Review Article

A scoping review of the effects of artificial intelligence on oral cancer treatment outcome and early diagnosis

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Background: Oral cancer (OC) has been more common across the globe recently. Early identification and diagnosis made possible by the use of modern technologies may help the practitioner manage patients more effectively. The objective of the study is to analyze the role of artificial intelligence (AI) in the detection and management of OC by looking at a number of academic publications from various online databases and to share the applications of AI to all the researchers that help in OC detection.

Methods: The terms "oral cancer", mouth neoplasms and "artificial intelligence" were used in a literature search in the PubMed, Scopus, and Web of Science databases for publications published in English between 2012 and 2022. There is a lot of information in reputable databases on the subject of AI and OC. The articles with full texts that matched the keywords were taken into consideration.

Results: The majorities of these articles were based on the diagnosis and treatment field related to OCs. The initial search yielded a total of 548 articles. Reports assessed for eligibility were 25. Upon the restriction to OC, articles related to AI in OC and research restricted to diagnosis and treatment plan, only ten articles were eligible.

Conclusions: In the subject of OC, as well as its subcategories AI can make a significant difference in the early diagnosis, disease prediction, prognosis and treatment planning of OC patients. Since it can raise living standards, AI research is essential for the treatment of OC.

Keywords: Artificial intelligence (AI); machine learning (ML); oral cancer (OC); oral squamous cell carcinoma (OSCC); premalignant lesions

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Introduction

Successful treatment of oral cancer (OC) depends on early identification. When OC is discovered in its later stages, it causes morbidity and mortality. Low survival, more symptoms, and more expensive treatment are linked to inaccessible lesions and late cancer discovery. The early diagnosis of malignant tumours is essential for successful treatment. About 70% of cases are discovered at a later stage, which lowers the 5-year survival rate from 83.7% when the disease is discovered at a localized stage to 38.5% if the cancer has spread (1).

Self-examination of the oral cavity and expert consultation are required for the initial diagnosis of OC. To prevent the late diagnosis, high-risk populations must be screened; however these populations are frequently found

in rural areas with poor access to medical services. Lack of understanding of OC symptoms is a significant barrier (2).

To identify anomalies that result in early diagnosis, a full mouth examination procedure should be established in dental practices. According to studies, medical professionals and students are confused of their diagnosis and course of therapy. This was an opportunity to develop a diagnostic test auxiliary device based on artificial intelligence (AI) that could identify early warning signs. By allowing for the detection of changes that the untrained human eye cannot catch, computational diagnosis enhances patient care (3,4).

Over the years, new medical technology has emerged, and we have experienced its benefits. Medical imaging techniques include X-rays, computed tomography, and magnetic resonance imaging. Some of the imaging methods used to treat various ailments includes ultrasound, mammography, and X-rays. AI may be used in sophisticated technologies to aid in the correct diagnosis and treatment of diseases. Oncology can benefit from AI's accurate analysis of a sizable dataset from a variety of imaging modalities. The development of AI has the potential to improve OC screening, therefore the current state of AI-based medical imaging and diagnosis research is intriguing (5,6).

The employment of human experts and researchers could compromise the outcome of the study. Pathologists today have a large quantity of patients to examine. They must examine numerous slides in order to obtain a thorough diagnosis. Over the years, machine learning (ML) has become increasingly important in almost all STEM fields (science, technology, engineering, and mathematics). ML, a branch of AI, uses a range of statistical, probabilistic, and optimization approaches to give computers the ability to "learn" from past experiences and find elusive patterns in large, noisy, or complex data sets (6-8).

In basic terms, it is a system that gathers data, searches for similarities, train services on that data, and then produces. ML analyses and interprets data in a similar manner to statistics. Medical researchers frequently use ML technologies because they can reliably predict outcomes for diseases like cancer (9,10).

To examine the possible role of AI and its effectiveness in screening OC, a scoping review was used. These methods are now being evaluated for OC detection, early diagnosis, disease prognosis, treatment planning, and prognosis. There are fewer qualified medical professionals and experts who can employ AI in practice. Thus, this article reviews and explores the benefits of AI in OC screening, early diagnosis, disease prediction, treatment planning, and prognosis and shares the applications of AI to the all the young researchers in field of dentistry. We present this article in accordance with the PRISMA-ScR reporting checklist (available at https://fomm.amegroups.com/article/view/10.21037/fomm-23-17/rc).

Highlight box

Key findings

- Artificial intelligence (AI) has the potential to significantly improve oral cancer patients' early detection, disease prognosis, and therapy planning.

What is known and what is new?

- Ultrasound, mammography, and X-rays are a few of the imaging techniques utilized to treat various illnesses.
- Understanding how AI can support precise disease identification and treatment is crucial.

What is the implication, and what should change now?

