Original Research Paper

Volume - 16 | Issue - 02 | February - 2026 | PRINT ISSN No. 2249 - 555X | DOI : 10.36106/ijar

Dentistry

ARTIFICIAL INTELLIGENCE–DRIVEN DECISION SUPPORT SYSTEMS IN CLINICAL DENTAL PRACTICE

Dr. Harsha Singh	Private Practitioner.
Dr. Shefali Gaurav*	Dentist With MBA In Hospital Administration. *Corresponding Author
Dr. Arjun Suresh	Private practitioner, Global Dental clinic & Implant center Kachani, Thiruvananthapuram, Kerala -695013
Dr. Neha Kumari	District Technical Officer In Homi Bhabha Cancer Hospital And Research Centre, Bihar -851205
Dr. Kalpana Bharti	District technical officer in Homi Bhabha Cancer Hospital and Research Centre, Bihar -804408
Dr. Sakshi Purohit	PGMO Jai prakash district hospital, Shivaji Nagar, Bhopal – 462003.

ABSTRACT

Background: Artificial intelligence (AI) is increasingly integrated into healthcare to support clinical decision-making through advanced data analysis and pattern recognition. In dentistry, digital records, radiographic imaging, cone-beam computed tomography, and intraoral scanning have generated large datasets suitable for AI-driven evaluation. AI-based decision support systems (DSS) help reduce diagnostic variability and improve clinical efficiency. **Aim:** To review the applications of artificial intelligence–driven decision support systems in clinical dental practice and assess their impact across dental specialties. **Methods:** A narrative review of peer-reviewed literature was conducted focusing on artificial neural networks, convolutional neural networks, and random forest models applied in cariology, periodontics, endodontics, prosthodontics, orthodontics, implant dentistry, and oral mucosal diseases. **Results:** AI-driven DSS demonstrated improved diagnostic accuracy and consistency, with performance comparable to experienced clinicians. Limitations include ethical concerns, data quality, and explainability issues. **Conclusion:** AI-based DSS are valuable adjuncts to clinical expertise and have the potential to enhance patient outcomes when ethically implemented

KEYWORDS : Artificial intelligence; Dentistry; Machine learning; Diagnostic imaging; Oral diseases; Clinical decision support

INTRODUCTION

Artificial intelligence (AI) refers to the ability of computer systems to emulate human cognitive processes such as learning, reasoning, problem-solving, and decision-making. Over the past few decades, AI has gained remarkable attention in healthcare due to its capability to analyze extensive datasets, identify complex patterns, and provide evidence-based recommendations that enhance clinical decision-making and efficiency[1 4]. The integration of AI technologies has profoundly transformed healthcare delivery, enabling predictive analytics, automated diagnostics, and personalized treatment planning[46].

In dentistry, which has traditionally relied on clinician expertise and manual interpretation of diagnostic data, a digital transformation is underway. The adoption of electronic dental records, digital radiographs, cone-beam computed tomography (CBCT), and intraoral scanning has generated massive volumes of clinical data suitable for AI-based analysis[9 2 4]. Conventional diagnostic approaches are often limited by inter- and intra-observer variability, time constraints, and subjective bias. AI-driven decision support systems (DSS) aim to overcome these limitations by offering objective, data-driven insights that assist clinicians in diagnosis, risk assessment, treatment planning, and predicting treatment outcomes[1 9].

By enabling early detection of pathology, optimized treatment workflows, and accurate prognostic assessment, AI has the potential to significantly improve clinical outcomes and patient satisfaction. Furthermore, AI facilitates patient education, enhances communication, and supports preventive dental strategies, which are critical components of modern dental practice. This article explores the historical evolution, core AI models, current applications across dental specialties, limitations, ethical considerations, and future directions of AI-driven DSS in clinical dentistry[1 4 6 9].

Historical Evolution Of Ai In Healthcare & AIM

The integration of AI into healthcare can be traced back to the 1960s, when early automated systems were introduced to improve laboratory diagnostics and reduce human error[11]. Sequential analysis systems, for example, were developed to streamline biochemical testing, enabling faster and more accurate clinical measurements[11]. These systems marked the first steps toward using computational methods to assist clinicians in data interpretation.

During the 1970s and 1980s, rule-based expert systems emerged as decision support tools. They relied on logical frameworks derived from clinical guidelines and literature to assist in tasks such as antimicrobial selection and disease diagnosis[12]. While innovative, these systems were limited in flexibility and could not adapt to new data or learn from outcomes.

