International Journal of Dental Research and Allied Sciences
2021, Volume 1, Issue 1, Page No: 12-17

Available online at: www.tsdp.net

ISSN: 3062-3502

Review Article

Role of Various Stakeholders in the Adoption of Artificial Intelligence in Forensic Dentistry

Eman Ahmed Alaa El-Din[1]*

[1]Department of Forensic Medicine & Clinical Toxicology, Faculty of Medicine, Zagazig University, Egypt.

***E-mail** ✉ Eman_alaa77@yahoo.com

Received: 15 May 2021; **Revised:** 26 August 2021; **Accepted:** 08 September 2021

ABSTRACT

Artificial Intelligence (AI) is one of the fastest-growing technological fields in the world. It addresses several intricate issues that currently exist and represents a breakthrough in digital science. It can be used to simplify the meta-analysis of the existing meta-knowledge clearly and concisely. Therefore, AI may play an important role in forensic dentistry (FO). In the interest of justice, FO entails the assessment, administration, presentation, and examination of dental evidence in criminal or civil cases. It is an essential component of forensic science and is crucial to identifying people, living or deceased. In terms of collecting, examining, and disseminating evidence, digital forensics has successfully and consistently supplanted traditional forensic investigations. When it comes to mass disasters, age estimation, personal identification, and communication with other forensic odontologists, digital forensic investigation is incredibly helpful. A wide range of stakeholders, including general dentists, dental radiologists, forensic odontologists, general pathologists, oral pathologists, biomedical engineers, data scientists, and government statutory bodies, may be able to help ensure that AI is widely and successfully used in forensic dentistry. This study aims to provide an outline of the possible roles of different stakeholders in the future use of AI in FO.

Keywords: Artificial intelligence, Forensic odontology, Forensic science, Digitisation

How to Cite This Article: Alaa El-Din EA. Role of Various Stakeholders in the Adoption of Artificial Intelligence in Forensic Dentistry. Int J Dent Res Allied Sci. 2021;1(1):12-7. https://doi.org/10.51847/3E4Eyi4ztA

Introduction

In the interest of justice, forensic dentistry (FO) examines, assesses, manages, and presents dental evidence in criminal or civil procedures [1]. One essential component of forensic science that is essential to identifying people, living or dead, is forensic odontology [2, 3]. In terms of gathering, examining, and disseminating evidence, digital forensics has successfully and consistently supplanted traditional forensic investigations. When it comes to mass disasters, age estimation, personal identification, and communication with other forensic odontologists, digital forensic investigation is incredibly helpful [4]. Analyzing complicated data sets' metaknowledge intelligently is essential to digital forensics. As a result, artificial intelligence (AI) is a digital scientific breakthrough that addresses several intricate problems that are currently present. A wide range of stakeholders might be able to help forensic dentistry adopt AI more widely and successfully. This paper's goal is to examine the likely roles of different stakeholders in the potential future applications of AI in forensic odontology.

Results and Discussion

AI

AI is one of the fastest-growing technological fields in the world. Since dentistry's beginnings, remarkable accomplishments have been observed. Since the application and execution of AI will be crucial to the future of forensic dentistry, all stakeholders should be familiar with this technology. It is possible to quickly transform complex data from multiple sources into an intelligible language by meta-analysis [5]. AI

applications in healthcare systems are essentially capable of analyzing the relationship between prevention, disease process, the biological behavior of the disease, treatment, and patient outcome. Digital forensic science has already included AI technologies. These days, sophisticated algorithms are utilized for DNA sequence matching, cybercrime detection, and e-discovery document analysis. Thus, AI might play a crucial role in forensic odontology as well.

"A field of science and engineering concerned with the computational understanding of what is commonly called intelligent behavior, and with the creation of artifacts that exhibit such behavior" is how John McCarthy defined AI in 1954 [6].

Types of AI of relevance to healthcare [7]:

1. Machine Learning- Neural networks and deep learning.
2. Natural Language Processing (NLP)- Statistical and Semantic NLP.
3. Rule-based expert systems
4. Physical Robots
5. Robotic process automation.

Stakeholders in the application of AI to forensic odontology

Several stakeholders may contribute to the future application of AI in forensic odontology **(Figures 1 and 2)**.

