ScientificScholar®
Knowledge is power
Publisher of Scientific Journals

www.ajohas.com

Asian Journal of Oral Health and Allied Sciences

Review Article

Artificial intelligence in dentistry: It's applications, impact and challenges

Bhavya Srivastava[1], Sunira Chandra[1], Siddharth Kumar Singh[1], Tanmay Srivastava[1]

[1]Department of Oral Medicine and Radiology, Saraswati Dental College and Hospital, Lucknow, Uttar Pradesh, India.

***Corresponding author:**
Bhavya Srivastava,
Department of Oral Medicine and Radiology, Saraswati Dental College and Hospital, Lucknow, Uttar Pradesh, India.

bhavyasri606@gmail.com

Received: 20 October 2023
Accepted: 08 December 2023
Published: 29 December 2023

DOI
10.25259/AJOHAS_10_2023

Quick Response Code:

ABSTRACT

In dentistry, artificial intelligence (AI) has shown great potential in improving diagnosis, treatment planning, and patient care. AI algorithms have been developed to analyze dental images, such as radiographs and intraoral scans, aiding in the detection of dental caries, periodontal diseases, and oral lesions. These algorithms can provide more accurate and efficient diagnoses, reducing the reliance on human interpretation. AI has also been utilized in treatment planning and helping dentists to determine the optimal approach for procedures such as dental implant placement and orthodontic treatment, and recently, AI has also been playing a significant role in forensic medicine as well as in forensic odontology. In addition, AI-based chatbots and virtual assistants have been developed to provide patients with personalized oral health information and guidance. Despite the numerous advantages, challenges remain in implementing AI in dentistry, such as ensuring data privacy and addressing ethical concerns. Nevertheless, AI has the potential to revolutionize dentistry by improving diagnosis, treatment planning, and patient care, ultimately leading to better oral health outcomes. This review provides an overview of the current applications of AI and its influence on dental practice, along with future prospects.

Keywords: Artificial intelligence, Machine learning, Dentistry, Artificial neural networks

INTRODUCTION

In 1956, the term "Artificial Intelligence (AI)" was first given by John McCarthy, the father of AI. He described AI as a machine with human potential, capable of performing tasks without any human intervention.[1,2]

Arthur Samuel gave the term "Machine Learning (ML)," a subset of AI.[1] ML concentrates on advancing algorithms and statistical framework that allow computer software to learn from past data and give prognosis, conclusion, or decisions with no direct human intervention.[3] The purpose of ML is to empower computer systems to learn patterns and interrelations in large data sets as well as use that knowledge to provide logical conclusions on new data.[4] For quite some time, AI has brought many innovations to improve our daily lives, such as car control, facial recognition, and more. Similarly, in healthcare, AI is providing several benefits, such as AI-assisted surgery, video surgery, and automated diagnosis and personalized treatment planning is developing in healthcare.[5] A plethora of data collection has fuelled the AI revolution in healthcare. However, the development of high-performance computing has made it possible to collect and extract all the important and complex data that are the basis of ML.[5]

The development of Al has had a long history. It was born at the same time when the question "Can machines think?" was published. In reality, this utterance by Alan turing in the imitation game is

regarded as the inception of AI. On the other hand, John McCarthy, a computer scientist who in 1956 arranged the Dartmouth conference, is responsible for coining the term. The so-called "Al winter"-a time period spanning the 1970s to the 1990s,which was marked by issues relating to the technology that was at hand- came after the early enthusiasm came to a sudden halt [Figure 1]. Later, thanks to progress in technology, beginning in the 2010s, Al is experiencing a new renaissance. Al in medicine had no exceptions in this new "Al spring," which was also made feasible by the widespread digitalization of health data, which allowed for the development of big data platforms that could serve as a strong foundation for intelligent algorithms. Substantial data analysis was done to examine the impact on key priorities in health indicators that was included in the European Program of Work (EPW) and the World Health Organization (WHO) General Program of Work 2019-2023. The study emphasized on how to promote real-time analysis for diagnosis and predictive purposes for enhancing the accuracy and management of various diseases.[6] History of the studies published on artificial intelligence in dental application was given by Bellini *et al.* [Table 1].[6]