The advent of machine learning (ML) and deep learning (DL) revolutionized AI in healthcare. Unlike rigid rule-based systems, ML algorithms can learn from large datasets, recognize complex patterns, and improve over time. Coupled with increased computational power and the availability of high-resolution medical imaging, these models have surpassed traditional methods in pattern recognition, predictive modeling, and diagnostic accuracy[14 23]. Consequently, AI has been integrated into medical imaging, prognosis prediction, and dental radiology, providing the foundation for AI-driven DSS in dentistry[14 6]. In dentistry, the transition from analog to digital workflows-including intraoral scanning, CBCT imaging, and electronic patient records-has generated rich datasets that can be analyzed using AI algorithms. These advancements have laid the groundwork for the widespread adoption of AI in clinical decision support systems, which aim to standardize care, reduce variability, and enhance patient outcomes.

REVIEW OF LITERATURE

A growing body of literature has demonstrated the utility of AI in dentistry across various domains, including diagnostics, disease classification, and treatment planning. **Khanagar et al.[9]** conducted a systematic review highlighting improvements in diagnostic accuracy and workflow efficiency through AI-based systems. Similarly, **Abusalim et al.[10]** reported that deep learning algorithms consistently outperform traditional diagnostic approaches in detecting dental caries and periodontal disease.

In cariology, neural network–based models have shown high sensitivity and specificity in detecting early dental caries. **Geetha et al.[26]** reported that back-propagation neural networks achieved remarkable accuracy in digital radiograph interpretation, while

Prados-Privado et al.[27] validated the reliability of neural networks in a systematic review. **Casalegno et al.**[28] applied deep learning to near-infrared transillumination images, enabling early caries detection with high precision. These models not only enhance diagnostic confidence but also facilitate preventive care by identifying lesions before they progress.

Endodontics has benefitted substantially from AI integration. **Endres et al.**[4] developed a deep learning algorithm capable of identifying periapical lesions on radiographs with accuracy comparable to expert clinicians. **Qu et al.**[18] demonstrated that machine learning models could predict outcomes in endodontic microsurgery, aiding clinicians in treatment planning, risk assessment, and prognostication.

Prosthodontics has also seen AI-driven transformation. **Çakmak et al.**[29] demonstrated that deep learning–designed anterior crowns met esthetic, functional, and morphological requirements, supporting the clinical feasibility of AI-assisted prosthetic workflows. **Katsumata**[23] highlighted AI's expanding role in three-dimensional imaging and diagnostics, improving implant planning, prosthetic rehabilitation, and occlusal assessment.

Despite these advancements, ethical concerns such as algorithmic bias, lack of explainability, and regulatory challenges remain prevalent. **Tripathi et al.**[32] emphasized the importance of transparency, clinician oversight, and the preservation of human judgment in AI-assisted dental care. Ensuring standardized datasets, data privacy compliance, and regulatory adherence are critical for safe AI deployment[19 20 34].

METHODS & CORE ARTIFICIAL INTELLIGENCE MODELS IN DENTISTRY

Artificial Neural Networks (ANNs)

Artificial neural networks are computational models inspired by the human brain, comprising interconnected nodes (neurons) that process input data through weighted connections[26]. ANNs are capable of learning complex, nonlinear relationships and continuously improving with new data. In dentistry, ANNs have been applied to dental caries detection, periodontal disease classification, prognosis prediction, and treatment planning, offering a flexible and adaptive approach to decision support.

Convolutional Neural Networks (CNNs)

Convolutional neural networks are deep learning architectures specifically designed for image analysis[4 23]. CNNs extract hierarchical features from dental radiographs, CBCT scans, and intraoral images, making them particularly effective in detecting carious lesions, periapical pathology, alveolar bone loss, and temporomandibular joint disorders. Studies have demonstrated that CNN-based models often surpass conventional diagnostic methods in accuracy, reproducibility, and efficiency.

Random Forest Classifiers

Random forest classifiers are ensemble learning methods that combine multiple decision trees to improve predictive accuracy and reduce overfitting[17 18]. These models are valuable for risk assessment, prognosis estimation, and treatment outcome prediction, particularly in endodontics and periodontics. By integrating diverse clinical parameters, random forest classifiers provide comprehensive, data-driven recommendations that support clinical decision-making.

AI In Periodontal Disease Diagnosis

Periodontal disease is a leading cause of tooth loss and systemic inflammation. Early detection and intervention are critical for successful management[9]. AI-based systems have shown remarkable capability in detecting alveolar bone loss and classifying periodontal disease severity using panoramic and periapical radiographs[10]. These systems enhance diagnostic consistency, reduce observer variability, and provide quantifiable metrics that can guide evidence-based interventions. Moreover, AI facilitates longitudinal monitoring of disease progression, enabling personalized treatment strategies and improving patient adherence.