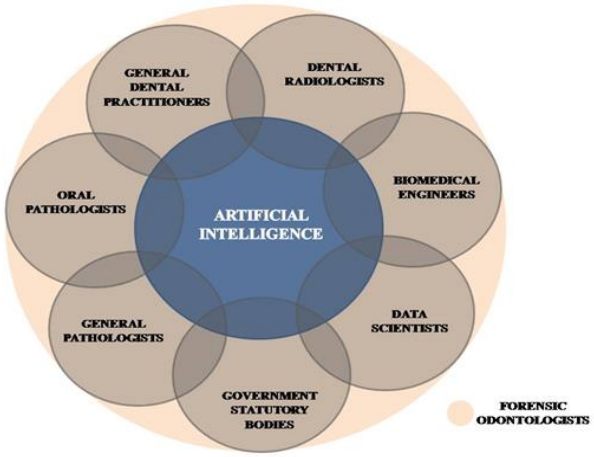

Figure 1. Various stakeholders contributing to forensic odontology fortified with AI

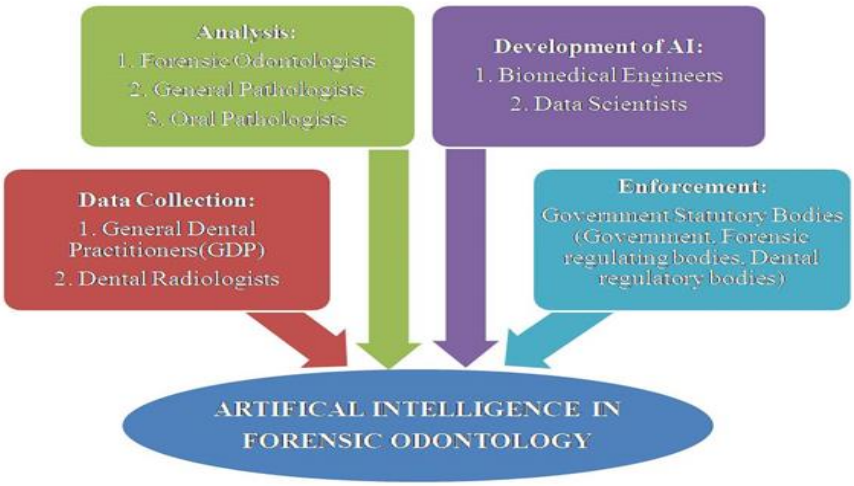

Figure 2. Contribution of various stakeholders in forensic odontology for application of AI

Role of various stakeholders in the application of AI to forensic odontology

General dental practitioners

Dental hard tissues are a very dependable source for identification because of their well-known resistance to changes in pressure, humidity, and high temperatures [8]. As a result, general dentists (GDP) play an unparalleled role. Dental records are gathered by GDPs in a variety of formats. All GDPs should have complete digital dental records in a common format so that victims can be personally identified by comparing antemortem and post-mortem data, particularly in

disaster victim identification (DVI). With the recently created new type of dental chart known as the Digital Dental Chart (DDC), it is now possible to produce detailed dental conditions and a large amount of information that is simple to upload on the internet website at a reasonable cost using dental data and real oral digital images [9]. As a result, all GDPs should electronically save data in the DDC, which will eventually be a quick and practical tool for personal identification thanks to AI. It is anticipated that in the future, several pertinent algorithms built with AI will be created especially for dentistry applications. By combining the patient's demographic information, 2D/3D diagnostic images, clinical findings, medical history, and/or intraoral/facial scans, this automated intelligent workflow system will assist in performing a comprehensive study of the patient. This could aid in creating a real-time database for forensics applications in the future.

Dental radiologists

Since digitization has transformed forensic investigations, all dental radiological data should be accessible and easily interpretable in digital format. This will allow radiologists to communicate via satellite and transmit digital images without losing image details [10]. AI-powered complex dental X-rays can generate less noisy images and more accurate outcomes. AI offers an additional benefit in identifying even the smallest departures from normalcy that would have gone overlooked during eye inspection [11]. The detection and numbering of teeth on orthopantomograms for automated dentistry charting purposes is made possible by a Convolutional Neural Network (CNN)-based system, according to a study done by researchers. This not only saves time but also improves the completeness of electronic-based data [12]. A deep learning method can be developed based on this convolutional neural network to automatically classify tooth kinds on CBCT pictures [13]. It has been demonstrated that deep learning methods improve CT picture resolution and reduce noise.

Forensic odontologist

Facial reconstruction

The process of reconstructing an unknown person's face from their skeletal remains using a combination of anthropology, anatomy, osteology, and art is known as forensic facial approximation or reconstruction. When unidentifiable remains are involved in a crime, the forensic community uses this technique. The computerized facial reconstruction approach uses a laser video camera that is interfaced with a computer or with CT scanning. With 95% accuracy, sex may be determined from skeletal features using artificial neural networks. When employed for sex determination of skeletal remains, AI techniques will remove human bias, require no specialized knowledge, and yield quick results [14].

