

Artificial Intelligence: Illuminating the Future of Periodontology

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ABSTRACT:

AIMS & OBJECTIVES : The application of computer systems to simulate human behavior is known as artificial intelligence (AI). Periodontitis, a prevalent condition worldwide, leads to the deterioration and eventual loss of the tissues supporting teeth. Its diagnosis and treatment are increasingly being supported by AI as a valuable tool for medical practitioners. The objective of this study is to evaluate existing literature concerning the utilization of AI in both the diagnosis and epidemiological analysis of this disease.

MATERIAL & METHOD: After a thorough search in April 2023, 50 papers were found that needed to have their abstracts screened after duplicates were removed. The publications that were chosen covered a broad spectrum of subjects, however the input data and photos were mostly focused on visual imaging.

RESULT: Over the last ten years, the field has experienced substantial expansion, but the variety of statistical tests available for research has resulted in inconsistent reporting of results. It is essential to standardize reporting techniques and methodology to allow meaningful comparisons. By doing this, it will be possible to fully utilize AI's potential to enhance periodontics and implantology diagnosis and therapy.

Key Words: Artificial intelligence, Periodontics, dental implant

INTRODUCTION:

The world we live in today is one that has seen many ups and downs over the 21st century. People in this generation are known for their prolific inventories. When they are impacted by anything, they are also planning for fresh approaches to deal with the circumstance. To meet the financial, physical, and emotional needs of our nation and the rest of the globe, we are now creating a wide spectrum of new technologies. AI and machine learning (ML) have exerted a substantial impact across numerous scientific and technical domains. Artificial intelligence (AI) encompasses the domains of research, development, and analysis of computer systems displaying "intelligent behavior". On the other hand, machine learning (ML) is a subset of artificial intelligence focused on instructing computers to identify statistical patterns within a provided dataset, enabling predictions for future data samples. The term "artificial intelligence" was coined by John McCarthy, often referred to as the father of AI.¹

He used this phrase to characterize devices that are capable of reasoning without the need for human input.² "Imitation Game" or "Turing test" by Alan Turing served as the model for the idea.³ The first artificial intelligence software was called Logic Theorist, and it was developed in 1955 by Allen Newell and Herbert Simon.⁴ Artificial intelligence has a specialized component known as machine learning (ML). Through dataset analysis and learning, machine learning—more especially, the use of algorithms such as artificial neural networks (ANN)—predicts results.⁵

The application of statistical methods to automate the creation of analytical models for data analysis is known as artificial intelligence (AI). Through the use of supervised learning, the system picks up knowledge by training models with predetermined outcomes. Artificial neural networks (ANNs), a subfield of AI, are more complex than conventional machine learning. An ANN considers the importance of factors

that affect both input and output while processing data. The most sophisticated type of machine learning is called deep learning. In order to forecast results, it uses a neural network model that can handle several variables and learns on its own from unstructured and unlabeled data.⁶

In the realm of dentistry, artificial intelligence (AI) has quickly acquired popularity, especially in periodontology and implantology. When used in conjunction with clinical evaluation, AI techniques can improve dentistry productivity and the diagnosis process. Using picture recognition, classification, and segmentation algorithms, AI can assist with a range of dental procedures. Convolutional neural networks (CNNs), which are more sophisticated variants of artificial neural networks, and deep learning techniques in computer vision can assist with tasks like photo identification and segmentation. These techniques can aid in the diagnosis of periodontal disease when used with radiography.⁷

AI technology can also be utilized to improve the efficiency and accuracy of implant insertion, treatment planning, and diagnostics. AI holds promise in enhancing patients' oral health and overall well-being by enabling early detection of periodontal disease. More than a billion people worldwide suffer from periodontal disease, which weakens the alveolar bone and ultimately results in tooth loss.⁸

