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Maria Clara Amorim Carvalho *

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Review Article

From Pixel to Diagnosis: Artificial Intelligence in the Recognition of Oral Mucosal Lesions Evidence, Accuracy, and Clinical Challenges

Maria Clara Amorim Carvalho [1]*, Victor Brenno Soares Alves [1], Rubia Hellen Nascimento Aires [1], Augusto Machado de Siqueira [2], Raquel Carvalho de Aguiar [3], Kelly Santos Rocha [3], Thiago Henrique Gonçalves Moreira [2]

[1]Academic League of Trauma, Emergencies and Intensive Care (LATECI), Faculty of Medicine, Federal University of Amazonas (UFAM), Manaus, Amazonas, Brazil.

[2]Department of Surgery, Faculty of Medicine, Federal University of Amazonas (UFAM), Manaus, Amazonas, Brazil.

[3]Faculty of Medicine, Federal University of Amazonas (UFAM), Manaus, Amazonas, Brazil.

***Corresponding Author:** Maria Clara Amorim Carvalho, Academic League of Trauma, Emergencies and Intensive Care (LATECI), Faculty of Medicine, Federal University of Amazonas (UFAM), Manaus, Amazonas, Brazil.

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Abstract:

The incorporation of artificial intelligence (AI) in the area of stomatology has promoted significant transformations in diagnostic methods, especially through the verification of digital images. The present study aims to analyze the scientific evidence on the application of artificial intelligence in the recognition of oral mucosal lesions, evaluating its diagnostic accuracy, clinical potential and the challenges related to its implementation in dental practice. The search engines used to select the articles included Google Scholar, PubMed, Scopus and Web of Science indexers, using the following Portuguese language descriptors: "Artificial Intelligence"; "Deep Learning" "Machine Learning by Representation"; "Oral lesions"; "Oral Neoplasms" and "Diagnosis", combined through the Boolean operators AND and OR, aiming to increase the sensitivity and specificity of the research strategy. The results show that AI systems have a high capacity for pattern recognition, with accuracy similar to or superior to conventional methods, favoring early screening and diagnostic standardization. However, limitations related to data quality, algorithmic biases, clinical validation, and ethical aspects still restrict its wide application. Thus, AI is a promising complementary tool in the diagnosis of oral mucosal lesions, acting as a support to the dentist and requiring further research to increase its clinical reliability.

Key words: artificial intelligence; oral diagnosis; lesions of the oral mucosa; deep learning; digital dentistry

Introduction

Artificial intelligence (AI) has emerged as one of the main technological milestones of the twenty-first century, consolidating itself over the years as a crucial tool for data analysis and its application in various scientific fields. In the health area, for example, the development of algorithms capable of processing large volumes of data has contributed to enhancing diagnostic capacity and assisting professionals in clinical interpretation, promoting greater accuracy, efficiency, agility, and support for evidence-based decision-making (SILVA et al., 2024).

Parallel to this, this advance is directly related to the growing digitalization of health systems and the massive availability of biomedical data, thus contributing to the development of computational models capable of recognizing increasingly complex patterns and being able to predict clinical outcomes more quickly. In this way, AI has come to occupy a strategic role in the contemporary health area, helping not only in the diagnosis, but also in the monitoring and prevention of diseases through the automated analysis of clinical and epidemiological information (OLIVEIRA; SANTOS, 2023).

In the field of diagnostic imaging, deep learning techniques have gained prominence for transforming digital images into structured sets of analyzable data. In this process, each image is composed of pixels, minimal units that store information on color, intensity, and texture, allowing artificial neural networks to detect visual patterns associated with pathological changes. Recent studies demonstrate that these systems can achieve high levels of accuracy in disease detection, consolidating computer vision as a complementary tool to human evaluation (COSTA et al., 2024).

