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Artificial Intelligence in Dentistry - A Review Article

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ABSTRACT

The ability of machines to carry out tasks that often call for human intelligence is known as artificial intelligence (AI). Big data (which comes from digital devices), processing power, and AI algorithms are the three pillars of modern AI technology that have developed quickly over the past 20 years. As a result, AI applications have begun to make people's lives more convenient. AI has enormous potential to influence dentistry in the future. AI has the potential to revolutionize dentistry practice and greatly improve patient outcomes through its capacity to analyze enormous volumes of data, provide precise diagnoses, aid in treatment planning, enhance image analysis, expedite patient management and provide individualized care.

Keywords: Artificial intelligence (AI), Dentistry, Diagnosis, Treatment planning

INTRODUCTION

Artificial intelligence (AI) is defined as "a field of science and engineering concerned with the computational comprehension which is commonly known as intelligent behaviour and with the creation of artifacts that show such behavior." Medical and dental imaging diagnostics, digital medicine, drug development, hospital monitoring, robotics, and virtual assistants have embraced AI.[1]

AI has enormous potential to improve patient care, optimize treatment planning, and support clinical workflows in the dental field. Dental practitioners may use enormous volumes of patient data to generate actionable insights, customize treatment plans to meet the needs of each patient, and more accurately forecast clinical outcomes by utilizing AI algorithms and data analytics. Furthermore, AI-powered diagnostic technologies can support more accurate treatment interventions, early illness detection, and preventative oral health initiatives.[2]

Additionally, it provides healthcare benefits by reducing post-operative problems, which reduces the need for complex operations and enhances quality of life. This is a summary of the ways artificial intelligence (AI) is being used in dentistry and tries to help dental practitioners realize that AI could be a useful tool to help them do their daily tasks more efficiently.[3]

HISTORICAL BACKGROUND

Artificial intelligence is not a new term. Alan Turing wrote in his paper "Computing Machinery and Intelligence" in the 1950 *issue of Mind.* [4]

The concept was first put forth by John McCarthy and Marvin Minsky in 1955, although it was still purely theoretical. AI grew rapidly between 1957 and 1974 as a result of accessibility and computer advancements, as well as the creation of AI systems like ELIZA, which can solve issues and understand spoken language. But there were setbacks in the middle of the 1970s and 1980s, which were referred to be "AI winters." Nevertheless, by 1980, AI had advanced in two directions: expert systems and machine learning. Experience is the basis for machine learning, whereas expert systems mimic human decision-making Deep learning networks with eight layers, such as GPV, were created in 2012. SCNET and Google AlphaGo followed in 2017.Eventually, in 2022, ChatGPT became a text-generation model that could use input language to produce responses that resembled those of a human.[5]

AI FOR HEALTHCARE

Machine learning (ML) and deep learning (DL) are two of the various subfields of artificial intelligence (AI). Machine learning (ML) is a system that can be trained using various models and problem-solving techniques to become capable of automating task completion. [6] DL is a branch of machine learning where the artificial neural network-based learning module is used. When it comes to performing a variety of tasks and analyzing and evaluating data from several sources, including as audio, sensors, and visual data, DL offers an exceptional ability to outperform state-of-the-art methodologies. AI has greatly enhanced our daily activities and lives in a number of ways since its inception. [7]

APPLICATIONS OF AI IN DENTISTRY

AI in dentistry has begun to take off in recent years, just like in other industries. Applications of AI in dentistry can be divided into four categories: diagnosis, treatment planning, decision-making, and result prediction. The most widely used AI use in dentistry is for diagnosis. AI can diagnose patients more quickly and accurately, which will lessen the strain for dentists. On the one hand, dentists are using computer systems more and more to make choices. Conversely, dental computer programs are growing increasingly sophisticated, precise, and dependable. AI research is now being conducted in all areas of dentistry. [8]

ROLE OF AI IN PATIENT MANAGEMENT

The AI software performs the following patient management tasks:

- Scheduling and organizing appointments based on the practitioner's and patient's convenience.
- Notifying patients and dentists about examinations if lifestyle or genetic data suggests heightened vulnerability to dental conditions
- Overseeing insurance and documentation tasks.
- Helping with clinical diagnosis and treatment planning; establishing recurring reminders for patients participating in tobacco or smoking cessation programs, etc.
- In situations where the dental health care provider cannot be reached, emergency teleassistance is offered.

