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Artificial Intelligence as a Diagnostic Decision Support System for Oral Lesions: An Observational Study

Salma M. Mohamed Mohy El-Din [a*], Ahmed Kaboudan [b], Sameh Talaat [c], Hagar M. Zayed [d], Suzan Seif Allah Ibrahim [e]

[a] Demonstrator at the Department of Oral Medicine, Oral Diagnosis and Periodontology, Faculty of Dentistry, Ain Shams University, Egypt*

[b] Professor at the Department of Oral Medicine, Oral Diagnosis and Periodontology, Faculty of Dentistry, Ain Shams University, Egypt

[c] Lecturer of Orthodontics, Faculty of Dentistry, Future University. Research Associate, Department of Oral Technology, University of Bonn, Germany

[d] Lecturer at the Department of Oral Medicine, Oral Diagnosis and Periodontolog, Faculty of Dentistry, Ain Shams University, Egypt

[e] Head and Professor of Oral Medicine, Periodontology and Oral Diagnosis, Faculty of Dentistry, Ain sham University, Egypt

Dean of Faculty of Oral and Dental Medicine, Nahda University, Egypt

Abstract

Early detection of oral lesions is a crucial factor in improving treatment outcomes and ensuring a better prognosis for patients. Identifying these conditions at an initial stage can reduce the risk of progression into advanced or malignant forms that significantly affect quality of life and survival. However, one of the main challenges lies in the limited knowledge and clinical experience of some general practitioners when diagnosing oral lesions. Inaccurate interpretation, false diagnosis, or inappropriate treatment can delay proper management, allowing the lesion to advance into a cancerous stage, which requires more complex interventions and has poorer outcomes. With the growing integration of technology in healthcare, artificial intelligence (AI) has emerged as a powerful tool in both medicine and dentistry. AI has been successfully applied in several diagnostic fields, demonstrating its ability to improve accuracy, efficiency, and cost-effectiveness. Building on these achievements, this study aims to develop a simple and accessible AI-based diagnostic tool that assists general practitioners in the preliminary recognition of oral mucosal lesions. The proposed tool functions using only a clinical photograph, making it highly practical in everyday practice, particularly in settings where advanced diagnostic equipment is unavailable. The implementation of such AI-assisted systems can help reduce diagnostic errors, support clinical decision-making, and promote earlier interventions. By bridging the gap between specialist expertise and general practice, this approach has the potential to improve diagnostic confidence, enhance patient care, and contribute to better oral health outcomes on a broader scale.

Keywords: Dentistry, Diagnosis, Artificial intelligence, oral mucosal lesions.

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1. Introduction

The AI is defined as the theory and development of computer systems able to perform tasks that normally require human intelligence. AI can be divided into traditional machine learning (ML) and deep learning. Traditional ML uses algorithms and computer processes to calculate information and recognize input data patterns to offer a quantified diagnostic result. Deep learning or neural networks are techniques comprising of nonlinear processing units with multiple layers to learn and understand input and associate. output with the relevant input [1]. Fig.1, The evidence supporting the oral diagnosis of oral lesions using AI according to clinical images are scarce and limited. Having a model that can diagnose in real time with a simple image in real- time is advantageous, as it can be used to guide the healthcare professionals in making a more accurate diagnosis. These tools can support those dentists who work and perform activities in rural areas where access to a specialist is difficult and complicated [2].

2. Different Oral mucosal lesions and their clinical pictures

The prevalence of Oral mucosal lesions (OMLs) are the third-most common oral pathology after caries and periodontal diseases with variable clinical appearance of each lesion, this leads to some difficulties for a human mind to remember all clinical features for each lesion such as Oral lichen planus, Oral squamous cell carcinoma, Oral irritational fibroma and oral racial pigmentation [3]. OLP is a chronic inflammatory condition that primarily affects the oral mucosa but may also involve the skin, nails, and genital mucosa. It can manifest in several clinical forms, including reticular, erosive, atrophic, and plaque-like variants. The hallmark of OLP is the presence of white, lacy striations (Wickham's striae) [4]. Oral Squamous Cell Carcinoma (OSCC) is the most common oral malignancy and contributes to one of important causes of mortality in human beings. The following table shows clinical features of this lesion [5]. Table 1 Oral irritational fibroma is a benign, firm, slow-growing lesion that commonly arises due to chronic irritation or trauma.

