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AI-POWERED DENTISTRY: REVOLUTIONIZING ORAL CARE

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ABSTRACT

The dentistry field is changing as a result of artificial intelligence (AI), which is increasing patient care overall, personalising treatment regimens, and boosting diagnostic accuracy. With applications ranging from diagnostic imaging to treatment simulation, AI benefits both practitioners and patients. However, integrating these technologies presents challenges, including data privacy, ethical concerns, and the need for regulatory frameworks. Responsible AI adoption can enhance access to oral healthcare while ensuring efficiency. Ultimately, AI promises a future of precision dentistry that caters to individual needs, while still emphasizing the importance of human qualities like empathy and commitment to patient well-being. In the broader healthcare arena, AI is a transformative force, improving accuracy and reducing human error for healthier smiles and better lives. Artificial Intelligence (AI) has brought significant changes to multiple industries, including dentistry, by improving patient care and optimizing workflows. Its swift progress has revolutionized oral healthcare delivery, offering cutting-edge solutions for everything from diagnosis to treatment planning. This narrative review delves into the diverse roles of AI in dentistry, analyzing its applications, benefits, challenges, and future outlook.

Keywords: Artificial Intelligence, Dental AI Applications, Dentistry, Diagnostic Imaging, Ethical Considerations, Machine Learning, Robotic Dentistry, Treatment Planning

1. INTRODUCTION

By helping with diagnosis and treatment planning, artificial intelligence (AI) technologies like computer vision systems and machine learning have the potential to significantly advance dentistry. With the use of these technology, dental surgeons may give more individualised care by analysing data, seeing trends, and making predictions. Artificial Intelligence (AI) enables dental practitioners to process and understand data more quickly by utilising robots, natural language processing, image recognition, and machine learning algorithms. Since its inception in 1956, AI

has evolved to include various applications, especially in robotics, where software mimics human intelligence. Although initially hampered by high expectations and limited data access, AI now refers to any technology that simulates human cognitive functions. Shan et al. (2021), Amisha et al. (2019), Schwendicke et al. (2020), Stevenson (2010), Cabitza et al. (2018), Hwang et al. (2019), Meghil et al. (2022), Schwendicke et al. (2019), Stevenson, A. (2010)

2. DISCUSSION

2.1. BENEFITS OF AI IN DENTISTRY

2.1.1. DIAGNOSTIC IMAGING AND IMPROVED DIAGNOSTIC ACCURACY

AI is crucial in dental diagnostic imaging, especially in the interpretation of radiographs and CBCT scans. AI algorithms can accurately detect conditions such as caries, fractures, and tumors, aiding in the early identification of diseases and the planning of treatments. Technologies like computer-aided detection (CAD) systems analyze dental images with high precision, speeding up diagnosis and enabling early intervention for improved patient outcomes. Khanagar et al. (2021), Alexander & John (2018)

2.1.2. ENHANCED TREATMENT PLANNING AND SIMULATION

AI software assists dental surgeons in treatment planning by simulating procedures like orthodontic adjustments and dental implants. By using patient data, AI can optimize outcomes and predict potential complications, allowing for personalized treatment plans that enhance results. Tandon & Rajawat (2020), Aminoshariae et al. (2021)

2.1.3. TRANSFORMING DENTAL PRACTICES, EXPANDING ACCESS, AND ELEVATING PATIENT CARE

AI technologies enhance workflow management in dentistry by automating administrative tasks such as appointment scheduling and patient record management, freeing up more time for patient care. Virtual consultations and tele-dentistry services, supported by AI chatbots and assistants, provide remote access to dental advice and patient triage, thereby improving care accessibility, especially in underserved regions. Deshmukh (2018), Nguyen et al. (2021)

2.1.4. PREDICTIVE ANALYTICS AND RISK ASSESSMENT

AI algorithms evaluate patient data, including medical history, habits, and genetic predispositions, to determine the risk of developing oral diseases like periodontitis or caries. This enables dental surgeons to implement personalized preventive measures and interventions for high-risk individuals, thereby reducing the likelihood of disease progression. Goyal et al. (2019), Bini (2018)

2.1.5. IMPROVING PRACTICE MANAGEMENT

AI revolutionizes practice management by automating administrative tasks, improving workflows, and boosting operational efficiency. It evaluates patient demographics, financial data, and scheduling patterns to streamline operations,

reduce overhead costs, and optimize resource allocation. Okada et al. (2015), Scott et al. (2023)

2.1.6. ROBOT-ASSISTED DENTISTRY

Robotics, combined with AI, have the potential to automate specific dental procedures, such as tooth cleaning or preparation for restorations. Robot-assisted systems can enhance precision, reduce procedural errors, and minimize patient discomfort, ultimately improving the overall patient experience. Lee et al. (2018), Moayeri & Khalili (2015).