Accurately identifying and diagnosing periodontitis presents substantial hurdles for medical professionals. Currently, radiographic imaging is the best method for examining hard tissues and utilizing a graded probe to evaluate soft tissues. Nevertheless, these techniques have poor dependability amongst operators and even within the same operator. Variations in radiographic angulation and probing pressure are the cause of this inaccuracy, which makes correct diagnosis challenging.⁷

Periodontitis examination presents a diagnostic challenge because of its intricate relationship with predisposing factors, which is challenging for medical professionals and scientific approaches to fully comprehend. Because of their complexity, the use of artificial intelligence (AI) may be utilized to better understand how these factors impact the diagnosis and understanding of the disease's origins (aetiology). By employing AI to learn more about the interactions between these variables, medical professionals and researchers can gain a better knowledge of periodontitis. Only a few number of research have examined the use of deep learning methods in the diagnosis of periodontal disease to date. For the purpose of identifying radiographic bone loss (RBL) in dental panoramic radiographs, several research have suggested CNN-based techniques. Other studies have assessed the efficacy of deep convolutional neural networks (CNN) in identifying marginal bone loss around dental implants in periapical radiographs.

Moreover, CNN has been used with intraoral radiographs to identify posterior teeth with poor periodontal health.⁷

The objective of this review paper is to provide a comprehensive overview of the current state of artificial intelligence (AI) within the fields of implantology and periodontology. It will examine the possible uses of AI in these fields and talk about the current restrictions and difficulties that come with using it, particularly when it comes to the tasks of determining implant types by analyzing periapical and panoramic radiographs, creating prediction models to assess osteointegration and forecast implant success, and refining implant designs. This article aims to provide an overview of artificial intelligence (AI), including its applications, advantages, and areas that still need development to reach its full potential in periodontology and implantology.

MATERIALS AND METHOD:

A thorough search was carried out using PubMed, MEDLINE, Science Direct, and Web of Science to find all pertinent studies. Furthermore, to guarantee the incorporation of all pertinent information, we conducted a thorough review of prior research' references to identify any studies that fulfilled our inclusion criteria. The search approach combined topic searching in Web of Science with subject headers and free text terms in MEDLINE. Artificial Intelligence, Machine Learning, Neural Network, Logistic Model, Case-Based Reasoning, Deep Learning, Periodontology, AND Implantology were the Boolean keywords utilized in the search. After going through the abstracts and manuscripts found through the search, the reviewer chose relevant publications that met the eligibility requirements. By applying our inclusion and exclusion criteria, we successfully selected all relevant studies. Some works were excluded after examining the inclusion criteria in their abstracts or titles. To determine relevance, the full texts of all remaining studies were reviewed. These standards were used to evaluate the research for this review.

Inclusion criteria

1. The primary emphasis of the article should center on artificial intelligence (AI) and its application within the realm of periodontics.
2. Quantifiable or predicted results should be presented in the paper.
3. The datasets that were utilized to assess the model have to be specifically mentioned in the publication.

Exclusion criteria:

1. Articles with no connection to artificial intelligence.
2. Articles that are not formally uploaded or published.
3. Articles having simply abstracts; no complete text is provided.
4. Works composed in a language other than English.
5. publications that assessed AI uses but excluded dentistry fields;
6. studies looking into AI models in fields unrelated to implant dentistry, such orthodontics, radiography, periodontics, endodontics, pediatric dentistry, and maxillofacial surgery;

Data was taken out of the research and entered into a tabular format. The author title, the year of publication, the data format, the application of the AI technique, the workflow of

the AI model, the ensuing datasets for training and testing, the validation technique, the type of comparison employed, and finally a brief explanation of the AI model's performance were all included in the standardised data collation sheet. Since this was a review, all texts that met the eligibility criteria were subject to a qualitative review. The key focus was on assessing the current clinical utilization of AI in periodontology and peri-implant health, as well as evaluating the efficacy of these AI models in aiding clinicians or patients.

