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The Current State of Clinical Diagnostic Algorithms for Mucosal Oral Lesions: A Scoping Review

Mohammed Al-Shehri[1] | Theerthika Dillibabu[1] | Belinda Nicolau[1] | Marco Magalhaes[2] | Nicholas Makhoul[3] | Faleh Tamimi[4] | Peter Chauvin[1] | Sreenath Madathil[1]

[1]Faculty of Dental Medicine and Oral Health Sciences, McGill University, Montréal, Quebec, Canada | [2]Oral Pathology and Oral Medicine, University of Toronto, Toronto, Ontario, Canada | [3]Montreal General Hospital, Montreal, Quebec, Canada | [4]College of Dental Medicine, QU Health, Qatar University, Doha, Qatar

Correspondence: Sreenath Madathil (sreenath.madathil@mcgill.ca)

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ABSTRACT

Background: Diagnosing oral lesions remains challenging for many dentists. Despite the availability of diagnostic algorithms, there is a dearth of comprehensive evidence synthesis and a discussion on their clinical and pedagogical applicability.

Methods: A scoping review was conducted to identify: (1) algorithms or flow diagrams that help clinicians to diagnose oral lesions in a clinical setting without additional software; (2) publications in English; (3) all age groups; (4) algorithms for oral lesions of soft tissue only. We excluded those that are: (1) black-box; (2) required additional tests; (3) older versions; (4) for non-mucosal lesions, and (5) intended for self-screening. A keyword and MeSH term search was performed across three peer-reviewed publication databases and gray literature.

Results: Seventeen algorithms from 15 peer-reviewed manuscripts and 1 online course were identified. Most studies did not mention how the algorithms were developed, and none had been validated in a clinical setting. The algorithms often focused on one or two types of lesions and were incomplete in differential diagnoses.

Conclusion: Few clinical diagnostic algorithms for oral lesions are available in the literature. Notably, there are no validated and comprehensive clinical diagnostic algorithms for oral mucosal lesions.

1 | Introduction

Globally, an estimated 3.5 million people are affected by oral diseases (Oral Health 2024). Oral health issues can significantly affect a person's quality of life by compromising their ability to eat and influencing their emotional well-being (Yang et al. 2018). Delayed diagnosis and improper management of oral and maxillofacial lesions can lead to substantial distress among patients (Villa et al. 2015). Studies indicate that patients may consult as many as four different specialists before ultimately being referred to an oral medicine specialist, resulting in a clinical diagnosis delay of about 16.8 months (Friesen et al. 2019).

Among these oral lesions, oral cancer (OC) presents a significant challenge in clinical practice due to their diverse manifestations and potential for malignant transformation (Gutmacher et al. 2016). OC remains a significant global issue, with more than 377,000 newly diagnosed cases and 177,000 deaths occurring annually worldwide (Sung et al. 2021). The high mortality, morbidity, and cost of treatment associated with OC place a

substantial burden on individuals and society as a whole. While 5-year survival rates for OC are approximately 60%, early-stage diagnosis can increase survival rates to over 80% (Silverman et al. 2010). Unfortunately, OC is often diagnosed in advanced stages, leading to poor prognosis and increased mortality rates (Hadzic et al. 2017). Evidence suggests that many dentists report a lack of knowledge in diagnosing oral lesions. This may be attributed to improper training related to the overwhelming number of oral lesions (Gigliotti et al. 2019; Cleveland and Thornton-Evans 2012). Many oral lesions, including precancerous and cancerous lesion cases, are diverse and initially manifest as abnormalities in the oral mucosa (an oral lesion) that later undergo malignant transformation (Allen and Farah 2015). Clinical examination remains the main method for evaluating patients with oral lesions, but the overlapping features of various lesions make diagnosis challenging. To address this challenge, simple rule-based clinical diagnostic flowcharts or algorithms have been developed and have been routinely used for pedagogical purposes.

Clinical algorithms are flowcharts representing a sequence of clinical decisions that guide the physician in decision-making regarding the diagnosis and management of patients (Margolis 1983). They provide a concise approach for clinicians, facilitating the initial diagnosis process. These algorithms have shown success in healthcare by saving time and thus improving efficiency (Margolis 1983; Ambrose et al. 1989).

