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Diagnostic accuracy of artificial intelligence models for detecting interproximal caries on bitewing radiographs using ICCMS as reference standard: a systematic review

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ADMINISTRATIVE INFORMATION

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Conflicts of interest - None declared.

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Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 1 March 2026 and was last updated on 1 March 2026.

INTRODUCTION

Review question / Objective The objective of this systematic review is to evaluate the accuracy of artificial intelligence models for detecting interproximal caries on bitewing radiographs, using ICCMS radiographic criteria as the reference standard. The review will address the following question: What is the diagnostic accuracy of artificial intelligence models for interproximal caries detection on bitewing radiographs when compared with ICCMS-based radiographic assessment.

Rationale Dental caries remains one of the most prevalent oral diseases worldwide, and interproximal caries detection continues to be a diagnostic challenge in routine clinical practice. Bitewing radiographs are a key method for detecting interproximal caries, and artificial intelligence (AI) models have shown increasing potential to support radiographic diagnosis. However, the available evidence is heterogeneous

regarding AI models, study design, diagnostic thresholds, and reference standard.

Recent systematic reviews have evaluated AI-assisted caries detection on bitewing radiographs, but there is still a specific gap in evidence focused on studies that use ICCMS radiographic criteria as the reference standard. This is important because the reference standard directly affects diagnostic accuracy estimates and comparability across studies. A review restricted to ICCMS based assessment may provide a more standardized and clinically relevant synthesis of evidence for interproximal caries detection.

Therefore, this systematic review is justified to identify, critically appraise, and synthesize the available evidence on the diagnostic accuracy of AI models for interproximal caries detection on bitewing radiographs using ICCMS as the reference standard, and to classify current evidence gaps for future research and clinical application.

Condition being studied Interproximal dental caries in primary and/or permanent teeth assessed on bitewing radiographs (digital or conventional). The review addresses AI based detection and diagnostic assessment of interproximal caries using ICCMS radiographic criteria as the reference standard.

METHODS

Search strategy A systematic search Will be conducted in electronic databases, including PubMed, Scopus and ScienceDirect, using combinations of keywords and descriptors related to artificial intelligence, interproximal caries, bitewing radiographs, and ICCMS.

In Pubmed, both MeSh terms and free- text terms will be used. The MeSh terms considered in the protocol include: Radiography, Bitewing; Dental Caries; Artificial Intelligence; Deep Learning; Machine Learning. Free- text terms include, among others: bitewings/bite-wing; interproximal/proximal/approximal caries; artificial intelligence/deep learning/machine learning; convolutional neural network/CNN; YOLO; object detection; computer-aided diagnosis; ICCMS/ International Caries Classification and Management System; and terms related to diagnostic accuracy.

The search strategy will be adapted to the syntax of each database (PubMed, Scopus and ScienceDirect), considering the characteristics of each platform (search fields, Boolean operators, truncation, and connector limits). In ScienceDirect, the search will be performed using separate queries due to limitations in the number of Boolean connectors allowed per field; subsequently, the results from each query will be exported and combined into a single record set.

The results obtained from each platform will be exported and consolidated into a single record set, which will be imported into Rayyan for the study selection process. Identification and removal of duplicates will be performed in Rayya, using the platform's deduplication tools, before screening begins.

Study selection will be conducted independently by two reviewers in two stages: (1) title and abstract screening and (2) full-text assessment of potentially eligible articles. Disagreements will be resolved by consensus and, if needed, with the participation of a third reviewer. Reasons for exclusion at the full-test stage will be recorded- The entire process will be reported according to the PRIMA 2020 guideline.

Participant or population The population of interest will include primary and/or permanent teeth assessed using bitewing radiographs (conventional or digital) for suspected or present interproximal caries, including studies with direct evaluation and retrospective analysis of previously obtained radiographs.

Intervention The intervention of interest is the use of image-based artificial intelligence models applied to the analysis of bitewing radiographs for the detection, localization, classification, or severity assessment of interproximal caries.

Comparator The comparator Will be radiographic assessment of interproximal caries on bite wing radiographs based on the International Caries Classification and Management System (ICCMS) criteria.

Study designs to be included Eligible study designs will include diagnostic accuracy studies assessing the performance of artificial intelligence models on bitewing radiographs for interproximal caries, including retrospective and prospective designs, as well as experimental in vitro and ex vivo studies when applicable. Observational, comparative, and diagnostic studies that allow estimation of diagnostic performance metrics will be considered.

Eligibility criteria Inclusion criteria

- Original studies evaluating artificial intelligence models (machine learning/deep learning) for detection or classification of interproximal caries on bitewing radiographs
- Studies using ICCMS radiographic criteria as the reference standard.
- Studies reporting at least one diagnostic accuracy (e.g., sensitivity, specificity, AUC/ROC, accuracy, precision, predictive values) or sufficient data to calculate it.
- Language: English or Spanish
- Availability: full text
- In vitro, ex vivo and clinical /retrospective dataset studies using real bitewing radiographs (digital or scanned).