Neural network is the ML technique inspired in biological neurons where the input is fed to one or multiple layers to produce an output. There are various types of neural networks like; Deep neural network, which is a type of neural network with multiple hidden layers, making more complex feature construction data, convolutional neural network (CNN), which is a special type of neural network. It can extract spatial information by means of filters, which use the convolution operator. Another type is generative adversarial networks that it is a type of methodology that is used to generate data similar to the input data. Make use of two different models that compete against each other.[5]

AI operates in two phases: first phase is the "training" phase, and "testing" is the second phase. The parameters of the model set are determined by the training data. Retrospectively, the model makes use of data from prior examples, such as patient data or data from data sets containing various examples. These parameters are then applied to the test sets.

In dentistry, the input data may be visual (pictures, spectral, or radiographic images), textual (medical or treatment records), or audio data. These input data are processed by the neural networks, which can then produce an output. The outcome could be a diagnosis, course of treatment, disease prediction, or prognosis. To arrive at a diagnosis, it can decipher clinical clues, do cephalometric analysis, or identify lesions based on voxel differences. By recognizing the typical structures, generating and assessing the results, converting the speech data, or connecting data acquisition and computer-aided design/computer-aided manufacturing (CAD/CAM), it foretells how the treatment will be done. The AI program may use gene analysis, risk factor prioritization, or outcome prediction to predict the disease or its prognosis.

AI seems quite capable to transform healthcare by making life easier for doctors and dentists. Although AI does not have many modern applications in dentistry, it is developing ways to examine dental images, caries detection, teaching radiographic and pathology research, and preserving electronic patient records with the help of robots.[7]

METHOD OF DATA COLLECTION

Search using the PubMed and Google Scholar electronic databases focusing on peer-reviewed articles from 2001 to 2023 using the keywords "artificial intelligence," "artificial intelligence in dentistry," "artificial intelligence in dentistry pros and cons," "application of artificial intelligence in dentistry" and "scope of artificial intelligence in dentistry" revealed 188,778, 3882, 123, 2792, and 967 papers, respectively. This review article is structured after thorough analysis and study of relevant data in English language on this topic. Duplicate data, animal studies, *in vitro* studies, case reports, pilot studies, and non-relevant repeated information

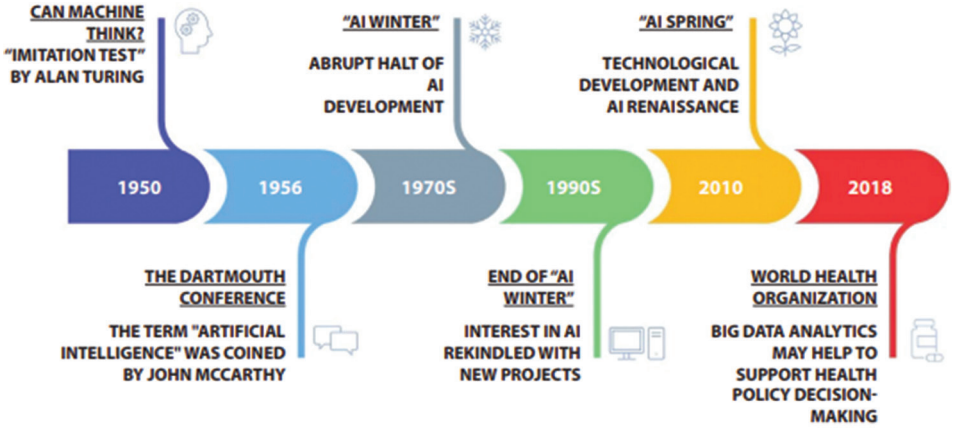

Figure 1: Timeline diagram showing the history of artificial intelligence.

were removed, and the remaining information was scrutinized thoroughly and finally included in this review. Relevant articles were selected, which included history, applications, and challenges of AI in systematic reviews, meta-analysis, and original research articles**.**

ROLE IN CRITICAL PRACTICE

AI software is currently investing in increasing the machine's ability to mimic human abilities in processing data and predicting outcomes on its own. AI software is created using robotic search engines with an increased ability to excerpt, review, and inter-relate large amounts of relevant data, and AI can be of use in the day-to-day practice in various branches of dental field to prevent and predict complications [Figure 2].