Although several algorithms have been developed, many are based on statistical or machine learning models or require histopathological assessment, which may have lower chairside utility. Also, limited evidence exists on their quality and applicability in clinical and pedagogical settings. Furthermore, a comprehensive review and collation of all the current clinical algorithms for diagnosing oral mucosal lesions is needed to aid in documenting the knowledge gaps.

Therefore, this scoping review was conducted with two aims: (1) identify and map the literature on clinical diagnostic algorithms for oral lesions; and (2) identify gaps in knowledge in this area.

2 | Methods

Following Arksey and O'Malley's framework for conducting scoping reviews (Arksey and O'Malley 2005), we assembled a research team of epidemiology and research synthesis experts, graduate students, a librarian, and oral pathologists. Our team engaged in extensive discussions to refine the research question, undergoing multiple iterations until a consensus was reached on the most relevant question that would increase the contribution of the scoping review. We also developed a detailed protocol to guide the review process, and below we provide the details of each phase of the framework.

3 | Research Question

The research question guiding this review was: "What are the clinical diagnostic algorithms to diagnose oral lesions?" Specifically, we included algorithms that are directed toward healthcare practitioners. Additionally, we specifically target usable decision tree-like algorithms that do not require any additional device or software (including Artificial Intelligence-based models) to be implemented in the clinical care pathway.

4 | Identifying Relevant Studies

With the help of a librarian, MA created a systematic scoping search strategy for peer-reviewed literature. An example of this search strategy based on MeSH terms from Ovid Medline is provided in Figure 1. Initially, the strategy was developed using a combination of Medical Subject Headings (MeSH) terms and title/abstract keywords using truncations and included concepts of oral lesions, algorithms, and diagnosis. Later, this search strategy was translated for Embase (via Ovid) and Web of Science. We used the JBI Manual for evidence synthesis (Joanna Briggs Institute 2017) for the gray literature search to ensure that our search captures all relevant information on algorithms. We included ProQuest Dissertations & Theses Global, Gray Literature Report, OpenGrey, Web of Science Conference Proceedings, and Google Scholar as sources for the gray literature search. We also hand-searched unpublished abstracts, textbooks, and websites (e.g., Gray Matters, MedRxiv, EBSCO, etc.). All databases were searched for publications from inception to 27 February 2023. All citations were later imported and deduplicated using Endnote 20 (Team TE (Clarivate), n.d.).

5 | Study Selection

After deduplication, the Endnote library was uploaded to the Rayyan web app (Ouzzani et al. 2016) for screening. Two independent reviewers (M.A. and T.D.) screened all the titles and abstracts. No disagreements were present concerning the included or excluded articles.

We included the full text for manuscripts or items that contained algorithms or flow diagrams that help clinicians diagnose oral lesions in a clinical setting without additional software devices, that were published in English, that included all age groups, and that included algorithms for oral soft tissue lesions only. No restrictions were placed on the year of publication. In addition to those which do not meet the inclusion criteria, we also excluded any articles where algorithms are black-box (do not provide an interpretable or human readable logic for diagnosis, i.e., machine learning-based models), algorithms that require additional tests (e.g., algorithms for histopathologic assessment, laboratory tests), older versions of an algorithm already included, algorithms of oral lesions related to hard tissues such as bone and teeth, and any flow charts or algorithms intended to be used by the general public for self-screening.

6 | Data Extraction

A data extraction table for the retrieved articles was developed into an Excel spreadsheet and reviewed independently and blindly by two reviewers (M.A. and T.D.). The title, author's name, date of publication, journal, peer review, format of publication, type of lesion, algorithm country of origin, algorithm