It often appears on the buccal mucosa, gingiva, tongue, or lips and is typically asymptomatic, although it can cause discomfort if repeatedly injured, they are typically small, firm, and painless nodules that can vary in size. They often present as a well-demarcated mass with a smooth surface and normal mucosal coloration, although they can sometimes appear pink or slightly reddish due to vascularization [6]. Oral Racial Pigmentation refers to the pigmentation variations in the oral mucosa that correlate with ethnicity, especially in individuals with darker skin tones. It is usually benign but can sometimes indicate underlying pathology such as melanocytic lesions or systemic diseases. The pigmentation is usually symmetrical, appearing as flat spots or patches ranging from brown to black on the mucosal surfaces, with the gingiva being the most commonly affected area. The color can vary from light brown to dark black [7].

3. Different techniques of diagnosis of oral lesions

Several cases with oral lesions are being misdiagnosed or even missed due to the limited tools for reaching the proper diagnosis such as: [8-10], Fig.3.

4. Applications of artificial intelligence in dentistry

4.1. Medical-Aided Diagnosis

It relies on a clinician's ability to analyze symptoms, diagnostic test results, and other relevant factors, but this process can be influenced by clinician's imperfect memory and cognitive biases. However, when artificial intelligence (AI) is trained on vast datasets, encompassing hundreds of thousands of cases, it can outperform even the most experienced specialists in clinical decision-making [11].

4.2. Oral and Maxillofacial Surgery

Machine learning have been explored for their potential in identifying various oral and maxillofacial conditions, such as cysts, benign tumors, oral cancer, and lymph node metastasis [12].

4.3. Cariology and Endodontics

DL has successfully segmented CBCT voxels into categories such as "lesion," "tooth structure," "bone," "restorative materials," and "background," with results that are comparable to those of clinicians when diagnosing periapical lesions [13].

4.4. Dental Implantology

AI has been implemented as a substitute for traditional technology to predict the mechanical performance of bioimplant systems, reducing the high computational costs associated with optimizing implant design variables [14].

4.5. Periodontics

AI-based classifiershave proven effective in distinguishing between aggressive and chronic periodontitis. Beyond enhancing our understanding of periodontitis, AI acts as a valuable tool for integrating conventional clinical indicators with immunologic and microbiological parameters, advancing periodontal diagnosis [15].

4.6. Oral Lesion Diagnosis

a. Detection and Classification of Oral Lesions AI systems are being trained to identify and categorize oral lesions using visual data from clinical photographs or radiographs.

b. Radiographic Analysis

AI has transformed the interpretation of radiographs, including panoramic X-rays, cone-beam computed tomography (CBCT), and digital intraoral radiographs [16].

c. Histopathological Analysis

AI-enhanced histopathological analysis is emerging as a valuable tool for diagnosing oral lesions. Digital pathology combined with machine learning allows pathologists to examine histological slides more precisely [17] Fig, 2. Table 1, Table 2.

