Journal of Research in Medical and Dental Science
2024, Volume 12, Issue 2, Page No: 01-05

Available Online at: www.jrmds.in
eISSN No. 2347-2367: pISSN No. 2347-2545

Artificial Intelligence and Machine Learning in Oral Cancer Detection: A Scoping Review of Modern Diagnostic Approaches and Future Frontiers in the Detection of Oral Cancer

Soumya Kavuluri[1]*, Raghava Danwada[2]

[1]*Doctor of Dental Surgery, Loma Linda School of Dentistry, California, United States*

[2]*Master of Public Health, University of North Texas Health Science Center, Texas, United States*

ABSTRACT

The advancement of AI in oral cancer screening and detection requires a comprehensive and strategic approach. Foundational to this progress is the accessibility and quality of diverse datasets, crucial for training AI models that can discern oral cancer in various demographics and stages. Technological integration, particularly with advanced imaging technologies and the amalgamation of multimodal data, ensures a more nuanced and precise analysis of oral lesions.

Key words: Artificial intelligence, Oral cancer, Convolutional neural networks.

HOW TO CITE THIS ARTICLE: Soumya Kavuluri, Raghava Danwada. Artificial Intelligence and Machine Learning in Oral Cancer Detection: A Scoping Review of Modern Diagnostic Approaches and Future Frontiers in the Detection of Oral Cancer. J Res Med Dent Sci, 2024, 12(2):01-05.

Corresponding author: Soumya Kavuluri

e-mail✉: kavsoumya25@gmail.com

Received: 26-January-2024, Manuscript No. jrmds-24-128427;

Editor assigned: 29-January-2024, PreQC No. jrmds-24-128427(PQ);

Reviewed: 12-February-2024, QC No. jrmds-24-128427(Q);

Revised: 16-February-2024, Manuscript No. jrmds-24-128427(R);

Published: 23-February-2024

INTRODUCTION

Oral Cancer remains a significant global health burden, with its incidence steadily rising and its prognosis often reliant on early detection and intervention. Despite advances in medical technology, timely diagnosis continues to pose a challenge, emphasizing the critical need for innovative diagnostic strategies [1]. In recent years, the integration of Artificial Intelligence (AI) and Machine Learning (ML) into healthcare has emerged as a transformative force, promising enhanced accuracy, efficiency, and accessibility in disease detection [2].

This scoping review explores the evolving landscape of AI and ML applications in the detection of oral cancer, shedding light on modern diagnostic approaches and delineating future frontiers [3]. By synthesizing current literature and insights, this review aims to provide a comprehensive overview of the state-of-the-art technologies, their clinical implications, and the potential avenues for advancement in oral cancer detection. From computer-aided image analysis to novel biomarker detection platforms, the integration of AI and ML holds immense promise in revolutionizing the landscape of oral cancer diagnostics, paving the way for a future marked by precision, efficiency, and accessibility in healthcare delivery [4].

The Emergence of AI and ML in Dentistry

Initially, the use of digital technologies in the dental field was limited to administrative and educational purposes. However, over time, advances in computational power and the advent of robust algorithms have enabled the dental personnel to harness AI and ML for clinical applications, including the detection of oral cancer [5]. Over the years, researchers have focused on refining AI models for greater accuracy and reliability. This has led to the introduction of more sophisticated ML approaches that can interpret complex medical and dental data to aid in early detection, diagnose more accurately, and predict patient outcomes better. AI-powered tools can now offer a supplementary layer of analysis to traditional examinations, which is increasingly valuable in areas with limited access to specialist care [6].

One of the key technological advancements in dental AI and ML is the development of

Convolutional Neural Networks (CNNs). These deep learning models are particularly well-suited for image recognition and have been repurposed for the analysis of medical and dental images. The ability of CNNs to learn from a large volume of data makes them effective for identifying patterns and anomalies in dental radiographs and visible light images indicative of oral cancer [7]. In addition to CNNs, advances in digital imaging and the application of AI for real-time risk assessment have further elevated the potential for AI in oral cancer detection. Techniques such as computer-aided detection systems have been developed to assist in the analysis of oral lesions, employing algorithms to help delineate suspicious areas from normal tissue [8].

