



Applications, capabilities, and limitations of artificial intelligence in forensic odontology: a scoping review protocol

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ABSTRACT

Introduction: Forensic odontology plays an essential role in legal investigations by facilitating human identification through dental records, bite marks, and age estimation. Historically dependent on expert-driven, manual evaluations, this field is being reshaped by technological advancements. The integration of artificial intelligence, including machine learning, deep learning, and computer vision—offers new possibilities to automate and enhance analyses, improving diagnostic accuracy, accelerating case processing, and reducing subjectivity.

Objectives: The general objective of this study is to map and understand the implications, capabilities, and limitations of artificial intelligence technologies for forensic practitioners and legal stakeholders. To facilitate a targeted data extraction strategy, this review will address specific operational objectives, namely: to identify the primary areas of forensic dentistry where artificial intelligence is currently applied; to assess the reported capabilities and performance outcomes of various artificial intelligence models in these applications, to categorize the technical limitations and challenges reported in the literature, such as data quality, sample size, and lack of standardization, and to map the ethical and legal implications surrounding the use of AI in forensic contexts, including algorithm transparency and biometric data privacy.

Methodology: A scoping review will be performed according to the Joanna Briggs Institute methodology and PRISMA-ScR guidelines. The protocol is registered on the Open Science Framework. Searches will be conducted across five scientific databases and grey literature, using specific keywords. Studies published between 2023 and 2025 in English, Portuguese, Spanish, and French will be considered. Study selection and screening will be managed via Rayyan.

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RESUMO

Introdução: A medicina dentária forense desempenha um papel essencial em investigações jurídicas ao facilitar a identificação humana por meio de registos clínicos, marcas de mordida e estimativa de idade. Historicamente dependente de avaliações manuais e baseadas em especialistas, essa área está sendo reformulada pelos avanços tecnológicos. A integração da inteligência artificial, incluindo *machine learning* e visão computacional, oferece novas possibilidades para automatizar e aprimorar análises, melhorando a precisão diagnóstica, acelerando o processamento de casos e reduzindo a subjetividade.

Objetivos: O objetivo geral deste estudo é mapear e compreender as implicações, capacidades e limitações das tecnologias de inteligência artificial para profissionais forenses e partes interessadas do setor jurídico. Para facilitar uma estratégia de extração de dados direcionada, esta revisão abordará objetivos operacionais específicos, nomeadamente: identificar as principais áreas da medicina dentária forense onde a inteligência artificial é atualmente aplicada, avaliar as capacidades relatadas e os resultados de desempenho de vários modelos de inteligência artificial nestas aplicações; categorizar as limitações técnicas e os desafios relatados na literatura, como a qualidade dos dados, o tamanho da amostra e a falta de padronização e mapear as implicações éticas e legais que envolvem o uso da IA em contextos forenses, incluindo a transparência dos algoritmos e a privacidade dos dados biométricos.

Metodologia: Uma revisão de escopo será realizada de acordo com a metodologia do *Joanna Briggs Institute* e as diretrizes PRISMA-ScR. O protocolo está registado no *Open Science Framework*. As buscas serão conduzidas em cinco bases de dados científicas e na literatura cinzenta, utilizando palavras-chave específicas. Serão considerados estudos publicados entre 2023 e 2025 nos idiomas inglês, português, espanhol e francês. A seleção e a triagem dos estudos serão gerenciadas por meio do Rayyan.

Resultados: Esperamos encontrar múltiplas técnicas de inteligência artificial aplicadas à medicina dentária forense, incluindo modelos de *machine learning* e *deep learning* para estimativa da idade e do sexo. A revisão irá provavelmente demonstrar que a inteligência artificial pode aumentar significativamente a precisão diagnóstica e a velocidade de análise, embora o seu desempenho possa ser limitado pela heterogeneidade dos dados e falta de padronização.

Conclusão: Esta revisão de escopo irá esclarecer o estado atual das evidências relativas à utilização da inteligência artificial na identificação forense. Os resultados poderão orientar investigações futuras e apoiar o desenvolvimento de diretrizes éticas e padronizadas para a implementação destas tecnologias em investigações médico-legais.