However, despite the strategic potential, the clinical incorporation of AI still involves challenges related to scientific validation, algorithmic transparency, and practical implementation in healthcare services. The need for consistent evidence is particularly pertinent, especially relevant in areas on the rise, such as dentistry, in which the automated identification of oral mucosal lesions emerges as an innovative strategy to expand early screening, reduce diagnostic failures, and strengthen clinical practice through the integration of technology and scientific evidence (FERREIRA et al., 2024).

This study aims to conduct a literature review on the application of artificial intelligence in the recognition of oral mucosal lesions, investigating its fundamentals based on the computational analysis of digital images, the diagnostic accuracy reported in the literature and the clinical challenges associated with the incorporation of these technologies in dental practice.

Methodology

The PubMed/MEDLINE, Scopus, Web of Science and Google Scholar indexes were used as search engines, using descriptors from the Portuguese language: "Artificial Intelligence", "Machine Learning", "Deep Learning", "Oral Lesions", "Oral Neoplasms" and "Diagnosis", and from the English language: "artificial intelligence"; "deep learning" and "machine learning" combined by the Boolean operators AND and OR. Only articles published in the last five years (2021–2026) were included. After removing duplicates and screening titles and abstracts, 23 studies were evaluated in full text, of which 10 were excluded because they did not meet the inclusion criteria or were out of scope. The inclusion criteria considered original studies and systematic reviews on artificial intelligence applied to the diagnosis of oral lesions; Editorials, opinion reports, duplicates, and studies without clinical or methodological relevance were excluded. In the end, 12 articles were included and analyzed regarding methodology, clinical relevance and scientific evidence.

Literature Review

Artificial intelligence has emerged as an innovative tool in the diagnosis of oral mucosal lesions, providing subsidies for the identification and classification of potentially malignant alterations and collaborating for greater diagnostic accuracy. However, its clinical application still faces some challenges related to the validation of systems and safe integration into dental practice, requiring additional methodological and scientific advances (WARNAKULASURIYA; KERR, 2022).

According to Hajibagheri et al. (2025), the application of artificial intelligence-based language models, such as ChatGPT-4, has shown promising performance in the diagnostic identification of oral lesions based on textual clinical descriptions. In the research, the model was evaluated through the resolution of multiple-choice clinical questions previously validated by specialists, showing assertiveness in the interpretation of signs and symptoms and in the elaboration of differential diagnostic reasoning. However, the authors emphasize that the tool does not replace direct clinical evaluation, since it depends exclusively on the information provided and does not perform physical examination, and should be established only as a complementary resource aimed mainly at educational support and aid in clinical decision-making, and not as a definitive diagnostic method.

In parallel to this, a study conducted by Tiryaki et al. (2024) found that deep learning models such as ResNet, VGG, and GoogLeNet, can act as a tool for classifying different types of lingual lesions, providing high diagnostic accuracy. The results indicate that the application of artificial intelligence can reduce the subjectivity of traditional clinical assessment, expanding the potential of automated screening in stomatology.

In this scenario, artificial intelligence has contributed to the early diagnosis of oral cancer through the automated analysis of clinical and histopathological images, through the use of deep learning architectures and artificial neural systems, thus allowing the identification of patterns associated with malignant lesions with high sensitivity and specificity. (SANTOS; BESERRA, 2025).

As described by Gomes et al. (2023), AI-based technologies have shown great potential in stomatology through the use of convolutional neural networks (CNN) capable of automatically classifying elementary lesions of the oral mucosa from clinical images, evidencing an agile and safe approach to initial screening based on the recognition of the different morphological patterns addressed.

In line with the elucidated data, it is also worth noting that artificial intelligence encompasses different computational approaches. In this sense, there are important differences between machine learning and deep learning in the diagnosis of oral cancer, especially regarding information processing and model performance. Machine learning generally relies on the researcher's prior selection of image characteristics or clinical data, which can limit the system's analytical capacity. On the other hand, deep learning, based on deep neural networks, automatically extracts patterns directly from the raw data, allowing the identification of more complex and subtle characteristics of the lesions. (AL-RAWI et al., 2022).