- One can build a comprehensive virtual database for each patient using artificial intelligence software, which can be both incredibly thorough and easily accessible. [5]
- Compared to a human equivalent, the AI software can much more quickly and efficiently record all required data and present it to the dentist (e.g., gathering all relevant dental records, extraoral pictures, and radiographs necessary for diagnosing any dental issue).
- Furthermore, the software's voice recognition and interactive features allow the dentist to complete many duties with ease. [9]

AI IN DIAGNOSIS AND TREATMENT:

AI can be used as a useful modality in diagnosis and treatment of lesions of oral cavity and can be employed in screening and classifying suspicious altered mucosa undergoing premalignant and malignant changes. Even minute changes at single pixel level which might go unnoticed by the naked eye are detected. Artificial intelligence might accurately predict a genetic predisposition for oral cancer for a large population. [10]

AI IN OPERATIVE DENTISTRY

The identification of dental caries and tooth wear evaluation have all been studied in operative dentistry using AI. Each grayscale pixel in a two-dimensional (2D) radiograph has an intensity or brightness that indicates the object's density. An AI algorithm may identify patterns and make predictions to segment teeth, identify cavities and more by learning from the aforementioned traits. [11] Kühnisch *et al.* [27] proposed a Convolutional Neural Network algorithm to detect caries on intraoral images.

AI APPLICATION IN ENDODONTICS

Deep learning can be used to automate the image classification process of detecting endodontic illnesses in periapical radiographs. The majority of research employed machine learning to help dentists identify and diagnose a single illness. Recent research, however, has concentrated on the multi-disease detection approach, which is more frequently employed in clinical settings. Li *et al.* [19] proposed an automated deep learning method to detect periapical lesions and caries using periapical radiographs. From manually annotated periapical radiographs, the model showed a good ability to learn features. Their model demonstrated good performance and high accuracy (86%) for recognizing periapical lesions and dental caries when compared to expert detection. The intricacy of the root canal architecture and accurately determining the working length are two of the main obstacles in endodontic treatment. Treatment may be more challenging for teeth with complicated root canal anatomy, such as numerous canals or unique forms. Incomplete therapy and a higher chance of failure can result from improper working length. The most popular technique for figuring out the working length in root canal therapy is radiographic evaluation. But it has a number of drawbacks. Accurately determining the length of the root is challenging due to the two-dimensional imaging, the position of the tooth, and the presence of hard bone and other nearby structures. When evaluating the composition of roots and root canals, cone-beam computed tomographic (CBCT) imaging has been shown to be more accurate than radiography.[20] However, it is not advised in standard clinical practice due to radiation concerns, and many practitioners do not

have easy access to the device. In a variety of ways, machine learning has demonstrated the ability to increase the precision and effectiveness of estimating the working length in root canal therapy. An Artificial Neural Network (ANN) increased the accuracy of identifying the apical foramen from radiographs by 93%, according to Saghiri *et al.* [21] When compared to the actual length of the root measurements using the stereomicroscope, the gold standard following tooth extraction, they found that their model was more accurate than endodontist's conclusions.

AI IN PERIODONTICS

AI has been widely employed in periodontology to investigate, comprehend, and create periodontal applications, such as detecting bone loss, identifying gingivitis, evaluating connective tissues, and identifying inflammation and other periodontal caries. By using AI systems to identify periodontal diseases, doctors may be able to increase dependability and attain detection accuracy on par with or higher than that of seasoned experts. In a comprehensive analysis, Revilla-Le´on *et al.* [17] assessed how well the AI models performed in identifying periodontitis and gingivitis. According to the investigations, the accuracy of identifying dental plaque, identifying gingivitis, and measuring alveolar bone loss was 47% and 99%, respectively. They came to the conclusion that while AI models created for periodontal applications have the potential to be effective therapeutic aids or diagnostic tools, they still require further refinement.

