Oral Oncology Reports 10 (2024) 100293

Contents lists available at ScienceDirect

Oral Oncology Reports

journal homepage: www.journals.elsevier.com/oral-oncology-reports

AI-powered oral cancer detection: A breakthrough in dental diagnostics

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ARTICLE INFO

Keywords
AI
Oral cancer
Dental diagnostics

ABSTRACT

Oral cancer is a global issue that poses challenges in both diagnosis and treatment. About 50% of cases are detected at an advanced stage, leading to a low 5-year survival rate. Visual assessments are conventionally employed in dental clinics for the detection of oral cancer, but, their precision is greatly influenced by the proficiency and knowledge of the practitioner, which can significantly differ. Furthermore, the subjective character of these tests might lead to inconsistencies in the diagnosis, hence increasing the probability of either an under- or overdiagnosis. Moreover, the diagnosis of oral cancer entails a substantial emotional burden as a result of protracted and intricate medical interventions, which in turn induces considerable worry in patients. In recent times, artificial intelligence has begun to assist in the diagnosis of oral cancer through many methods. AI-based diagnostic systems have the capability to analyse large amounts of data, including intraoral camera pictures, radiographs, and advanced imaging like MRI or CT scans. This allows them to detect even small changes and enhance image analysis. Thus, the present paper discusses the ways AI powered oral cancer detection can reduce the risks and increase accuracy to give better quality of life to patients.

1. Introduction

Globally, oral cancer presents a landscape of diagnostic and therapeutic problems, resulting in 50% of diagnoses occurring at an advanced stage with a poor 5-year survival rate [1]. As the risk factors are largely lifestyle-based, detecting the disease at an early stage would increase the chances of cure and survival, but there are several challenges, such as the lack of knowledge about oral cancer's early signs, asymptomatic nature of the disease or non-specific symptoms such as mouth ulcers, persistent sore throat, difficulty swallowing, and others, causing intervention to be delayed [2]. A recent systematic review revealed a diagnostic delay of 45 days to 6 months in oral squamous cell carcinoma particularly due to lack of patient awareness [3].

Visual evaluations are traditionally used in dental clinics to diagnose oral cancer, but their accuracy depends heavily on the expertise and experience of the practitioner, which can vary considerably. Moreover, the subjective nature of these tests might result in variation in the diagnosis, which increases the risk of an under- or overdiagnosis [4]. The variety in the presentation of oral lesions further complicates the process of getting a definitive diagnosis [5]. Procedures like biopsies help detect oral cancer, however, because of their invasive nature, it is uncomfortable for patients and particularly not feasible to apply for diagnosis in a vast population. Another significant impediment is access to specialty care and, lack of the necessary infrastructure and qualified doctors, particularly in low-resource settings [6]. Furthermore, being diagnosed with oral cancer carries a significant psychosocial cost due to lengthy and complicated procedures, causing patients a great deal of anxiety. These issues highlight the need for significantly better diagnostic instruments that are non-invasive, simple to use, efficient and do not strain patients' lives.

2. The role of AI in strengthening oral cancer detection

The transformative potential of Artificial Intelligence (AI) can be realized in terms of the oral cancer diagnosis challenge. AI is distinguished by machine learning and deep learning skills, which can analyse complex medical data and outperform humans in specific domains with high accuracy and speed [2]. Such algorithms are trained to recognize patterns associated with cancerous lesions in the mouth, even when such initial signs are not visible to the naked eye.

AI can aid with oral cancer diagnoses in a variety of ways. Some AI-based diagnostic systems can analyse enormous quantities of data, including intraoral camera images, radiographs, and advanced imaging such as MRI or CT scans, to detect even little alterations and hence

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https://doi.org/10.1016/j.oor.2024.100293
Received 13 March 2024; Accepted 14 March 2024
Available online 21 March 2024

improve image analysis [4]. Also, artificial intelligence may aid in more accurately discriminating between benign and malignant lesions, resulting in fewer intrusive biopsies and less pain and anxiety for patients can also help with predictive analytics in cases of oral cancer. According to Kim et al.'s systematic review, artificial intelligence (AI) image analysis for cancer diagnosis can swiftly determine the need for additional testing and treatment, and it can accurately distinguish between precancerous lesions and normal tissues with a sensitivity of over 90% when used as a means of detection [7].