AI In Cariology

AI-driven diagnostic models enhance the detection and classification of dental caries, particularly in early-stage or proximal lesions[26 27]. Deep learning algorithms trained on radiographs and transillumination images provide objective, reproducible diagnostic outputs, reducing human error and improving preventive care[28]. By integrating AI into caries risk assessment, clinicians can develop individualized preventive strategies, monitor high-risk patients, and optimize restorative treatment plans, ultimately reducing the incidence of advanced decay and tooth loss.

Decision Support Systems In Endodontics

Endodontic treatment relies heavily on accurate interpretation of radiographs and anatomical assessments. AI applications in this field include detection of periapical lesions, root fracture identification, canal morphology assessment, working length estimation, and prognosis prediction[4 18]. AI-assisted DSS reduces procedural errors, improves treatment planning, and enhances outcomes in complex cases. Evidence indicates that AI models can match or surpass experienced endodontists in diagnostic performance, enabling clinicians to make informed decisions efficiently.

AI Applications In Prosthodontics And Orthodontics

In prosthodontics, AI supports digital smile design, crown fabrication, and implant planning[29 30]. These systems allow precise customization, reduce chairside time, and optimize functional and esthetic results. AI models can also simulate occlusal forces and predict long-term restoration performance, enhancing clinical outcomes.

In orthodontics, AI facilitates automated cephalometric landmark identification, malocclusion classification, and prediction of treatment duration[1 9]. By analyzing large datasets, AI can suggest optimized treatment strategies, predict tooth movement, and monitor patient compliance. This integration improves clinical efficiency, reduces human error, and ensures consistent treatment outcomes.

AI In Implant Dentistry

AI applications in implantology include implant detection, surgical planning, and outcome prediction[30 31]. Deep learning models identify optimal implant positions, assess bone quality, and predict post-surgical prognosis. Integration with virtual reality, intraoral scanning, and guided surgery platforms enhances precision, reduces complications, and improves patient satisfaction[37 38]. AI also enables automated planning for multiple implants, complex edentulous cases, and immediate loading protocols, expanding the scope of implant rehabilitation.

AI Applications In Oral Mucosal Diseases

Oral lichen planus is a persistent inflammatory disorder affecting the oral mucosa and adjacent epithelial tissues. It is clinically characterized by flat, purplish lesions that commonly involve the gingiva, buccal mucosa, and other intraoral soft tissues. Accurate diagnosis generally requires a comprehensive approach that includes clinical assessment, adjunctive laboratory tests, and appropriate imaging modalities. In a recent study, **Keser et al.**[39] utilized a convolutional neural network employing the Inception v3 framework to evaluate intraoral photographic images for automated classification of oral lichen planus. The proposed deep learning model achieved a diagnostic accuracy of 100%, underscoring the effectiveness of artificial intelligence–based image analysis as a reliable tool for the early detection and diagnosis of oral mucosal pathologies.

Ethical Considerations And Limitations

Despite its potential, AI adoption in dentistry faces significant challenges. Data privacy, algorithmic bias, high implementation costs, and lack of transparency remain major concerns[32 33]. Over-reliance on AI without clinician oversight can result in diagnostic errors or ethical dilemmas.

Explainable AI, which allows clinicians to understand the reasoning behind algorithmic recommendations, is critical for trust and accountability. Regulatory compliance, clinician training, patient consent, and standardized clinical datasets are essential to ensure ethical and effective AI integration. Additionally, disparities in dataset representation may lead to biased predictions, necessitating diverse and inclusive data collection for robust AI models[19 20 34].

FUTURE DIRECTIONS & RESULT

The future of AI in dentistry includes the development of explainable, real-time AI models that integrate seamlessly into clinical workflows[14]. Personalized treatment planning, continuous learning algorithms, and predictive risk assessment will enhance preventive, restorative, and surgical care.

Emerging trends include AI-assisted robotic procedures, augmented reality for surgical guidance, multimodal data integration (radiographs, CBCT, intraoral scans, and clinical data), and predictive analytics for complex cases[37 38]. AI can also support teledentistry, enabling remote diagnostics, patient monitoring, and virtual consultations. As AI matures, interdisciplinary collaboration among clinicians, engineers, policymakers, and regulatory authorities will ensure safe, ethical, and effective implementation.

