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Review

Radiographic caries detection: A systematic review and meta-analysis

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ABSTRACT

Objectives: This systematic review aimed at evaluating the accuracy of radiographic caries detection for different lesions at different locations.
Data: Studies reporting on the accuracy (sensitivity/specificity) of radiographic detection of natural primary caries lesions under clinical or in vitro conditions were included. Risk of bias was assessed using QUADAS-2. Pooled sensitivity, specificity and diagnostic odds ratios (DORs) were calculated using random-effects meta-analysis. Analyses were performed separately for occlusal and proximal lesions, with further discrimination between any kind of lesions, dentine lesions, and cavitated lesions.
Sources: Electronic databases (Medline, Embase, Cochrane Central) and grey literature were systematically searched, complemented by cross-referencing from bibliographies.
Study selection: From 947 identified articles, 442 were analyzed full-text. 117 studies (13,375 teeth, 19,108 surfaces) were included, the majority of them reporting on permanent teeth and having high risk of bias. The detection of any kind (i.e. also initial) lesions had low sensitivities (pooled DOR [95% CI]: 0.24 [0.21/0.26] to 0.42 [0.31/0.34]), but moderate to high specificities (0.70 [0.76/0.84] to 0.97 [0.95/0.98]). For dentine lesions, sensitivities were higher (from 0.36 [0.24/0.49] for proximal to 0.56 [0.53/0.59] for occlusal lesions), and specificities ranged between 0.87 [0.85/0.89] and 0.95 [0.94/0.96]. No studies reported on cavitated occlusal lesions, whilst for cavitated proximal lesions, sensitivities increased above 0.60, whilst sensitivities remained high (above 0.90).
Conclusions: Radiographic caries detection is highly accurate for cavitated proximal lesions, and seems also suitable to detect dentine caries lesions. For detecting initial lesions, more sensitive methods could be considered in population with high caries risk and prevalence.
Clinical significance: Radiographic caries detection is especially suitable for detecting more advanced caries lesions, and has limited risks for false positive diagnoses. For groups with high caries risk and prevalence, alternative detection methods with higher sensitivity for initial lesions might be considered.

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1. Introduction

Q2 Screening for dental caries lesions is presumably one of the most frequent exercises in general dental practice, aiming to detect early caries lesions to then provide non- or micro-invasive treatments and thereby prevent more invasive, expensive restorative therapy.[1–3] The generally used visual-tactile detection means have only limited accuracy for detecting non-cavitated lesions, especially on proximal surfaces.[1] Dentists thus regularly use additional caries detection aids, with (bitewing) radiography likely being the most frequent one.[3] Alternative methods comprise, for example, fluorescence-aided caries detection, and have been found highly sensitive and, to a lesser degree, specific. These methods might eventually be advantageous compared with radiography, as they avoid potential harm by ionizing radiation and could be easier to perform with less technical efforts.[4]

To assess the accuracy of caries detection methods, the yielded proportion of false or true positively or negatively diagnosed lesions, as compared with a ''gold standard'' like histologic assessment of dental hard tissues, is assessed, and sensitivity (*true positives per all diseased surfaces*) and specificity (*true negatives per all health sound surfaces*) are calculated. By evaluating both values, dentists can assess the risks of over- and under-treatment associated with different detection methods, and can decide which method might be most appropriate in which population.[5] The latter is relevant when considering the increasing polarization of caries prevalence between populations, with only few individuals bearing most lesions, and large groups of young or adolescent patients having only few or no caries lesions at all.[6,7] There is, however, great variability in the reported accuracy (sensitivity and specificity) between studies,[1] which might be due to underlying clinical (lesion depth, dentition, surface location) or methodological (technical standard of the radiographic index test, used reference test, number and experience of examiners) heterogeneity. Systematically compiling the available data of studies which investigated the accuracy of radiographic caries detection should allow to assess this accuracy and its potential modification by various confounders.

The present review aimed to systematically appraise studies investigating the accuracy of radiographic caries detection and to meta-analyze them, with separate analyses for occlusal and proximal lesions. Moreover, we aimed at assessing the effects of histologic lesion stage (initial/any lesions, only dentine lesions, only cavitated lesions). The latter is of importance, as these stages guide the allocation of treatments, i.e. act as thresholds for clinical decision making. Last, we investigated if the accuracy of radiographic caries detection differs between primary or permanent teeth, if it has improved recently due to technical advances of radiographic methods, or if it varies greatly even within studies (i.e. between examiners or applied radiographic techniques).

2. Materials and methods

Reporting of this review follows the PRISMA guideline.[8]

2.1. Eligibility criteria

We included clinical or in vitro studies reporting on the following items:

- Participants: Humans with primary caries lesions (clinical studies), or human teeth with primary natural caries lesions (in vitro studies), which were submitted to caries detection via radiographic means. Studies investigating teeth with secondary lesions/lesions adjacent to restorations, or teeth with artificially induced lesions were excluded. We performed separate analyses to account for the potential difference between clinical and in vitro settings. Neither caries prevalence in the population nor lesion depth were used to exclude studies. Studies should have allowed separate analysis of caries detection in occlusal and proximal surfaces.
- Index test: Intraoral radiography, i.e. bitewing or peri-apical radiographs. We did not attempt to differentiate between both, as most studies did not clearly report which radiographic technique was used.
- Reference test: The caries status of the examined surface needed to be assessed using a reference test, i.e. a ''gold standard''. Used standards were first categorized as (a) destructive or (b) non-destructive (visual-tactile assessment without [occlusal] or with [proximal] tooth separation). Destructive methods were further divided into histologic, microradiographic or operative assessment, with the latter typically performed in clinical studies when invasively accessing the lesion. It should be noted that the latter might lead to under-estimation of false negative findings (Woodward, 1996).
- Outcomes: Reported data should allow to construct a diagnostic 2×2 table, i.e. to determine true positive, false negative, false positive and true negative detections. Studies which only reported *receiver operating characteristics* (*ROC*) *curves* (*see below*) were not included.

2.2. Information sources

Electronic databases (Medline via PubMed, Embase via Ovid, Cochrane Central) were screened for articles published until September 2014, without any further restriction regarding publication date or language. Diagnostic reviews were additionally searched via the Medion database, which was designed specifically for that purpose (http://www.mediondatabase.nl). Grey literature was retrieved via opengrey.eu. Cross-referencing was performed using the bibliographies of full-text articles.[9]

2.3. Search and study selection

Electronic searches used a specificity-optimised strategy based on recommendations for diagnostic reviews[9] and a similar review.[4] A three-pronged approach combining the condition (caries OR carious OR decay), the detection method (bitewing OR radiograph OR radiography OR xray OR x-ray OR roentgen OR radiology OR radiologic OR radiographic) and the outcomes (detection OR roc OR sensitivity OR specificity OR predictive value OR receiver) using Boolean operators, without

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