Review Article

Smarter smiles: The role of AI in modern periodontics

Prerna Joshi[1]*, Amrinder Singh Tuli[1]

[1]*Dept. of Periodontology, Seema Dental College & Hospital, Rishikesh, Uttarakhand, India*

A R T I C L E   I N F O

A B S T R A C T

The profound impact of unmet oral health needs on systemic health remains a significant concern, particularly among vulnerable populations. Disparities such as low health literacy and limited access to care contribute to higher rates of oral diseases and poorer health outcomes. These disparities can exacerbate chronic systemic conditions like diabetes, cancer, and cardiovascular disease. Additionally, the absence of standardized practices among dental clinicians regarding the diagnosis, treatment, and management of periodontitis leads to inconsistencies in care utilization. Therefore, prioritizing approaches to care that enhance patient engagement, improve health literacy, and promote standardized care is imperative. Dentistry has historically emphasized delivering comprehensive care by embracing emerging technology and scientific evidence. The integration of AI holds promises in empowering patients through standardized care processes and enhanced access to health information.

1. Introduction

Artificial intelligence (AI) represents an emerging field aimed at replicating human intelligence within machines. Its scope is broad, encompassing the development of intelligent machines capable of performing tasks that typically require human cognitive abilities.[1] AI is a multidisciplinary science incorporating various approaches, with advancements in machine learning and deep learning revolutionizing numerous industries, including healthcare.[2] In the current landscape, AI encompasses technologies or machines capable of emulating human cognitive skills, such as problem-solving.[3] The recent pandemic has significantly influenced dental practices, prompting the adoption of novel operational methods and technological innovations. As the world evolves, AI stands poised to play a pivotal role in shaping and enhancing various professional domains, including dentistry.[4] The experiences of the past year have underscored the importance of embracing technology-driven processes, including computer vision, data mining, predictive analytics, and AI solutions for diagnosis, treatment planning, and business intelligence. One of the primary advantages of such technology is its capacity to address complex problems that conventional methods may struggle with.[5] Beyond dental healthcare, AI is also making significant strides in modern health science applications, such as the detection of COVID-19 using deep learning algorithms with chest radiographic images and enhancing diagnostic accuracy in different medical conditions.[6] In dentistry, AI initially made its mark with the digitization of dental records, enabling automated localization of anatomical landmarks, disease recognition, and tumor classification.[7] The potential applications of AI in dentistry are vast and rapidly evolving, with notable advancements in detecting precancerous lesions, improving maxillofacial radiology quality, enhancing orthodontic treatment efficacy, and utilizing virtual reality to alleviate anxiety in young patients. However, there remains a need for systematic

---

* *Corresponding author.*
E-mail address: bhatiaarchana16@yahoo.com (P. Joshi).

exploration of AI's diagnostic capabilities in identifying common orofacial diseases and associated pain.[8]

2. Paradigm of Artificial Intelligence

1. Artificial intelligence refers to a machine's ability to exhibit intelligence by learning from data to solve problems.[1]
2. Machine learning, a subset of AI, utilizes algorithms to predict outcomes based on data, enabling machines to resolve issues without human input. Representation learning, a subtype of machine learning, involves algorithms learning features to classify provided data.[3]
3. Neural networks are algorithms processing signals through artificial neurons, aiming to create networks that function similarly to the human brain.
4. Deep learning, part of machine learning, employs deep neural networks with multiple computational layers to analyze input data and automatically identify patterns for improved feature detection.
5. Clinical decision support systems (CDSS) integrate broad dynamic medical knowledge, databases, and inferencing output mechanisms through evidence-based medical practice algorithms. These systems assist healthcare professionals in efficient and cost-effective clinical dental practice, often featuring intuitive interfaces with voice controls.
6. Augmented reality superimposes computer-generated images on a user's real-world perspective, providing a composite view.[4]
7. Virtual reality creates computer-generated simulations of three-dimensional images or environments that users can interact with, offering the perception of a real or physical experience through specialized electronic equipment.

3. Application of AI in Periodontics

Periodontal disease, a complex inflammatory condition influenced by multiple factors, ranks among the most prevalent oral diseases affecting humanity. Numerous studies have explored AI technology applications in diagnosing and predicting periodontal diseases, including:

1. Utilizing a Computer-Aided Diagnosis (CAD) system powered by a deep Convolutional Neural Network (CNN) algorithm to diagnose and predict compromised teeth with periodontal health issues. The CNN algorithm demonstrated high accuracy in diagnosing periodontally compromised teeth and predicting the need for tooth extraction, with variations observed among different tooth types.
2. Implementing AI-based systems employing CNNs to correlate poor periodontal health with systemic health outcomes, facilitating automated diagnosis and screenings of other diseases.

3. Using Artificial Neural Networks (ANN) to differentiate between aggressive periodontitis and chronic periodontitis based on immunologic parameters, achieving high accuracy in classifying patients.
4. Deploying a Digital Convolutional Neural Network (DCNN) system to detect periodontitis in premolars and molars using radiographs, aiding in early detection and treatment planning by integrating conventional indicators and immunologic and microbiological parameters into periodontal diagnosis.

