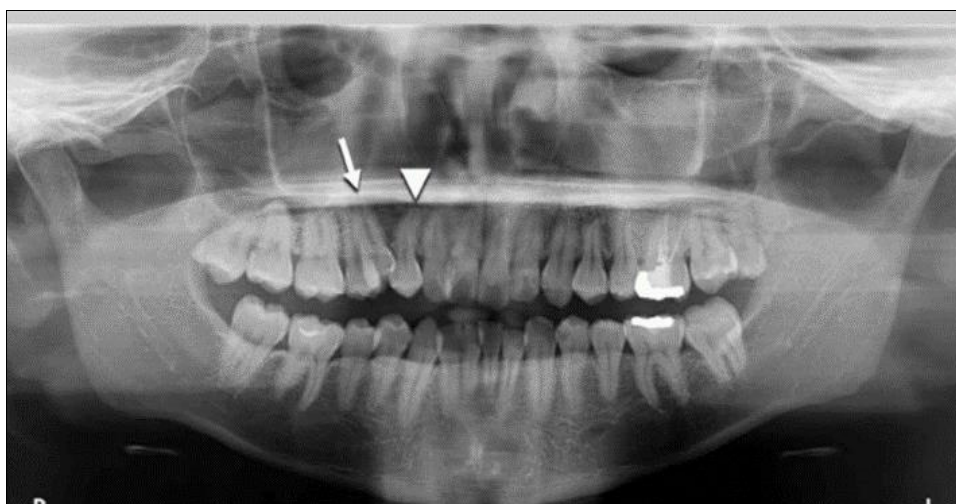


Fig 1: Illustrates the antemortem dental panoramic radiograph. Notably, the right maxillary canine (Tooth 6, indicated by the arrow) and the first premolar (Tooth 5, indicated by the arrowhead) are transposed. Additionally, the left maxillary first molar (Tooth 14) exhibits discernible features such as the pulp, root canal filling, and crown. Similarly, a crown is evident on both the left mandibular first molar (Tooth 19) and the right mandibular first molar (tooth 30).

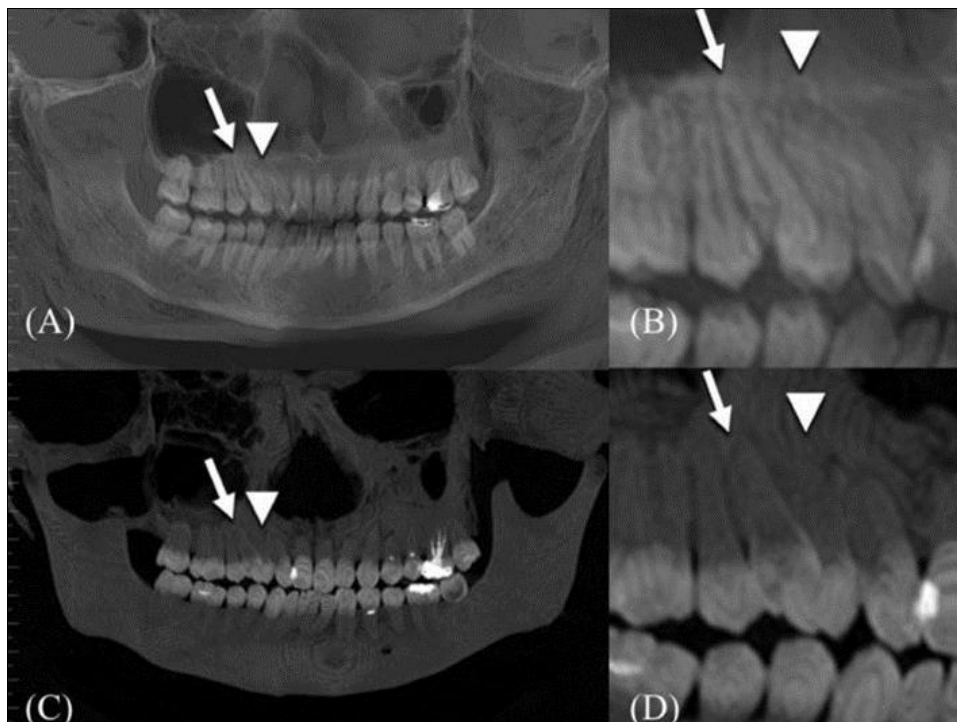


Fig 2: Depicts dental panoramic images reconstructed from postmortem computed tomography (CT). Panel (A) showcases the volume rendering (VR) mode. Panel (B) provides an enlarged view of the transposed teeth in (A). Panel (C) presents the maximum intensity projection (MIP). Panel (D) further extends the view of the transposed teeth in (C). The right maxillary canine (tooth 6, denoted by the arrow) and the first premolar (tooth 5, denoted by the arrowhead) are discernibly displaced. The left maxillary first molar (tooth 14) displays the pulp, root canal filling, and crown. Crowns are also observable on the left mandibular first molar (Tooth 19) and the right mandibular first molar (tooth 30). Notably, the mandibular third molars (teeth 17 and 32) are absent, likely due to extraction.

