Artificial Intelligence in Dentistry: The New Opportunity to Discover

Dr Nisha Pandey[1], Dr. Medha Lakhanam[2]
[1]Dental Practitioner, Balrampur Uttar Pradesh, India
[2]Dental Practitioner, Lucknow Uttar Pradesh, India

ABSTRACT: Artificial intelligence (AI) is revolutionizing the field of dentistry by enabling advanced diagnostic, treatment planning, and procedural precision. From automated radiographic analysis to robotic-assisted surgeries, AI technologies enhance efficiency and accuracy in patient care. AI-powered imaging tools improve early detection of oral diseases, such as caries, periodontal conditions, and malignancies, by analyzing patterns beyond human capability. In restorative dentistry, AI aids in designing prosthetics and optimizing implant placement with unprecedented precision, reducing complications and improving patient outcomes. Robotic surgery systems leverage AI for minimally invasive procedures, offering greater accuracy, reduced operative times, and safer manipulation of delicate anatomical structures. Additionally, AI facilitates personalized treatment by analyzing large datasets to tailor interventions to individual patient needs. Its applications extend to patient management systems, streamlining appointment scheduling, and predictive analytics for treatment outcomes. As AI continues to evolve, ethical considerations, data privacy, and training integration remain critical for its successful adoption. The synergy between AI and dentistry promises a transformative impact, enhancing both clinical practice and patient experience.
This review helps us to recognize the artificial intelligence application in different fields of dentistry.

INTRODUCTION

The term artificial intelligence (AI) describes computer programs that are able to carry out sophisticated operations that were previously exclusive to humans, such as problem-solving, thinking, and decision-making.

These days, "AI" refers to a broad spectrum of technologies that underpin many of the products and services we use on a daily basis, from chatbots that offer real-time customer care to apps that suggest TV series. During the 1956 Dartmouth conference, John McCarthy first proposed artificial intelligence, or AI as it is now more often known. 2. The simulation of human intelligence processes by machines, particularly computer systems, is known as artificial intelligence (AI). AI uses machines and computers to simulate how the human mind makes decisions and solves problems. 3. Artificial intelligence's history dates back to the era when time when the question "Are machines capable of thought?" The final three decades of the 20th century saw a lull in the development of artificial intelligence. OneNumerous industrial domains, including financial analysis, smart cities, robots, and cars, have embraced artificial intelligence. Medical and dental imaging diagnostics, decision support, precision and digital medicine, drug development, wearable technology, hospital monitoring, and robotics are just a few examples of how it has been applied in these fields.AI is frequently seen as a useful tool to assist clinicians and dentists in lightening their workload. AI may learn from various information sources (multi-modal data) to identify diseases beyond human capabilities, in addition to diagnosing diseases using a single information source targeted at a particular ailment.. For example, fundus photographs with other medical data such as age, gender, BMI, smoking habits, blood pressure, and the likelihood of diabetes has been used to predict heart disease.[2]

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.[3].AI applications in the dental field are still very new. Nonetheless, the advancement of these technologies has affected dental imaging, robotic

Artificial Intelligence in Dentistry: The New Opportunity to Discover

assistance, and diagnostics, caries detection, radiography and pathology, and electronic recordkeeping. In line with the expansion of other dental specialties, endodontic AI research has increased.[4]

This review will enlighten the latest advancement in the field of dentistry and will help us to utilize its potential benefits and cope with the challenges in upcoming future with its application.

Participation of Artificial Intelligence in Dentistry

The field of dentistry has witnessed a significant surge in the adoption of artificial intelligence (AI) technologies in recent years. AI can assist dentists in various aspects, such as streamlining clinical documentation, aiding in diagnostic processes through image analysis, and supporting clinical decision-making, including treatment planning and execution. Research highlights numerous advantages of AI in dentistry, particularly its ability to integrate data from imaging techniques with other sources, such as clinical records and patient histories. This capability enhances diagnostic accuracy. However, the widespread implementation of AI in dentistry remains a topic of debate, as recent studies have flagged concerns about possible adverse effects[5].

AI is also enhancing imaging quality, which contributes to more accurate diagnoses and effective treatment planning. For instance, the introduction of CBCT technology has proven beneficial for both dentists and patients. It allows precise measurements, such as identifying canal locations, evaluating the proximity of teeth to the mandibular canal, and assessing bone availability for implants. These advancements have led to reduced procedure times and less invasive treatment approaches[6].