Introduction

In legal and disaster scenarios, forensic odontology plays a critical role in human identification through the analysis of dental characteristics. Due to the high resistance of teeth to

external factors and the uniqueness of their features, dental records provide invaluable biological evidence. Traditionally, human identification has relied heavily on manual and comparative analyses, which are inherently time-consuming and susceptible to observer subjectivity. However, the

rapid advancement of computational sciences has prioritized the search for objective and automated methods. In this context, the integration of Artificial Intelligence (AI) through approaches combining forensic anthropology with computational frameworks¹ has emerged as a promising frontier, making it essential to understand the applicability, capacity, and limitations of these technologies in a field where precision and legality are the cornerstones of rigorous evidence.^{1,2}

The application of AI in forensic odontology has significantly accelerated through the utilization of machine learning, deep neural networks, and image processing algorithms.³ These integrated approaches allow for the automation of complex tasks traditionally performed by experts, such as age and sex estimation, tooth morphological analysis, and the evaluation of maxillofacial bone structures. Recently, the implementation of convolutional neural networks (CNNs) has demonstrated the ability to analyze and compare thousands of ante-mortem (AM) and post-mortem (PM) panoramic radiographs in seconds to identify potential matches,^{4,5} substantially reducing analysis time while enhancing diagnostic accuracy. Nevertheless, despite this immense potential, the integration of AI into forensic practice faces substantial challenges concerning data quality and availability, algorithm transparency, and the ethical and legal implications of handling biometric data, thereby demanding a robust governance framework to ensure the reliability and trustworthiness of outcomes in legal contexts.^{6,7} Despite the rapid proliferation of primary studies and the recognized challenges of implementing AI in forensic odontology, there is currently a lack of synthesized evidence mapping the full scope of these technologies. Existing literature remains fragmented, making it difficult for forensic practitioners and legal stakeholders to fully grasp the capabilities, limitations, and ethical implications of AI tools. Therefore, this scoping review is necessary to systematically map the current landscape, identify existing knowledge gaps, and provide a comprehensive foundation to guide future research, standardization, and policy development.

Methodology

A research protocol will be drawn up according to Joanna Briggs Institute (JBI) model^{9,10} which leads to the formulation of the following question: What are the challenges and impacts of applying artificial intelligence in forensic dentistry? Thus, the acronym PCC will be Population (P): Dentists; Concept (C): Artificial Intelligence; Context (C): Forensic Dentistry.

The methodology applied will be based on a search of scientific articles written in English, Portuguese, Spanish, French, and from 2023 till 2025.

The databases to be used in this study are PubMed/Medline, Web of Science (Clarivate), Science Direct, Semantic Scholar and Google Scholar, where the Mesh term (dentist*) AND (artificial intelligence) OR (AI artificial intelligence) OR (machine learning) AND (forensic dentistry) will be applied. The articles will be selected through Rayyan after being retrieved from the databases.

For the final review, the items identified in the reports prepared for the guidance of systematic reviews and the extension of meta-analyses (PRISMA-ScR) will be used. This protocol was registered in the Open Science Framework (<https://osf.io/psgm5/>).

Inclusion and exclusion Criteria

Inclusion criteria: articles that address the proposed theme; studies published with no restrictions; studies in English, Portuguese, French or Spanish from the last 3 years. Exclusion criteria: articles that do not address the proposed theme; narrative, systematic or scoping reviews; non-dentist population; duplicates.

Search strategy

The search strategy was planned by two reviewers and will be peer-reviewed by an expert third reviewer considering the Peer Review of Electronic Search Strategies (PRESS) checklist.¹²

In this scoping review, the search will be carried out in the following databases: PubMed/Medline, Web of Science (Clarivate), Science Direct, SemanticScholar e Google Scholar. The research strategy recommended by JBI will be imple-

Database	Articulations of keywords	Number of articles
PubMed / Medline	(((((((((dentist*[MeSH Terms]) OR (dentist*[Title/Abstract])) AND (artificial intelligence[MeSH Terms])) OR (artificial intelligence[Title/Abstract])) OR (ai artificial intelligence[MeSH Terms])) OR (ai artificial intelligence[Title/Abstract])) OR (machine learning[MeSH Terms])) OR (machine learning[Title/Abstract])) AND (forensic dentistry[MeSH Terms])) OR (forensic dentistry[Title/Abstract]))	140
Web Of Science (Clarivate)	(((((TI=(dentist*)) OR AB=(dentist*)) AND TI=(artificial intelligence)) OR AB=(artificial intelligence)) AND TI=(forensic dentistry)) OR AB=(forensic dentistry))	86
ScienceDirect	dentist AND artificial intelligence AND forensic dentistry	44
SemanticScholar	dentist AND artificial intelligence AND forensic dentistry	152
Google Scholar	(((((TI=(dentist*)) OR AB=(dentist*)) AND TI=(artificial intelligence)) OR AB=(artificial intelligence)) AND TI=(forensic dentistry)) OR AB=(forensic dentistry))	692

mented.

A preliminary search was carried out in PubMed/Medline, Web of Science (Clarivate), Science Direct, SemanticScholar e Google Scholar databases to identify the keywords and index terms used in the publications concerning the theme.