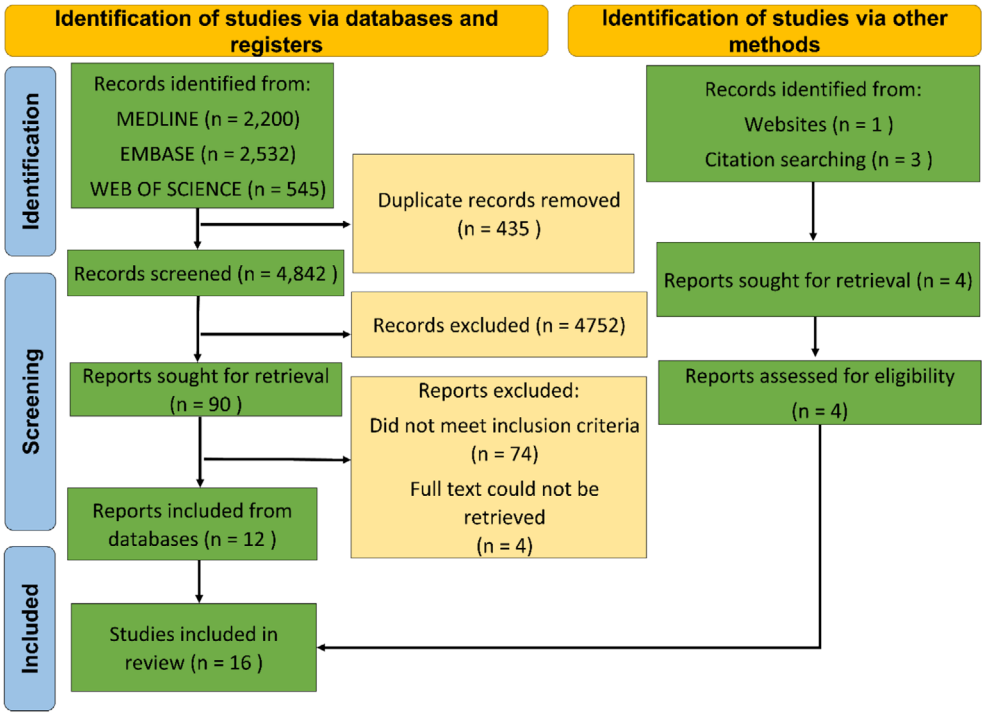

FIGURE 1 | PRISMA flowchart displaying the selection process.

construction, algorithm validity, and if the authors seek any consensus for the algorithms among experts for each full-text article selected were extracted.

7 | Results

Our search resulted in 5277 potentially relevant articles, with 2200, 2532, and 545 articles from Medline (Ovid), Embase (Ovid), and Web of Science, respectively. After removing 435 duplicate articles, we screened a total of 4842 articles. After screening titles and abstracts, we included 90 articles for full-text retrieval. Further detailed screening excluded the majority (77) of these articles for the following reasons: absence of a clinical diagnostic algorithm (72), inability to retrieve the full text (4), and articles written in languages other than English (1) (Figure 1). Although we emailed the authors for the four articles with only the title and abstract, we have not received any responses. Gray literature and searching via other methods resulted in four articles containing algorithms. Overall, our scoping review yielded 17 clinical diagnostic algorithms for oral lesions from 15 peer-reviewed publications and one material for an online course. Table 1 provides an overview of all the included studies.

8 | Algorithms for Diagnosis of Oral Lesions

Our search identified diagnostic algorithms for the following oral lesions: two for exophytic lesions (Mortazavi et al. 2017; Santosh 2015), one for oral immune-mediated disorders (Patil et al. 2023), three for oral pigmented lesions (Kauzman et al. 2004; Müller 2010; Hassona et al. 2016), three for white lesions (Subramanyam 2014; Mortazavi et al. 2019; Mccormick et al. 2016), one for gingival growth or swelling (Subramanyam 2014), one for oral lichen planus (Shavit et al. 2020), one for oral lesions of viral, bacterial, and fungal origin (Guillouet et al. 2022), two for ulcerative lesions and recurrent oral ulcers (Mortazavi et al. 2016; Bilodeau and Lalla 2019), two for desquamative gingivitis and the mucocutaneous diseases associated with it (Lo Russo et al. 2008; Romano et al. 2020), and 1 for oral mucosal lesions in general (Bilodeau and Lalla 2019) as shown in Table 2. There was some overlap noted between different articles for the same lesion (e.g., white lesions, and pigmented lesions).

Most of the studies were from the United States and Iran, with only two studies conducted in Canada. Most of them were published in dental journals except for two (Müller 2010; Hassona et al. 2016) that were published in Dermatology and Pediatric medical journals (Guillouet et al. 2022). Most of the studies focused on adults, except one specifically focusing on children (Guillouet et al. 2022). The oldest algorithm included in our review was by Kauzman et al. (2004), while the most recent algorithm was by Guillouet et al. (2022).

No standard terminology was used across the studies to describe the algorithms. These terminologies included diagnostic algorithm, decision tree, decision-making tree, and diagnostic pathway.

