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An Integrative Literature Review Of The Potential Technical Challenges In Forensic Odontology Practice - An Exploratory Study

SUMMARY

Every academic discipline faces distinct challenges, and Forensic Odontology is no exception. Our study aimed to examine the potential technical challenges within the field, to augment the overall quality of practice. In this study, we conducted an integrative literature review spanning the years 2000-2023. The analysis included 29 relevant papers sourced from SCOPUS and Web of Science. The results revealed that technical issues were pervasive in various aspects of Forensic Odontology, with the role of expert witnesses being the most commonly reported concern. Specifically, dental age estimation emerged as an area of the highest reported challenges. Conversely, incidents of child abuse and neglect were notably underreported. Our findings emphasize the need for improved support for researchers to validate methodologies, mandatory formal training, and proficiency testing within the field. The study also sheds light on the inadequate awareness among dentists regarding child abuse and neglect emphasizing the need for targeted and comprehensive training initiatives. The findings led to recommendations for Forensic Odontologists, incorporating insights from the study and the codes of ethics of forensic organizations, aiming to enhance the quality of practice in the field.

ABSTRACT

Forensic Odontology deals with the presentation of dental evidence in a court of law. An academic exploration revealed instances of technical challenges within the field. This study endeavours to delve into the spheres where these challenges occur, with the core objective of enhancing the quality of practice. An integrative literature review was conducted using the online platforms SCOPUS and Web of Science. Based on the selection criteria, 29 pertinent papers dated 2000-2023 were included. Quantitative analysis of the categories of selected articles was performed using Microsoft Excel 2019 (Microsoft Corp., Redmond, WA, USA). Technical concerns were reported in all facets of Forensic Odontology with the general role of expert witnesses being reported the most (n=8; 27.58%). Within the different facets of the field, age estimation was the most prominent

area of concern (n=8; 27.58%) and child abuse and neglect (n=1; 3.57%) represented the least reported category. Findings indicate that there is a need to prioritize avenues to enhance the quality of practice in the general role of expert witnesses and the specific area of dental age estimation. To this end, increased support for researchers must be provided to help validate methodologies. It is advisable to institute mandatory formal training and proficiency testing within the field. Inadequate knowledge of dentists regarding child abuse and neglect has been noted, demonstrating the need for more dedicated quality training. Recommendations for Forensic Odontologists have been curated combining this study's results and the codes of ethics of various forensic organisations.

Keywords: Forensic Dentistry; Technical challenges; Dentists; Expert Witnesses; Age Estimation.

INTRODUCTION

Forensic Odontology, the convergence of Dentistry and Law, holds a unique position in the world of Forensic Sciences. It harnesses the principles and techniques of dentistry for legal purposes, playing a pivotal role in various aspects of legal investigations¹. From comparative dental identification and age estimation to sex estimation, bitemark analysis, and the recognition of abuse cases, Forensic Odontology serves as an indispensable tool in the pursuit of justice.

Notably, teeth are recognized as one of the primary identifiers by the International Criminal Police Organization (INTERPOL)². This acknowledgement underscores the critical role that dental evidence plays in victim identification and the resolution of legal cases. The field's primary focus is the meticulous examination, evaluation, and interpretation of evidence, regardless of its form.

However, the application of Forensic Sciences, including Forensic Odontology, has faced significant challenges, as revealed by the Innocence Movement. It has become evident that the misapplication of Forensic Science ranks as the second leading cause of wrongful convictions in the United States³. Central to this issue is the lack of validated methodologies for evidence analysis. Unfortunately, recreating case scenarios for randomized control trials is often an insurmountable task⁴.

Studies have delved into various technical challenges within Forensic Odontology, including age estimation, expert witness testimonies, bite mark analysis, and victim identification. These investigations have uncovered challenges such as possible bias, examiner errors, methodological inconsistencies, and the absence of standardized guidelines for handling deceased individuals⁵⁻⁹.