Artificial intelligence models based on natural language processing have demonstrated relevant performance in the formulation of differential diagnoses from simulated clinical cases, evidencing the ability of these systems to interpret signs and symptoms described in textual language, during anamnesis and organize diagnostic hypotheses in a coherent and skillful way. (HUH, 2023).

In this scenario, despite the advancement of artificial intelligence in the diagnosis of oral mucosal diseases, it is possible to perceive important limitations related mainly to the dependence on the quality and diversity of the databases used to train the algorithms, which can compromise the generalization of the results in different clinical populations. In addition, it is also notorious that variations in the conditions of image capture, differences between equipment, and lack of methodological standardization can negatively influence the performance of the models, generating a risk of diagnostic biases (ANDRZEJCZAK et al., 2026).

Results And Discussion

The analysis of the studies presented in Table 1 showed significant advances in the application of artificial intelligence in the recognition of oral mucosal lesions, especially in improving early diagnosis and supporting clinical decision-making. The recent development of machine learning and deep learning techniques has demonstrated a consistent increase in diagnostic sensitivity and a greater ability to differentiate between benign and malignant lesions, mainly through the automated analysis of intraoral images and digital clinical data (AL-RAWI et al., 2022; ROKHSHAD et al., 2024).

Contemporary reviews have highlighted that convolutional neural networks have enabled pixel-by-pixel analyses of clinical images, favoring greater diagnostic accuracy and contributing to the standardization of visual evaluation, traditionally dependent on the examiner's individual experience (BMC MEDICAL IMAGING, 2024; ANDRZEJCZAK et al., 2026). At the same time, applications based on natural language processing have expanded the scope of artificial intelligence by demonstrating the ability to assist in clinical reasoning and the formulation of differential diagnoses, evidencing the growing integration between computer systems and dental practice (HUH, 2023).

In the clinical context, the studies also indicated the potential of artificial intelligence for personalizing therapeutic planning, longitudinal monitoring, and organization of scientific data, reinforcing its role as a complementary tool to the dental surgeon (OSSOWSKA et al., 2023; AGUIAR, 2025). However, despite the promising diagnostic performance consistently reported, limitations persist related to the heterogeneity of the databases, lack of methodological standardization,

and the need for multicenter clinical validations before the definitive incorporation of these technologies into the care routine (DIAGNOSTICS, 2026; BMC ORAL HEALTH, 2025). Thus, recent literature converges in indicating that artificial intelligence acts as a support system capable of increasing diagnostic accuracy and reducing interpretative biases, without replacing professional clinical judgment (SILVA et al., 2022).

Author/Year	Country	Type of study	Application of AI	Database / Methods	Conclusion
Al-Rawi et al., 2022	United Kingdom	Narrative review	Diagnosis of oral cancer	Machine learning and neural networks applied to clinical imaging	It showed that AI increased diagnostic sensitivity and helped in the early detection of oral malignant lesions.
Silva et al., 2022	Brazil	Integrative review	Early diagnosis of mouth cancer	Automated clinical image analysis and literature review	It indicated that AI favored the early identification of potentially malignant lesions and aided the diagnostic process.
Huh, 2023	South Korea	Experimental study	AI-assisted diagnostic reasoning	Natural language processing applied to simulated clinical cases	It demonstrated that AI systems correctly included differential diagnoses in most of the simulated clinical analyses.
Ossowska et al., 2023	Poland	Literature review	AI-based dental diagnosis	Machine learning applied to clinical images and digital data	It concluded that AI showed potential for diagnostic personalization and dental therapeutic planning.
Rokhshad et al., 2024	Iran	Systematic review	Classification of oral mucosal lesions	Deep learning applied to intraoral photography	It demonstrated that AI algorithms achieved high diagnostic accuracy in differentiating
					between benign and malignant lesions.
BMC Medical Imaging, 2024	International	Systematic review	Automated Injury Recognition	Convolutional neural networks with pixel-by-pixel analysis	It showed that deep learning models improved diagnostic accuracy in the analysis of medical images.
Aguiar, 2025	Brazil	Narrative review	Monitoring and diagnosis of oral changes	AI-assisted literature review	He indicated that AI contributed to scientific organization and support for the clinical follow-up of patients at risk.
BMC Oral Health, 2025	International	Systematic review	Automated Dental Diagnosis	Deep learning applied to clinical imaging	It demonstrated that AI showed high diagnostic performance and potential future clinical application.
Andrzejczak et al., 2026	Poland	Systematic review	Diagnosis of oral mucosal diseases	Machine learning and deep learning in digital clinical imaging	It concluded that AI showed promising diagnostic performance, but dependent on additional clinical validation and methodological standardization.

