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EDITORIAL

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Revolutionizing oral pathology and medicine: The artificial intelligence advantage

In recent years, the field of oral pathology has undergone a profound transformation propelled by advancements in artificial intelligence (AI) technology. From diagnosing oral diseases to guiding treatment decisions, AI-powered tools are changing the way oral pathologists approach their work.[1] By leveraging deep learning algorithms, natural language processing, and image recognition, these innovative solutions can analyze vast amounts of data with unprecedented speed and accuracy.[2] As a result, clinicians now have access to cutting-edge tools that not only enhance diagnostic precision but also streamline workflows, ultimately leading to more effective patient care in the realm of oral health.

The diagnostic process for suspicious head and neck lesions typically involves a combination of clinical evaluation, radiological imaging, and histopathological assessment. While histopathology serves as the standard of care for diagnosis, providing essential prognostic information is crucial for guiding treatment decisions. However its subjectivity, inconsistencies in interpretation, and limited capacity for effective risk stratification pose significant challenges.[3] The prospect of undergoing a biopsy can be anxiety-inducing for many patients, as it involves the possibility of receiving a cancer diagnosis or discovering a serious medical condition.[4] Patients may experience post-operative pain, swelling, bruising, and temporary limitations in function or mobility. Additionally, there may be concerns about potential complications such as bleeding, infection, or scarring, which can add to patients' apprehension and discomfort.[5]

Deep learning is a subset of the machine learning branch of AI where algorithms are inspired by the structure and function of the human brain, particularly neural networks. Convolutional neural networks (CNN) are computational models composed of interconnected nodes, or neurons, organized in layers. Each neuron applies a transformation to its input and passes the result to neurons in the next layer.[6] In oral medicine, deep learning and neural networks can be utilized for various tasks such as disease diagnosis, treatment planning, and outcome prediction. For instance, in the diagnosis of oral diseases, neural networks can be trained on large datasets of macrographs, micrographs, histopathology slide images, and other sources of patient data.[7] These networks can learn complex patterns and features from this data, enabling them to make accurate diagnoses with high sensitivity and specificity.[8] Upon analyzing patient data, such as medical and dental histories, genetic information, and imaging results, these deep learning models could recommend personalized treatment strategies.[9] They can also predict treatment outcomes based on various factors, helping clinicians make informed decisions about patient care.

The utility of AI models in oral medicine can be understood broadly based on the two main branches of machine learning which are supervised learning and unsupervised learning. Supervised learning is useful in situations where there is a predefined problem with well-structured categories of objects that need to be detected or identified. This type of learning is especially apt for medical image identification or histopathology slide image detection where disease categories are known. Supervised learning models are trained on annotated data based on the category to which they belong. Several supervised learning approaches are being studied in head and neck cancer diagnoses such as decision trees, random forest, K-nearest neighbor, Bayesian classifier, linear discriminate analysis, and support vector machines to name a few.[10–14] On the other hand, unsupervised learning shines in situations where the goal of training an algorithm is to discover underlying patterns or structures within the data without explicitly defined categories.[8] In oral medicine, unsupervised learning techniques can be applied to tasks such as clustering similar patient profiles based on their medical histories or grouping similar patterns in dental images without predefined labels. For instance, unsupervised learning algorithms can identify clusters of patients with similar risk factors, history, and lesion presentation.[15] The most used unsupervised learning methods are Otsu and Watershed (for image segmentation into two or more classes) and Clustering (e.g., K-mean and agglomerative hierarchical clustering).[16]

The prowess of these models in oral pathology diagnosis is becoming increasingly prevalent in oral medicine literature with a recent systematic review showing that about 22% of classification machine learning papers in dentistry are related to oral medicine and pathology.[17] Camalan et al.[18] validated a method of classifying clinical photographs of oral epithelial dysplasia using an Inception-Resnet-V2 model with an accuracy of up to 90.9%. Tanriver et al.[19] used image segmentation (instance and semantic), object detection, and classification experiments using a range of deep learning models such as U-Net, Mask R-CNN, and DenseNet-161 to successfully identify benign oral lesions, oral squamous cell carcinoma, and oral potentially malignant disorders such as leukoplakia, erythroplakia, and submucous fibrosis. Shamin et al.[20] recently developed a ResNet50 deep learning model that demonstrated the capability to differentiate among five varieties of tongue lesions, specifically: hairy tongue, fissured tongue, geographic tongue, strawberry tongue, and oral hairy leukoplakia, with an impressive average classification accuracy of 0.97. Jubair et al.[21] also developed their own version of the EfficientNet-B0 model to detect benign and malignant lesions or oral cancer using clinical images with an accuracy of 85%. As AI models are being integrated into clinical diagnosis software packages such as MeMoSA® and MouthMap™, education and training in using such technological advancements along with ongoing professional development would be an important goal for oral medicine and pathology professionals.[22,23]

Despite AI models being exceptionally powerful and quick, they come with a few drawbacks. Interpretability is a major concern with several large-scale models such as modern CNNs. They are often treated as black boxes since their exact mechanisms are often lost within the complexity of these models. Extracting meaningful insights as to how these models reach their decisions is challenging.[8] Another consideration is the ethical implications of creating certain AI models since there are concerns regarding deception, manipulation, or coercion which could adversely affect human autonomy.[24] To account for this 11 ethical principles have recently been suggested, which need to be kept in mind when designing AI models such as diversity, transparency, wellness, privacy protection, solidarity, equity, prudence, law and governance, sustainable development, accountability, and responsibility, respect of autonomy and decision-making.[25] Challenges in AI research within oral medicine stem from issues like small training datasets, unclear data generation processes, and ambiguous data annotation strategies, alongside uncertainties in model selection and validation methods. The ITU/WHO Focus Group on Artificial Intelligence for Health (FG-AI4H) has suggested a checklist for authors and reviewers for AI publications in dentistry to attempt to account for such issues.[26]

The transformative potential of AI in oral pathology and medicine is profound, promising enhanced diagnostic accuracy, personalized treatment plans, and streamlined patient care. Looking ahead, the ongoing evolution of AI in this field holds the potential for even greater advancements, including novel diagnostic tools, more efficient workflows, and improved patient outcomes through integrated AI-driven solutions.

CONFLICT OF INTEREST STATEMENT

The author declares no conflicts of interest.

PEER REVIEW

The peer review history for this article is available at https://www.webofscience.com/api/gateway/wos/peer-review/10.1111/jop.13534.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Rishi Sanjay Ramani

Oral Medicine and Oral Cancer (OMOC) Group, Melbourne Dental School, University of Melbourne, Melbourne, Victoria, Australia

Correspondence

Rishi Sanjay Ramani, Oral Medicine and Oral Cancer (OMOC) Group, Melbourne Dental School, University of Melbourne, Melbourne, VIC, Australia.
Email: rramani@student.unimelb.edu.au

ORCID

Rishi Sanjay Ramani https://orcid.org/0000-0002-3924-2133

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