Periodontal Healing Through AI

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Abstract

Artificial intelligence (AI) is revolutionizing various fields, including business, medicine, education, and the arts. In the medical field, AI has made remarkable progress. AI algorithms designed for medical imaging can analyze images to detect abnormalities, leading to more precise and timely diagnose. In dentistry, it is used in diagnostic imaging, dental analytics, treatment planning, virtual and augmented reality training, natural language processing for medical records, patient experience through chatbots, and oral hygiene with smart devices. In periodontics, AI is being explored for tasks such as diagnosing and predicting periodontally compromised teeth, severity prediction of chronic periodontitis, correlation with systemic health outcomes, and detection of periodontal bone loss in radiographic images.While AI holds great potential, it also poses challenges. Privacy, security, transparency, accountability, and the impact on economic inequality and job markets are important considerations.

Keywords: Artificial intelligence; medical; dental; periodontics; deep learning; neural network.

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INTRODUCTION

Artificial intelligence (AI) is a game-changing technology that is altering not only business and medicine but also education and the arts. The rise of AI has been met with both enthusiasm and trepidation. The ability to swiftly and accurately handle and analyze large amounts of data is a major asset of AI.

The progress that AI has made in the medical field is astonishing. Algorithms designed specifically for medical imaging can examine images for abnormalities, allowing for mor precise and timely diagnoses [(1)] . Clinical decision-making is aided by AI-powered systems because they can filter through terabytes of patient data to find patterns and risk factors. In addition, AI is helping to advance personalized medicine, which customizes medicines for specific patients based on their genetic profiles and medical histories.

What is AI?

(AI) is a field of computer science that is concerned with making systems that can think, learn, and act on their own. AI research has been very good at finding effective ways to solve various problems, from playing games to diagnosing health problems. AI is, in simple words, the ability of machines to act like humans. This means being able to learn, think, and make choices.

AI is used for many different things, including:

- **Natural language processing**[(2)]: This is when computers can understand and work with human language. AI-powered robots, for example, can understand and answer customer questions using natural language processing.

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- **Machine vision**[3]: This is when computers can understand and work with human language. For example, chatbots that AI drives can use natural language processing to understand customer questions and answer them.
- **Speech recognition** [4]: This is when robots can understand what people say. For example, voice assistants that AI drives can use speech recognition to know what you say and do what you ask.
- **Robotics**[5] : This means that computers can understand what people say. For example, voice assistants that AI drives can use speech recognition to know what you say and act on it.

AI in History

With all the recent press around advancements in AI, it is easy to overlook that the discipline has a long history. Throughout the history of artificial intelligence, there have been a few distinct epochs, each marked by a shift in emphasis from proving logical theorems to modelling the human mind using neuroscience.

In the late 1940s, computer scientists investigated whether computers could " think. " British mathematician Alan Turing [6] wrote a paper in 1950 proposing a test to assess if a machine could be called intelligent, making him one of the most influential pioneers in the early history of artificial intelligence. This Turing test continues to be used as a benchmark for the development of AI.

However, in 1956, researchers demonstrated that, given unlimited memory, a machine could solve any issue. This was a breakthrough in artificial intelligence. As a result, we have GPS or the General Problem Solver. Fig 1 shows some of the critical milestones in the history of AI.

Year	AI Landmarks
1950	Alan Turing publishes “Computing machinery and Intelligence”, Which proposes the Turing test.
1955	Allen Newell & Herbert A. Simon create the Logic Theorist, the first Al program to prove mathematical theorems.
1956	The Dartmouth Conference is held, which is considered to be the birth of Al research.
1965	ELIZA, a chatbot that simulates human conversation, is developed.
1975	The first expert system, DENDRAL, is developed for molecular chemistry.
1981	The first neural network, the perceptron, is developed.
1997	Deep Blue, a chess-playing computer, defeats world champion Garry Kasparov.
2012	Image Net Large Scale Visual Recognition Challenge (ILSVRC) is won by AlexNet, a deep learning model.
2016	AlphaGo, a deep learning model, defeats world champion Go player Lee Sedol.