This allowed the development of the search strategy for each database (Table 1). This survey was conducted on 22 March 2025.

Table 1. Bibliographic research strategy.

The reference lists of all included articles will be reviewed for the possibility of the inclusion of additional articles. After the search, the identified articles will be deposited in the ENDNOTE program. The electronic search results will be exported to Rayyan® [11], and duplicates will be eliminated. The developer of the software is Rayyan Systems Inc. from Cambridge, MA, USA. Software AI-driven was not used to select articles. Rayyan software will be used as a support tool, only to gather all the articles found in the different databases described above and identify duplicates.

Study selection

Two reviewers, independently, will collect the data from the articles to decide their inclusion in this scoping review. Doubts and disagreements will be discussed using a third reviewer according to the peer review of the Electronic Search Strategies (PRESS) checklist.¹²

The preliminary test will be carried out by two independent reviewers, that will start with the analysis of title/abstract of articles and then, the full text. Following this analysis, 5% of the total articles will be used to get at least 75% consensus between reviewers. In the next step of the research, 2% of the full-text articles will be used to obtain the same level of agreement.

Studies that include the key goal of this review will be obtained through the identification, selection, eligibility and application of the inclusion and exclusion criteria and research limiters.

The data of each selected article will include specific details about the sample size, methodology used, study method and

main evidence relevant to the objective of this review, as shown in Table 2.

Table 2. Form used for data collection.

A PRISMA-ScR flow diagram¹³ will document the selection process (Figure 1).

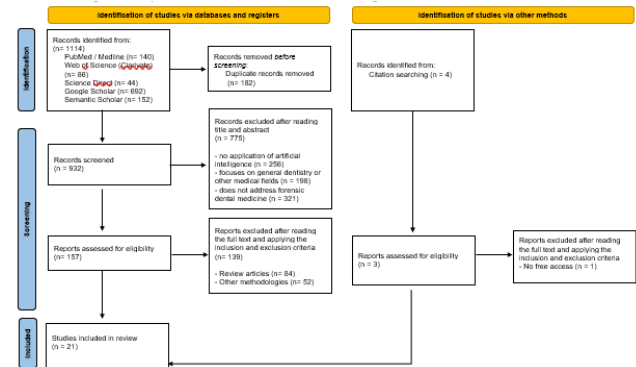


Figure 1. Flowchart of the article’s selection process, adapted from PRISMA 2000 flow diagram.¹³

Data analysis and presentation

After reading the full articles included in this review, data will be extracted according to goals and research questions of the present review. The tool used for that, will be conducted by the methodology proposed by Joanna Briggs Institute,^{9,10,14} including the following relevant information: title, author(s), year of publication, country of origin, type of study, objective(s) and results, as shown in Table 2.

Results

Based on the preliminary literature review, this scoping review is expected to identify a wide range of Artificial Intelligence applications in forensic dentistry, particularly in age estimation, sex determination, and human identification. These technologies will probably include machine learning algorithms, Convolutional Neural Networks (CNNs), and hybrid models utilizing panoramic radiographs. The review is likely to show that AI models achieve high accuracy rates and significantly reduce analysis time. However, it is also anticipated that several challenges will be identified, including the use of limited and non-representative datasets, variable image quality, and the urgent need for methodological standardization.

Discussion

This scoping review intends to demonstrate the transformative potential of AI approaches for forensic dental analysis. AI models are anticipated to offer highly reproducible and

Scoping Review Title	Application of Artificial Intelligence in Forensic Dentistry: Approaches, Challenges and a Scoping Review
Review objective(s)	Analyse and map the application of Artificial Intelligence in Forensic Dentistry: approaches, and challenges.
Review Question(s)	What are the challenges and impacts of applying artificial intelligence in forensic dentistry?
Inclusion/Exclusion Criteria:	Inclusion criteria: articles that address the proposed theme; studies published with no restrictions; studies in English, Portuguese, French or Spanish from the last 3 years. Exclusion criteria: articles that do not address the proposed theme; narrative, systematic or scoping reviews; non-dentist population; duplicates.
Population	Dentists
Context	Artificial intelligence
Concept	Forensic Dentistry
Types of Evidence Sources	
Evidence Source Details and Characteristics	
Author(s)	
Year of Publication	
Origin/Country of Origin (where the source was published or conducted)	FERNANDO PESSOA
Aims/Purpose	
Population and Sample size	
Details/Results extracted from the Source of Evidente	

scalable solutions that reduce observer subjectivity, facilitating rapid evaluations in forensic contexts. However, the review is likely to identify significant challenges regarding algorithmic transparency, data privacy, and the ethical/legal implications of handling biometric data. The integration of robust governance frameworks is expected to be a major point of discussion to ensure the reliability of outcomes in legal contexts. Collectively, this review will probably demonstrate that while AI approaches can strongly complement traditional forensic assessments, their successful integration depends on addressing dataset limitations and standardizing methodologies.