Role of Artificial Intelligence in Patient Management

Administrative Support

Artificial intelligence (AI) streamlines administrative tasks in dental practices, such as scheduling and organizing routine appointments to suit both patients and dentists. It also simplifies handling paperwork and insurance processes. AI can manage complex responsibilities, such as alerting dentists about a patient's allergies or medical conditions and sending reminders for smoking cessation programs. Additionally, AI has proven effective in emergency teleassistance during dental crises, particularly when healthcare providers are unavailable[7].

Diagnosis and Treatment of Dental Diseases

AI is widely used in maxillofacial radiography to improve diagnostic accuracy. Techniques like Artificial Neural Networks (ANNs) are applied for classification, detection, and segmentation. Classification helps determine the presence or type of pathology, detection identifies disease progression, and segmentation isolates anatomical structures or abnormalities in images from modalities such as X-rays, CT, MRI, and ultrasound[8]. AI facilitates diagnosing conditions like dental caries, periodontal disease, odontogenic cysts, and temporomandibular joint disorders by combining clinical and radiological data to suggest differential diagnoses[9].

Restorative Dentistry

AI plays a critical role in restorative dentistry, particularly in detecting dental caries. Studies highlight its effectiveness in screening for caries using various techniques. In root canal therapy, AI assists in determining appropriate working lengths, preventing complications like apical foramen damage or inadequate microbial control[10]. Additionally, AI enhances the detection of vertical root fractures, particularly with CBCT data, which outperforms traditional radiography. A dynamic navigation system proposed by Chong et al. in 2019 combines CBCT with AI to guide drill paths for precise procedures[11].

Prosthetic Dentistry

AI has transformed prosthetic dentistry by integrating anthropometric data, patient preferences, and digital design systems. Tools like RaPiD combine computer-aided design (CAD) with knowledge-based systems for crafting esthetic dental prostheses. From crowns to bridges, AI-powered algorithms aid in fabricating fixed and removable dental prosthetics[12]. In implant planning, AI merges CBCT and intraoral scans to map the mandibular canal and evaluate bone height, enabling precise placement. AI also streamlines the design and production of maxillofacial prostheses, ensuring functional and aesthetic restoration for patients with facial injuries or abnormalities[13].

Implant Dentistry

In implantology, AI supports every stage, from diagnosis to restoration. It creates 3D jaw and tooth models, automates tooth segmentation, and provides guided implant placement. AI also predicts implant outcomes, monitors implant health, and anticipates maintenance or replacement needs. These innovations enhance treatment accuracy and long-term success rates[14].

Orthodontics

AI assists in orthodontic treatment planning and future needs assessment. Thanathornwong et al. demonstrated that AI could analyze data from adolescents (ages 14–19) to predict future orthodontic needs by correlating variables like overjet, overbite, and crossbite[15]. For complex cases, AI models, including deep learning (DL), detect asymmetries in the maxilla, aiding treatment of conditions like cleft lip and palate[16].

Artificial Intelligence in Dentistry: The New Opportunity to Discover

Oral Surgery

The development of robotic-assisted surgery is one of AI's most significant contributions to oral surgery. AI-driven systems enhance accuracy in procedures such as dental implant placement, tumor removal, biopsies, and TMJ surgeries. Image-guided cranial surgery reduces operation time, improves precision, and ensures safe handling of delicate structures. Robotic surgeons, supervised by human experts, perform semi-automated surgeries, offering improved outcomes even in challenging scenarios[17].

CONCLUSION

Artificial intelligence (AI) is revolutionizing the field of dentistry, offering numerous benefits that enhance both clinical care and operational efficiency. From improving diagnostic accuracy through advanced imaging analysis to enabling personalized treatment plans and even assisting in complex dental procedures, AI is proving to be a powerful tool for dental professionals. It aids in reducing human error, predicting dental conditions before they become severe, and streamlining administrative tasks, allowing dentists to focus more on patient care.

However, as with any technological advancement, the integration of AI in dentistry comes with challenges, including data privacy concerns, the need for proper training, and ethical considerations regarding the potential for bias. To fully realize the benefits of AI, dental professionals must embrace its capabilities while ensuring that proper safeguards are in place.

