

Forensic Odontology: Identification, Innovation, Justice

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Introduction

Forensic odontology encompasses critical methodologies for personal identification, notably including age estimation. A systematic review and meta-analysis thoroughly evaluated the reliability of pulp-to-tooth ratio and secondary dentin deposition as key methods in this area. This research confirmed their utility but highlighted significant variability across different populations, underscoring the absolute necessity for integrating population-specific data to achieve greater accuracy in forensic investigations[1].

Another pivotal aspect of forensic odontology is the meticulous examination of bite mark analysis. A comprehensive systematic review delved into the methodologies for collecting, analyzing, and comparing bite mark evidence. It openly addressed the prevailing controversies and inherent challenges, advocating strongly for the establishment of standardized protocols and the seamless integration of advanced technologies. These improvements are vital for enhancing both the reliability and the ultimate admissibility of bite mark evidence within legal frameworks[2].

In crisis situations, forensic odontology takes on a crucial role in disaster victim identification (DVI). One review meticulously outlined the established protocols and diverse techniques employed in such scenarios. It particularly stressed the profound importance of maintaining accurate dental records, facilitating both antemortem and postmortem comparisons. This collective effort highlights the absolute necessity of an interdisciplinary approach to ensure efficient and highly reliable identification processes during mass casualty incidents[3].

The field also provides invaluable contributions to the identification and systematic documentation of child abuse and neglect cases. A narrative review illuminated the significant role of forensic odontology here, discussing various dental indicators and characteristic injury patterns. It emphasized the essential responsibility of dental professionals in recognizing and promptly reporting suspected abuse, thereby supporting legal proceedings and vigilantly safeguarding vulnerable children[4].

Underpinning many forensic identification efforts is the critical importance of dental records. A review underscored their unique advantages, primarily due to the exceptional resistance of teeth to decomposition and diverse environmental factors. It detailed how meticulously maintained and comprehensive dental charts, radiographs, and physical models become indispensable tools, streamlining individual identification across a spectrum of forensic scenarios, from isolated cases to widespread mass disasters[5].

Looking to the future, emerging technologies are set to profoundly transform forensic odontology. A narrative review explored the groundbreaking impact of innovations such as 3D imaging and Artificial Intelligence (AI). These advancements are

poised to significantly enhance accuracy in core areas like age estimation, bite mark analysis, and overall identification, promising more precise and remarkably efficient forensic investigations moving forward[6].

Beyond age and general identification, sex determination also falls within the purview of forensic odontology. A systematic review comprehensively assessed diverse dental parameters, including specific tooth dimensions, unique morphological features, and distinct dental arch characteristics. This research consolidated compelling evidence regarding the accuracy and reliability of these methods, underscoring their substantial potential as supplementary tools, particularly valuable in complex cases where skeletal remains are found fragmented or are otherwise incomplete[7].

As the practice evolves, forensic odontology practitioners face a range of ethical and legal challenges. A contemporary review delved into critical issues such as informed consent, the paramount importance of data privacy, the intricacies of expert witness testimony, and the overarching need for strict adherence to professional guidelines and established legal frameworks. Addressing these aspects is fundamental to maintaining integrity and consistently ensuring justice in all forensic dental investigations[8].

The intricate details provided by dental data are also crucial for forensic facial reconstruction. A review explored this contribution, detailing precisely how dental characteristics—including tooth morphology, arch form, and jaw structures—directly inform the reconstruction of facial features. It examined both current methodologies and projected future directions, highlighting the integration of 3D imaging and advanced digital tools to significantly improve the accuracy and overall utility of facial approximation techniques in complex identification efforts[9].

To further refine age assessment, another systematic review and meta-analysis meticulously evaluated the accuracy of various dental age estimation methods commonly employed in forensic odontology. This study rigorously compared different techniques, focusing on dental development and regression analyses. It provided invaluable insights into their respective strengths and limitations across diverse populations, ultimately serving to guide practitioners toward the most reliable and precise methods for age assessment in crucial forensic cases[10].

Description

Forensic odontology heavily relies on robust methods for age estimation. A systematic review and meta-analysis affirmed the utility of pulp-to-tooth ratio and secondary dentin deposition, though it stressed that accuracy benefits significantly from population-specific data [1]. Building on this, another extensive systematic review and meta-analysis rigorously evaluated the accuracy of various dental age

estimation methods. This research compared techniques based on dental development and regression analyses, offering insights into their strengths and limitations across diverse populations. The findings are vital for guiding practitioners toward more reliable methods for age assessment in forensic cases [10]. These studies collectively emphasize the continuous effort to refine and validate age estimation techniques, ensuring their scientific rigor and practical applicability in legal contexts.