- The integration of contemporary AI technology is required in diagnostic medicine.

Methods

Literature search

The following research questions are based on the aim of this review.

- RQ1. To examine the possible role of AI and its effectiveness in screening OC?
- RQ2. To explores the benefits of AI in OC screening, early diagnosis, disease prediction, treatment planning, and prognosis?

Inclusion criteria: all papers with an accessible full text published between 2012 and 2022 that contained any or all of the keywords listed above were included in the study. Only articles written in English were taken into consideration.

Exclusion criteria: the analysis omitted all articles that did not include the keywords, as well as case reports and patency-related articles and also studies on animals.

The terms used in the PubMed, Web of Science, and Scopus databases were as follows: ("artificial intelligence"[MeSH Terms] OR ("artificial"[All Fields] AND "intelligence"[All Fields]) OR "artificial intelligence"[All Fields]) AND ("mouth neoplasms"[MeSH Terms] OR ("mouth"[All Fields] AND "neoplasms"[All Fields]) OR "mouth neoplasms"[All Fields] OR ("oral"[All

Fields] AND "cancer"[All Fields]) OR "treatment of oral cancer"[All Fields]).

Using the PubMed database, a thorough literature search was carried out by the Principal Investigator. The co-investigator compared the results obtained after screening. The search parameters were based on the goals of the study based on the idea of AI and how it relates to OC. The initial search was conducted using the terms "artificial intelligence", "mouth neoplasms", and "oral cancer".

The goal of the study is to compile and arrange information on the distribution of AI in OC from various studies that have been published all over the world. Several databases, including PubMed, Scopus, and Web of Science, were used to gather the data. In the aforementioned databases' advanced search section, phrases including malignant lesions, premalignant lesions, AI, mouth neoplasms, and OC were used. The information was composed of articles about the keywords specified earlier. They underwent bibliometric analysis evaluation, which considered factors including article kind, quantity of citations, journal name, authors, and year of publication.

Data collection

The relevance of each and every one of the found articles to the inclusion criteria was examined and cross-checked. The Principal Investigator performed the literature search. Independent search was carried out during the study and the co-investigator compared the results obtained after screening.

After reviewing the publications on AI's contribution to the identification and treatment of OC, the principal investigator evaluated the ones that were eligible for the data collection process. The evaluation only included the publications that shown benefits of AI in treating OC. After being evaluated, the reports on AI's role in the detection and treatment of OC were added to the review (*Figure 1*).

Results

A set of words (artificial intelligence/oral cancer/neoplasms) were used as a query in databases, such as PubMed, Web of Science, and Scopus. This process resulted in a reduction of the core search parameters used to identify the key components related to AI in OC.

A first keyword search turned up 548 articles in total. After first filtering, only 92 publications remained, which the author analyzed based on AI/ML in OC. A total of 25 reports were evaluated as being eligible. Only ten papers that addressed the requirements or goals of this review qualified. Out of the ten articles that qualified, two featured comparative and evaluations of AI and OC.

The accompanying *Figure 1* provides a clear explanation of the data collection and sequencing procedure. The following *Table 1* provides an explanation of the AI idea and its implications for the detection and treatment of OC.

AI offers a wide range of opportunities for OC screening. The automated screening of the oral cavity is now possible because to advancements in the field of AI. This would give patients' examinations by medical expert's feedback, as well as input to individuals for self-examination.

Discussion

On a global scale, cancer is becoming more common and killing more people. The World Health Organization (WHO) predicts that cancer will be either the top or second cause of death in 2015. The sixth most prevalent type of cancer is oro-pharyngeal and pharyngeal carcinoma combined (6).

A study was undertaken in 2021 by Ilhan *et al.* to offer an overview of the factors that contribute to delayed OC diagnosis and to assess the usefulness and consequences of emerging AI-based approaches for increasing OC detection. According to the study's findings, new technologies offer a tremendous deal of promise to enhance outcomes, particularly in low-resource environments. By giving a real-time risk assessment, such methods can be utilized to predict OC risk as a supplement to population screening (11).

In order to predict malignant transformation in oral leukoplakia and oral lichenoid lesions, Adeoye *et al.* in 2021 used time-to-event learning models. They discovered that DeepSurv (c-index: 0.95, IBS: 0.04) and RSF (c-index: 0.91, IBS: 0.03) were the two outperforming models based on discrimination and calibration after internal validation (12).