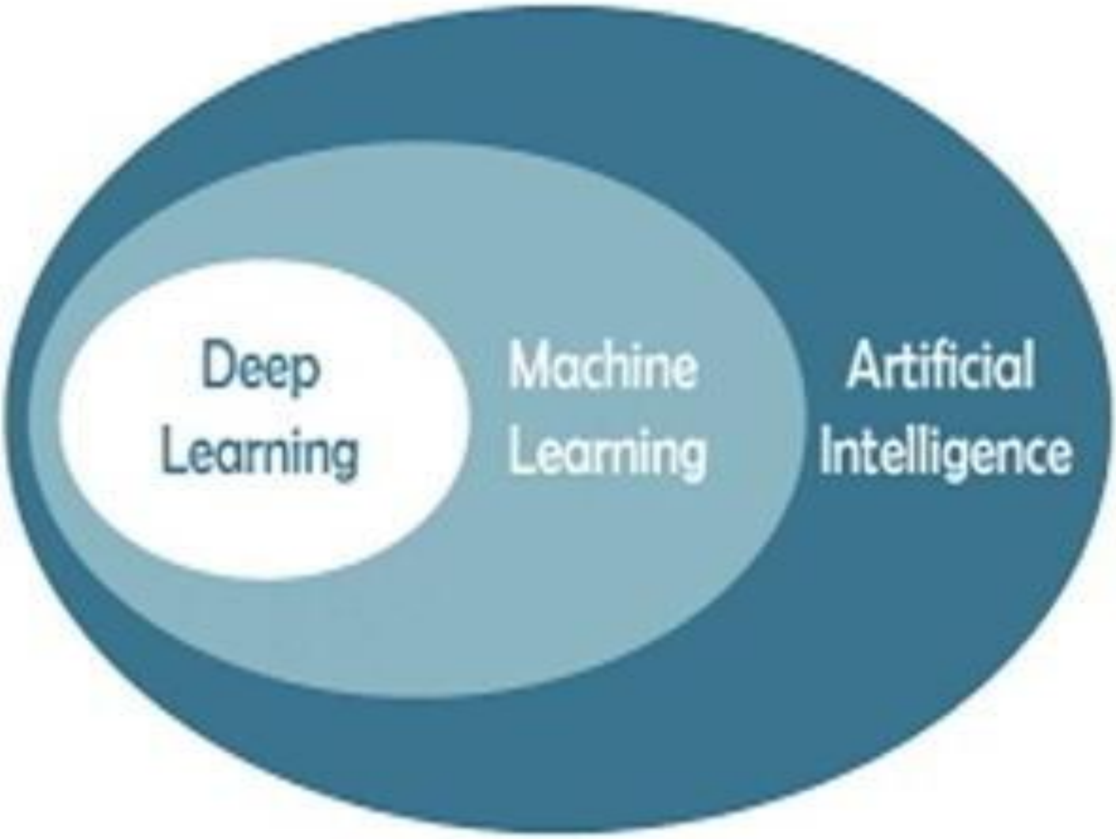

Fig.1. Showing the nested relationship between core AI domains.