Identification is a cornerstone of forensic odontology, particularly in challenging scenarios like mass casualty incidents. A review highlighted the crucial role of the discipline in disaster victim identification (DVI), detailing established protocols and techniques. It underscored the importance of accurate dental records and the necessity of both antemortem and postmortem comparisons, advocating for an interdisciplinary approach for efficient and reliable identification [3]. This capability is largely due to the inherent advantages of dental records themselves. Another review emphasized the critical importance of these records in forensic identification, noting teeth's high resistance to decomposition. It elaborated on how well-maintained dental charts, radiographs, and models facilitate individual identification across various forensic scenarios, from single cases to mass disasters [5]. These works demonstrate the fundamental reliance on comprehensive dental documentation for successful identification efforts.

Beyond general identification, forensic odontology provides specialized analytical techniques. Bite mark analysis, for example, underwent thorough examination in a systematic review, assessing collection, analysis, and comparison methods. This review critically discussed associated controversies and challenges, calling for standardized protocols and advanced technologies to improve reliability and admissibility in legal settings [2]. The field also aids in determining biological attributes. A systematic review assessed various dental parameters for sex determination, including tooth dimensions and morphological features. It consolidated evidence on the accuracy and reliability of these methods, affirming their potential as supplementary tools, especially when skeletal remains are fragmented or incomplete [7]. Furthermore, dental data plays a significant role in forensic facial reconstruction. One review detailed how characteristics like tooth morphology, arch form, and jaw structures inform facial feature reconstruction, exploring current methodologies and future directions, including the integration of 3D imaging and advanced digital tools to enhance accuracy [9].

Forensic odontology extends its utility to safeguarding vulnerable populations. A narrative review explored its significant contribution to identifying and documenting child abuse and neglect cases. It discussed various dental indicators and patterns of injury, stressing the essential role of dental professionals in recognizing and reporting suspected abuse, thereby supporting legal proceedings and protecting children [4]. This area of practice requires a keen eye for detail and a strong ethical commitment from dental practitioners.

The landscape of forensic odontology is continuously shaped by technological advancements and ethical considerations. A narrative review explored the transformative impact of emerging technologies like 3D imaging and Artificial Intelligence (AI) on the field. These innovations promise enhanced accuracy in age estimation, bite mark analysis, and identification, paving the way for more precise and efficient investigations [6]. However, this progress is balanced by critical ethical and legal challenges. A contemporary review addressed issues such as informed consent, data privacy, and expert witness testimony. It highlighted the imperative for practitioners to adhere to professional guidelines and legal frameworks to maintain integrity and ensure justice in forensic dental investigations [8]. This dual focus on innovation and ethics ensures the field remains both advanced and accountable.

Conclusion

Forensic odontology is a multidisciplinary field central to identification and legal investigations. Research shows the reliability of methods like pulp-to-tooth ratio and secondary dentin deposition for age estimation, though acknowledging the need for population-specific data. The discipline addresses complex areas like bite mark analysis, advocating for standardized protocols and advanced technologies for better reliability. Its role is particularly crucial in disaster victim identification, where accurate dental records are indispensable. Dental records themselves are key identification tools due to the resilience of teeth. Beyond identification, forensic odontology helps identify child abuse and neglect through specific dental indicators. The field continually evolves with emerging technologies such as 3D imaging and Artificial Intelligence, which significantly enhance accuracy in various applications. Sex determination using dental parameters provides valuable supplementary information in challenging cases. Dental data also contributes significantly to forensic facial reconstruction, informing facial features. Continuous evaluation of age estimation methods ensures practitioners use the most accurate techniques. This entire practice is underpinned by critical ethical and legal frameworks, ensuring integrity and justice in all forensic dental investigations.

Acknowledgement

None.

Conflict of Interest

None.

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Forensic Sci 68 (2023):910-921.

How to cite this article: Connors, Lara J.. "Forensic Odontology: Identification, Innovation, Justice." *J Forensic Med* 10 (2025):416.

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Received: 01-May-2025, Manuscript No. jfm-25-173734; **Editor assigned:** 05-May-2025, PreQC No. P-173734; **Reviewed:** 19-May-2025, QC No. Q-173734; **Revised:** 22-May-2025, Manuscript No. R-173734; **Published:** 29-May-2025, DOI: 10.37421/2472-1026.2025.10.416