In light of these challenges, quality assurance in forensic practices emerges as a complex yet indispensable endeavour. This study embarks on a comprehensive examination of these multifaceted aspects of Forensic Odontology. Our objective is to shed light on the characteristics of these challenges and their possible causative factors. Ultimately, we aim to create a list of recommendations for Forensic Odontologists (FO) to help improve the quality of practice.

MATERIALS AND METHODS

To investigate the technical challenges in Forensic Odontology the following research questions were utilized: 1) What is the role of guidelines in Forensic Odontology?; 2) What are the areas in which technical challenges in Forensic Odontology have been investigated?; and 3) Are there any articles on quality assurance and recommendations for the same? Two electronic databases namely SCOPUS (which included PubMed) and Web of Science were utilized for the search on October 16, 2020, for articles between 2000 and 2020. An updated search was conducted on September 11, 2023, with the same search protocol, including articles from 2021 to 2023. The search strategy has been tabulated in Table 1.

Table 1- Search strategy to investigate technical challenges in Forensic Odontology

DATABASE	SEARCH STRATEGY
Scopus	<i>Forensic AND (Odonto* OR Dent*) AND (Ethics OR Guidelines OR Standards)</i>
Web of Science	<i>Forensic AND (Odonto* OR Dent*) AND (Ethics OR Guidelines OR Standards)</i>

Only original articles and review articles published in the English language were eligible for inclusion. The exclusion criteria included (a) Correspondence such as

letters to editors, editorials, conference papers, opinions, books, and book chapters (b) articles that did not address the research questions (c) articles lacking full-text availability (d) articles presenting unconfirmed hypotheses (e) articles addressing issues that are irrelevant in the current context.

The Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines were followed¹⁰. The articles were scanned for duplicates on EndNote X9.2. Subsequently, titles, abstracts, and keywords were screened for inclusion on the Rayyan Qatar Computing Research Institute (QCRI) web application¹¹. Selected articles underwent a comprehensive full-text screening.

To facilitate data analysis, information was systematically categorized into six categories based on the type of work and respective challenges with the role of the expert witness as an overall category. Statistical analysis was carried out using charts and tables in Microsoft Excel 2019 (Microsoft Corp., Redmond, WA, USA). The authors also aimed to assess the Code of Ethics and Conduct of various forensic organisations to curate recommendations for good practice in Forensic Odontology.

RESULTS

1. Search Process

The database search process yielded 1258 articles, which upon elimination of duplicates resulted in 824 articles for initial screening. After full-text analysis, 29 articles that were in accordance with our criteria were included (Fig.1)