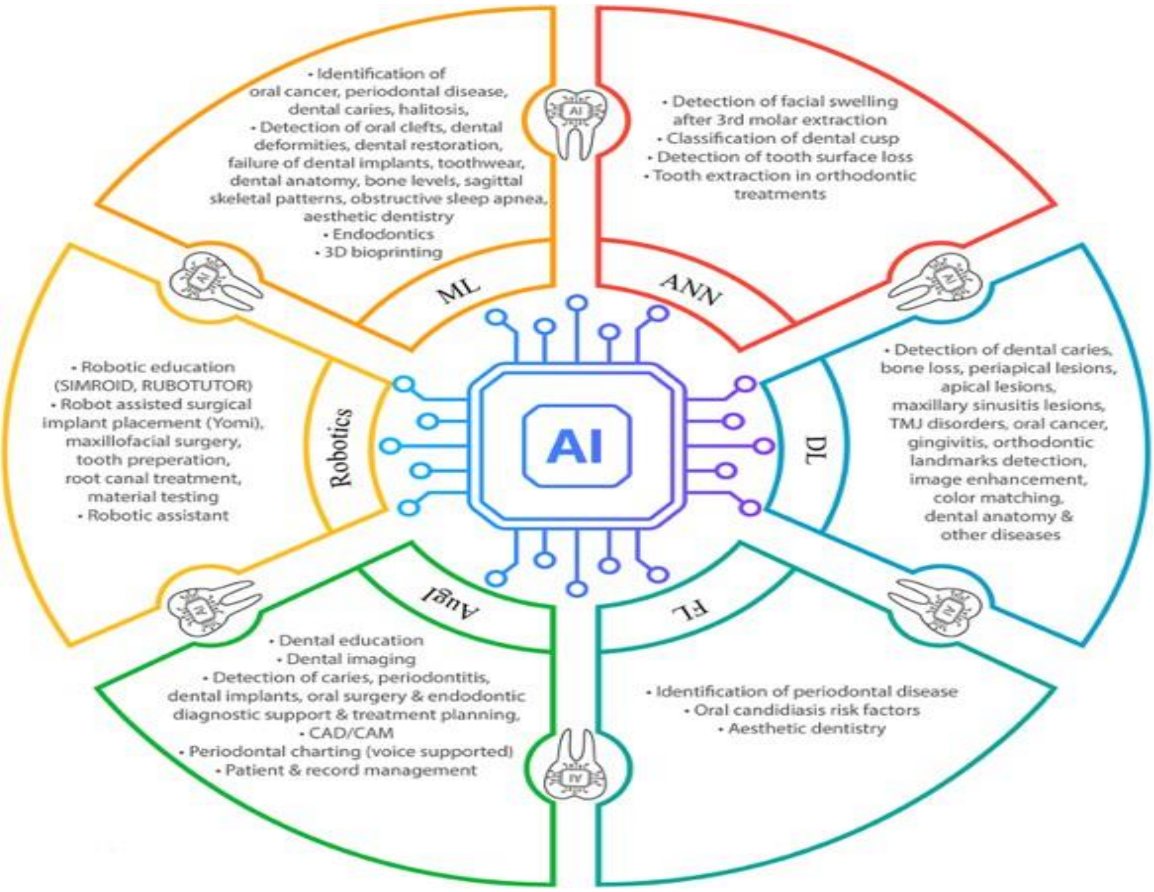

Fig.2. Applications of AI in dentistry (infographic) [17].

o Non healing ulcer with or without induration/nonhealing socket.

o White patch with firm consistency.

o Red lesion or lesion with erythematous appearance (Erthroplasia).

o Abnormal lump in the mouth wuth increase in size.

o Exophytic/ulceroproliferative growth.

o Mass or lump in the neck and neighbouring regions (Lymph node Enlargement).

o Mobility/displacement/non vital teeth/peri implantitis.

o Tooth pain and refrral pain.

o Bleeding from the mouth (hemorrhage).

Fig.3. Potential warning signs/symptoms of the oral cancer

Table 1. Summary of Different techniques of diagnosis of oral lesions.

Diagnostic Tool	Advantages	Drawbacks
Vital tissue staining	Helps identify the most appropriate site for biopsy	Not sufficient on its own for a definitive diagnosis
Exfoliative cytology	—	Effectiveness and reliability remain debated. The limitations are primarily due to the inability of cytology instruments to sample deeper layers of the oral lesion and a higher incidence of false negatives.
Vizilite and Veloscope	Using them alongside a conventional screening examination for lesions that appear clinically harmless has not proven effective in detecting dysplasia or cancer.	Further clinical studies are required before these devices can be recommended. Additionally, the high cost of purchasing the device is a significant drawback.
Oral biopsy	Is the best method for proper diagnosis.	However, there is ongoing debate, as this method requires specialized expertise for optimal biopsy collection and accurate histopathological diagnosis. Additionally, concerns about surgery and postoperative pain often make patients hesitant to apply for this approach.

Table 2. Summary of studies examining the use of artificial intelligence in dentistry [1].

Study	Algorithm Used	Study Factor	Modality	Number of Input Data	Performance	Comparison	Outcome
Aubreville et al. (2017)	CNN	Oral squamous cell carcinoma	Confocal laser endomicroscopy (CLE) images	7894	AUC 0.96; Mean accuracy sensitivity 86.6%; specificity 90%	Not clear	This method seemed better than the state-of-the-art CLE recognition system
Uthoff et al. (2018)	CNN	Precancerous and cancerous lesions	Autofluorescence and white light imaging	170	Sensitivity, specificity, positive, and negative predictive values ranging from 81.25 to 94.94%	None	The proposed model is a low-cost, portable, and easy-to-use system
Devito et al. (2008)	ANN	Proximal caries	Bitewing radiograph	160	ROC curve area of 0.884	25 examiners	ANN could improve the performance of diagnosing proximal caries
Ozden et al. (2015)	ANN	Periodontal disease	Risk factors, periodontal data, and radiographic bone loss	150	Performance of SVM & DT was 98%; ANN was 46%	SVM & DT	SVM and DT showed good performance in the classification of periodontal disease while ANN had the worst performance
Orhan et al. (2021)	ML	Temporomandibular disorders	Magnetic resonance imaging	214	The performance accuracy for condylar changes and disk displacement are 0.77 and 0.74	Logistic regression (LR), random forest (RF), decision tree (DT), k-nearest neighbors (KNN), XGBoost, and support vector machine (SVM)	The proposed model using KNN and RF was found to be optimal for predicting TMJ pathologies

5. Conclusions

Understanding the model is not only a research objective; it allows the practitioner to be guided in his clinical thinking, to identify variables of high importance and, therefore, optimize the diagnosis of lesions.

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