Overall, AI technology holds promise in revolutionizing the diagnosis and treatment planning of periodontal diseases, offering early detection and intervention possibilities that can significantly benefit implantology and periodontal care.[3]

4. Discussion

AI has emerged as a reliable source of second opinions and a means of enforcing consistency in various fields, including dentistry. Beyond these applications, AI's integration of practice and patient data with diagnostic and treatment outcome data can establish new care standards and improve operational efficiencies.[9] As AI becomes an integral tool in care and practice management, integrating diverse datasets will enable crucial connections between systemic and dental health, delivering revolutionary value.[7]

Ozden et al. conducted research utilizing support vector machine (SVM), decision tree (DT), and artificial neural networks (ANNs) to classify periodontal diseases effectively. The SVM and DT achieved impressive performances, both reaching 98% accuracy, with computational times of 19.91 and 7.00 seconds, respectively.[10] Similarly, Krois et al. employed Convolutional Neural Networks (CNNs) to detect periodontal bone loss on panoramic dental radiographs, reducing dentists' diagnostic efforts.[11]

Despite significant advancements, challenges such as data collection, interpretability, computing power requirements, and ethical considerations persist.[12] It's essential to ensure that technology remains beneficial while addressing practical questions concerning its value, usefulness, ethics, and responsibility.[13]

5. Conclusion

Periodontitis is a prevalent inflammatory condition affecting adults, often leading to tooth loss if left untreated due to a lack of standardized procedures in diagnosis and management. To address this, innovative approaches such as integrating AI technology into dental practice software are being explored. By leveraging AI, dental providers can achieve greater consistency in diagnosing periodontitis, leading to improved treatment acceptance

rates as patients gain a better understanding of their oral health.[6] Incorporating AI technology into dental practices offers numerous advantages, including enhanced clinical efficiency, standardized practices, streamlined clinical decision-making, and fostering collaboration among dental professionals.[9]

Potential misinterpretations and concerns about patient privacy, AI will persist in its integration with dentistry from a holistic standpoint, driven by the demand for precise treatment protocols and immediate information sharing. Furthermore, these advancements will facilitate professionals in exchanging health-related big data and providing insights that enhance patient care across hospitals, providers, researchers, and patients.[14]

In recent years, significant strides have been made in the field of science and technology, aiding in our understanding of the etiology and risk factors associated with periodontal disease. These recent advancements have opened up vast opportunities for newer treatment modalities that could potentially revolutionize the field of periodontology. However, there is still much to uncover to overcome existing barriers and equip us with even more advanced technologies and techniques for the future.[15]

6. Source of Funding

None.

7. Conflict of Interest

None.

References

1. Ensmenger N, Nilsson J. The Quest for Artificial Intelligence: A History of Ideas and Achievements. Cambridge USA: Cambridge University Press; 2010. p. 588–9.
2. Turing AM. On Computable Numbers with an Application to the Entscheidungsproblem. *Monatsheftc Math Phys*. 1931;38(2):173–98.
3. Newell A, Simon H. Computer Science as Empirical Inquiry. *Commun ACM*. 1976;19(3):113–9.
4. 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(12):508–22.
5. Shivania S, Amita M, Hirala V, Harishb S, Shubhangic M, Nishantd M, et al. Artificial intelligence in periodontics: A dip in the future. *J Cell Biotechnol*. 2021;7(2):119–24.
6. Monsarrat P, Bernard D, Marty M, Cecchin-Albertoni C, Doumard E, Gez L, et al. Systemic Periodontal Risk Score Using an Innovative Machine Learning Strategy: An Observational Study. *J Pers Med*. 2022;12(2):217. doi:10.3390/jpm1202021.
7. Glick A, Clayton M, Angelov N, Chang J. Impact of explainable artificial intelligence assistance on clinical decision-making of novice dental clinicians. *JAMIA Open*. 2022;5(2):ooac031. doi:10.1093/jamiaopen/ooac031.
8. Kierce EA, Kolts RJ. Improving Periodontal Disease Management With Artificial Intelligence. *Compend Abstr*. 2023;44(6):e1–4.
9. Krois J, Ekert T, Meinhold L, Golla T, Kharbot B, Wittemeier A, et al. Deep Learning for the Radiographic Detection of Periodontal Bone Loss. *Sci Rep*. 2014;8(1):8495. doi:10.1038/s41598-019-44839-3.
10. Cervantes J, Garcia F, Rodríguez L, Lopez A. A comprehensive survey on support vector machine classification: Applications, challenges and trends. *Neurocomputing*. 2020;408:189–215.
11. Thanathornwong B, Ouivirach K. Clinical Decision Support System for Geriatric Dental Treatment Using a Bayesian Network and a Convolutional Neural Network. *Healthc Inform Res*. 2023;29(1):23–30.
12. Tai MC. The impact of artificial intelligence on human society and bioethics. *Tzu Chi Med J*. 2020;32(4):330–43.
13. Schwendicke FA, Samek W, Krois J. Artificial intelligence in dentistry: Chances and Challenges. *J Dent Res*. 2020;99(7):769–74.
14. Chen YW, Stanley K, Att W. Artificial intelligence in dentistry: current applications and future perspectives. *Quintessence Int*. 2020;51(3):248–7.
15. Sood R, Sharma E, Garg R, Kaur S, Chhavi A. Artificial intelligence (AI) and recent advancements in periodontology. *Int J Periodontol Implantol*. 2022;7(3):99–102.

Author biography

Prerna Joshi, Post Graduate Student

Amrinder Singh Tuli, Professor