The most common malignancies worldwide are those of the lips and mouth. Up to 3.8 percent of all malignancies are mouth, throat, and pharynx cancers. 3.6% of cancer cases and 3.6% of cancer deaths occur in nations with a high cancer risk. A portable, reliable optical coherence tomography (OCT) device was validated in 232 patients (with 347 lesions) in various clinical situations, according to James *et al.* in 2021. The study's findings gave support for the use of the reliable and affordable OCT equipment as a point-of-care tool in resource-constrained settings and

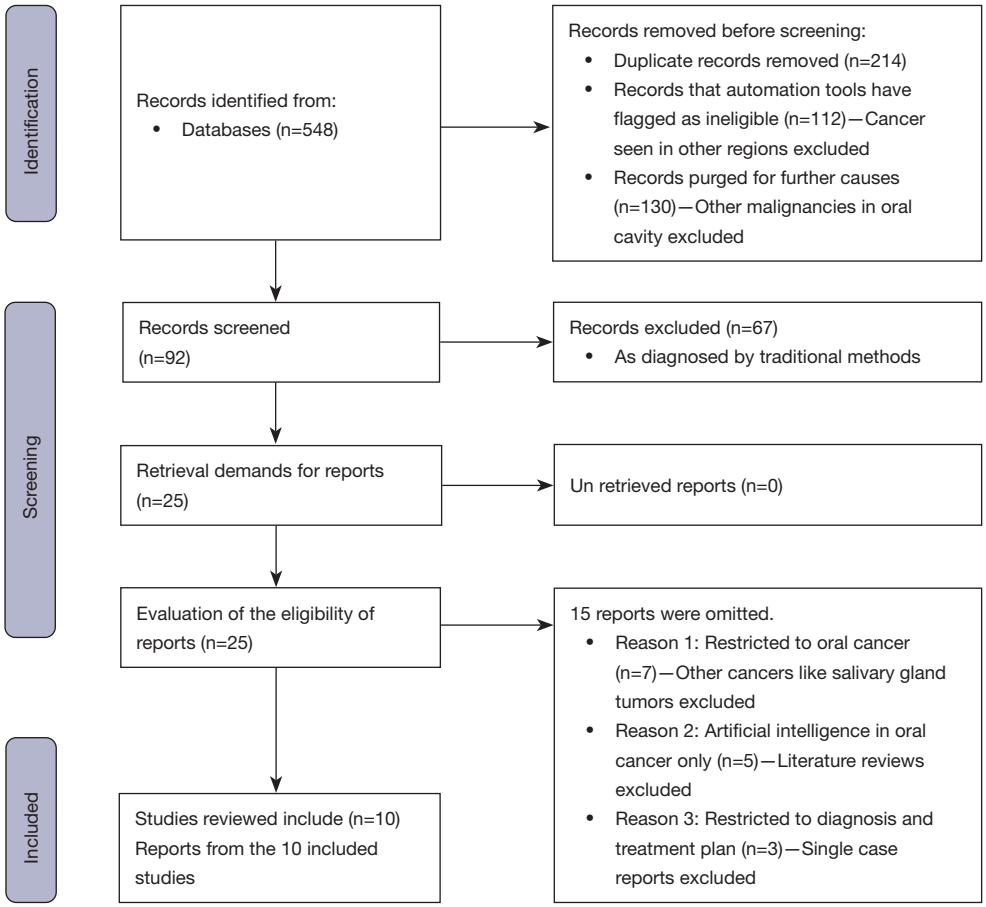

Figure 1 Show the order of data gathering as specified by PRISMA (Preferred Reporting Items for Systematic Review and Meta-analysis 2020).

for the device's prospective clinical use in the detection and monitoring of OC (13). In the current review results supported the role of AI in detecting OC.

Six hundred oral picture images were acquired retrospectively and divided into 300 photographs of oculopharyngeal muscular dystrophies (OPMDs) and 300 images of normal oral mucosa for Warin *et al.*'s study from 2022. DenseNet-121 and ResNet-50 were used to build CNN-based classification models. In conclusion, there is potential for the classification and detection of OPMDs in oral pictures using the DenseNet-121, ResNet-50, and Faster R-CNN models. The findings on advanced technology in this review were consistent with the research conducted by Warin *et al.* in 2022 (14).

Al-Rawi *et al.*, in 2022 conducted a study to critically analyze the available evidence concerning the utility of AI in the diagnosis of OC. Special consideration was given to the diagnostic accuracy of AI and its ability to identify the early stages of OC. Along with the results of the present study, Al-Rawi *et al.*, Tobias *et al.*, 2022 concluded that AI is a valuable diagnostic tool that represents a large evolutionary leap in the detection of OC in its early stages (15,16).

Microscopic morphology is the gold standard for morphology in pathology diagnoses. Tissue sectioning, paraffin embedding, and finally staining are some of the procedures that are performed on pathology specimens in addition to formalin fixation and grossing. A diagnosis is made by looking at a stained specimen on a piece of glass and looking at a slide under a microscope. For accurate results, AI must be used as part of the diagnostic procedure. Several recent initiatives have been made in the field of pathology. The entire histopathological slide was scanned, and after that, the image was then saved as a digital file (17,18).

