AI-Driven Image Processing for Early Detection of Oral Cancer: Current Advances and Future Directions

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Oral cancer, particularly oral squamous cell carcinoma (OSCC), presents a global health challenge, marked by low survival rates due to delayed diagnosis. Early detection, however, greatly improves prognosis. Recent advancements in AI-based image processing have revolutionised oncology, enabling rapid and accurate detection of oral cancer, transforming dental diagnostics through sophisticated image analysis. This study aims to evaluate the effectiveness of AI-based image analysis techniques for detecting early-stage oral cancer, with a focus on OSCC. It assesses the accuracy of various imaging tools and explores recent advancements, clinical applications, and future directions to enhance diagnostic precision and improve oral health outcomes through early detection. A narrative review was conducted, synthesising studies from PubMed, Google Scholar, ScienceDirect, and other online databases. The review examines AI-driven image segmentation, focusing on advanced deep learning methods such as Convolutional Neural Networks (CNNs), and explores their transformative potential in oral carcinoma detection. The findings were thematically integrated to highlight the current state of AI in dental and oncology settings, with an emphasis on qualitative insights, without a quantitative meta-analysis. AI-based image segmentation, particularly through CNNs, has proven effective in detecting early oral carcinoma across various imaging modalities, including radiographs, histopathology, and endoscopic images. However, challenges such as image variability, resolution limitations, and model interpretability persist, particularly in low-resource settings. Despite these challenges, these AI-driven advancements significantly enhance the early detection and diagnostic accuracy of oral cancer, showing promise for improved patient outcomes. AI-driven approaches, combined with imaging technologies, are demonstrating considerable potential in oral cancer diagnosis. The integration of AI in clinical evaluation could play a pivotal role in early-stage cancer detection. However, further research and thoughtful implementation are required to maximise its potential and contribute to more effective oral cancer management.

Keywords: Artificial intelligence, convolutional neural networks, early detection, narrative review, oral squamous cell carcinoma