Conclusion

This scoping review is expected to show that AI technologies provide accurate, efficient, and objective tools for human identification and age estimation in forensic dentistry. The review is expected to emphasize the importance of high-quality, annotated datasets and protocol standardization to reduce bias and improve predictive performance across diverse populations. Furthermore, the combination of computational techniques with traditional forensic expertise is anticipated to provide a comprehensive framework for future investigations. Ultimately, the findings will likely support evidence-based methodological development, guide future research, and enable broader, ethically responsible implementation of AI in medico-legal settings.

The data supporting the results can be found or stating that it will be provided on request.

References

- Guimarães MI, Silveira A, Sequeira T, Gonçalves J, Carneiro Sousa MJ, Valenzuela A. Forensic Medicine and the Military Population: International Dental Records and Personal Identification Concerns. *Acta Med Port.* 2017;30(2):100-107.
- Guimarães MI, Martínez Chicón J, Gonçalves J, Carneiro Sousa MJ, Márquez Ruiz AB, Valenzuela Garach A. Estudio comparativo de la diversidad de las características clínicas dentales en poblaciones militares de Portugal y España. *Rev Esp Med Legal.* 2018;44(3):99-107.
- Bewes J, Low A, Morphet A, Pate F, Henneberg M. Artificial intelligence for sex determination of skeletal remains: Application of a deep learning artificial neural network to human skulls. *J Forensic Leg Med.* 2019;62:40-43. <https://doi.org/10.1016/j.jflm.2019.01.004>
- Guimarães, M. I. (2026) Artificial intelligence in forensic odontology: technological developments and future directions. *Forensic Sciences Research*, 11(2): tfsr20250201 DOI: 10.3788/tfsr20250201 https://doi.org/10.4103/sjhs.sjhs_124_2
- Fan F, Ke W, Wu W, Tian X, Lyu T, Liu Y. Automatic human identification from panoramic dental radiographs using the convolutional neural network. *Forensic Sci Int.* 2020;314:110416. <https://doi.org/10.1016/j.forsciint.2020.110416>
- Enomoto A, Lee AD, Sukedai M, Shimoide T, Katada R, Sugimoto K, et al. Automatic identification of individuals using deep learning method on panoramic radiographs. *J Dent Sci.* 2023;18(2):696-701. <https://doi.org/10.1016/j.jds.2022.10.021>
- Rizvi S, Scanlon M, McGibney J, Sheppard J. Application of artificial intelligence to network forensics: Survey, challenges and future directions. *IEEE Access.* 2022;10:110362-110384. <https://doi.org/10.1109/ACCESS.2022.3214506>
- Stacey J, Fleming R, Sheppard D, Sheppard J, Dobbie G, Karunakaran D. A responsible artificial intelligence framework for forensic science. *Forensic Sci Int.* 2025;375:112548. <https://doi.org/10.1016/j.forsciint.2025.112548>
- Pearson A, Wiechula R, Court A, Lockwood C. The JBI model of evidence-based healthcare. *Int J Evid Based Healthc.* 2005;3(8):207-215. doi: 10.1111/j.1479-6988.2005.00026.x.
- Pearson A, Jordan Z, Munn Z. Translational science and evidence-based healthcare: A clarification and reconceptualization of how knowledge is generated and used in healthcare. *Nurs Res Pract.* 2012;2012:792519. doi: 10.1155/2012/792519.
- Ouzzani M, Hammady H, Fedorowicz Z, Elmagarmid A. Rayyan — a web and mobile app for systematic reviews. *Syst Rev.* 2016;5(1):210. doi: 10.1186/s13643-016-0384-4.
- McGowan J, Sampson M, Salzweid DM, Cogo E, Foerster V, Lefebvre C. PRESS Peer Review of Electronic Search Strategies: 2015 Guideline Statement. *J Clin Epidemiol.* 2016 Jul;75:40-46. doi: 10.1016/j.jclinepi.2016.01.021.
- Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *Syst Rev.* 2021;10(1):89. doi: 10.1186/s13643-021-01626-4.
- Jordan Z, Lockwood C, Munn Z, Aromataris E. The updated Joanna Briggs Institute model for evidence-based healthcare. *Int J Evid Based Healthc.* 2019;17(1):58-71. doi: 10.1097/XEB.0000000000000155.