Bite mark analysis

In a variety of heinous situations, including child abuse, sexual assault, and crimes involving physical violence, bite scars on human tissues can be seen. Digital photography using visible and infrared/UV light, intraoral 3D optical scanners, computer-assisted overlays, and Dental Print 3D software are some of the methods used to analyze bite marks [4]. By choosing certain elements of the bite marks that are collected and examined using a certain model, AI may create trained networks that can provide a respectable matching accuracy. Bite marks can be a valuable source of identification if they are collected as antemortem information and kept in a database. These records can then be compared with postmortem records using algorithms created by AI. For instance: If the bite marks can be acquired before the flight, this information may help identify the passengers in the event of a mass calamity, like an airplane accident [15].

Cheiloscopy

Each person's lip print is different. The examination of lip prints, or cheiloscopy, is a common identifying technique in forensic investigations. One new biometric modality is the human lip. For lip-based biometric verification, a probabilistic neural network is used to create a novel biometric system that relies solely on lip shapes and new lip geometrical measures, as opposed to previous techniques like the texture of the lip surface [16].

Age estimation

One of the key components of human identification is age estimation. Since teeth are the hardest parts of the human body and typically resist post-mortem degradation, they play a pioneering role in identifying unknown corpses and skeletal remains at crime scenes, accidents, and mass disaster instances. As such, they play a crucial role in both reconstructive and comparative identification. Dental age estimation accuracy is increased by several machine learning algorithms. Numerous programming neural networks can teach computers to automatically estimate age thanks to the development of AI [17].

3D printing

Bite mark analysis, sex determination, cheiloscopy, age estimation, facial reconstruction, palatoscopy, tongue print pattern analysis, and the illustration of bone injury patterns are all common applications of 3D printing in forensic odontology [4]. By enabling

automated production and lowering the possibility of error, AI improves the performance of 3D printers.

Gender determination

Estimating gender has enormous forensic relevance since it is a crucial component of personal identification. Artificial neural network-based methods can take the place of previously employed models such as logistic regression and discriminant analysis. Because of its simplicity and low human mistake rate due to automation, the use of this approach in forensic odontology is therefore encouraging [18].

Personal identification

Forensic personal identification is a basic scientific field that uses suitable methods to identify live, recently deceased and compromised human remains. It is frequently employed as a tool in crime scene investigations. When employing dental panoramic radiographs, the Personal Identification System, which is based on the meta-heuristic algorithm, reported an identification percentage of 97.7% [19].

General pathologist

The scalpel-free autopsy can be performed by imagistic modalities instead of the conventional autopsy. This is called- Virtual Autopsy / Virtopsy. It is a non-invasive technique. There can be a virtual biobank created to which machine learning is applied. Several algorithms can be formulated, by building a model from sample inputs, which will make data-driven predictions or decisions [20].

Oral pathologist

Digital pathology benefits greatly from deep learning and AI. There may be intra-observer and inter-observer variability in the histological diagnosis. To acquire consistent, dependable, and more accurate diagnoses, AI is therefore essential in the field of oral pathology. When slides are positioned side by side and digital images are taken, oral pathologists should employ forensic comparison microscopes to compare two images so they can be viewed concurrently. AI can then interpret the results [21].

Biomedical engineer

The automation of the DNA sampling procedure was made possible in large part by biomedical engineers' creation of forensic biorobots. Forensic scientists can now focus on analyzing and interpreting data that has been processed. It has been discovered that the BioRobot M 48 is highly efficient at extracting DNA [4]. In addition to lowering human error, its application in forensic odontology and the development of analysis algorithms would expedite the DNA profiling procedure.

Data sciences

Database administration, data wrangling, statistical analysis, visualization, and predictive modeling on both structured and unstructured data are all part of a data scientist's job description. Data science has become more and more integrated into forensic, preventative, and predictive medicine in recent years. A typical pipeline of the possible stages of data science collaboration with medical domain specialists for the creation of AI and predictive data models is depicted in **Figure 3** [22].