In 2022, Sharma *et al.* used a dataset of clinically annotated photographic images to train pre-trained

Table 1 Demonstrate the role of the artificial intelligence in oral cancer with concluding statements

Author (ref.)	Name of journal	Type of study	Sample size	Conclusion
Ilhan B, *et al.* (7)	*J Dent Res. 2020*	Survey	130	The results of these investigations show that combining artificial intelligence with imaging techniques can significantly improve oral cancer outcomes. Applications range from low-cost screening using smart phone-based probes to algorithm-guided optical coherence tomography detection of oral lesion heterogeneity and margins
Rahman TY, *et al.* (8)	*Cancer Rep (Hoboken). 2020*	Original research	40	When diagnosing OSCC, morphological and textural characteristics are both crucial
Hung M, *et al.* (9)	*World J Clin Oncol. 2020*	Original research	257,880	Medical decision-making and oral cancer survival prediction can both be done with artificial intelligence
Alhazmi A, *et al.* (10)	*J Oral Pathol Med. 2021*	Observational study	73	Based on knowledge of the individuals' risk factors, systemic medical conditions, and clinic-pathological data, artificial neural networks may perform well in estimating the probability of malignancy and improving the positive predictive value that may help to predict the individuals' risk of developing OC
Ilhan B, *et al.* (11)	*Oral Oncol. 2021*	Review	–	By offering real-time risk assessment, artificial intelligence can be utilized to predict oral cancer risk as a supplement to population screening
Adeoye J, *et al.* (12)	*Cancers (Basel). 2021*	Original research	1,098	Deep survey model to promote beginning use in clinical practice. Overall, oral leukoplakia and oral lichenoid lesions can be predicted to progress to malignancy using time-to-event models
James BL, *et al.* (13)	*Cancers (Basel). 2021*	Original research	127	The study offered proof for the usefulness of the durable and affordable OCT instrument as a point-of-care tool in resource-constrained settings and for the device's prospective clinical use in oral cancer screening and surveillance
Warin K, *et al.* (14)	*Int J Oral Maxillofac Surg. 2022*	Original research	600	The categorization and identification of OPMDs in oral pictures has the potential to be achieved using the DenseNet-121, ResNet-50, and Faster R-CNN models
Al-Rawi N, *et al.* (15)	*Int Dent J. 2022*	Review	–	AI is a useful diagnostic tool that provides a significant evolutionary advance in the early detection of OC
Tobias MAS, *et al.* (16)	*Oral Oncol. 2022*	Original research	152	Acceptable AI results allow for both the identification of lesions and the classification of the pathology they are associated with

OSCC, oral squamous cell carcinoma; OC, oral cancer; OCT, optical coherence tomography; OPMD, oculopharyngeal muscular dystrophy; AI, artificial intelligence.

convolutional neural networks (CNNs) to recognise oral pre-cancerous and malignant lesions and distinguish them from normal mucosa. The findings of this investigation demonstrated that VGG19 performed better than other models for identification and classification, simulating a biopsy report. According to a study by Marzouk *et al.*, 2022, AI may one day be used to identify OC (17,19).

Only 20% of the approximately one million prostate cancer biopsies undertaken in the United States were on those who tested positive for the disease. This shows that pathologists spend a lot of time examining benign tissue, which is typically easy to remove and is not to be confused with cancer. This emphasizes the necessity for computer assisted diagnostics, which allows pathologists to make more accurate diagnosis rather than sieving, concentrate on cases that are difficult to diagnose via unaffected tissue (19,20).

Modern AI technology integration into diagnostic medicine has gained significant momentum in recent years. A new era of improved precision in oncologic pathology has begun as a result of AI, which has created a plethora of new opportunities for bettering healthcare. Although the effects of AI on oncologic pathology are now obvious, oral

oncology applications of AI are still in their infancy (21,22).

The results of this scoping review emphasize that AI in OC screening and detection, AI in OC prediction and AI in OC management will become a valuable tool for oncologists, clinicians and dentists.

Limitations

Only data from publications in the PubMed, Web of Science and Scopus databases were used for the research information in this review. The specifics of this review were impacted by the limits of those papers.

Implications and actions needed

The current restrictions might be overcome with the aid of future research in the fields of AI and OC. A new area of study called "radiomics" makes use of data characterization techniques and radiographic images. This can be utilized as a diagnostic tool in the future for the quick diagnosis of OC.

Conclusions

Many models for survival rates and recurrences in individuals with oral squamous cell carcinomas (OSCC) have indeed been created, with the majority of the work focusing on estimation techniques for survival rates and recurrences in individuals with OSCC. Only a few researches have looked at OSCC digital histopathologic images while using ML techniques. The field of oral oncology could benefit from future collaborations with computer scientists, but more research at the entire slide picture level is certainly needed.

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Footnote

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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