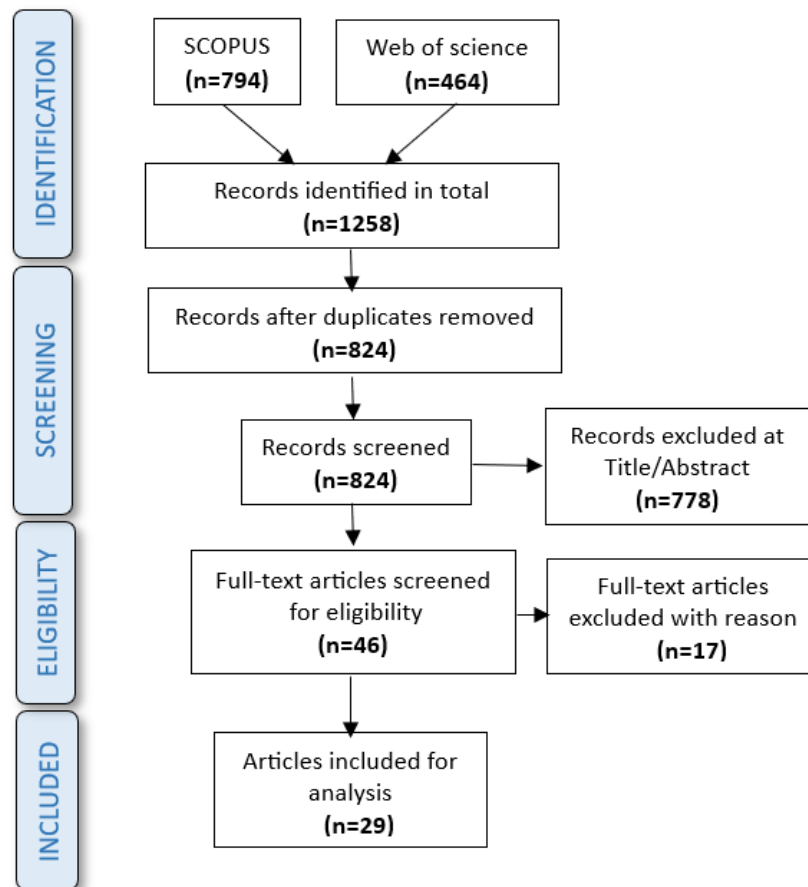


Figure 1- PRISMA flowchart of the search process

II. Analysis of results

A sizeable number of articles (n=29) were included and categorised as Expert Witness (n=8; 27.58%), Age Estimation (n=8; 27.58%), Disaster victim identification (n=5; 17.24%), Bite Mark (n=4; 13.79%), Comparative Dental Analysis (n=3; 10.34%) and Child abuse and neglect (n=1; 3.44%). The data extracted from these publications were tabulated in Table 2 based on the areas addressed.

Table 2 - Data extracted from included articles

CATEGORY	INSIGHTS
Role of Expert Witness	1. <i>Reports</i> – Need for meticulous proofreading; utilizing biased language; not stating only the scientific opinion; drawing legal conclusions; omission of material specifications; not adhering to the accepted Interpol nomenclature and forms; difficult to read with complicated terminology; inadequate description of findings, details of radiographs; the absence of a concise summary with the range of

	<p>opinions, reasons for the opinion, scientific papers supporting the opinion, and a summary of the conclusion.</p> <p>2. <i>Testimony</i> – Lacking clarity, comprehensibility, and intricately presenting opinions.</p> <p>3. <i>Qualities of FO</i> – Lacking objectivity and failing to acknowledge the boundaries of one’s knowledge and expertise.</p>
Age Estimation	<p>1. <i>Methods used</i>- Need for clear information regarding accuracy. It should be transparent and provable.</p> <p>2. <i>Handling of the deceased</i> – Handle living subjects and the deceased with respect.</p> <p>3. <i>Ethical codes</i> –</p> <p>Autonomy – the need to provide information regarding the purpose, radiation effects, the implication of results, and obtain consent from the individual or guardian.</p> <p>Beneficence – should be free from cognitive bias.</p> <p>Justice – should request a radiograph when in the best interests of the child.</p> <p>4. <i>Radiation protection</i> – Follow As Low As Reasonably Achievable (ALARA) principle. I3M and Demirjian’s methods have been reported to follow ethical principles.</p> <p>5. <i>Parameters reported</i> – Reports should indicate variations and spread of age-related parameters.</p> <p>6. <i>Results</i> – Necessary to present the final opinion on age range with a stress on minimum age.</p>
Disaster Victim Identification (DVI)	<p>1. <i>Methodology followed</i> – Tested methodologies should be prepared in advance of a DVI.</p> <p>2. <i>Standardization</i> – Necessity for standardization of agreements between national DVI teams and forensic scientists, standardized equipment and supplies lists, and qualifications and proficiency testing for DVI personnel.</p> <p><i>Ante-mortem data collection</i> – Each country should have assigned forensic odontologists to retrieve Ante-Mortem (AM) data.</p>
Bite Mark	<p>1. <i>Evidence collection</i> – Some FOs did not routinely perform an oral examination. Most are not collecting salivary samples from suspects.</p> <p>2. <i>Collection of saliva samples</i> – Low frequency in the collection of salivary swabs from the bite site.</p>