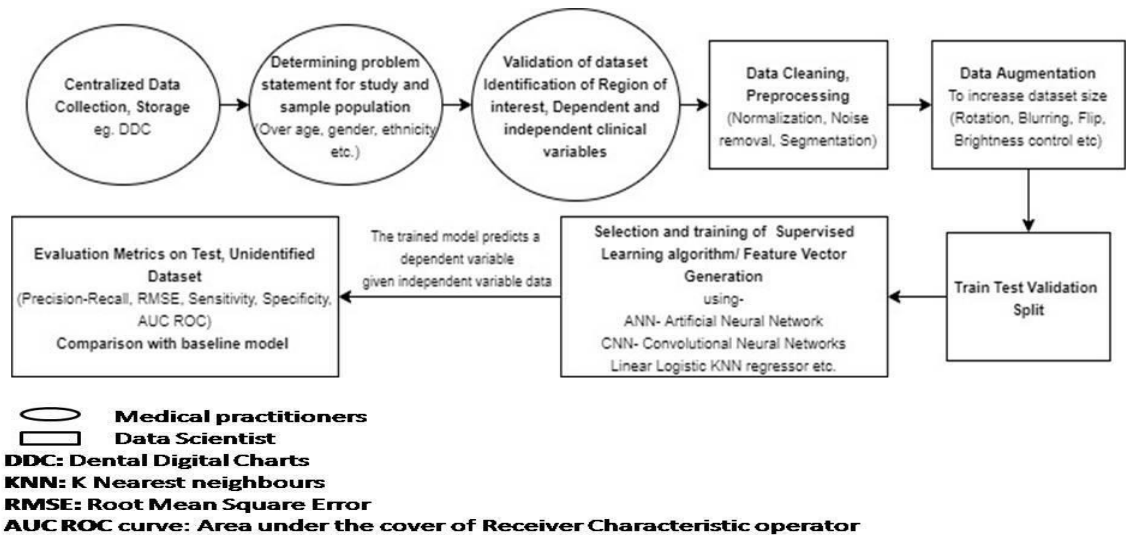

Figure 3. Potential phases of involvement of data science in various medical domains.

Government Statutory Bodies

A consistent coding system should be used to standardize the format of the dental records that are gathered. Therefore, a code that unifies the display of dental records should be developed, similar to the Japan Dental Association Oral Examination Standard

code (JDAOES) [23]. Therefore, it is necessary to develop model projects. The government should promote the adoption of Electronic Health Records (EHRs), which allow appropriate parties to communicate medical and dental health information. Cloud technology then makes it easy to store and access patient data, resulting in cloud-based electronic health records with standardized data formats for easy access. However, the security of personal data necessitates legal upkeep. The development of AI-based diagnostic technology should receive funding. Several regulatory organizations, including dental councils, dental associations, and forensic odontology associations, ought to unite and establish regulations that will advance the scientific community that relies on technology.

Several limitations encompass the stakeholders which one should try to overcome. These are listed in **Table 1**.

Table 1. Limitations of stakeholders in AI

Sr. No.	Stakeholder	Limitations
1.	General dental practitioners	-Lack of standardized format for data collection. -Lack of adequate knowledge of AI and its use in FO.
2.	Forensic odontologist	-Limited number of forensic odontologists available -Limited resources
3.	Dental radiologist	-Insufficient digitization of available records -Inadequate application of AI to digitized records.
4.	General pathologist	-Lack of armamentarium for performing technology-based autopsy for forensic studies.
5.	Oral pathologists	-Limited emphasis on forensic odontology training amongst specialists.
6.	Biomedical engineers	-Lack of integration amongst science and technology for evolution in the field of biotechnology.
7.	Government statutory bodies	-Lack of coherence amongst various other stakeholders. -Limited resources and political considerations before bringing in reforms.

Conclusion

The finest tool for storing, analyzing, and applying product data gathered for forensic evidence in court cases is AI. A collection of digital forensic investigations can be produced and made available by it. To do this, a variety of computational models can be developed and adjusted, allowing all relevant parties to make the greatest possible contributions to the field of forensic odontology. Most significantly, AI can be a benefit in forensic dentistry that will increase the effectiveness of the finished product if all stakeholders adopt an interdisciplinary integrated strategy. But it's important to remember that AI is a human invention that only helps with effective task completion. It cannot, in any way, take the place of human intelligence or subjugate humanity.

