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Application of Artificial Intelligence in Oral Cavity Cancer: A Review

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ABSTRACT

Oral cavity cancer is a prevalent form of cancer with significant morbidity and mortality rates. Timely and accurate diagnosis is crucial for effective treatment outcomes. In recent years, artificial intelligence (AI) has emerged as a promising tool in the field of oral cavity cancer, aiding in early detection, diagnosis, prognosis, and treatment planning. This review article explores the current applications of AI in oral cavity cancer, discussing machine learning and deep learning algorithms and highlighting their potential benefits and limitations.

KEY WORDS: Machine learning; Deep learning; Oral cancer; Artificial intelligence.

Introduction

Oral cavity cancer poses a significant global health burden, accounting for a substantial number of new cases and fatalities annually. Oral cavity cancer often arises from precursor lesions known as oral potential malignant disorders (OPMDs), including oral lichen planus, leukoplakia, and erythroplakia.[1] Unfortunately, a significant proportion of oral squamous cell carcinoma cases are diagnosed at an advanced stage, leading to poor survival rates despite advances in understanding the disease and treatment options. Early detection of OPMDs and oral cavity cancer is crucial for effective preventive strategies and improved clinical management. Current diagnosis methods involve clinical history, oral examination, and invasive incisional biopsy, which have limitations due to clinical heterogeneity and subjectivity. The integration of artificial intelligence (AI) into oral cavity cancer research and clinical practice holds tremendous potential in improving patient outcomes. However, there is still a lack of consensus on the reliable application of automated approaches in healthcare settings. This review aims to provide an overview of the utilization of AI in oral cavity cancer, examining its applications and discussing the implications for diagnosis and treatment.

Artificial Intelligence (AI) Applications in Oral Cavity Cancer

Diagnosis

AI has shown promise in facilitating early detection and accurate diagnosis of oral cavity cancer. In a systemic review and meta-anaylsis by Elmakaty et al. in 2022, the sensitivity, summary specificity, positive and negative likelihood ratios as well as the pooled diagnostic odds ratio (DOR) were 92.0% (95% confidence interval [CI] 86.7%–95.4%), 91.9% (95% CI 86.5%–95.3%), 11.4 (95% CI 6.74–19.2), 0.087 (95% CI 0.051–0.146) and 132 (95% CI 62.6–277), respectively.[2] Their findings could support the capability of

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AI-assisted systems to detect oral cavity cancer with high accuracy, potentially aiding the histopathological examination in early diagnosis.

Kim et al. also reported in 2022, a systemic review and meta-anaylsis, the efficacy of AI -assisted discrimination of oral cancerous lesions from normal mucosa based on the oral mucosal image.[3] The comparison is made between AI-assisted screening using photographic images, autofluorescence, and optical coherence tomography (OCT), and the reference results obtained from histology findings. The DOR is used as a measure of diagnostic accuracy. The analysis includes multiple studies and reveals that AI-assisted screening has a high DOR for discriminating oral cancerous lesions from normal mucosa (121.66, 95% CI: 29.60, 500.05) and for discriminating all oral precancerous lesions from normal mucosa (63.02, 95% CI: 40.32, 98.49). Subgroup analysis shows that OCT is more diagnostically accurate and negatively predictive compared to photographic images and autofluorescence for detecting all oral precancerous lesions. Their results suggest that AI-based automated detection can serve as a rapid and non-invasive diagnostic tool, potentially aiding in early diagnosis of pathological oral lesions.

Prognosis

AI techniques have also been employed in predicting the prognosis of oral cavity cancer patients. Machine learning, a subset of AI, has gained prominence in the field of cancer research due to the growing availability of large national databases and increased computing power. The abundance of potential input data has necessitated the exploration of novel approaches to data analysis, aiming to achieve more accurate and precise predictions. Machine learning offers an alternative method for developing cancer survival prediction models, providing opportunities for improved prognostic accuracy and personalized treatment strategies.

Chiesa-Estomba et al. reported in 2022, a systemic review, the application of machine learning in predicting the risk of progression, recurrence, and survival in oral cavity cancer patients.[4] Variables such as area under the curve, sensitivity, specificity, positive predictive value, and negative predictive value, which are used to measure the performance of the algorithms. Machine learning shows promise in improving prognostic accuracy and reducing overtreatment. However, there are limitations and challenges, including small sample sizes, retrospective nature of studies, imbalanced data, missing data, lack of consensus on training algorithms, infrastructure requirements, privacy concerns, and the need for interdisciplinary expertise. Adeoye et al. reported in a systemic review, accuracy of machine learning models on the internal or external validation sets ranged from 0.85 to 0.97 for malignant transformation prediction, 0.78–0.91 for cervical lymph node metastasis prediction, 0.64–1.00 for treatment response prediction, and 0.71–0.99 for prognosis prediction.[5] But, machine learning models that have incorporated molecular biomarkers together with other demographics, while clinicopathological information have shown very high prediction accuracy.

Treatment planning

There has been a longstanding reliance on the American Joint Committee on Cancer (AJCC) TNM (tumor, node, metastasis) staging scheme for making treatment decisions in head and neck cancer. However, there are doubts about whether the tongue cancer stage alone is adequate for accurate prognostication.[6] The optimal treatment approach for patients with advanced-stage oral cavity cancer is a subject of ongoing debate. Therefore, there is a critical need to develop accurate risk stratification methods to make informed treatment recommendations in these cases. AI has demonstrated potential in assisting treatment planning for oral cavity cancer patients. Alabi et al. reported that the overall survival predictive machine learning model showed an accuracy of 86.3% for overall survival likelihood prediction.[7]

By ensuring appropriate management of oral cancer, patients can experience enhanced treatment planning, precision, and personalized medicine, leading to increased survival rates. Deep learning methodology offers valuable support in achieving more precise detection, diagnosis, and prognostication in oral cancer management. Its implementation can lead to early detection, reduced costs, and fewer mistakes in the recognition process, ultimately improving the chances of survival and overall management of oral

cancer. Additionally, the workload of clinicians can be significantly reduced through rapid data processing, providing crucial prognostic information about patient outcomes. Furthermore, automated deep learning tools have the potential to minimize cognitive bias and errors in treatment planning by accurately predicting treatment outcomes.

Benefits and limitations

The integration of AI in oral cavity cancer offers numerous advantages, including enhanced accuracy, efficiency, and cost-effectiveness. AI algorithms can facilitate early detection, enabling timely interventions and improved patient outcomes. Furthermore, AI assists in treatment planning, minimizing the risk of complications and optimizing treatment efficacy. However, several challenges must be addressed. AI models require large datasets for training, posing difficulties for rare cancer cases. Moreover, the interpretability of AI models remains a concern, limiting their clinical adoption due to the lack of transparent decision-making processes. Still, studies on the application of AI in oral cancer are mainly conducted in the diagnosis stage. In the future, if many studies applying AI at the stage of prognosis and treatment planning, it can be helpful for the optimal treatment of oral cancer.

Conclusion

AI has emerged as a useful tool in various aspects of oral cavity cancer, ranging from early detection and diagnosis to prognosis and treatment planning. The integration of AI technologies has the potential to revolutionize oral cavity cancer care, offering improved patient outcomes and cost-effective solutions. However, further research is necessary to validate the efficacy, safety, and ethical considerations surrounding the implementation of AI in oral cavity cancer.

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Conflicts of Interest

No potential conflict of interest relevant to this article was reported.

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Author Contribution

The article is prepared by a single author.

Ethics Approval

Not applicable.

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