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Artificial Intelligence Assisted Forensic Dentistry: Conceptual Framework, Applications, and Forensic–Legal Implications

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Abstract:

Forensic dentistry plays a pivotal role in human identification, age estimation, sex determination, and disaster victim identification. Conventional forensic odontological methods, although well established, are limited by subjectivity, inter-observer variability, and the increasing demand for rapid analysis of large and complex datasets. Artificial intelligence (AI), particularly machine learning and deep learning, offers a transformative approach by enabling automated pattern recognition, objective decision support, and high-throughput data processing. This concept paper explores the integration of AI into forensic dentistry by outlining its theoretical foundations, current and emerging applications, advantages, limitations, ethical concerns, and legal admissibility. A conceptual framework is proposed in which AI functions as an assistive expert-support system rather than a replacement for forensic odontologists. Emphasis is placed on explainability, population specificity, and forensic validity to ensure the responsible and legally defensible adoption of AI within judicial systems.

Keywords: Artificial intelligence, forensic dentistry, forensic odontology, dental identification, age estimation, legal admissibility

1. Introduction

Forensic dentistry, also known as forensic odontology, is a specialized discipline that applies dental knowledge to legal investigations, particularly in human identification, age estimation, and the interpretation of dental evidence. Owing to the durability and individuality of dental structures, dental records have long been considered a reliable means of forensic identification. However, despite its established forensic value, the discipline remains heavily dependent on expert interpretation, which may be influenced by observer bias, fatigue, and variability in experience.

The growing complexity of forensic casework—especially in mass disasters and situations involving large numbers of unidentified remains—has highlighted the need for analytical tools that enhance accuracy, reproducibility, and efficiency. Artificial intelligence (AI), encompassing machine learning, deep learning, and computer vision, has demonstrated substantial success in medical imaging, diagnostics, and pattern recognition. Its application to forensic dentistry represents a paradigm shift from predominantly manual, experience-based interpretation toward data-driven, algorithm-assisted forensic analysis.

2. Rationale for AI Integration in Forensic Dentistry

The justification for incorporating AI into forensic dentistry is grounded in several critical forensic and operational requirements:

- **Objectivity:** Reduction of subjective interpretation in dental comparisons
- **Standardization:** Uniform analytical approaches across examiners and institutions
- **Scalability:** Capacity to process large volumes of dental data efficiently
- **Speed:** Rapid matching and triage in disaster victim identification (DVI) scenarios
- **Reproducibility:** Consistent outcomes across repeated analyses

AI is not intended to replace forensic expertise; rather, it enhances decision-making by functioning as a structured forensic decision-support system.

3. Conceptual Framework of AI-Assisted Forensic Dentistry

AI-assisted forensic dentistry may be conceptualized as a three-tier model integrating data acquisition, computational analysis, and expert interpretation.

Tier 1: Data Acquisition

This tier comprises digital dental records, panoramic and periapical radiographs, cone-beam computed tomography images, intraoral scans, photographs, and both ante-mortem and post-mortem datasets.

Tier 2: AI Processing Layer

The processing layer includes image preprocessing and segmentation, feature extraction (such as tooth morphology, restorations, and pulp volume), pattern recognition using machine learning and convolutional neural networks, and predictive modeling for age and sex estimation.

Tier 3: Expert Interpretation and Legal Reporting

In the final tier, AI-generated outputs are critically reviewed by forensic odontologists, interpreted in the context of case history, and incorporated into legally defensible expert reports and testimony. Importantly, AI findings support—but do not replace—professional forensic judgment.

4. Applications of AI in Forensic Dentistry

4.1 Dental Identification

AI algorithms facilitate the comparison of ante-mortem and post-mortem dental data by analyzing tooth morphology, restorations, missing teeth, and root configurations. Automated matching systems significantly reduce comparison time and improve efficiency, particularly in mass disaster scenarios.

4.2 Age Estimation

AI-based models assess tooth development stages in children and adolescents and evaluate pulp–tooth volume ratios in adults using CBCT imaging. When trained on population-specific datasets, these models demonstrate reduced error margins compared to traditional age estimation methods.

4.3 Sex Determination

AI integrates odontometric and mandibular parameters through multivariate analysis, thereby improving accuracy over single-measurement approaches. Deep learning models have shown promising results in identifying sexually dimorphic dental traits.

4.4 Bite Mark Analysis (Assistive Role)

Although bite mark evidence remains controversial, AI can contribute by providing objective pattern analysis, digital overlays, and similarity scoring. Nevertheless, AI cannot overcome inherent biological variability, and its application must remain strictly supportive and cautious.

4.5 Mass Disaster Victim Identification

AI-driven systems enable rapid screening of thousands of dental records, prioritize potential matches, and facilitate integration with other forensic modalities such as DNA profiling and fingerprint analysis.