CONCLUSION

Artificial intelligence-driven decision support systems are transforming clinical dental practice by improving diagnostic accuracy, treatment planning, workflow efficiency, and patient outcomes. Across specialties-cariology, endodontics, prosthodontics, orthodontics, and implantology-AI serves as a valuable adjunct to clinician expertise. Responsible implementation, ethical oversight, clinician training, and continuous validation are essential to maximize AI's benefits while maintaining patient safety and professional judgment. With ongoing advancements and careful integration, AI has the potential to revolutionize dental care, enabling more precise, personalized, and efficient treatment strategies.

REFERENCES

1. Alexander, B., & John, S. (2018). Artificial intelligence in dentistry: Current concepts and a peep into the future. International Journal of Advanced Research, 6(12), 1105–1108.
2. Aminoshariae, A., Kulild, J., & Nagendrababu, V. (2021). Artificial intelligence in endodontics: Current applications and future directions. Journal of Endodontics, 47(9), 1352–1357.
3. (2021). Artificial intelligence in detecting temporomandibular joint osteoarthritis on orthopantomogram. Scientific Reports, 11, 10246. https://doi.org/10.1038/s41598-021-89742-y
4. Endres, M. G., Hillen, F., Salloumis, M., Sedaghat, A. R., Niehues, S. M., Quatela, O., et al. (2020). Development of a deep learning algorithm for periapical disease detection in dental radiographs. Diagnostics, 10(6), 430. https://doi.org/10.3390/diagnostics 10060430
5. Ding, H., Wu, J., Zhao, W., Matinlinna, J. P., Burrow, M. F., Tsoi, J. K. H., et al. (2024). [Details missing in original citation]
6. Agrawal, P., & Nikhade, P. (2022). Artificial intelligence in dentistry: Past, present, and future. Cureus, 14(7), e27405. https://doi.org/10.7759/cureus.27405
7. Umer, F. (2022). Could AI offer practical solutions for dentistry in the future? BDJ Team, 9, 26–28. https://doi.org/10.1038/s41407-022-0830-1
8. Hung, K., Yeung, A. W. K., Tanaka, R., & Bornstein, M. M. (2020). Current applications, opportunities, and limitations of AI for 3D imaging in dental research and practice. International Journal of Environmental Research and Public Health, 17(12), 4424. https://doi.org/10.3390/ijerph1712442
9. Khanagar, S. B., Al-Ehaideb, A., Maganur, P. C., Vishwanathaiah, S., Patil, S., Baeshen, H. A., et al. (2021). Developments, application, and performance of artificial intelligence in dentistry—a systematic review. Journal of Dental Sciences, 16(1), 508–522.
10. Abusalim, S., Zakaria, N., Islam, M. R., Kumar, G., Mokhtar, N., Abdulkadir, S. J., et al. (2022). Analysis of deep learning techniques for dental informatics: A systematic literature review. Healthcare, 10(10), 1892.
11. Skeggs, L. T., & Hochstrasser, H. (1964). Multiple automatic sequential analysis. Clinical Chemistry, 10, 918–936. https://doi.org/10.1093/clinchem/10.10.918
12. Yu, V. L. (1979). Antimicrobial selection by a computer: A blinded evaluation by infectious diseases experts. JAMA, 242, 1279. https://doi.org/10.1001/jama.1979. 03300120033020
13. Chen, A., Brown, R., Esposito, D., Schore, J., & Shapiro, R. (2008). Report to Congress on the evaluation of Medicare disease management programs. Washington, DC: Mathematica Policy Research.
14. Rajpurkar, P., Chen, E., Banerjee, O., & Topol, E. J. (2022). AI in health and medicine. Nature Medicine, 28, 31–38. https://doi.org/10.1038/s41591-021-01614-0
15. Ecenbarger, W. (1997). How dentists rip us off. Reader's Digest Interactive Archive. Retrieved from https://www.readersdigest.com
16. Nguyen, K. T. P., Medjaher, K., & Tran, D. T. (2023). A review of artificial intelligence methods for engineering prognostics and health management with implementation guidelines. Artificial Intelligence Review, 56, 3659–3709. https://doi.org/10.1007/s 10462-022- 10260-y
17. Logunova, I. (2022). Random forest classifier: Basic principles and applications. Retrieved from https://serokell.io/blog/random-forest-classification
18. Qu, Y., Lin, Z., Yang, Z., Lin, H., Huang, X., & Gu, L. (2022). Machine learning models for prognosis prediction in endodontic microsurgery. Journal of Dentistry, 118, 103947. https://doi.org/10.1016/j.jdent.2022.103947