Significance of CNNs in Image Analysis

AI techniques, particularly CNN, excel in image analysis, analyzing dental radiographs, optical coherence tomography, and visible light images. These deep learning algorithms can detect anomalies indicative of oral cancer, classifying and segmenting images with greater accuracy than traditional methods. A range of studies have explored the use of AI in dental image analysis [9]. A method for automatic analysis using artificial immune systems, focusing on malocclusion detection, applied AI to classify panoramic radiographs, using a CNN and other image cognition algorithms provided a comprehensive review of AI methodologies in dental image analysis, including conventional ML and deep learning approaches tool pipeline for automated clinical quality evaluation of periapical dental X-ray images, achieving a high F1 score [10]. The study evaluated the performance of deep CNN algorithms for the classification and detection of Oral Potentially Malignant Disorders (OPMDs) and Oral Squamous Cell Carcinoma (OSCC) in oral photographic images, demonstrating high accuracy and potential as a diagnostic tool for assisting general practitioners in early cancer detection [11]. Recent strides in dental AI, as illuminated and unveil promising prospects in histopathological image analysis. Pereira-Prado emphasizes the pivotal role of AI in nuanced tumor differential diagnosis and prognosis, while Panigrahi delves into its application for predicting and prognosticating cancer. In this narrative by showcasing AI's efficacy in the precise segmentation and classification of oral cancer lesions, as well as its discriminative power in distinguishing cancerous lesions from normal mucosa. The amalgamation of these studies presents a compelling narrative on the transformative role of AI in enhancing dental diagnosis and treatment, particularly in the realm of oral cancer [12].

Pattern Recognition

ML models are strategically trained to identify intricate patterns characteristic of oral cancer. This involves the detailed recognition of irregularities in tissue structure, color, and morphology that may elude the human eye. Algorithm-guided detection has proven to be a successful avenue for distinguishing between benign and malignant lesions, with a particular emphasis on crucial features such as oral lesion heterogeneity and margins, achieved remarkable accuracy, boasting a perfect 100% in diagnosing oral cancer through the implementation of textural pattern classification [13]. Shed light on the substantial potential of CNN, demonstrating their efficacy in both clinical and histopathological image analysis. The power of deep learning to automate the detection and classification of oral lesions, yielding consistently high F1 scores. In a distinct approach, an innovative method describing an approach for cancer detection and prevention based on analysis using association rule mining, unveiling promising results. These cumulative findings emphasize the pivotal role of AI in pattern recognition, making a substantive contribution to the early detection and diagnosis of oral cancer within the existing body of literature [14].

Predictive Modeling

Expanding the scope to oral cancer, predictive models in AI leverage patient data and historical outcomes to forecast the likelihood of oral cancer development, contributing significantly to risk assessment provided a tangible example of success in the field of orthodontic treatment planning, achieving a commendable 84% accuracy rate through the application of ML predictive models [15]. These models play a pivotal role in identifying individuals at higher risk who may benefit from more rigorous screening protocols. Incorporating extensive datasets encompassing demographic information, lifestyle factors, genetic predispositions, and clinical examination results predictive modeling in AI becomes a comprehensive tool [16].

Smartphone-based Probes

Numerous studies have delved into the application of smartphone-based probes for the detection of oral cancers. In the work, innovative dual-modality imaging systems were crafted, seamlessly integrating auto fluorescence and white light imaging. The latter study additionally introduced a pliable, handheld probe into the equation. Results from these investigations substantiated the efficacy of these systems in identifying cancerous conditions within the oral cavity [17]. A device designed to empower smartphones in the detection of oral cancer. Building on this foundation, elevated the field through the development of a mobile-based image classification method and an Android application tailored for point-of-care oral cancer detection, boasting a commendable accuracy rate. Collectively, these studies showcase the considerable potential inherent in smartphone-based probes for enhancing the early detection of oral cancers [18].