Table 1: Summary of the included studies on the application of artificial intelligence in the recognition of oral mucosal lesions

Table 2 shows that artificial intelligence has had relevant clinical advantages in the recognition of oral mucosal lesions, especially due to the high capacity for image analysis, speed in data processing, and potential increase in diagnostic accuracy, contributing not only to early screening, but also to the standardization of clinical evaluations. However, the limitations observed included dependence on large and well-labeled databases, the possibility of algorithmic biases, the need for validation in real clinical scenarios, and difficulties related to the interpretation of the models by health professionals. In this way, the studies analyzed converged in indicating that AI should be understood as a complementary tool to clinical judgment, whose effectiveness depends on the integration between technology, professional training, and robust scientific evidence (SANTOS et al., 2022; SILVA et al., 2023; LI et al., 2024; OLIVEIRA et al., 2023; FERREIRA et al., 2025).

The flowchart shown in (Figure 1) exposes in a summarized way the process of applying artificial intelligence in the recognition of oral mucosal lesions, which begins with the acquisition of clinical images, followed by algorithmic processing and ends with diagnostic support. It is observed that the integration between computational analysis and clinical evaluation contributed to greater diagnostic standardization and potential increase in the early detection of potentially malignant lesions. However, limitations remain related to the quality of databases, the need for expanded clinical validation, and the dependence on professional interpretation, reinforcing the role of AI as an auxiliary tool for dental surgeons and not as a substitute for face-to-face assessment and clinical decision (SANTOS et al., 2022; SILVA et al., 2023; LI et al., 2024; OLIVEIRA et al., 2023; COSTA et al., 2020; FERREIRA et al., 2025).

Analyzed Appearance	Clinical advantages of AI	Clinical limitations of AI
Diagnostic performance	It increased sensitivity and accuracy in the identification of potentially malignant lesions and early oral cancer.	It may present performance variations depending on the quality and diversity of the database used.
Clinical image analysis	It allowed pixel-by-pixel evaluation and recognition of patterns imperceptible to the human eye.	Susceptible to errors when images have poor patterning, inadequate lighting, or visual noise.
Diagnostic standardization	It reduced inter-rater variability and helped less experienced professionals.	It still lacks universal protocols and broad clinical validation.
Clinical Decision Support	It assisted in the formulation of differential diagnoses and prioritization of suspected cases.	It does not replace clinical judgment and can generate technological dependence if used alone.
Clinical applicability	It favored screening, teledentistry and longitudinal monitoring of patients.	Limited integration into actual clinical flows and need for technological infrastructure.
Continuous learning	Systems improved performance as the volume of data analyzed increased.	Possibility of algorithmic bias when trained with non-representative samples.
Time and clinical efficiency	Optimized diagnostic time and assisted in prioritizing care.	It requires professional training and adaptation to technology.
Implementation in health	Potential to expand access to diagnosis in regions with few specialists.	Ethical, regulatory, and legal barriers still developing.