8.1 | Algorithms for Exophytic Lesions

Mortazavi et al. (2017) proposed a decision tree focused explicitly on peripheral exophytic lesions. The algorithm was constructed using information retrieved by searching online databases and authenticated textbooks. They selected

TABLE 1 | Overview of Included Studies.

Title	Authors	Date of publication	Journal	Type of lesion	Country of origin	Algorithm presentation	Algorithm construction
Peripheral Exophytic Oral Lesions: A Clinical Decision Tree	Hamed Mortazavi et al.	July 2017	*International Journale of Dentistry* (Hindawi)	Peripheral oral exophytic lesions	Tehran, Iran	Decision tree	Three textbooks and 78 papers including 13 reviews, 55 case reports or case series, and 10 original articles from different databases
Identification of oral immune disorders—A review and a diagnostic algorithm	Shankargouda Patil et al.	March 2022	*Disease-a-Month* (Elseiver)	Oral immune-mediated disorders	Saudi Arabia/ India/USA	Diagnostic algorithm	No methodology mentioned
Pigmented Lesions of the Oral Cavity: Review, Differential Diagnosis, and Case Presentations	Adel Kauzman et al.	November 2004	*Journal of the Canadian Dental Association*	Pigmented lesions of the oral cavity	Canada	Algorithm	Based on predominant clinical presentations of pigmented lesions and should not be taken as absolute indicator of diagnosis
Proposed clinico-pathological classification for oral exophytic lesions	Arvind Babu Rajendra Santosh et al.	September 2015	*Journal of Clinical and Diagnostic Research*	Oral exophytic lesions	West Indies	Decision-making tree	Literature search in PubMed database yielding a total of 66 published papers
The clinical presentation of oral potentially malignant disorders	Neal J McCormick et al.	February 2016	*Primary Dental Journal*	White macules/ patches	United Kingdom	Algorithm	No methodology mentioned
Oral lichen planus: a novel staging and algorithmic approach and all that is essential to know	Eran Shavit et al.	March 2020	*F1000Research*	Oral lichen planus	Israel/ Canada	Diagnostic algorithm	No methodology/Literature search on PubMed
Oral lesions of viral, bacterial, and fungal diseases in children: A decision tree	Charlotte Guillouet et al.	July 2022	*Frontiers in Pediatrics*	Oral lesions of viral, bacterial, and fungal diseases in children	France	Decision tree	Review of the literature in PubMed database resulting in data extraction from 85 articles. The review found epidemiological data for 28 diagnoses, mainly in Europe and the United States

(Continues)

TABLE 1 | (Continued)

Title	Authors	Date of publication	Journal	Type of lesion	Country of origin	Algorithm presentation	Algorithm construction
Oral Pathology in Clinical Dentistry: A systematic approach	R. V. Subramanyam	October 2014	*Journal of the International Clinical Dental Research Organization*	White lesions	India	Diagnostic algorithm	No methodology mentioned
Oral Pathology in Clinical Dentistry: A systematic approach	R. V. Subramanyam	October 2014	*Journal of the International Clinical Dental Research Organization*	Growth or swelling of gingiva	India	Diagnostic algorithm	No methodology mentioned
Diagnostic features of common oral ulcerative lesions: an updated decision tree	Hamed Mortazavi et al.	September 2016	*International Journal of Dentistry*	Oral ulcerative lesions	Tehran, Iran	Decision tree	Search strategies used in online databases and authenticated textbooks. Oral ulcerative lesions were categorized into three major groups: acute, chronic, and recurrent ulcers and into five subgroups: solitary acute, multiple acute, solitary chronic, multiple chronic, and solitary/multiple recurrent, based on the number and duration of lesions. In total, 29 entities were organized in the form of a decision tree
Oral white lesions: an updated clinical diagnostic decision tree	Hamed Mortazavi et al.	February 2019	*Dentistry Journal* (MDPI)	Oral white lesions	Tehran, Iran	Diagnostic Decision Tree	Online databases and authenticated textbooks. 20 entities were described where they were categorized into 2 major groups: congenital and acquired followed by 4 subgroups: lesions that can be scrapped off or not; patterned and non-patterned
Recurrent oral ulceration: etiology, classification, management, and diagnostic algorithm	Elizabeth A. Bilodeau et al.	May 2019	*Periodontology 2000* (WILEY)	Recurrent oral ulcers	USA	Diagnostic ALgorithm	No methodology mentioned