Table 1: History of the studies published on artificial intelligence in dental application.

S. No.	Scientists	Year	Work
1.	John McCarthy	1956	Arranged the Dartmouth conference and coined the term
2.	Carmody *et al.*	2001	Used software to distinguish the accuracy of periapical diseases according to their provisional diagnosis
3.	Lee *et al.*	2003	Took previous intraoral periapical radiographs (IOPAR)
4.	Takata *et al.*	2009	Tested an AI model to give prediction if tooth extraction is needed or not to achieve a good outcome in a given orthodontic case
5.	Saghiri *et al.*	2012	Took the help of ANN to locate the apical foramen and working length accurately
6.	Endres *et al.*	2020	Used a deep learning software to examine radiolucent lesions present periapically in panoramic radiographs by 24 craniofacial surgeons
7.	Moayeri *et al.*	2022	By W-J48 decision tree (DT) method that helps in classification of records

ANN: Artificial neural networks

Lee *et al.* took previous intraoral periapical radiographs (IOPAR) to assess the diagnosis and prognosis of extraction of periodontally damaged teeth using a CNN, a type of deep learning algorithm. As an example, 651 IOPARs, and the inference of the precision in diagnosis of premolars was 81.0%, and molars was 76.7%. Periodontal damage requiring extraction was estimated in 82.8% of premolars and 73.4% of molars.[8]

Carmody *et al.*[9] used software to distinguish the accuracy of periapical diseases according to their provisional diagnosis. Endres *et al.*,[10] used a deep learning software to examine radiolucent lesions present periapically in panoramic radiographs by 24 craniofacial surgeons. Hence, it is helping in enhancing the quality of radiological diagnosis for general dentists and new doctors in the field of dentistry.

Dental implant performance was predicted by Moayeri *et al.* by W-J48 decision tree method that helps in classification of records. They reviewed 224 implants, concluding an accuracy, sensitivity, and specificity of 89.31%, 67.17%, and 95.92%, respectively with simulation using 10-fold cross validation.[11] This can predict if the implant will be successful or not in different patients.

In orthodontic treatment planning, the decision of orthodontic extraction is of key importance. Recently, cognitive models have been developed to help make better decisions. Takada *et al.*[12] tested an AI model to give a prediction of whether tooth extraction is needed or not to achieve a good outcome in a given orthodontic case. In this study, a total of 188 patients were identified, which predicted the need for tooth extraction, and the success rate of the study was 90.4%.

AI in conservative dentistry is very useful in restorative sciences in predicting the type of restorative material on the basis of its durability that is appropriate for the

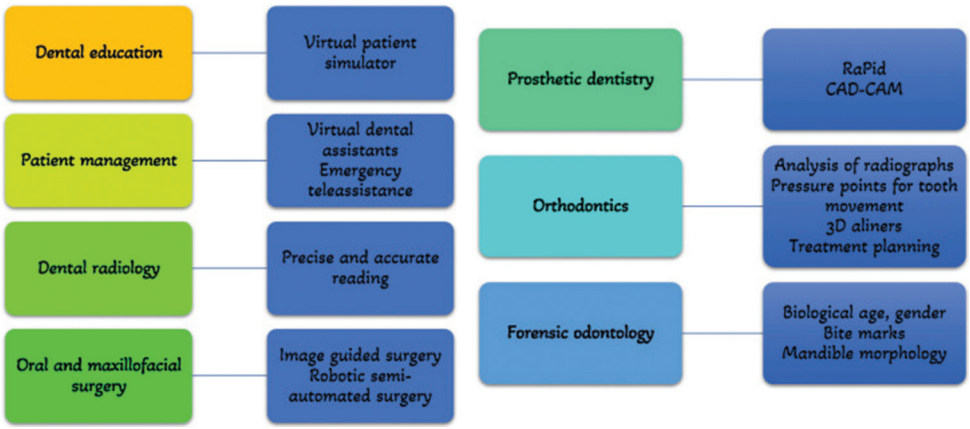

Figure 2: Day-to-day use of artificial intelligence in dental practice. CAD-CAM: Computer-aided design - Computer-aided manufacturing.