DISCUSSION:

The human brain's remarkable ability allows us to anticipate the near future and take preventative measures to lessen risks. The present focus of AI research is on enabling robots to act independently, program a flexible path to a destination, and emulate human abilities in goal-setting and achievement.⁹ Electronic dental records, or EDRs, are extensively used in both academic and non-academic contexts in the area of dentistry. However, manually evaluating these records tends to be inefficient, biased, expensive, and time-consuming.¹⁰

Artificial intelligence (AI) offers a solution by simplifying the process of gaining access to vast quantities of data and enabling comprehensive analysis. AI is being used in several dental specialties to provide value-based treatment and to anticipate and prevent dental problems.¹¹

Previous assessments in the dental sector have highlighted the underutilization of this instrument and the postponement of dental research related to this topic.^{12, 13} However, as of 2018, the number of studies on periodontal imaging alone surpassed that of dental imaging, indicating that this delay has probably been overcome. Considering the success that patients have had in comparable medical projects, there is little question that this helps to improve dental patient care.¹⁴

AI for Diagnosing Periodontal Diseases:

For periodontal disease to stop becoming worse and causing tooth loss, early diagnosis and treatment are essential. By analyzing radiographic and clinical data, artificial intelligence (AI) algorithms have been created to aid in the diagnosis of periodontal disease. In a research by Lee et al., a deep learning system was used to analyze panoramic radiographs and reliably and highly specifically predict the existence of periodontal bone loss. Another study analyzed clinical data and highly correctly predicted the existence of periodontal disease using machine learning techniques.

A study by Özden et al. evaluated and numerically coded 11 variables as input conditions in order to determine how well three distinct decision support systems (DSS) performed in the diagnosis and prediction of periodontal disease: Support Vector Machines (SMV), Decision Trees (DT), and Artificial Neural Networks (ANN). Gender, age, education, smoking status, clinical attachment level (CAL), probing pocket depth

(PD), gingival recession (GR), bleeding on probing (BOP), gingival recession index (GI), plaque index (PI), gingival recession (GI), and radiographic bone loss (RBL) were among these factors. The DSS divided the outputs into six diagnostic categories: gingivitis, generalized chronic periodontitis, localized aggressive periodontitis, generalized aggressive periodontitis, and healthy.¹⁵

AI in the Planning of Treatments:

The planning of periodontal disease treatments can potentially be aided by AI technology. AI systems, for instance, may evaluate radiography data to precisely measure the alveolar bone's dimensions and identify the best location for an implant. AI may also aid in the selection of the most suitable treatment modalities and in the identification of risk factors that may influence the results of therapy.

AI in the field of implants:

Implant placement is a difficult process that needs to be planned carefully and carried out precisely to provide the best results. By evaluating radiographic data and determining the ideal implant size, location, and angulation, artificial intelligence (AI) can help in implant placement. AI can also help in the development of surgical guides, which can enhance implant placement efficiency and accuracy.

Generally, 2-dimensional (2D) radiography has been used as the input dataset for AI models created for implant type detection in different findings. A variety of deep convolutional neural network (CNN) designs have been used in certain research to investigate the usage of three-dimensional (3D) computed tomographic pictures.^{16–17} Periapical and panoramic radiographs, for example, show higher distortion in 2D pictures than in 3D scans.

Incorporating cone beam computed tomography (CBCT) images could potentially enhance the refinement of AI models for detecting implant types, despite the common use of periapical radiographs by clinicians for evaluating dental implants. Hence, the AI model in the featured study was trained using CBCT images.¹ Moayeri et al.'s research utilized the W-J48 decision tree (DT) algorithm to categorize records and forecast the success rate of dental implants. The goal of the study was to create a decision tree with 11 different criteria that were connected to the effectiveness of the implant.¹⁸

Papantonopoulos et al. sought to group radiological, clinical, and demographic data from 237 dental implants in 72 individuals. Finding probable implant "phenotypes" and indicators of the bone levels surrounding the implants was the goal. The researchers created an implant map that showed the existence of two separate implant clusters using the AI model. The scientists classified these clusters as possible implant "phenotypes," making a distinction between implants that showed resistance or vulnerability to peri-implantitis.¹⁹