Looking ahead, the future of AI in dentistry is bright, with continued innovation expected in diagnostic tools, robotic systems, personalized care, and patient experience. As technology evolves, AI has the potential to not only improve patient outcomes but also shape the future of dental practice, education, and research, making dentistry more efficient, accessible, and effective for everyone.

REFERENCES

1) Schwendicke F, Samek W, Krois J. Artificial Intelligence in Dentistry: Chances and Challenges. J Dent Res. 2020;99(7):769–74.

2) Poplin R, Varadarajan AV, Blumer K, Liu Y, McConnell MV, Corrado GS, et al. Prediction of cardiovascular risk factors from retinal fundus photographs via deep learning. Nat Biomed Eng. (2018) 2(3):158–64. doi: 10.1038/s41551-018-0195-

3) 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(1):508–22. doi: 10.1016/j.jds.2020.06.019

4) Aminoshariae A, Kulild J, Nagendrababu V: Artificial intelligence in endodontics: Current applications and future directions. J Endod. 2021, 47:1352-7. 10.1016/j.joen.2021.06.003

5) Meghil MM, Rajpurohit P, Awad ME, McKee J, Shahoumi LA, Ghaly M. Artificial intelligence in dentistry. Dent Rev. 2022; 2: 10009.

6) M Y Shaheen Applications of Artificial Intelligence (AI) in healthcare: A reviewScienceOpen Preprints202110.14293/S2199-1006.1.SOR-.PPVRY8K.v

7) Khanna S, Dhaimade P. Artificial Intelligence: Transforming Dentistry Today. Indian J Basic Appl Med Res. 2017; 6: 161-167.

8) Heo M, Kim J, Hwang J, Han S, Kim J, Yi W, et al. Artificial intelligence in oral and maxillofacial radiology: what is currently possible? Dentomaxillofac Radiol. 2021; 50: 20200375.

9) Asiri AF, Altuwalah AS: The role of neural artificial intelligence for diagnosis and treatment planning in endodontics: A qualitative review. Saudi Dent J. 2022, 34:270-81.

10) Karobari, M.I.; Adil, A.H.; Basheer, S.N.; Murugesan, S.; Savadamoorthi, K.S.; Mustafa, M.; Abdulwahed, A.; Almokhatieb, A.A. Evaluation of the Diagnostic and Prognostic Accuracy of Artificial Intelligence in Endodontic Dentistry: A Comprehensive Review of Literature. Comput. Math. Methods Med. **2023**, 2023, 7049360.

11) BS Chong M Dhesi J Makdissi Computer-aided dynamic navigation: a novel method for guided endodonticsQuintessence Int201950319620210.3290/j.qi.a41921.

12) Hammond P, Davenport JC, Fitzpatrick FJ. Logic based constraints and design of dental prosthesis. Artif Intell Med 1993;5(5):431–446. DOI: 10.1016/0933-3657(93)90035-2.

Artificial Intelligence in Dentistry: The New Opportunity to Discover

13) A Komuro Y Yamada S Uesugi H Terashima M Kimura H Kishimoto Accuracy and dimensional reproducibility by model scanning, intraoral scanning, and CBCT imaging for digital implant dentistryInt J Implant Dent2021711710.1186/s40729-021-00343.

14) Bianchi J, Mendonca G, Gillot M, Oh H, Park J, Al Turkestani N, Gurgel M, Cevidanes L. Three-dimensional digital applications for implant space planning in orthodontics: a narrative review. J. World Fed. Orthod. 2022;11:207–15. https://doi.org/10.1016/j.ejwf.2022.10.006.

15) Thanathornwong B. Bayesian-Based Decision Support System for Assessing the Needs for Orthodontic Treatment. Health Inform Res. 2018; 24: 22-28.

16) Wang X, Pastewait M, Wu T. 3D morphometric quantification of maxillae and defects for patients with unilateral cleft palate via deep learning-based CBCT image autosegmentation. Orthod Craniofac Res. 2021; 1: 1-9.

17) Khanna SS, Dhaimade PA: Artificial intelligence: transforming dentistry today. Indian J Basic Appl Med Res. 2017, 6:161-7