(Continues)

TABLE 1 | (Continued)

Title	Authors	Date of publication	Journal	Type of lesion	Country of origin	Algorithm presentation	Algorithm construction
Diagnostic pathways and clinical significance of desquamative gingivitis	Lucio Lo Russo et al.	January 2008	*Journal of Periodontology*	Desquamative gingival lesions	Italy, London	Diagnostic pathway	Medical history, intraoral clinical examination, extra oral involvement, histopathology, immunopathology
Desquamative diseases and periodontal health/ treatment	Romano et al.	May 2020	*Current Oral Health Reports*	Mucocutaneous diseases associated with desquamative gingivitis	Italy	Diagnostic pathway	No methodology mentioned
Melanin-associated pigmented lesions of the oral mucosa: presentation, differential diagnosis, and treatment	Susan Müller	May 2010	*Dermatologic Therapy*	Pigmented lesions of the oral cavity	USA	Diagnostic algorithm	No methodology mentioned
Prevalence and clinical features of pigmented oral lesions	Hassona et al.	September 2016	*International Journal of Dermatology*	Pigmented oral lesions	Jordan	Diagnostic and management algorithm	No methodology mentioned
A guide to clinical differential diagnosis of oral mucosal lesions	Finkelstein et al.	March 2020	dentalcare.com	Oral mucosal lesion	USA	Diagnostic algorithm	No methodology mentioned

TABLE 2 | Algorithms identified for different types of oral lesions.

Lesion type	Number of algorithms
Exophytic lesions	2
Oral immune-mediated disorders	1
Oral pigmented lesions	3
White lesions	3
Gingival growth or swelling	1
Oral lichen planus	1
Oral lesions of viral, bacterial, and fungal origin	1
Ulcerative lesions and recurrent oral ulcers	2
Desquamative gingivitis and the mucocutaneous diseases associated with it	2
General oral mucosal lesions	1

three textbooks and 78 papers, including 13 reviews, 55 case reports or case series, and 10 original articles. The main clinical feature used to differentiate between peripheral exophytic lesions was surface texture, followed by features such as color, the shape of the base, and consistency. The lesions were categorized as either smooth (mesenchymal or nonsquamous epithelium-originated) or rough (squamous epithelium-originated). Smooth surface lesions were further divided into three categories: reactive hyperplastic lesions/inflammatory hyperplasia, salivary gland lesions (nonneoplastic and neoplastic), and mesenchymal lesions (benign and malignant neoplasms). Their decision tree included 29 peripheral exophytic lesions, with 23 having smooth surfaces and 6 having rough surfaces.

Santosh (2015) proposed another decision tree including peripheral/extraosseous and central/intraosseous lesions. The authors conducted a literature search on PubMed using MeSH terms, resulting in 66 published papers for studies between 1980 and 2015 to construct the decision tree. The clinical characteristics used as parameters in the algorithm were the consistency of the lesion (soft/hard), the shape of the swelling, the location of the lesion (anterior/posterior jaw; labial/buccal mucosa), color and pigmentation of the lesion, and base of the exophytic growth.

8.2 | Algorithms for Oral Immune-Mediated Disorders

Patil et al. (2023) provided an algorithm specifically focused on immune disorders that have oral manifestations, including conditions such as pemphigus, pemphigoid, erythema multiforme, lichen planus, lupus erythematosus, chronic ulcerative stomatitis, among others. Although the paper does not provide a detailed description of the methodology used to construct the algorithm, the authors used family, medical, and dental history, demographic details, and clinical evaluation to eliminate disorders that are not immune-related.

8.3 | Algorithms for Pigmented Oral Lesions

Kauzman et al. (2004) developed a diagnostic algorithm specifically for pigmented lesions of the oral cavity, such as physiologic pigmentation, heavy metal pigmentation, amalgam tattoo, melanoma, etc. The algorithm initially divides lesions into diffuse or focal lesions, with further subdivision based on factors such as the lesions' number, size, shape, distribution, and color. The authors mention that the algorithm is intended to serve as a guide for clinicians and not as an absolute diagnostic tool. Like the previous authors, Müller (2010) and Hassona et al. (2016) also emphasized the importance of detailed history taking for the diagnostic process. Accurate history taking is required and should include information regarding the onset and duration of the lesion, the presence of systemic signs and symptoms (e.g., malaise, fatigue, weight loss), associated skin hyperpigmentation, use of prescription and nonprescription medications, and smoking habits.