Fig 1. Key AI landmarks

AI in Healthcare

AI is being used to implement efficient and precise innovations across various medical fields, from radiography to the treatment of chronic diseases like cancer[7] . AI has significant advantages over human-only analytics and clinical decision-making [8] . As AI algorithms are given the chance to learn from training data, the systems become increasingly accurate, allowing for previously unattainable insights into treatment variability, care processes, diagnostics, and patient outcomes. It has been predicted that the worldwide market for AI in healthcare will reach $8 billion by 2026. Fig 2 shows some of the key milestones in the history AI.

Year	AI Landmarks in Health Care
2015	The FDA approves the first AI-powered medical device, a software system that can help doctors diagnose diabetic retinopathy
2016	Google AI researchers develop a deep learning model that can accurately diagnose skin cancer as well as, or even better than, human dermatologists.
2017	An AI-powered system developed by IBM watson Oncology is used to help doctors develop personalized treatment plans for cancer patients.
2018	Barkeley develop an AI system that can predict the risk of heart attack with 90% accuracy.
2019	A group of scientists from the University of Oxford develop an AI system that can identify and track COVID-19 cases from chest X-rays.

Fig 2. Key AI landmarks in HealthCare

Company	Year	AI Used	Areas of application
Google Health/ Deep Mind	2006	Machine learning, deep learning	Medical diagnosis, personalized treatment, clinical decision support
Oncora Medical	2008	Machine learning, deep learning	Cancer risk assessment, personalized treatment
Arterys	2010	Machine learning, deep learning	Medical imaging, vascular disease diagnosis
Enlitic	2012	Machine learning, deep learning	Cancer detection, personalized treatment
Babylon Health	2013	Natural language processing, machine learning, deep learning	Medical diagnosis, symptom tracking, prescription management
Cloud MedX Health	2014	Machine learning, deep learning	Medical imaging, clinical decision support
Butterfly Network	2014	Machine learning, deep learning	Medical imaging, point-of-care diagnostics
Caption Health	2014	Natural language processing, machine learning, deep learning	Medical transcription, captioning
IBM Watson Health	2015	Natural language processing, machine learning, deep learning	Medical diagnosis, personalized treatment, clinical decision support, drug discovery
Corti	2016	Machine learning, deep learning	Clinical decision support, risk assessment

Fig 3. Top AI-based Healthcare Companies

A few promising areas where AI has been able to make a mark in recent years are:

- **Medical diagnosis**: Large-scale medical data analysis can help clinicians spot trends they might otherwise miss. This can potentially improve the speed and accuracy with which diseases are diagnosed. Skin cancer, diabetic retinopathy, and cardiac illness are only some conditions that AI-powered systems can accurately diagnose.
- **Personalized treatment:** The patient's genetic makeup and medical history can be used with AI to create individualized treatment strategies. This has the potential to lead to more precise and efficient medical care. For instance, AI-driven algorithms are being utilized to create individualized cancer therapies designed to address the unique genetic alterations present in each patient's tumor.

- **Clinical decision support:** AI can be utilized to aid with healthcare decision-making in real time. Better medical decisions and fewer mistakes in patient care could result from this. X-rays and MRI scans, for instance, are being interpreted with the aid of AI-powered devices.
- **Robotics:** Robots with surgical capabilities, aged care companionship, and pharmaceutical delivery are all in the works, thanks to AI. AI-driven robots are already employed in surgery, where they can conduct complex procedures with better precision than human surgeons.
- **Healthcare administration:** AI is being leveraged to automate various administrative tasks presently executed by human personnel within healthcare establishments. This has the potential to result in decreased expenses and enhanced effectiveness. AI-based technologies are currently employed in processing insurance claims, appointment scheduling, and patient record management.

AI in Dentistry

Many of the administrative duties that are now carried out by people in healthcare organizations are being automated with the help of AI. This may result in better efficiency and lower expenses. AI-driven systems are increasingly handling healthcare operations such as insurance claims processing, appointment scheduling, and record keeping. Fig 4. Shows few of the AI-based Oral Healthcare Companies

Here are some ways AI is being utilized in dentistry:

- **Diagnostic Imaging [9] :** AI is being used to replace humans in many healthcare administrative roles. This has the potential to increase productivity while decreasing expenses. Insurance claims, appointment scheduling, and patient records management are some areas where AI-powered systems are used.
- **Dental Analytics [10] :** Humans in healthcare organizations perform various administrative tasks, but AI is helping to automate many of these jobs. Possible benefits include increased productivity and decreased prices. Insurance claims, appointment scheduling, and patient records are just a few examples of the many areas where AI-powered systems are used.
- **Treatment Planning [11] :** By analyzing a patient's dental records, medical history, and imaging data, AI algorithms can recommend the most effective courses of treatment, such as orthodontic planning or implant placement, by evidence-based guidelines and previous successful cases.
- **Virtual Reality (VR) and Augmented Reality (AR) [12]:** Dental students and practitioners can benefit from AI-enhanced virtual and augmented reality training environments. Virtual simulations provide a safe space for professionals to hone their skills and learn new techniques. Dental operations can also benefit from AR's ability to guide dentists in real time and superimpose digital data onto a patient's dental structure.
- **Natural Language Processing (NLP) [13]** : Medical records, dentist notes, and patient reports are natural language inputs that AI may analyze and comprehend thanks to NLP approaches. This can help dentists and patients share information effectively and save time by quickly highlighting key details in medical records.
- **Patient Experience and Chatbots [14] :** Chatbots powered by AI can help patients with tasks like making dental appointments, getting answers to common inquiries, and understanding what to expect before and after treatment. These chatbots have the potential to be accessible around the clock, cut down on wait times, and boost patient satisfaction.
- **Oral Hygiene and Smart Devices [15] :** Intelligent systems can be included in toothbrushes and other dental care devices. These gadgets may monitor how often you brush your teeth, provide immediate feedback on how well you brush, and gently remind you to stick to your dental hygiene routine. AI algorithms can also analyze the data, which can provide specific suggestions for better care for your teeth and gums.

AI Company / Program	Utility
Pearl AI	Focuses on creating AI-powered dental assistants that automate administrative tasks. Such as appointment scheduling insurance processing and patient communication. Their goal is to streamline dental practice operations and improve the patient experience.
Dental Monitoring	Utilizes AI and computer vision technology to offer remote orthodontic monitoring solutions. Their system allows orthodontists to remotely track the progress of their patients treatment by analyzing photos or scans taken by the patients themselves reducing the need for frequent in-person appointment.
Dentulu	A moblie dental platform that incorporates AI technology to connect patients with dentists through telemedicine. The platform provides virtual consultations dental triage services and oral health education making dental care more accessible and convenient.
Dentacoin	A blockchain based platform that integrates AI algorithms to offer a range of dental solutions. Their services include patient reviews dental insurance and a decentralized dental database that support AI analytics for dental research and development.
3 DISC	Develops AI-based imaging solutions for dentistry. Their AI algorithms aid in the analysis of dental images such as panoramic and intraoral radiograph to assist dentists in diagnosing various conditions and disease accurately.
Apteryx imaging	Provides imaging software solutions for dental pratices and they have incorporated AI technology into their offerings. Their AI algorithms can assist with automated image analysis, image enchancement and advanced diagnosing, helping dentists in improving their diagnostic accuracy.
Dental AI Co.	Focused on developing AI algorithms for dental image analysis and diagnosis. Their AI-powered software can assist in detecting and diagnosing various dental conditions, including caries, periodontal diseases and abnormalities in dental structures.

Fig 4. AI-based Oral Healthcare Companies

AI in Periodontics

In patients with periodontal disease, the alveolar bone, gingiva, and periodontal ligaments that support the tooth gradually deteriorate [16, 17]. Most of the adult tooth loss is attributable to this condition. AI is still in its infancy and has yet to be utilized fully within periodontology and implantology. There could be a lot to gain from using this tool due to its diagnostic aid, data analysis, and thorough regression benefits. Fig 5. Shows few of the AI- based companies in periodontics.

The latest advancements in artificial intelligence have primarily focused on deep learning techniques, particularly in medical image classification. **Lee et al.** [18] suggested that the digital storage and accumulation of medical data present an opportunity for the application of deep convolutional neural networks (CNNs) with computer-aided detection (CAD) systems in the medical field. This emerging area of research has demonstrated impressive results in radiological and pathological examination, particularly in diagnosis and prediction. They explored the potential usefulness and accuracy of this system for the diagnosis and prediction of periodontally compromised teeth, the study revealed that the employment of a deep learning algorithm resulted in a diagnostic accuracy of 81.0% for premolars and 76.7% for molars in relation to PCT. The predictive accuracy for extraction was found to be 82.8% for premolars and 73.4% for molars.