Acknowledgments: None

Conflict of Interest: None

Financial Support: None

Ethics Statement: None

References

1. Janardanan RP, Logeswaran R. Recent image processing techniques in forensic odontology-a systematic review. Biomed J Sci Tech Res. 2018;2(5):1-6.
2. Kharalampos M, Put VA, Tarasenko SV, Reshetov IV. Comprehensive patient rehabilitation while performing immediate dental implant placement with the use of information-wave therapy (literature overview). J Adv Pharm Educ Res. 2020;10(2):11-4.
3. Shahraki HA, Maserrat V, Moghadam MD, Tabatabaei A, Forghani F. Evaluation of the prevalence of c-shaped canals in maxillary molars by cone beam computed tomography in Iranian population. Int J Pharm Phytopharmacol Res. 2020;10(1):164-9.
4. Nagi R, Aravinda K, Rakesh N, Jain S, Kaur N, Mann AK. Digitization in forensic odontology: a paradigm shift in forensic investigations. J Forensic Dent Sci. 2019;11(1):5-10.
5. Chinnikatti SK. Artificial intelligence in forensic science. Forensic Sci Add Res. 2018;2(5):182-3.

6. Sharma S. Artificial intelligence in dentistry: the current concepts and a peek into the future. Int J Contemp Med Res. 2019;6(12):L5-9.
7. Davenport T, Kalakota R. The potential for artificial intelligence in healthcare. Future Healthc J. 2019;6(2):94-8.
8. Fereira JL, de Fereira AE, Ortega AI. Methods for the analysis of hard dental tissues exposed to high temperatures. Forensic Sci Int. 2008;178(2-3):119-24.
9. Hanaoka Y, Ueno A, Tsuzuki T, Kajiwara M, Minaguchi K, Sato Y. Proposal for internet-based digital dental chart for personal dental identification in forensics. Forensic Sci Int. 2007;168(1):57-60.
10. Chiam SL. A note on digital dental radiography in forensic odontology. J Forensic Dent Sci. 2014;6(3):197-201.
11. Katne T, Kanaparthi A, Srikanth Gotoor S, Muppirala S, Devaraju R, Gantala R. Artificial intelligence: demystifying dentistry–the future and beyond. Int J Contemp Med Surg Radiol. 2019;4(4):D6-9.
12. Tuzoff DV, Tuzova LN, Bornstein MM, Krasnov AS, Kharchenko MA, Nikolenko SI, et al. Tooth detection and numbering in panoramic radiographs using convolutional neural networks. Dentomaxillofac Radiol. 2019;48(4):20180051.
13. Hung K, Yeung AW, Tanaka R, Bornstein MM. Current applications, opportunities, and limitations of AI for 3D imaging in dental research and practice. Int J Environ Res Public Health. 2020;17(12):4424.
14. Bewes J, Low A, Morphett A, Pate FD, 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;62:40-3.
15. Mahasantipiya PM, Yeesarapat U, Suriyadet T, Sricharoen J, Dumrongwanich A, Thaiupathump T. Bite mark identification using neural networks: a preliminary study. Proc Int Multiconference Eng Comput Sci. 2011;1:65-8.
16. Wrobel K, Doroz R, Porwik P, Naruniec J, Kowalski M. Using a probabilistic neural network for lip-based biometric verification. Eng Appl Artif Intell. 2017;64:112-27.
17. Tao J, Wang J, Wang A, Xie Z, Wang Z, Wu S, et al. Dental age estimation: a machine learning perspective. Future Healthc J. 2019;6(2):94-8.
18. Patil V, Vineetha R, Vatsa S, Shetty DK, Raju A, Naik N, et al. Artificial neural network for gender determination using mandibular morphometric parameters: a comparative retrospective study. Cogent Eng. 2020;7(1):1723783.
19. Al-Mashhadani TS, Ramo FM. Personal identification system using dental panoramic radiograph based on meta_heuristic algorithm. Int J Comput Sci Inf Secur (IJCSIS). 2016;14(5):344-50.
20. O'Sullivan S, Holzinger A, Zatloukal K, Saldiva P, Sajid MI, Wichmann D. Machine learning enhanced virtual autopsy. Autops Case Rep. 2017;7(4):3-7.
21. Krishna AB, Tanveer A, Bhagirath PV, Gannepalli A. Role of artificial intelligence in diagnostic oral pathology-a modern approach. J Oral Maxillofac Pathol: JOMFP. 2020;24(1):152-6.
22. Lefevre T. Big data in forensic science and medicine. J Forensic Leg Med. 2018;57:1-6.
23. Takano H, Momota Y, Ozaki T, Shiozawa S, Terada K. Personal identification from dental findings using AI and image analysis against great disaster in japan. Forensic Leg Investig Sci. 2019;5(3):100041. doi:10.24966/FLIS-733X/100041