8.4 | Algorithms for White Lesions/Gingival Growth or Swelling

A diagnostic algorithm for white macules/patches was proposed by Mccormick et al. (2016) in a study discussing Oral Potentially Malignant Disorders (OPMDs). This algorithm includes lesions resulting from trauma (frictional keratosis, chemical burns), developmental disorders (leukoedema), and infective diseases (hairy leukoplakia). However, the article does not provide information on the methodology used to construct the algorithm.

Subramanyam (2014) provided two algorithms in the same paper. One for oral white lesions and another for gingival growth/swelling. The algorithm for white lesions asks clinical questions such as “Can the lesion be scraped?”, “is the lesion flat or elevated?”, “is the lesion opaque?”, among others. Examples of questions to create the algorithm for gingival growth are: “Is the lesion firm or soft?”, “Does the lesion have a similar colour to the adjacent mucosa?”, “Is the lesion associated with a non-vital tooth?”. Like other articles, the authors did not mention the process by which these algorithms were created.

In contrast, Mortazavi et al. (2019) performed an online database (PubMed, PubMed Central, EBSCO, Science Direct, Scopus, and EMBASE) and a textbook search to develop the diagnostic decision tree of white lesions. They used MeSH terms such as “mouth disease,” “oral keratosis,” “oral leukokeratosis,” and “oral leukoplakia” to identify relevant articles published between 2000 and 2017. Their study included five textbooks and 45 studies, including reviews, case reports or series, and original articles. The lesions were broadly divided based on whether they were congenital or acquired, and further subdivisions were made based on clinical evaluation. This decision tree resulted in 20 entities.

8.5 | Algorithms for Oral Lichen Planus

The algorithm described in this paper (Shavit et al. 2020) was constructed based on a literature search on PubMed. Similar to

other algorithms for oral white lesions, the algorithm begins by dividing them into congenital or acquired lesions. In addition, this algorithm provides subtypes of oral lichen planus (reticular, atrophic, erosive, bullous) as the final diagnosis. These subtypes are specific manifestations of oral lichen planus, highlighting the variability in clinical presentation within this condition.

8.6 | Algorithms for Oral Lesions of Viral, Bacterial, and Fungal Origin

Guillouet et al. (2022) established their diagnostic decision tree by searching PubMed for oral mucosal symptoms related to children's viral, bacterial, fungal, and parasitic diseases. They extracted data from 85 articles, which included case reports or case series (48), prospective or retrospective studies (13), and literature reviews (24). The information extracted included descriptions of oral lesions, associated systemic signs, incidence/prevalence of the disease, complementary exams, and details about the infection mechanism and agents involved. The decision tree is directed explicitly toward pediatricians and pediatric dentists and encompasses 28 conditions for which epidemiological data can be retrieved, mainly in Europe and the United States. The diagnostic questions used to create the decision tree include: (1) What is the general clinical aspect? (2) What type of lesion (macule, papule, plaque, vesicle, bulla, nodule, erosion, ulcer, tumefaction) is present, and how many lesions are there? (3) What is the location of the lesion(s) (salivary gland, tongue, hard/soft palate, masticatory mucosa, lining mucosa)? (4) What are the characteristics of the lesion(s)? (5) What is the diagnosis? The authors mention that they will evaluate their decision tree's validity in clinical situations.

8.7 | Algorithms for Oral Ulcerative Lesions

The decision tree for common ulcerative lesions (Mortazavi et al. 2016) was assembled using MeSH terms such as "oral ulcer," "stomatitis," and "mouth diseases" in several online databases (PubMed, PubMed Central, Medline Plus, EBSCO, Science Direct, Scopus, Embase) and textbooks. 71 papers (32 reviews, 27 case reports or case series, and 12 original articles) and 4 textbooks were selected as references for constructing the decision tree. The initial division of the decision tree included three major groups based on duration: acute, chronic, and recurrent. Further subdivisions were made based on the number of lesions, yielding categories such as solitary acute, multiple acute, solitary chronic, multiple chronic, and solitary/multiple recurrent. This decision tree aided in the diagnosis of 29 oral ulcerative lesions.