	3. <i>Assessment of Bitemark</i> - More definitive guidelines for the assessment are required.
Comparative Dental Analysis	1. <i>Guideline requirement for Post-Mortem Computed Tomography (PMCT)</i> : Ideal imaging parameters- 120 Kv, 800mAs, pitch factor 0.35, rotation time 1 s, SL 0.4 mm, increment of 0.2 mm, curved multiplanar reconstruction for complete jaw. 2. <i>Telemedicine database</i> - Need for informed consent, follow protocols and clarify some technical, legal, and ethical aspects.
Child Abuse	1. <i>Identification of child abuse</i> – Dental team should be trained to identify physical signs, psychological and emotional behaviour. Meticulously monitor and record observations.

DISCUSSION

According to the results, most challenges were stated in the overall 'role of the expert witness' and age estimation categories. In the role of expert witness, the issues ranged from writing a report to personal misconduct. It is posited that an expert witness' report should be regarded as a legal document that contains confidential and decisive information about a particular case. It should be written by a qualified person and all scientific jargon must be simplified or explained in the glossary. Feedback from judges has emphasized the need for reports to avoid complex terminology that may affect understanding by laypersons¹². The expert witness when asked to give their opinion on procedures performed a few years earlier should consider the technological status and common dental practice at that period. They should remember that their duty is only to provide a comparison report and not a final identification as that is the duty of the court. This approach safeguards against overstepping boundaries and ensures quality assurance¹³. Bias is a common, yet relevant issue in Forensic Odontology that can adversely affect the verdict of the case. The conclusions of the expert when weighed by the influence of bias, can affect the verdict of the case as these conclusions are expected to be independent of external factors. It is advanced that bias can be minimised by independent data collection and analysis by different experts and by limiting their communication with law enforcement agencies.

When problems with FOs include selecting and applying a method for age estimation, it indicates a problem at the foundational level – training and

application of knowledge. Numerous scholarly articles and book chapters have elucidated the requirements for age estimation methods. These prerequisites include methods published in peer-reviewed journals that are accurate, transparent, and reproducible; considering the ethical and legal regulations of living subjects; techniques studied amongst certain populations or ethnicities; and equally distributed study samples across age and sex¹⁴⁻¹⁷. If these criteria along with age estimation guidelines are followed correctly, issues in this subject can be avoided. Other concerns included not abiding by the ethical principles of a particular country during age estimation, issues with handling the deceased, and unnecessary radiation exposure. When prescribing radiographs, one must ensure that this action is justified and follow the ALARA principle to mitigate any adverse effects on the individual. Complicating matters further, variations in ethical standards persist not only among different countries but even within various regions of the same country, posing significant challenges to the forensic community when working with human tissues⁶. A viable approach to surmounting these challenges involves the development of country-specific guidelines tailored to the needs of forensic practitioners.

Concerning Bitemark analysis, the primary issues noted in the results involved evidence collection and assessment. These issues can be handled by following validated contemporary methodologies, creating guidelines for bitemark analysis, discouraging statistical certainty, and acknowledging one's limitations and limitations in the subject itself. However, this cannot be achieved without proper education and training of FOs. As an increasing number of short-term certificate programs and workshops in Forensic Odontology proliferate, numerous individuals within the dental community declare themselves as Forensic Odontologists following their attendance. Despite program disclaimers that explicitly state the absence of degree accreditation, the practice of self-proclamation remains prevalent. When these individuals are subsequently called upon as expert witnesses in legal proceedings or contribute to scientific literature, it has a detrimental impact on the overall credibility of the field. Proficiency testing is one viable measure to ensure that only properly trained and qualified personnel serve as expert witnesses in a legal context. This issue warrants attention from dental councils and forensic odontology associations worldwide to establish

regulations on the qualifications required to recognize an individual as a Forensic Odontologist.