Exclusion criteria

- Studies not using bitewing radiographs (e.g., periapical, panoramic, CBCT, intraoral photography, or other non-bitewing images).
- Studies focusing on non-interproximal caries (occlusal, root, smooth-surface) or secondary caries, without specific analysis of interproximal caries.
- Studies not using ICCMS as the reference standard.

- Narrative/systematic/scoping reviews, editorials, letters, comments, protocols without results, conference abstracts/posters, theses, or book chapters.
- Duplicates or studies with insufficient methodological information for assessment.

Information sources The search will be conducted in the following bibliographic databases: PubMed, Scopus, and ScienceDirect.

Main outcome(s) Diagnostic accuracy of artificial intelligence models for interproximal caries on bite wing radiographs, primarily measured as:

- Sensitivity
- Specificity
- ROC/AUC.

Additional outcome(s)

Additional diagnostic outcomes, when available:

- Overall accuracy
- Predictive values (PPV/NPV)
- Precision
- Reproducibility (agreement measures reported by the study).

Data management Records retrieved from each database will be exported and consolidated into a single dataset and managed in Rayyan. Duplicate identification and removal will be performed in Rayyan before screening (title/abstract and full-text screening). Disagreements will be resolved by consensus and, if needed, by a third reviewer.

Reference management will be performed using Mendeley. Data extraction will be conducted using a pre-defined standardized form in Microsoft Excel, including at minimum: study characteristics, AI Model type, dataset characteristics, reference standard and diagnostic accuracy outcomes (sensitivity, specificity, ROC/AUC). Screening decision and reasons for exclusion will be recorded in Rayyan.

Quality assessment / Risk of bias analysis

Methodological quality and risk of bias of included studies will be independently assessed by two reviewers using QUADAS-2, covering the domains of patient/sample selection, index test (AI model), reference standard (ICCMS), and flow and timing, as well as applicability concerns. Disagreements will be resolved by consensus or a third reviewer.

The overall certainty of the evidence per outcome will be rated using the GRADE approach when applicable, considering risk of bias, inconsistency, imprecision, indirectness, and publication bias.

Strategy of data synthesis Results will be presented through a structured qualitative synthesis of the evidence. Outcomes to be synthesised will consist of diagnostic accuracy measures reported by the included studies (primarily sensitivity, specificity, and ROC/AUC; and, when available, overall accuracy and predictive values).

The synthesis will compare diagnostic performance according to: AI model type (e.g., machine learning/deep learning), model task (detection, classification, or segmentation), dataset characteristics (size and source), and validation approach (internal/external, when reported). The synthesis will also describe the ICCMS-based reference standard and any relevant variation in how ICCMS radiographic criteria were applied.

Subgroup analysis If sufficient comparable information is available, a descriptive subgroup analysis will be conducted to explore potential differences in diagnostic performance across studies. To minimize spurious findings, only the following pre-specified subgroups will be examined:

- Model task: detection vs classification vs segmentation
 - Model validation type: internal or external validation.
 - Bitewing type: digital vs conventional /scanned
- Subgroup will be reported narratively and will only be explored when an adequate number of studies is available per category; otherwise, differences will be described qualitatively without formal comparisons.

Sensitivity analysis A sensitivity analysis will be conducted only if the available evidence allows consistent comparisons. To assess the robustness of the conclusion, the synthesis will be repeated after excluding:

- Studies rated as high risk of bias using QUADAS-2.
- Studies with incomplete reporting of diagnostic outcomes or key methodological information.

If conclusions remain similar after these exclusions, findings will be considered more robust. If these comparisons are not feasible, the impact of excluding lower-quality studies will be described narratively.

Language restriction Yes. Only studies published in English or Spanish will be included.

Country(ies) involved Ecuador.

Other relevant information Additional methodological note: In ScienceDirect, the search

will be run using separate queries due to platform limits on the number of Boolean connectors allowed per field. Results will be exported merged into a single record set, and deduplicated in Rayyan prior to screening.

Duplicates check: Similar systematic reviews on AI-Assisted caries detection on bitewing radiographs exist; however, this protocol focuses specifically on interproximal caries detection on bitewing radiographs using IIMS radiographic criteria as the reference standard, aiming to provide a more standardized synthesis based on a consistent reference framework.

Keywords Bitewing radiographs; interproximal caries; artificial intelligence; deep learning; diagnostic accuracy; ICCMS; machine learning; computer-aided diagnosis.

Dissemination plans The results of this systematic review will be disseminated as part of a postgraduate thesis in Oral Rehabilitation and Implant-Assisted Prosthodontics at the University of Cuenca, including the corresponding academic presentation and thesis defense. Subsequently, a scientific manuscript will be prepared and submitted for publication in a peer-reviewed journal.

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