AI IN ORAL SURGERY

Recent advancements in oral research have highlighted the significant impact of AI and deep learning technologies in improving diagnostic accuracy, treatment planning, and clinical outcomes in oral surgery. Lee *et al.* [22] evaluated an automated deep convolutional neural network (DCNN) for classifying dental implant systems from radiographic images, demonstrating high accuracy and surpassing most dental professionals. Matsuda *et al.* [23] analyzed the anatomical aspects of horizontally impacted mandibular third molars in young Japanese patients, identifying predictors for lingual cortical bone perforation. The study provides valuable insights for treatments involving impacted mandibular third molars, underscoring the importance of considering specific factors such as gender, age, and available space. A recent study also investigated the use of ResNet models for diagnosing the need for orthognathic surgery based on cephalometric radiograph images. Their findings suggested that an AI model structure significantly impacts medical image predictions. This research is crucial for enhancing orthognathic surgery planning and highlights the effectiveness of AI in cephalometric analysis. Zhang *et al.* [24] employed artificial neural networks to predict facial swelling after impacted mandibular third molar extraction with high accuracy. Their study demonstrates the potential of AI in predicting post-surgical outcomes, facilitating better patient care and clinical decision making. Tanikawa *et al.* [25] explored AI's capability to predict 3-D facial morphology changes following orthognathic surgery and orthodontic treatment. Their systems demonstrated high accuracy in anticipating post-treatment facial topography, indicating the potential of AI in planning various facial treatments, including aging, cancer surgery, or cosmetic interventions. Choi *et al.* [26] developed an AI model using a deep convolutional neural network to determine the spatial relationship

between the mandibular third molar and the inferior alveolar nerve from panoramic radiographs. This model showed superior diagnostic accuracy compared to experienced oral and maxillofacial surgeons, suggesting AI could significantly aid surgical planning and reduce the need for CBCT scans. [13]

AI IN PROSTHETIC DENTISTRY

For usage in prosthodontics, a design assistant named Rapid has incorporated anthropological calculations, facial dimensions, ethnicity, and patient preferences to create the most esthetic prosthesis for the patient. Rapid uses a logic-based representation as a unifying medium to combine databases, knowledge-based systems, and computer-aided design.16 In dentistry, the process of fine-milling ready ceramic blocks to create a completed dental restoration is known as computer-aided design/computer-aided manufacture, or CAD-CAM. It is employed in the production of crowns, bridges, inlays, and onlays. In essence, the CAD-CAM process uses numerically controlled mechanics to produce both two-dimensional and three-dimensional models and materialize them. It has taken the role of the tedious and time-consuming traditional casting process, lowering the possibility of human error in the finished product. [14]

AI IN ORTHODONTICS

Intraoral scanners and cameras can analyze radiographs and photos to make diagnoses and arrange treatments. This removes the need for patient impressions and a number of laboratory procedures, and the outcomes are typically far more accurate than what is perceived by humans. Algorithms and statistical analysis can be used to forecast the movement of the teeth and the ultimate result of therapy. AI-driven individualized orthodontic therapy is the most talked-about and recent advancement in orthodontic dentistry. AI is currently utilized in orthodontics at several stages, from diagnosis to treatment planning and monitoring. When evaluating dental and craniofacial anomalies, three-dimensional scans and virtual models are helpful. These 3D scans allow for the customization of therapy and the printing of aligners. Following the printing of these aligners, a data algorithm is developed that makes intelligent decisions about how to move the patient's teeth, how much pressure to apply, and even which pressure points are appropriate for that particular tooth or teeth. In addition to offering accurate treatment, the AI conjugated aligners significantly shorten treatment times and minimize error rates. [15]

CONCLUSION

There is tremendous potential for research in AI in medicine and dentistry. The research should be integrated with clinical practice for better results. Even though advanced sign natural language processing, image recognition, neural networking and speech recognition are on the anvil the high initial costs can often be a deterrent. AI can certainly be tool in making significant in delivering better health care to the patient. However, it is important to note that AI is not a replacement for human expertise, and its use in medicine should always be guided by ethical principles. AI can only assist clinicians in performing their tasks professionally. It cannot replace human knowledge, skill, or treatment planning. Despite the challenges of data collection, interpretation, computational power, and ethical concerns that must be addressed. Careful design and long-term clinical

validation make AI unbiased, reproducible, user-friendly, and transparent. Future AI development must continue to prioritize human interests while improving our ability to process big data. Although AI can help in many ways, dentistry is a multidisciplinary field in which the final decision must be made by the dentist. This review showed that AI has progressed rapidly in recent years and has the potential to become a standard tool in modern dentistry in the near future.

Declaration by Authors

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