Optical Coherence Tomography (OCT) with AI

Optical Coherence Tomography (OCT) has emerged as a promising tool for the detection of oral cancers, capitalizing on its high resolution and noninvasive characteristics. Substantive evidence supports its effectiveness in diagnosing oral cancerous lesions, showcasing commendable sensitivity and specificity [19]. The integration of artificial intelligence and automated algorithms has further augmented its diagnostic sensitivity, marking a significant advancement in diagnostic capabilities. Notably, OCT has demonstrated proficiency in distinguishing between various types of oral mucosa, encompassing both normal and abnormal tissues. Cumulatively, these findings underscore the substantial value of OCT as a diagnostic tool for the early detection and diagnosis of oral cancers [20].

Computer-Aided Detection Systems (CAD)

CAD systems use algorithms to assist in the analysis of oral lesions, contributing to improved diagnostic accuracy and reliability. Specific algorithms such as Support Vector Machines (SVM), Artificial Neural Networks (ANN), and Logistic Regression (LR) have demonstrated effectiveness. Studies conducted have illuminated the potential of CAD systems, showcasing their ability to reduce the necessity for invasive biopsies while aiding surgeons in informed decision-making [21]. In a novel approach, employs deep learning techniques for automated detection and classification of oral lesions, yielding promising results. These collective findings emphasize the significant potential of CAD systems in enhancing the early detection and management of oral cancers. The integration of such advanced technologies into dental practices marks a crucial step towards more effective and patient-friendly diagnostic approaches in oral healthcare [22].

CHALLENGES

The integration of AI and ML technologies into routine dental practices for oral cancer screening is currently in its budding stages and researchers such as accentuated the capabilities of these technologies, especially when employed in conjunction with various imaging modalities. Despite these advancements, observe that the integration of AI into everyday dentistry, specifically for routine oral cancer screening, is not yet widespread. There is a lack of specific data on the integration of these technologies in dental practices, particularly in different regions or countries [23]. Further investigation is needed to determine if there are geographical disparities in the adoption of AI and ML in dental practices.

Several technological challenges like the need for adequate data input, methodological rigor, and standards in AI development lack of data curation, sharing, and readability, as well as the inability to illustrate the decision-making process, are also significant obstacles. Furthermore, the need for specialized training in the use of these technologies is crucial to ensure their effective implementation [24].

Highlight the need for guidelines and safeguards to protect patient privacy and uphold ethical standards. This is particularly important given the potential for privacy breaches through AI-driven methods. These findings underscore the need for robust data protection measures in dental practices, including the use of secure AI and ML technologies and the implementation of stringent cybersecurity protocols. Despite the potential benefits of AI in streamlining care and increasing efficiency, the practical questions around the value and usefulness of these solutions, financial burden, as well as ethical and privacy concerns, remain significant barriers to widespread adoption [25].

CONCLUSION

The advancement of AI in oral cancer screening and detection requires a comprehensive and strategic approach. Foundational to this progress is the accessibility and quality of diverse datasets, crucial for training AI models that can discern oral cancer in various demographics and stages. Technological integration, particularly with advanced imaging technologies and the amalgamation of multimodal data, ensures a more nuanced and precise analysis of oral lesions. The real-time diagnostic capabilities of AI provide immediate feedback during oral examinations, enabling timely intervention and treatment planning. Collaboration between AI systems and healthcare professionals is emphasized, highlighting the importance of viewing AI as a supportive tool rather than a replacement. Interdisciplinary teamwork, involving dentists, oncologists, radiologists, and data scientists, contributes to the development of comprehensive and effective AI tools. Ethical considerations and adherence to regulatory standards are paramount to building trust among both healthcare professionals and patients. Education programs for healthcare providers, as well as patient-focused initiatives, enhance understanding and acceptance of AI in oral cancer detection. Integrating AI into mobile and telehealth platforms expands accessibility, while cost-benefit analyses underscore the economic advantages of these technologies. Rigorous research and validation studies are essential to establish the credibility and reliability of AI models in oral cancer detection. Ultimately, by addressing these multifaceted aspects, AI emerges as an invaluable tool, augmenting early detection and management of oral cancer, and contributing to the evolution of oral healthcare practices with improved patient outcomes.