AI'S LIMITATIONS IN PERIODONTOLOGY & IMPLANTOLOGY:

Although artificial intelligence (AI) has shown great promise across a number of industries, including healthcare, there are a number of obstacles to its use in implantology and periodontal therapy. First of all, the data that AI systems are trained on is extremely important. Inaccurate treatment plan suggestions or forecasts may arise from inadequate, biased, or low-quality training data. Furthermore, AI systems could find it difficult to keep up with the constant updates and changes needed due to the dynamic nature of implantology and periodontal disorders. Furthermore, particular patient preferences, feelings, and intricate clinical decisions—all of which are frequently crucial in these specialized dental treatments—cannot be taken into account by AI algorithms. The use of AI in periodontal therapy and implantology also requires careful consideration of ethical issues, including patient privacy, security, and responsibility. Although AI can help with clinical decision-making, in these complex dental procedures, human skill and judgment should still be valued as a supplementary tool.

SUGGESTIONS:

To fully harness the potential of artificial intelligence (AI) in the dental field, particularly in periodontology and implantology, further research is imperative. Emphasis should be placed on developing more robust AI algorithms that can enhance diagnostic accuracy, streamline treatment planning, and improve the precision of implant insertions. Additionally, addressing the current limitations of AI technologies, such as data privacy concerns and the need for large, high-quality datasets, is crucial. Collaborative efforts between researchers, dental professionals, and technology developers will be essential in advancing these technologies and integrating them effectively into clinical practice.

CONCLUSION:

In conclusion, AI technologies hold significant promise for revolutionizing dentistry, particularly in the specialized areas of periodontology and implantology. These advancements have the potential to enhance diagnostic capabilities, treatment planning, and the accuracy and efficiency of implant procedures. While the current progress is promising, continued research and development are vital to overcome existing challenges and fully realize AI's benefits. Ultimately, with sustained innovation and application, AI is poised to significantly elevate patient outcomes and the standard of care within the dental profession.

CONFLICT OF INTEREST: The authors declare no conflict of interest.

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DATA AVAILABILITY STATEMENT: The data presented in this study are available on reasonable request from the corresponding author.

REFERENCES:

1. Revilla-León M, Gómez-Polo M, Vyas S, Barmak BA, Galluci GO, Att W, Krishnamurthy VR. Artificial intelligence applications in implant dentistry: A systematic review. *J Prosthet Dent.* 2023 Feb;129(2):293-300. <https://doi.org/10.1016/j.prosdent.2021.05.008> PMID:34144789
2. Ensmenger, N.; Nilsson, N.J. *The Quest for Artificial Intelligence: A History of Ideas and Achievements.* Xv + 562 pp., Index; Cambridge University Press: Cambridge, MA, USA; New York, NY, USA, 2010; Volume 102, pp. 588-589. <https://doi.org/10.1086/663065>
3. Turing, A. M. On Computable Numbers, with an Application to the Entscheidungsproblem. *Proceedings of the London Mathematical Society Series 1937* 2, 42, 230-265. <https://doi.org/10.1112/plms/s2-42.1.230>
4. Newell A, Simon HA. The logic theory machine. A complex information processing system. *IRE Trans Inf Theory.* 1956;IT-2(3):61-79. <https://doi.org/10.1109/TIT.1956.1056797>
5. Newell A, Simon, H.A. *Communications of the ACM.* Volume 19 Issue 3 March 1976; 113-126. <https://doi.org/10.1145/360018.360022>
6. 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 Apr 19;12(5):1029. <https://doi.org/10.3390/diagnostics12051029> PMID:35626185 PMCID:PMC9139975
7. Park WJ, Park JB. History and application of artificial neural networks in dentistry. *Eur J Dent* 2018;12:594-601. https://doi.org/10.4103/ejd.eid_325_18 PMID:30369809 PMCID:PMC6178664
8. Alotaibi G, Awawdeh M, Farook FF, Aljohani M, Aldhafiri RM, Aldhoayan M. Artificial intelligence (AI) diagnostic tools: utilizing a convolutional neural network (CNN) to assess periodontal bone level radiographically—a retrospective study. *BMC Oral Health.* 2022 Sep 13;22(1):399. <https://doi.org/10.1186/s12903-022-02436-3> PMID:36100856 PMCID:PMC9469589
9. Scott J, Biancardi AM, Jones O, Andrew D. Artificial Intelligence in Periodontology: A Scoping Review. *Dent J (Basel).* 2023 Feb 8;11(2):43. <https://doi.org/10.3390/dj11020043> PMID:36826188 PMCID:PMC9955396
10. Shabbir J., Anwer T. Artificial Intelligence and its Role in Near Future. *Journal of Latex Class Files,* 2015;14(8), 1-11. <http://arxiv.org/abs/1804.01396>
11. Acharya A, Schroeder D, Schwei K, Chyou PH. Update on Electronic Dental Record and Clinical Computing Adoption Among Dental Practices in the United States. *Clin Med Res.* 2017 Dec;15(3-4):59-74. <https://doi.org/10.3121/cmrr.2017.1380> PMID:29229631 PMCID:PMC5849439
12. Ahmed Z, Mohamed K, Zeeshan S, Dong X. Artificial intelligence with multi-functional machine learning platform development for better healthcare and precision medicine. *Database (Oxford).* 2020 Jan 1;2020:baaa010. <https://doi.org/10.1093/database/baaa010> PMID:32185396 PMCID:PMC7078068
13. Schwendicke F, Golla T, Dreher M, Krois J. Convolutional neural networks for dental image diagnostics: A scoping review. *J Dent.* 2019 Dec;91:103226. <https://doi.org/10.1016/j.ident.2019.103226> PMID:31704386

14. 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;49:1. <https://doi.org/10.1259/dmfr.20190107> PMID:31386555 PMCID:PMC6957072
15. Rajpurkar P, Chen E, Banerjee O, Topol EJ. AI in health and medicine. *Nat Med*. 2022 Jan;28(1):31-38. <https://doi.org/10.1038/s41591-021-01614-0> PMID:35058619
16. Ozden FO, Özgönenel O, Özden B, Aydogdu A. Diagnosis of periodontal diseases using different classification algorithms: a preliminary study. *Niger J Clin Pract*. 2015 May-Jun;18(3):416-21. <https://doi.org/10.4103/1119-3077.151785> PMID:25772929
17. Jaskari J, Sahlsten J, Järnstedt J, Mehtonen H, Karhu K, Sundqvist O, et al. Deep learning method for mandibular canal segmentation in dental cone beam computed tomography volumes. *Sci Rep* 2020;10: 5842 <https://doi.org/10.1038/s41598-020-62321-3> PMID:32245989 PMCID:PMC7125134
18. Yang H, Liang K, Zhang L, Kang K, Xing Y. Improve 3D cone-beam CT reconstruction by slice-wise deep learning. In: 2018 IEEE Nuclear Science Symposium and Medical Imaging Conference Proceedings. Sydney, Australia: NSS/MIC; 2018. p. 1-3 <https://doi.org/10.1109/NSSMIC.2018.8824423>
19. Morais P, Queirós S, Moreira AHJ, Ferreira A, Ferreira E, Duque D, et al. Computer-aided recognition of dental implants in X-ray images. *Proc SPIE* 9414, Medical Imaging 2015: Computer-Aided Diagnosis, 94142E 20 March 2015 <https://doi.org/10.1117/12.2082796>
20. Papantonopoulos G, Takahashi K, Bountis T, Loos BG. Artificial neural networks for the diagnosis of aggressive periodontitis trained by immunologic parameters. *PLoS One*. 2014 Mar 6;9(3):e89757. <https://doi.org/10.1371/journal.pone.0089757> PMID:24603408 PMCID:PMC3945718

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