By contrast, Bilodeau and Lalla (2019) did not describe the methodology used to create the algorithm for recurrent oral ulcers. The parameters included in the algorithm were duration, clinical appearance, and number of ulcers.

8.8 | Algorithms for Desquamative Gingivitis and Associated Lesions

The diagnostic pathway included in the Romano et al. paper (Romano et al. 2020) focuses on diseases associated with desquamative gingivitis, such as oral lichen planus, erythema multiforme, mucous membrane pemphigoid, pemphigus vulgaris, etc. The authors initiate the diagnostic pathway by conducting a detailed medical history, demographic characteristics, general health conditions, onset and progression of any existing gingival lesion, symptoms, and drug intake. The location, morphology of the gingival lesions, contact with dental materials, and presence of similar lesions at other sites of the body through intraoral and extraoral examination are the next steps within the pathway leading to a diagnosis.

8.9 | General Oral Mucosal Lesions

The decision tree included is part of an online course directed toward all dental practitioners (Finkelstein et al. n.d.). The first decision to be made is whether a lesion is a surface lesion (involves epithelium and superficial connective tissue) or soft tissue enlargement. Based on clinical appearance, surface lesions are further divided into pigmented, white, vesicular-ulcerated-erythematous. Soft tissue enlargements are further divided into reactive and tumors/neoplasms, with further subdivisions within these categories. Of all the algorithms identified, this algorithm was the most extensive.

9 | Discussion

The summary of our findings has included algorithms for oral lesions that are different in nature and presentation. All the algorithms we have found used clinical characteristics along with pertinent patient history to reach a diagnosis. Other factors used in the construction of these algorithms were the clinicians' experience.

9.1 | Lack of a Universal and Comprehensive Algorithm

Throughout our search, we could not find a comprehensive algorithm that covers the complete range of oral lesions. This is expected considering the broad spectrum and diversity of oral lesions. Many of the algorithms found lacked a comprehensive overview regarding the different types of oral lesions. For example, the algorithm for peripheral exophytic lesions (Mortazavi et al. 2017) does not include any subdivisions based on color. The same algorithm mentions salivary gland lesions but does not include any salivary gland stones or salivary duct cysts. Although they can appear similar clinically, no subdivision is present for benign and malignant lesions under the neoplastic lesions branch of the algorithm. There is also some confusion with nomenclature as pyogenic granuloma and pregnancy tumor are mentioned as two separate entities, indicating a lack of correctness.

Many of the algorithms we found required additional testing to reach a differential diagnosis. Such tests include bloodwork, mucosal and throat swabs, immunopathologic evaluation, direct and indirect immunofluorescence, and histopathologic examination. Although these tests are necessary to reach a final diagnosis, they are not performed in a dental clinic and require the patient or samples to be sent to other centers. This is considered

the next step after clinical examination and for that reason, they cannot be added to the clinical algorithm.

We found multiple diagnostic algorithms for different lesions; namely white lesions and pigmented lesions, where some commonalities and differences between the clinical characteristics are present. In general, algorithms for white lesions (Subramanyam 2014; Mortazavi et al. 2019; Mccormick et al. 2016) were very similar, initiating the diagnostic sequence by asking the clinician if the white lesion is genetic or acquired and whether it can be scraped or rubbed off. Following that, further questions regarding history (e.g., trauma, drug use, etc.) and clinical patterns (e.g., striated, fissured, linear, etc.) are asked. Pigmented lesion algorithms (Kauzman et al. 2004; Müller 2010; Hassona et al. 2016) also had similar decision steps to reach the final diagnostic category. Assessing whether these lesions were diffuse or focal was the first step, followed by distinguishing based on clinical appearance, namely color. The algorithm proposed by Müller (2010) differs from other pigmented algorithms by branching into melanocytic and nonmelanocytic lesions, as opposed to focusing on color.

Creating a diagnostic algorithm is a difficult task for researchers and clinicians. One of the reasons behind this difficulty is the overwhelming number of oral lesions that healthcare practitioners encounter in clinical practice. Additionally, many of these lesions exhibit overlapping features such as shape and color, making accurate diagnosis more complex. Also, diagnostic algorithms for oral lesions often involve complex decision-making processes that are usually based on clinical questions. To further complicate the issue, algorithm developers may suggest different decision paths for the same type of oral lesion.