Artificial intelligence in diagnostic processes also allow for a "second opinion" that is not only extremely exact but also homogeneous and objective leading to more consistent evaluations. According to a systematic review and meta-analysis, artificial intelligence (AI) can identify oral lesions in photographs with an accuracy of 74%–100%, which is higher than that of doctors (61%–98%) [8] which shows that AI is far more successful in recognising serious or malignant oral lesions. Warin et al. argued that convolutional neural network models, particularly DenseNet-169 and ResNet-101, surpassed expert-level classification performance, thereby enhancing the accuracy of early identification of malignant tumours [9].

Furthermore, AI can accelerate diagnosis by reducing the time between initial screening and diagnosis to hours or minutes by leveraging the capacity of data processing and analysis, thud can lead to improved outcomes in oral cancer. Large datasets, such as patients' medical histories, lifestyle characteristics, and genetic information, could be analysed using AI models to uncover patterns and risk factors that could predict susceptibility to oral cancer. Alhazmi et al. developed an artificial intelligence model employing a neural network for predicting malignant oral cancer based on 29 variables gathered from 73 patients. The model demonstrated good accuracy (about 79%), with a sensitivity of approximately 86% and specificity of 60% [10]. In resource-constrained contexts, AI can help to democratize expert diagnosis. Non-experts can undertake tests and receive rapid competent feedback by using AI-powered tools, which enable them to reach out to remote areas plagued by oral cancer. This technology can effectively close the healthcare gap, encouraging equitable distribution of early detection and medical treatment. Various AI based tools are currently being tested and developed for oral cancer diagnosis. One such emerging tool is saliva biomarkers analysis through AI to detect molecular changes indicative of cancer. A recent network metanalysis concluded that Chemerin, MMP-9 and Phytosphingosine were the most sensitive salivary biomarkers for oral cancer across the included studies, however further research to refine the identification of these oral cancer biomarkers are warranted [11]. Data mining tools, with AI algorithms like ANN (Artificial Neural Network) AND Multi-Layer Perceptron (MLP) have also shown to be used in scientific research for the diagnosis, staging and treatment planning of oral cancer. Besides, With the help of genomic data and DNA microarray techniques, genetic algorithms complemented with tools such Dynamic Bayesian Networks and support vector Machine (SVM) are now widely used in oral cancer research early detection as well as monitoring progression of oral cancer [12,13].

3. Implementation challenges

However, the comprehensive implementation of AI in oral cancer diagnosis has presented several problems. Concerns about data privacy and security arise while dealing with sensitive patient information. Furthermore, the enormous quantity of diverse datasets that address AI model training can be a barrier [2,7]. Additionally, there is a risk connected with over-reliance on AI, which may substitute for the physician in diagnostics. It is critical to improve the availability of affordable AI technologies for healthcare providers worldwide, particularly in low-resource areas where the oral cancer burden may be highest [6]. The most significant problem is that integrating AI capabilities into existing healthcare systems frequently presents technical and logistical challenges. Medical personnel must have substantial training and instruction to use it properly [14].

4. Road ahead with AI

The future of AI in oral cancer diagnosis hinges on enhancing algorithm accuracy and usability, as well as adapting it to varied clinical scenarios. To eliminate prejudice, the focus should be on improving AI algorithms, particularly keeping them equal and prepared across many diverse datasets. The integration of AI techniques in routine dental check-ups may be an important stage of early detection. Collaboration among technologists, clinicians, and researchers would be one of the most important techniques for advancing this field. It is also critical to align and generate high-quality datasets for training AI models. Furthermore, ethical concerns and the requirement for regulatory compliance will play a key role in the widespread deployment of AI products. Finally, public-private collaborations will be crucial in ensuring that these technologies are inexpensive for use in making accessible oral cancer diagnoses, as well as directing such efforts into improved global healthcare.

Source of funding

None.

CRediT authorship contribution statement

Asmita Kharche: Conceptualization, Writing – review & editing. **Ankita Mathur:** Conceptualization, Writing – original draft, Writing – review & editing. **Vini Mehta:** Conceptualization, Supervision, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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