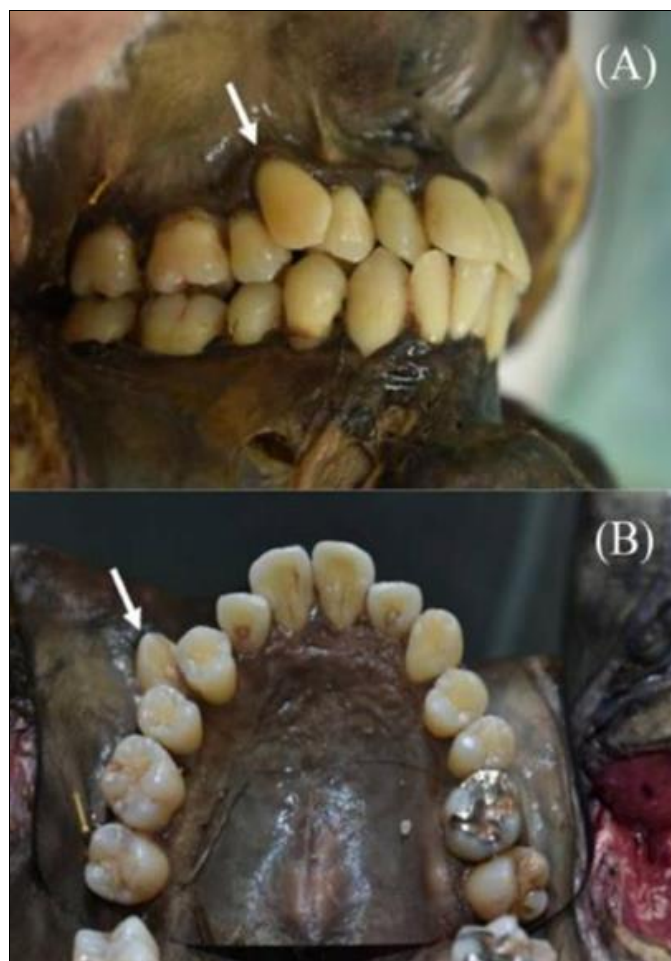


Fig 3: Photograph of the right maxillary dentition (A) and the maxillary dental arch (B). The right canine (tooth 6, indicated by the arrow) is situated on the buccal aspect of the dental arch. The first premolar (tooth 5) is positioned distal to the right lateral incisor (tooth 7).

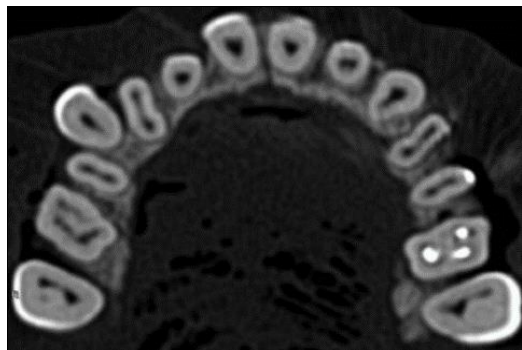
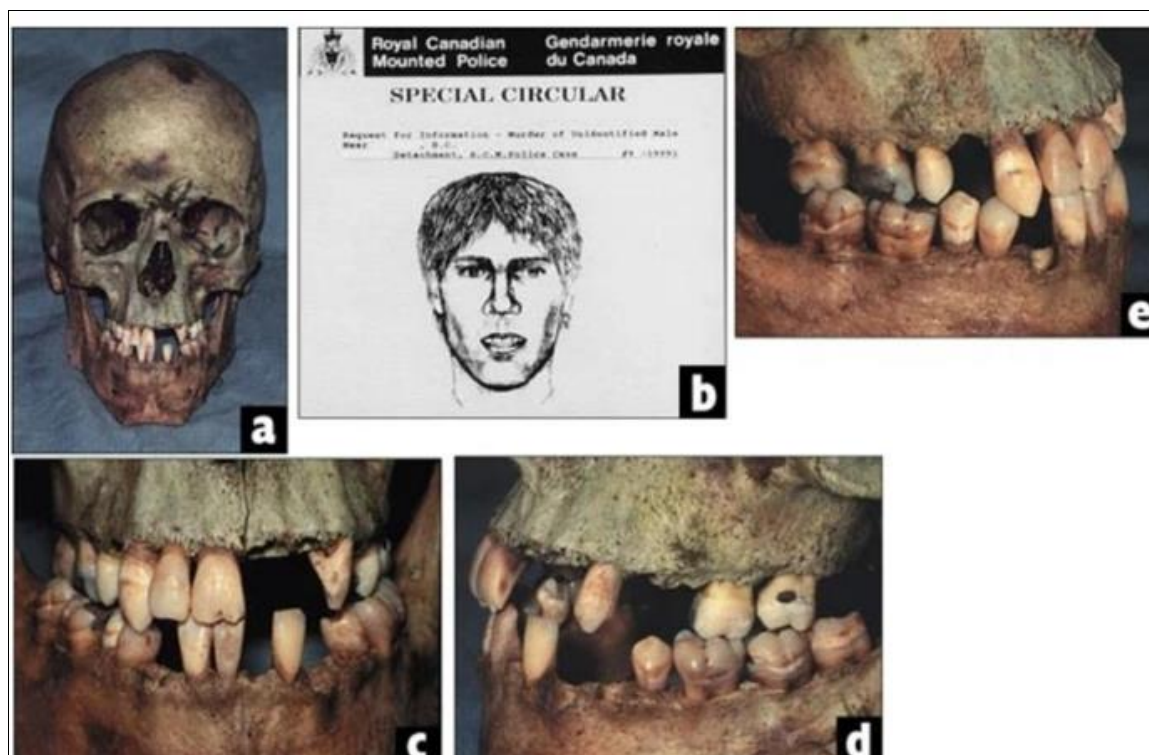


