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Review Article

Exploring the role of artificial intelligence in oral cancer diagnosis: Review

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ABSTRACT

Oral cancer (OC) is the most common forms of head and neck cancer. Even with advancing research it still continues to have lowest survival rate globally. Histopathologiy still remains the gold standard for oral cancer diagnosis. But, it has few drawbacks being prone to errors (variability) and is time consuming leading to delay in diagnosis. In order to overcome these pitfalls there is a need for alternative diagnostic approaches which are faster and accurate at the same time. Considerable efforts have been focused on exploring the role of artificial intelligence (AI) in medical diagnostics in recent times. The role of AI in medical imaging and diagnosis seems promising. Key benefit of AI is better accuracy, rapid diagnosis and reduced manual visualization of slides. This review article focuses on the role of AI in oral cancer detection with emphasis on machine learning and deep learning methods, decision support systems. Future challenges, benefits and limitations of AI have also been discussed.

1. Introduction

Oral cancer is the most common malignancy affecting oral cavity. It ranks 6^{th} globally and affects middle aged males more than females.[1] Most common risk factors associated with Oral cancer are tobacco and alcohol usage, Human Papillomavirus (HPV) infection and poor oral hygiene. Early symptoms are subtle leading to delayed diagnosis.[1]

Oral cancer is a significant global health issue due to its high mortality and morbidity rates, primarily stemming from late diagnosis.[2] Detection at early stage is essential for effective treatment and better patient outcomes. Traditional methods using visual evaluation can lead to underdiagnosis and biopsy being invasive procedure isn't comfortable to many patients and cannot be done on a larger population. Imaging modalities using (Magnetic Resonance Imaging) MRI, (computed tomography) CT scan and (positron emission tomography) PET scan can be used but are expensive and technique sensitive.[3]

Histopathological analysis using microscopy is the gold standard of diagnosis. However, it can be slow and can lead to errors due to variability in interpretation. So in order to overcome these drawbacks there is need for better diagnostic techniques.[3]

Recently Artificial intelligence (AI) is revolutionizing the medical field, providing innovative solutions for early detection and diagnosis of oral cancer.[4] AI-powered technologies promise to enhance the accuracy, speed, and consistency of oral cancer detection, potentially leading to earlier diagnosis and better prognosis.[5] Digital pathology is now gaining momentum in quantitative analysis as effective approach. Automated methods have been developed recently which provide architectural details

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of epithelium for oral cancer detection using morphological parameters.[5]

2. AI Technologies in Oral Cancer Detection

AI technologies, particularly machine learning (ML) and deep learning (DL) algorithms, are increasingly being used to develop models that can assist in the detection, classification, and prediction of oral cancer. Key applications include:

1. Image analysis and classification AI can analyze medical images (e.g., histopathological slides, radiographs, and intraoral photographs) more efficiently than human experts. Deep learning models, such as convolutional neural networks (CNNs), have shown high accuracy in detecting abnormal lesions and differentiating between benign and malignant conditions.[6] AI-driven systems can process vast datasets and identify patterns that may be too subtle for the human eye, improving diagnostic sensitivity and specificity.
   (a) Oral cytology: AI can be employed to analyze cytological samples, automating the process of identifying malignant cells. This reduces the need for invasive biopsies and accelerates the diagnostic process.[7]
   (b) Radiomics: AI can extract features from radiographic images that are not visible to the naked eye, enabling early identification of potentially cancerous lesions.[8]
2. Histopathological image analysis Histopathological examination remains the cornerstone of oral cancer diagnosis. AI can assist pathologists by automating the analysis of tissue samples, enhancing precision and reducing inter-observer variability.[9] Automated systems using DL have demonstrated superior performance in identifying cancerous tissue, grading tumor severity, and predicting patient outcomes based on histological features.[10]
3. Early detection of precancerous lesions AI can assist in the early detection of oral cancer by identifying precancerous lesions, such as leukoplakia and erythroplakia, which have a higher risk of malignant transformation. AI tools can also predict the likelihood of lesion progression, enabling timely interventions and monitoring.[7]
4. Risk stratification and prognostic prediction AI models can integrate multiple data sources, including patient demographics, clinical history, genetic markers, and imaging results, to stratify patients based on their risk of developing oral cancer.[11] Predictive algorithms can also estimate the probability of tumor recurrence and overall survival, aiding in personalized treatment planning.
5. Telemedicine and remote diagnosis AI enables the development of remote diagnostic tools that can be integrated into telemedicine platforms. These systems allow healthcare professionals to provide accurate assessments of suspicious lesions in under-served areas or regions with limited access to specialized care. AI-powered smartphone applications, for example, can analyze intraoral images and provide real-time feedback on the likelihood of malignancy.[11]
6. Natural language processing (NLP) AI's NLP capabilities can assist in the analysis of electronic health records (EHRs), extracting relevant clinical information related to oral cancer. This aids in clinical decision support, automating the identification of patients at higher risk, and facilitating timely follow-up care.[8]

3. Benefits of AI in Oral Cancer Detection[12]

1. Increased accuracy: AI algorithms can achieve high accuracy levels, reducing misdiagnosis rates and ensuring timely interventions.
2. Efficiency: AI can analyze vast amounts of data rapidly, accelerating the diagnostic process and enabling prompt decision-making.
3. Cost-effectiveness: Automating diagnostic processes with AI reduces the need for multiple invasive procedures and expensive tests, potentially lowering healthcare costs.
4. Standardization: AI provides standardized analyses, minimizing variability in diagnostic interpretations among different clinicians
5. Accessibility: AI tools can be deployed in remote or resource-limited settings, improving access to quality diagnostic services for underserved populations.

4. Challenges in Implementing AI for Oral Cancer Detection[13,14]

1. Data quality and quantity: High-quality, annotated datasets are essential for training effective AI models. The availability of such data remains a limiting factor.
2. Integration with clinical workflow: Seamless integration of AI tools into existing clinical workflows is crucial for practical use. This requires user-friendly interfaces and interoperability with electronic health records.
3. Regulatory and ethical considerations: Ensuring the safety, efficacy, and ethical use of AI in healthcare is paramount.
4. Training and education: Clinicians need adequate training to use AI tools effectively and interpret their outputs correctly.

5. Future Directions[10,12,15]

1. Enhanced data sharing and collaboration: Creating large, annotated datasets through collaboration among institutions will enhance AI model training and validation.
2. Advanced AI algorithms: Continued development of AI algorithms that can handle diverse data types and integrate multi-modal information will improve diagnostic accuracy and robustness.
3. Clinical trials and validation: Conducting extensive clinical trials to validate AI tools will ensure their efficacy and safety in real-world settings.
4. Patient-centric AI: Developing AI tools with a focus on patient-centric care, ensuring these technologies address patient needs and improve overall healthcare experiences.

6. Conclusion

AI-powered technologies are poised to transform oral cancer detection by enhancing diagnostic accuracy, efficiency, and consistency. Despite challenges, continued research, collaboration, and investment in AI will enable its integration into clinical practice, ultimately improving early detection and treatment outcomes for oral cancer patients.

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8. Conflict of Interest

None.

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