A common issue encountered in Disaster Victim Identification (DVI) scenarios is the lack of standardized protocols, uniform methodologies, clear lines of authority, and the absence of robust quality assurance measures, which can potentially lead to misidentification¹⁸. Other essential considerations include the method of charting data, the software used and the ethical guidelines of the host country where the DVI personnel are deployed. An effective approach to address these issues is the development of a comprehensive Standard Operating Procedure (SOP) encompassing all aforementioned aspects. The SOP could be delivered to FOs before reaching the site to ensure strict compliance with the regulations. Globalisation and global conflicts result in the displacement of thousands of people for whom obtaining dental records could be a daunting task. In such circumstances, telemedicine could be an effective tool to aid medico-dental identification provided confidentiality is maintained. The 'Recommendation on Ethics in Telemedicine' by the World Medical Association can serve as a valuable ethical framework for practitioners¹⁹. Until the development of telemedicine to aid identification, individual countries may consider establishing their teams of forensic dentists for ante-mortem (AM) data collection. In terms of quality assurance, FOs should be mindful to prepare a comparison report rather than an identification report, as the final identification of an individual falls outside their purview. Similarly, FOs are responsible for completing provided forms for Identification cases with Interpol nomenclature, leaving no fields blank to ensure clarity during the reconciliation stage⁶. In victim identification, Post-mortem Computed Tomography is being increasingly employed by forensic pathologists before autopsy. Since autopsy is often performed prior to dental identification, PMCT can be utilized by FOs as well. The key benefits of this procedure include observer-independent documentation, facilitating data acquisition without contact, and the images obtained can be reformatted to study alongside any AM images²⁰. The recommended guidelines for PMCT imaging are outlined in Table 1.

Only a single paper on child abuse and neglect (CAN) that discussed the training of dentists and their teams to identify child abuse was included²¹. This paper, however, did not include the role of FOs in CAN. It is not unreasonable to suggest

that CAN is not recognised by dentists, not reported if suspected, or dentists are not aware that FOs can provide their expert opinion. This could stem from a lack of training and knowledge to recognise the indications, due to a lack of confidence in their opinion or insufficient awareness regarding reporting. A comprehensive literature search indicated a general deficiency in dental training related to child abuse and neglect. Nevertheless, select institutions in Brazil, Australia, Jordan, and the United States exhibited a strong understanding of this topic²²⁻²⁶. Knowledge regarding reporting was low as evidenced by the limited number of reported cases^{27,28}. The barriers for dentists failing to report included inadequate awareness of their role in reporting CAN, concerns about potential repercussions for the child, fear of incorrect diagnosis, reluctance to get entangled in legal matters, apprehension of losing patients, confidentiality issues, and fear of being confronted by the child's family^{23,25,29}. A recent study on non-accidental head and neck injuries in children and adolescents has advanced 3D models depicting injuries associated with CAN³⁰. These models can be utilized by Dentists and FOs to enhance their knowledge and to better identify and report cases of CAN. To curate a list of recommendations for best practice, the Codes of Ethics and Conduct of the British Association of Forensic Odontology (BAFO), American Board of Forensic Odontology (ABFO), National Commission on Forensic Science, International Organisation for Forensic Odonto-Stomatology (IOFOS), United Kingdom and Ireland Association of Forensic Toxicologists (UKIAFT), and Forensic Science Regulators were studied³¹⁻³⁶. Due to the group-specific nature of the codes of conduct of IOFOS, it was not included in this universal compilation. Of the remaining organisations, a similarity in regulations was observed in general, with BAFO, National Commission on Forensic Science, and Forensic Science Regulators containing more specific and FO-pertinent guidelines. Therefore, they were compiled along with the results of our study to create the following list of recommendations for good practice in Forensic Odontology:

1. To accurately represent their education, qualification, training, and area of expertise.
2. To recognize their primary duty to the court and administration of justice.
3. To provide a Declaration of Truth and obtain verification of critical findings from a second expert in their report.