patients through case-based reasoning system to predict the type of restorative material based on the effectiveness of the filling material for the patient. In this system, 4336 records of 2023 patients were collected, including dental and patient records. The results of this study mean an error of 0.42 and 0.21 years for the combination.[13] Even in endodontic dentistry, Saghiri *et al*. took the help of artificial neural network (ANN) to locate the apical foramen and working length accurately.[14]

Another study used Bayesian networks (BN) for predicting the development of temporomandibular joint disorders (TMDs). Magnetic resonance imaging data of 33 patients with two diagnoses of (bone changes and disc dislocation) in 33 patients, the detections accuracy of bone displacement and disc dislocation in the BN model was 97.62% and 99.66%, respectively.[15] This demonstrates that it can be potentially used in the radiodiagnosis of the TMDs, and it can even diagnose minute bony changes in temporomandibular joints, leading to early detection of any joint disorders.

AI has also been used in forensics to determine the natural age and sex of the sound and diseased people. Lately, AI has also been used to describe bite marks and mandible morphology.[16] It has been reported in studies that AI is quite accurate and precise in forensics, just like any trained examiners. It can prove to be a promising tool in identifying mass accidents or disasters promptly and with quite precision.

ROLE IN MEDICAL AND DENTAL TEACHING/ LEARNING

AI integration in healthcare and education sector is rapidly transforming the fields, bringing about advancements in patient care, diagnosis, treatment, student learning, teaching practices, and can even support reproducibility in scientific publications. AI can analyze medical literature and provide doctors with updates and recommendations for best practices. It can also help doctors to stay up to date with the latest advancements in their field. AI allows students to practice complex procedures on virtual patients without risking harm to real patients. It can assist in developing personalized treatment plans based on a patient's individual medical history and needs.[17]

APPLICATION IN MEDICAL WRITING

AI streamlines the peer review process, improves the quality of peer review, and enables new forms of publication, thereby enhancing the overall quality of scientific publications.

ChatGPT is a large language model developed by OpenAI in San Francisco, California. It was trained with a substantial number of words in a database, teaching it the complex relationship between words to construct language. ChatGPT gained formal authorship on four published papers and preprints in January 2023. It has appeared in numerous scientific publications since its release in November 2022. Although ChatGPT may sound plausible, it might provide incorrect answers and is sensitive to changes in phrasing of input. It can also overuse certain phrases and has limitations in providing references and fact-checking.[17]

CHALLENGES

Although AI models sound quite impressive and promising, there are still some limitations, such as the need to validate their reliability with appropriate data from new patients or other dental services[18]. It still requires constant human supervision as errors can occur. Being a machine- and software-oriented model, it does not care about relationships, such as feelings and compassion for patients. It can also cause security risks because all the information is in the system. It could also even lead to unemployment if AI takes over dentistry as promised. There are some concerns regarding the quality of AI-generated questions, unpredictability, lack of creativity, and ethical considerations. There is also a risk of students becoming overly reliant on AI and neglecting to develop critical thinking and problem-solving skills.[17]

CONCLUSION

AI is rapidly evolving to fill a gap in healthcare, but is still mostly in the research phase. Having more information can make research faster and provide better results. However, AI can present many threats, including breaches of privacy, ethical concerns, and medical/dental malpractice. AI's success and rewards in medicine will need collaboration from software developers, controllers, and patrons. There are so many questions that are still to be answered that anybody can even fathom and this gives the sole reason to continue exploring – not to hold back.

Ethical approval

The Institutional Review Board approval is not required.

Declaration of patient consent

Patient's consent was not required as there are no patients in this study.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

Use of artificial intelligence (AI)-assisted technology for manuscript preparation

The authors confirm that there was no use of artificial intelligence (AI)-assisted technology for assisting in the writing or editing of the manuscript and no images were manipulated using AI.