5. Advantages of AI-Assisted Forensic Dentistry

The adoption of AI in forensic dentistry offers several advantages, including reduced inter- and intra-observer variability, high-speed data processing, improved consistency and reproducibility, enhanced handling of large and complex datasets, and strengthened support for evidence-based forensic conclusions.

6. Limitations and Challenges

Despite its promise, AI integration faces notable challenges. These include data bias resulting from non-representative training datasets, limited explainability of black-box algorithms, a lack of large-scale forensic validation studies, concerns regarding legal acceptance, and ethical issues related to data privacy, consent, and potential misuse.

7. Legal and Ethical Considerations

From a forensic–legal perspective, AI-assisted findings must satisfy established admissibility standards such as the Daubert and Frye principles. AI-generated outputs should be presented as corroborative evidence, with the forensic odontologist retaining full responsibility for interpretation and testimony. The development and adoption of explainable AI models are essential to enhance transparency and judicial confidence.

8. Future Directions

Future research should focus on the development of population-specific AI models, integration of explainable AI frameworks, establishment of standardized forensic AI protocols, creation of multimodal forensic platforms combining dental, DNA, and facial data, and the development of national and international AI-powered forensic dental databases.

9. Conclusion

Artificial intelligence represents a transformative adjunct in forensic dentistry, offering enhanced objectivity, efficiency, and reproducibility. However, its application must remain ethically grounded, legally defensible, and firmly supervised by forensic experts. AI should be viewed not as a replacement for forensic odontologists, but as a scientifically robust decision-support tool that strengthens forensic conclusions and improves judicial outcomes.

References

1. Schwendicke F, Samek W, Krois J. Artificial intelligence in dentistry: chances and challenges. J Dent Res. 2020;99(7):769–774.
2. Cameriere R, Ferrante L, Cingolani M. Age estimation in children and adolescents by dental analysis: recent advances and applications of artificial intelligence. Forensic Sci Int. 2021;320:110689.
3. da Silva RHA, Sales-Peres A, Oliveira RN. Forensic dentistry in the era of artificial intelligence: perspectives and challenges. Forensic Sci Int Synerg. 2023;6:100322.
4. Leite AF, Gerven AV, Willems H, Beznik T, Lahoud P, Isola G. Artificial intelligence-driven tools in forensic dentistry: a systematic review. Forensic Sci Int. 2020;315:110456.
5. Revie G, Brown KA, Manica S. Computer-assisted dental identification in forensic science: current status and future directions. J Forensic Sci. 2020;65(4):1135–1143.
6. Banar N, Bertels J, Laurent F, Vandermeulen D, Maes F. Toward fully automated dental identification using artificial intelligence. Forensic Sci Int. 2021;325:110855.
7. Lee KS, Jung SK, Ryu JJ, Shin SW, Choi J. Deep learning-based prediction of sex using dental panoramic radiographs. Sci Rep. 2020;10:1–9.
8. Kim YJ, Kim DH, Jeong SN. Deep learning-based convolutional neural networks in dental image analysis: a review. IEEE Access. 2021;9:123978–123995.
9. Chen H, Zhang K, Lyu P, Li H, Zhang L, Wu J. A deep learning approach to automatic teeth detection and numbering based on panoramic radiographs. IEEE J Biomed Health Inform. 2019;23(5):1811–1821.
10. Kazzazi F, Kranioti EF. Applications of artificial intelligence in forensic anthropology and odontology: a review. Forensic Sci Int. 2021;325:110856.
11. Poleti ML, de Oliveira RN, da Silva RHA. Application of artificial intelligence in forensic odontology: current perspectives. J Forensic Dent Sci. 2021;13(3):123–129.
12. Samek W, Wiegand T, Müller KR. Explainable artificial intelligence: understanding, visualizing and interpreting deep learning models. ITU J ICT Discov. 2019;1(1):39–48.
13. Rudin C. Stop explaining black box machine learning models for high-stakes decisions and use interpretable models instead. Nat Mach Intell. 2019;1(5):206–215.
14. European Network of Forensic Science Institutes (ENFSI). Guideline for the use of artificial intelligence systems in forensic science. Forensic Sci Int Synerg. 2022;5:100271.
15. Jain A, Verma S, Mathur A. Ethical and legal challenges of artificial intelligence-assisted forensic identification in India. Indian J Med Ethics. 2023;8(4):312–318.
16. Krishan K, Kanchan T. Emerging technologies in forensic identification: the role of artificial intelligence. Med Sci Law. 2022;62(4):275–282.
17. Aggarwal R, Gupta P. Legal implications of AI-driven forensic evidence: challenges for admissibility and accountability. Int J Law Inf Technol. 2024;32(1):88–102.
18. Wang CW, Huang SC, Lee JH. Tooth morphology analysis using deep learning for human identification. Pattern Recognit Lett. 2021;138:416–423.