Fig 4: Axial computed tomography image of the maxillary dentition.

Case 2: Investigators were initially unable to ascertain a tentative identification and thus requested a postmortem dental profile. The skeletal morphology and dental attributes suggested the following profile: Caucasian male, aged between 25 and 35 years at the time of death, exhibiting moderate adult periodontitis, nicotine stains, an absence of recent dental treatments, and previous dental work consistent with Canadian standards. Utilizing this comprehensive data, a forensic artist rendered a facial reconstruction. This subsequently led to the identification of the decedent as a 28-year-old missing Caucasian male smoker (fig. 5) ^[19].



B. Technological Advancements and Future Directions

Cone-Beam Computed Tomography (CBCT) stands out as a remarkable three-dimensional imaging modality with a multitude of applications. It offers substantial technical and practical advantages while remaining cost-effective. Forensic investigators should increasingly consider its use for postmortem imaging. Further research into its potential within dental and forensic fields could significantly enhance its utility, ultimately establishing CBCT as an invaluable tool in forensic science ^[20].

Technological advancements have profoundly transformed forensic investigations. Digital forensics, in particular, has revolutionized data collection and analysis. Computerized images are now more reliable and accurate, substantially minimizing the risk of manipulation. These advancements are especially crucial in disaster victim identification, where the digital transfer of information without loss is paramount. Effective practice and the legal implementation of sophisticated software are essential for optimizing forensic investigations. As the costs associated with these technologies continue to decrease, digital forensics will become an integral component of the investigative process, broadening its application across various specialties ^[21].

Conclusion

In the intricate nexus of forensic odontology and endodontics,

this comprehensive review has illuminated the profound impact of dental sciences on the pursuit of justice and the resolution of complex forensic challenges. Forensic odontology, anchored in the meticulous examination and interpretation of dental evidence, stands as a stalwart discipline in identifying individuals amidst mass fatality incidents and diverse forensic contexts. Despite the advent of advanced biometric techniques, dental records remain indispensable for corroborating identity, especially when ante-mortem records are scarce or absent. Endodontics, with its nuanced understanding of dental anatomy and meticulous therapeutic interventions, emerges not merely as a remedy for dental ailments but as a pivotal tool for forensic specialists. The discipline's ability to discern minute variations in dental morphology, aided by sophisticated technologies like CBCT and digital forensics, underscores its evolving role in enhancing precision and reliability in forensic investigations. The presented case reports vividly illustrate how endodontic insights, from detailed pulp chamber anatomy to distinctive restorative materials, have facilitated positive identifications in challenging forensic scenarios. These cases underscore the discipline's capacity to bridge critical gaps in personal identification, thereby delivering closure to families and crucial evidence to investigative authorities. Looking forward, the integration of cutting-edge technologies promises to

further refine forensic odontology's capabilities. Continuous advancements in imaging modalities and digital forensics are poised to elevate the discipline's efficacy, ensuring robust practices and standards across forensic investigations. As such, the future holds promising prospects for endodontics within forensic odontology, solidifying its position as an indispensable ally in the pursuit of truth and justice.

Conflict of Interest

Not available

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