4. To advocate for the use of validated new technologies while refraining from employing invalid methods or misapplying established ones.
5. To utilize methods that have been published, transparent, and reproducible with clear information regarding the accuracy of the method and the populations it has been tested on.
6. To provide technically correct statements in all written and oral reports, testimony, public addresses, and publications and avoid any misleading or inaccurate claims.
7. To base conclusions on scientific data following guidelines put forth by governing organisations and acknowledge the limitations of their methods.
8. To retain full, clear, and accurate written records of all examinations conducted, methods followed, and conclusions drawn in sufficient detail to allow meaningful review and assessment by an independent person competent in the field.
9. To refrain from providing conclusions in areas beyond their expertise.
10. To use simple, unambiguous terminology in their oral and written communication to prevent misleading the judge or jury.
11. To accurately represent the data underlying their expert opinions.
12. To avoid tampering, adulteration, or loss of evidentiary material for litigation advantage.
13. To uphold their integrity and not accept any obligations that might influence their professional duties.
14. To provide unbiased, objective expert opinions on dental evidence and avoid cases with potential conflicts of interest.
15. To take accountability for their decisions and actions which may be scrutinised by internal and external bodies.
16. To be honest, impartial, and transparent in their professional duties.
17. To safeguard the confidentiality of case materials and refrain from disclosing them without authorised consent or as required by law.
18. To treat living subjects and the deceased with respect.
19. To provide information regarding the purpose, radiation effects, the implication of results and obtain consent from the individual or guardian before taking a radiograph. This radiograph should follow the ALARA principle while

providing maximum accurate diagnostic information keeping the individual's best interest in mind.

20. To utilize methods involving the victim/suspect/patient that are sexually and culturally appropriate.

21. To continuously enhance professional competence through participation in Continuing Professional Development Programs, proficiency testing, certification, research presentation, and publication.

22. To be willing to re-evaluate any casework should new information or developments arise that could affect the previous conclusion.

23. To uphold their professional behaviour within the society and judicial system, as it reflects on the broader perception of the forensic odontological community.

24. To advocate for equality and diversity and always treat others with respect.

The limitations of this study encompass the lack of qualitative analysis and the exclusion of grey literature. The authors recommend future studies on ethical regulations pertinent to forensic practices across diverse cultural and gender contexts, and to delve into the relationships of Dentists and FOs in cases of abuse and neglect.

CONCLUSION

In conclusion, this study has highlighted the potential technical issues in the field of Forensic Odontology, they can be ameliorated by making various necessary improvements in practice. Fostering a supportive and non-judgmental culture within the professional community is imperative, particularly considering persistent criticisms. Addressing these challenges requires a commitment to learning from past mistakes and providing increased support for researchers to validate methodologies, as the credibility of the field is at stake. It is essential to mandate formal training and proficiency testing for recognition as a member of the community. Key solutions to technical challenges include standardizing methodologies and implementing Standard Operating Procedures (SOPs) in Disaster Victim Identification (DVI), utilizing current practices in bitemark analysis, and acknowledging the inherent limitations of the field. Additionally, adopting population-specific age estimation methods with clearly defined ranges,

as well as delivering concise and explicit reports and testimonies devoid of scientific jargon, can significantly address our concerns.

The study results demonstrated technical concerns in the main role of the expert witnesses followed by specific challenges with dental age estimation. Notably, there is a prevalent lack of awareness among Dentists regarding child abuse and neglect, along with a noticeable gap in communication between Dentists and FOs. This emphasizes the urgency for more specialized training. Improving awareness among Dentists about the roles of FOs and enhancing communication channels between these two groups are essential objectives. A list of recommendations for Forensic Odontologists has been collated combining the results of this study and the codes of ethics of various forensic organisations. This can be utilized by FOs to improve their professional standards and address the challenges within the field.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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