Table 2: Comparison between the clinical advantages and clinical limitations of artificial intelligence applied to the recognition of oral cavity lesions

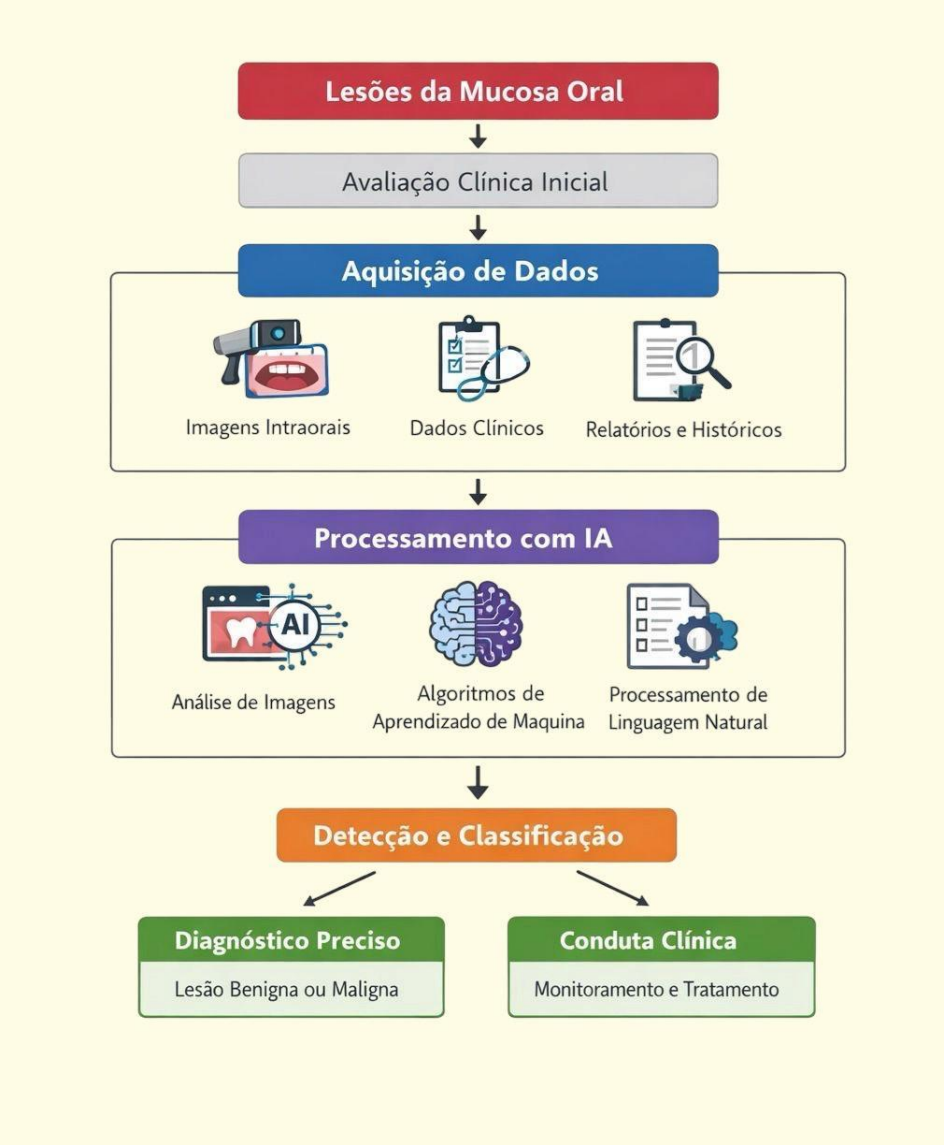

Figure 1: Flowchart representative of the process of applying artificial intelligence in the recognition of oral mucosal lesions, from the acquisition of clinical images, algorithmic processing and analysis by machine learning models, to the support of diagnostic decision-making by the dentist.

Final Considerations

The present literature review found through the synthesis of the information mentioned above that artificial intelligence, by transforming information from the pixel to the clinical diagnosis, has high potential as an auxiliary tool in the recognition of lesions of the oral mucosa, contributing to greater diagnostic accuracy, standardization of clinical opinions and early detection of potentially malignant alterations. However, its application still faces obstacles since it depends directly on expanded clinical validation, methodological standardization and integration into professional judgment, thus consolidating itself as a complementary resource — and not a substitute — for dental practice.

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