2.1.7. COST SAVINGS AND RESOURCE OPTIMIZATION

By streamlining workflows and minimizing the need for manual intervention, AI enables dental practices to operate more efficiently, resulting in cost savings and better resource utilization. Ryu et al. (2023), Aliaga et al. (2015)

2.2. APPLICATIONS OF AI IN DENTISTRY

2.2.1. PERIODONTICS

AI programs assist in diagnosing and treating periodontal pathologies using panoramic radiographs, utilizing techniques such as deep learning and CAD systems. These technologies offer high diagnostic accuracy and shorten examination times. Li et al. (2015), Chen et al. (2016)

2.2.2. PROSTHODONTICS

AI improves CAD/CAM fabrication of dental prostheses by aiding in precise color matching and identifying implant locations, enhancing the design and creation of dental implants. Sahiwal et al. (2002)

2.2.3. ORAL IMPLANTOLOGY

AI techniques, including deep learning, enhance the identification of dental implants and the detection of peri-implantitis, leading to improved treatment outcomes. Michelinakis et al. (2006), Morais et al. (2015)

2.2.4. FORENSIC DENTISTRY

AI accelerates the identification process with panoramic radiographs, demonstrating potential in age determination, identifying sexual dimorphism, and disaster victim identification. Vodanović et al. (2023)

2.2.5. ORAL MEDICINE AND PATHOLOGY

AI applications in oral pathology involve diagnosing odontogenic cystic lesions and predicting tumor margin positivity and survival outcomes for oral cancer, thereby enhancing diagnostic accuracy and improving patient care. Lovgren et al. (2017), Bas et al. (2012)

2.2.6. ORAL RADIOLOGY

AI aids in interpreting radiographic lesions, analyzing dental images, and detecting caries. Its tasks include diagnosing fractures, assessing tooth development stages, and evaluating bone density. Nakano et al. (2014), Dar-Odeh et al. (2010)

2.2.7. PEDODONTICS AND PREVENTIVE DENTISTRY

AI models predict children's oral health status and assist in diagnosing conditions such as mesiodens and supernumerary teeth, facilitating early diagnosis and preventive care. Kositbowornchai et al. (2013), Anil & Anand (2017)

2.2.8. ORTHODONTICS

AI is utilized in orthodontics to assess treatment effects, predict third molar locations, analyze variations in maxillary structures, and automate cephalometric analysis, enhancing treatment planning and monitoring. Olszowski et al. (2012)

2.2.9. ORAL SURGERY

AI supports decision-making for tooth extractions, localizes the inferior alveolar nerve canal, and offers insights into complex surgical procedures, thereby enhancing surgical precision and improving patient outcomes. Fisher-Owens et al. (2007)

2.2.10. DIAGNOSIS, CARIES, AND ENDODONTICS

AI enables early diagnosis of dental caries, accelerates endodontic diagnosis, and accurately identifies periapical lesions, thereby improving treatment planning and patient outcomes. Takada et al. (2009), Jung & Kim (2016)

2.2.11. PUBLIC HEALTH DENTISTRY

AI-driven virtual dental assistants excel in diagnosis, appointment management, and health risk identification, supporting public health surveillance and offering personalized health advice. Chang et al. (2013), Scrobotă et al. (2017)

2.3. CHALLENGES AND CONSIDERATIONS

2.3.1. DATA PRIVACY AND SECURITY

The use of AI in dentistry requires extensive collection and analysis of patient data, which raises concerns about privacy and security. Dental practitioners must comply with relevant regulations to protect patient confidentiality and ensure data security. Keskin & Keleş (2021)

2.3.2. INTEGRATION WITH EXISTING SYSTEMS

Integrating AI technologies into existing dental practice management systems and workflows may require substantial investments in infrastructure and training. It's essential to carefully assess the compatibility and scalability of AI solutions. Berdouses et al. (2015)

2.3.3. ETHICAL AND LEGAL IMPLICATIONS

As AI systems become more autonomous in decision-making, ethical challenges related to accountability and liability emerge. It is vital to address concerns regarding patient data privacy, algorithmic biases, and equitable access to AI-enabled services. Tiwari et al. (2023), Praveena et al. (2023)

2.3.4. BIAS AND FAIRNESS

AI algorithms can be affected by biases in training data, which may result in disparities in diagnosis and treatment recommendations. Reducing these biases is essential to ensure fairness and equity in treatment outcomes. Thurzo et al. (2022), Zhang et al. (2021)

2.3.5. REGULATORY OVERSIGHT

Strong regulatory frameworks are necessary to protect patient safety, maintain quality of care, and ensure compliance with professional standards. Regulatory bodies must provide guidance and oversight to achieve these goals.

3. CONCLUSION

Artificial Intelligence (AI) is set to revolutionize dentistry by enabling accurate diagnoses, personalized treatment planning, and enhanced patient care. Its applications range from diagnostic imaging to treatment simulation, benefiting both practitioners and patients. However, challenges such as data privacy, ethical issues, and regulatory frameworks need careful consideration for smooth integration. Responsible adoption of AI can democratize access to oral healthcare, ensuring both efficiency and effectiveness. AI holds the promise of precision dentistry tailored to individual needs while highlighting the ongoing importance of human qualities in the field, such as empathy, compassion, and commitment to patient well-being. In the broader healthcare context, AI acts as a catalyst for transformative change, fostering healthier smiles and improved lives by enhancing the accuracy of specialists and reducing human errors.

CONFLICT OF INTERESTS

None.

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