REFERENCES

1. Araujo AL, da Silva VM, Kudo MS, et al. Machine learning concepts applied to oral pathology and oral medicine: a convolutional neural networks' approach. J Oral Pathol Med 2023;52:109-18.
2. Chitnis G, Bhanushali V, Ranade A, et al. A review of machine learning methodologies for dental disease detection. IEEE INDISCON 2020;63-65.
3. Dixit S, Kumar A, Srinivasan K, et al. Advancing genome editing with artificial intelligence: opportunities, challenges, and future directions. Front bioeng Biotechnol 2023;11.
4. Hassani H, Silva ES, Unger S, et al. Artificial intelligence (AI) or intelligence augmentation (IA): what is the future?. Ai 2020;1:8.
5. Ilhan B, Guneri P, Wilder-Smith P. The contribution of artificial intelligence to reducing the diagnostic delay in oral cancer. Oral oncol 2021;116:105254.
6. Ilhan B, Lin K, Guneri P, et al. Improving oral cancer outcomes with imaging and artificial intelligence. J Dent Res 2020;99:241-8.
7. Khanagar SB, Naik S, Al Kheraif AA, et al. Application and performance of artificial intelligence technology in oral cancer diagnosis and prediction of prognosis: a systematic review. Diagnostics 2021;11:1004.
8. Kim JS, Kim BG, Hwang SH. Efficacy of artificial intelligence-assisted discrimination of oral cancerous lesions from normal mucosa based on the oral mucosal image: a systematic review and meta-analysis. Cancers 2022;14:3499.
9. Murdoch B. Privacy and artificial intelligence: challenges for protecting health information in a new era. BMC Med Ethics 2021;22:1-5.
10. Panigrahi S, Swarnkar T. Machine learning techniques used for the histopathological image analysis of oral cancer-a review. Bioinformatics J 2020;13.
11. Patil S, Albogami S, Hosmani J, et al. Artificial intelligence in the diagnosis of oral diseases: applications and pitfalls. Diagnostics 2022;12:1029.
12. Pereira-Prado V, Martins-Silveira F, Sicco E, et al. Artificial intelligence for image analysis in oral squamous cell carcinoma: a review. Diagnostics 2023;13:2416.
13. Pethani F. Promises and perils of artificial intelligence in dentistry. Aust Dent J 2021; 66:124-35.
14. Prasad J, Mallikarjunaiah DR, Shetty A, et al. Machine learning predictive model as clinical decision support system in orthodontic treatment planning. Dent J 2022;11:1.
15. Rahman TY, Mahanta LB, Chakraborty C, et al. Textural pattern classification for oral squamous cell carcinoma. J Microsc 2018;269:85-93.
16. Schwendicke FA, Samek W, Krois J. Artificial intelligence in dentistry: chances and challenges. J Dent Res 2020;99:769-74.
17. Shan T, Tay FR, Gu L. Application of artificial intelligence in dentistry. J Dent Res 2021;100:232-44.
18. Sharma N, Om H. Extracting significant patterns for oral cancer detection using apriori algorithm. Intell Inf Manag 2014.
19. Uthoff RD, Song B, Sunny S, et al. Small form factor, flexible, dual-modality handheld probe for smartphone-based, point-of-care oral and oropharyngeal cancer screening. J biomed optics 2019; 24:106003.
20. Uthoff RD, Song B, Sunny S, et al. Point-of-care, smartphone-based, dual-modality, dual-view, oral cancer screening device with neural network classification for low-resource communities. PLOS 2018 ; 13:e0207493.

21. Warin K, Limprasert W, Suebnukarn S, et al. AI-based analysis of oral lesions using novel deep convolutional neural networks for early detection of oral cancer. PLOS 2022;17:e0273508.

22. Welikala RA, Remagnino P, Lim JH, et al. Automated detection and classification of oral lesions using deep learning for early detection of oral cancer. IEEE 2020; 8:132677-93.

23. Jung W, Zhang J, Chung J, et al. Advances in oral cancer detection using optical coherence tomography. IEEE J Sel Top Quantum Electron 2005; 11:811-7.

24. Yang J, Xie Y, Liu L, et al. Automated dental image analysis by deep learning on small dataset. COMPSAC 2018;492-497.

25. Youssef B, Hamid Z, Abdelkhalak B. Computer-aided diagnostics of facial and oral cancer. WCCS 2015; 1-7.