Kim et al [19] in their study of prediction of chronic periodontitis severity using machine learning models based on salivary bacterial copy number of nine pathogens; Porphyromonas gingivalis , Tannerella forsythia, Treponema denticola, Prevotella intermedia, Fusobacterium nucleatum, Campylobacterrectus, Aggregatibacter actinomycetemcomitans, Peptostreptococcus anaerobius, and Eikenella corrodens. They used four well-known machine learning algorithms: neural network, random forest, support vector machines with linear kernel, and regularized logistic regression, in three models to distinguish slight chronic periodontitis patients from healthy controls with an average accuracy of 0.78, AUC = 0.82, sensitivity of 0.71, and specificity of 0.84. Similar taxonomic profiling was also done by Szafranski et al (20) and **Chen et al.** [21]

Yauney et al. [22] utilized a CNN-powered AI system to establish a correlation between suboptimal periodontal health and systemic health outcomes, their classifier (Area under Curve (AUC)=0.677) found that optic nerve anomalies on retinal scans were linked to gingivitis and early periodontal disease, and people who complained of swollen joints and a family history of eye disease were also more likely to have periodontal disease.

Papantonopoulos et al. [23] attempted to estimate the probability density functions of clinical and immunologic datasets obtained from patients with aggressive periodontitis using ANN to classify patients into aggressive or chronic periodontitis. They found that the best overall prediction was given by an ANN with CE of monocyte, eosinophil, neutrophil counts and CD4/CD8 ratio as inputs. **Satpathy et al.**[24] deve-loped and evaluated the performance of low-complexity Adaptive Nonlinear Models using nonlinear expansion (Trigonometric, Legendre and Chebyshev polynomial) schemes for the diagnosis of periodontal disease. They observed that a high prediction of diagnostic accuracy (99.11%) was achieved with the model with 7 trigonometric expansion polynomials during the testing phase.

Denti.AI	Helps dentists interpret x-ray images, automate charting and seamlessly perio chart using the latest technology in AI.
Diagnocat	Identifies early signs of periodontal disease.
Pearl AI	Identifies dental landmarks on dental radiographs.
ORCA Dental AI	Provides dentists with tools to indentify and measure dental landmarksusing a variety of techniques, such as machine vision and deep learning, to identify dental landmarks.
Videa Health	Provides dentists with tools to analyze video recording of dental examinations. The platform can be used to identify dental problems, track patient progress and provide educational resources to patients.

Fig 5. AI-based companies in Periodontics

Krois et al [25] utilised a seven-layered feed-forward method to detect periodontal bone loss in panoramic radiographs and found that the accuracy of the CNN was higher for molars.

Moran et al [26] also found region-CNN (R-CNN) efficient in detecting periodontal bone loss in periapical radiographic images. Similarly, Kurt et al (27) used Google Net Inception v3 CNN network and confusion matrix to detect periodontal bone loss. Chang et al (28) developed an automatic method for staging periodontitis on dental panoramic radiographs using the deep learning hybrid method. Most recently Ryu et al (29) evaluated whether panoramic radiographs are a reliable source for the detection of periodontal bone loss using deep learning and found the AUC for detecting periodontally compromised and healthy teeth was 0.88 each, and the overall AUC for the entire jaw, including edentulous regions, was 0.91. AI models for predicting alveolar bone loss from radiographic images have an accuracy between 73.4% and 99%, according to a recent comprehensive evaluation [30] .

CONCLUSION

While AI holds a lot of promise, it also comes with some major challenges. Concerns about privacy and security must be given top priority. Transparency and accountability are essential for AI algorithms and decision-making processes. The challenge of developing an AI system that strikes a balance between human control and total autonomy is another obstacle. How AI might impact economic inequality and the job market is also an important consideration.

To fully grasp the potential of AI while reducing its risks, collaboration and interdisciplinary approaches are necessary. Experts in computer science, ethics, law, and the social sciences must work together to create guidelines, legislation, and ethical frameworks for the appropriate development and deployment of AI systems. Ethical artificial intelligence prioritises people's needs over its own.

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