19. Mortaheb, P., & Rezaeian, M. (2016). Metal artifact reduction and segmentation of dental computerized tomography images using least square support vector machine and mean shift algorithm. Journal of Medical Signals and Sensors, 6, 1. https://doi.org/10.4103/2228-7477.175867
20. Fahad, S., Sohail, M. U., James, G., Witten, D., Hastie, T., & Tibshirani, R. (2013). An introduction to statistical learning with applications in R. Springer Science and Business Media.
21. Pramoditha, R. (n.d.). Overview of a neural network's learning process. Retrieved from https://rukshanpramoditha.medium.com/overview-of-a-neural-networks-learning-process-61690a502fa
22. Anaya-Isaza, A., Mera-Jiménez, L., & Zequera-Diaz, M. (2021). An overview of deep learning in medical imaging. Information Medicine Unlocked, 26, 100723. https://doi.org/10.1016/j.imu.2021.100723
23. Katsumata, A. (2023). Deep learning and artificial intelligence in dental diagnostic imaging. Japanese Dental Science Review, 59, 329–333.
24. Fatima, A., Shafi, I., Afzal, H., Díez, I. T., Lourdes, D. R. M., Breñosa, J., Espinosa, J. C. M., & Ashraf, I. (2022). Advancements in dentistry with artificial intelligence: Current clinical applications and future perspectives. Healthcare, 10, 2188.
25. Lee, S. J., Chung, D., Asano, A., Sasaki, D., Maeno, M., Ishida, Y., Kobayashi, T., Kuwajima, Y., Da Silva, J. D., & Nagai, S. (2022). Diagnosis of tooth prognosis using artificial intelligence. Diagnostics, 12, 1422.
26. Geetha, V., Aprameya, K. S., & Hinduja, D. M. (2020). Dental caries diagnosis in digital radiographs using back-propagation neural network. Health Information Science and Systems, 8, 8.
27. Prados-Privado, M., García Villalón, J., Martínez-Martínez, C. H., Ivorra, C., & Prados-Frutos, J. C. (2020). Dental caries diagnosis and detection using neural networks: A systematic review. Journal of Clinical Medicine, 9, 3579.
28. Casalegno, F., Newton, T., Daher, R., Abdelaziz, M., Lodi-Rizzini, A., Schürmann, F., Krejci, I., & Markram, H. (2019). Caries detection with near-infrared transillumination using deep learning. Journal of Dental Research, 98, 1227–1233.
29. Çakmak, G., Cho, J.-H., Choi, J., Yoon, H.-I., Yilmaz, B., & Schimmel, M. (2024). Can deep learning-designed anterior tooth-borne crown fulfill morphologic, aesthetic, and functional criteria in clinical practice? Journal of Dentistry, 150, 105368.
30. Revilla-León, M., Gómez-Polo, M., Vyas, S., Barmak, B. A., Gallucci, G. O., Att, W., & Krishnamurthy, V. R. (2023). Artificial intelligence applications in implant dentistry: A systematic review. Journal of Prosthetic Dentistry, 129, 293–300.
31. Takahashi, T., Nozaki, K., Gonda, T., Mameno, T., Wada, M., & Ikebe, K. (2020). Identification of dental implants using deep learning-pilot study. International Journal of Implant Dentistry, 6, 53.
32. Tripathi, S., Augustin, A., Dako, F., & Kim, E. (2023). Turing test-inspired method for analysis of biases prevalent in artificial intelligence-based medical imaging. AI Ethics, 3, 1193–1201.
33. de Fine Licht, K., & de Fine Licht, J. (2020). Artificial intelligence, transparency, and public decision-making: Why explanations are key when trying to produce perceived legitimacy. AI & Society, 35, 917–926.
34. Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the Protection of Natural Persons with Regard to the Processing of Personal Data and on the Free Movement of Such Data. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32016R0679
35. Regulation (EU) 2024/1689 of the European Parliament and of the Council of 13 June 2024 laying down harmonised rules on artificial intelligence. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=OJ:L_202401689
36. Von Elm, E., Altman, D. G., Egger, M., Pocock, S. J., Gøtzsche, P. C., & Vandenbroucke, J. P. (2007). The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: Guidelines for reporting observational studies. PLoS Medicine, 4, e296.
37. College of Dentists in Bucharest. (2024). Retrieved from https://cmsr.
38. Sukotjo, C., Schreiber, S., Li, J., Zhang, M., Yuan, J. C., & Santoso, M. (2021). Development and student perception of virtual reality for implant surgery. Education Sciences, 11, 176.
39. Keser G, Bayrakdar ˙IS¸, Pekiner FN, Çelik ¨O, Orhan K. A deep learning algorithm for classification of oral lichen planus lesions from photographic images: a retrospective study. J. Stomatol. Oral Maxillofac. Surg. 2023;124:101264.