REFERENCES

1. Ensmenger N, Nilsson NJ. The quest for artificial intelligence: A history of ideas and achievements. Cambridge, MA, USA: Cambridge University Press; 2010. p. 588-9.
2. Khanagar SB, Al-Ehaideb A, Maganur PC, Vishwanathaiah S, Patil S, Baeshen HA, *et al*. Developments, application, and performance of artificial intelligence in dentistry-a systematic review. J Dent Sci 2021;16:508-22.
3. Bowling M, Fürnkranz J, Graepel T, Musick R. Machine learning and games. Mach Learn 2006;63:211-5.
4. Patil S, Albogami S, Hosmani J, Mujoo S, Kamil MA, Mansour MA, *et al*. Artificial intelligence in the diagnosis of oral diseases: Applications and pitfalls. Diagnostics (Basel) 2022;12:1029.
5. Carrillo-Perez F, Pecho OE, Morales JC, Paravina RD, Della Bona A, Ghinea R, *et al*. Applications of artificial intelligence in dentistry: A comprehensive review. J Esthet Restor Dent 2022;34:259-80.
6. Bellini V, Cascella M, Cutugno F, Russo M, Lanza R, Compagnone C, *et al*. Understanding basic principles of Artificial Intelligence: A practical guide for intensivists. Acta Biomed 2022;93:e2022297.
7. Agrawal P, Nikhade P. Artificial Intelligence in dentistry: Past, present, and future. Cureus 2022;14:e27405.
8. Lee JH, Kim DH, Jeong SN, Choi SH. Diagnosis and prediction of periodontally compromised teeth using a deep learning-based convolutional neural network algorithm. J Periodontal Implant Sci 2018;48:114-23.
9. Carmody DP, McGrath SP, Dunn SM, van der Stelt PF, Schouten E. Machine classification of dental images with visual search. Acad Radiol 2001;8:1239-46.
10. Endres MG, Hillen F, Salloumis M, Sedaghat AR, Niehues SM, Quatela O, *et al*. Development of a deep learning algorithm for periapical disease detection in dental radiographs. Diagnostics 2020;10:430.
11. Moayeri RS, Khalili M, Nazari M. A hybrid method to predict success of dental implants. Int J Adv Comput Sci Appl 2016;7:1-6.
12. Takada K, Yagi M, Horiguchi E. Computational formulation of orthodontic tooth-extraction decisions: Part I: To extract or not to extract. Angle Orthod 2009;79:885-91.
13. Aliaga IJ, Vera V, De Paz JF, García AE, Mohamad MS. Modelling the longevity of dental restorations by means of a CBR system. BioMed Res Int 2015;2015:540306.
14. Saghiri MA, Asgar K, Boukani KK, Lotfi M, Aghili H, Delvarani A, *et al*. A new approach for locating the minor apical foramen using an artificial neural network. Int Endod J 2012;45:257-65.
15. Iwasaki H. Bayesian belief network analysis applied to determine the progression of temporomandibular Disorders using MRI. Dentomaxillofac Radiol 2015;44:20140279.
16. Khanagar SB, Vishwanathaiah S, Naik S, Al-Kheraif AA, Divakar DD, Sarode SC, *et al*. Application and performance of artificial intelligence technology in forensic odontology-a systematic review. Leg Med (Tokyo) 2021;48:101826.
17. Dave M, Patel N. Artificial intelligence in healthcare and education. Br Dent J 2023;234:761-4.
18. Hung K, Montalvao C, Tanaka R, Kawai T, Bornstein MM. The use and performance of artificial intelligence applications in dental and maxillofacial radiology: A systematic review. Dentomaxillofac Radiol 2020;49:20190107.

How to cite this article: Srivastava B, Chandra S, Singh SK, Srivastava T. Artificial intelligence in dentistry: It's applications, impact and challenges. Asian J Oral Health Allied Sci. 2023; 13:7. doi: 10.25259/AJOHAS_10_2023