9.2 | Lack of Information on Evidence Backup for Algorithms

Our review identified several diagnostic algorithms for different oral lesions. However, there was a lack of mention of the reasoning behind the construction of these algorithms in most studies. For example, although some studies mentioned a literature search through online databases and consulting authenticated textbooks as part of their knowledge-gathering phase, they did not provide specific details on how this knowledge was translated into a clinical algorithm. This lack of transparency on the methodology reduces the final algorithms' replicability and overall trustworthiness. This issue is further exacerbated in studies that did not mention any knowledge-gathering phase. In such cases, the readers had to rely only on the author's clinical expertise, raising concerns about the validity and generalizability of the algorithms presented.

9.3 | Lack of Clinical Validation

Another knowledge gap we discovered was the lack of investigation and discussion around the clinical applicability of these algorithms. None of the studies in our review provided information on how these algorithms were or could be validated. Given the uncertainty around the development method of these algorithms, checking their validity is of utmost importance. The knowledge they embed and the diagnostic decisions they suggest need to be validated through clinical trials in addition to a consensus on the context validity by multiple experts. However, currently there are no guidelines to construct and validate clinical flowcharts for oral lesion diagnosis. Alternatively, methods recommended for validation of clinical prediction models are an avenue to build upon for clinical flowcharts.

9.4 | Lack of Clinical Utility Assessment

Even with the presence of clinical validity, these algorithms need to be evaluated for their utility in clinical situations. Guillouet et al. (2022) concluded in their paper that they plan to test the reproducibility and reliability of their decision tree in the pediatric dentistry department. They also mention their decision tree needs to be tested clinically to ensure clinicians can use it.

10 | Limitations

To the best of our knowledge, this is the first attempt to map the existing literature for clinical diagnostic algorithms of oral lesions. A systematic review was not possible for this reason. Moreover, in contrast to systematic reviews, scoping reviews are used to answer a broader research question and to identify, map, collate, and summarize the current literature (Arksey and O'Malley 2005). The potential limitations of gray literature are inconsistencies in how information is presented and biases.

We did not appraise the quality of the included manuscripts. The primary reason is the lack of validated tools for appraising the quality of such article types. However, we evaluated the manuscripts from a methodological aspect and their contribution to the substantive knowledge to identify the gaps in the literature.

We also excluded algorithms that used any machine- or AI-based algorithms. Artificial intelligence can prove helpful in specific applications. However, most of these models are black-box algorithms and cannot be used in clinical settings without additional machinery (e.g., mobile applications). Furthermore, clinical examination by a trained professional remains the most common way lesions are diagnosed. Also, clinical algorithms, as opposed to AI-based algorithms, are a way to encode clinicians' knowledge and have added value to be used for the pedagogy of clinical reasoning in the diagnosis process.

11 | Future Direction

This paper can aid research investigating these algorithms' clinical validity, utility, and usability in real-life settings. We also hope to see the possibility of these algorithms being used in pedagogical settings and integrated into AI-based tools for the same. Dental students are taught on a case-by-case basis by gaining more experience and becoming more familiar with oral lesions with each patient. There is potential to use algorithms as a teaching tool to assist dental students and residents in diagnosing oral lesions. Moreover, a repository of standardized and validated clinical decision-making algorithms for oral disease would be beneficial in reducing the barrier to clinical adoption.

12 | Conclusion

This review revealed gaps in knowledge regarding clinical diagnostic algorithms for oral lesions. Current algorithms need to be validated in clinical settings, and a consensus by experts needs to be reached while constructing them. We hope this review provides future researchers with the ability to assess the utility of these algorithms in clinical and pedagogical settings and see the possible implication as a decision-support tool.

Author Contributions

Mohammed Al-Shehri: methodology, conceptualization, investigation, formal analysis, data curation, visualization, writing – original draft, writing – review and editing. **Theerthika Dillibabu:** conceptualization, methodology, data curation, formal analysis, visualization, writing – review and editing. **Belinda Nicolau:** methodology, supervision, writing – review and editing. **Marco Magalhaes:** methodology, conceptualization, supervision, writing – review and editing. **Nicholas Makhoul:** methodology, writing – review and editing, supervision. **Faleh Tamimi:** methodology, writing – review and editing, resources. **Peter Chauvin:** methodology, conceptualization, writing – review and editing, supervision. **Sreenath Madathil:** conceptualization, methodology, supervision, funding acquisition, writing – review and editing.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

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

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.