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Indication of bitewing radiographs in adolescents: a systematic review of clinical guidelines.

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Abstract: **Objectives:** to identify and to analyse current guidelines/directives on the use of bitewing radiograph among adolescents, evaluating the evidence supporting the parameters used for its indication and for the determination of the time interval prescribed between successive shots for the caries diagnosis. **Methods:** A systematic review was conducted in 2022/23, in Spanish, English and Portuguese to identify papers classifiable as "guides", "guidelines" or "directives" for the use of bitewing radiography. Two reviewers consulted MEDLINE, LILACS, SCOPUS and Google Scholar. Each guideline was analysed according to the Appraisal of Guidelines for Research and Evaluation II (AGREE II). **Results:** Six guidelines and five documents were included. Five guidelines comply adequately with domain 1 but none of them included patient's opinions or preferences. They are based on expert opinion, with adequate and clear language. Only two guidelines members declare having no conflicts of interest. While ADA 2012, AAPD 2017, EAPD 2019, ITALIA 2019 suggest using the presence of caries lesions/caries risk assessment as an indicator for taking Rx at the first visit, the others do not present an indicator or do so in all patients and documents indicate key ages for radiographic examination. The frequency varies according to the risk assessment and presence of caries lesion. **Conclusion:** There is no consensus in parameters used for the indication/timing and frequency of radiographs examination, however, the guidelines condemns the indiscriminate use of radiographs. The frequency should be established in relation to the baseline conditions and determining factors present. Frequencies less than 12 months require justification.

Key words: Dental caries/diagnosis; Dental radiography; bitewing radiography; adolescents.

Indicación de radiografías interproximales en adolescentes: una revisión sistemática de guías clínicas.

Resumen: **Objetivo**: Identificar y analizar guías/directivas actuales sobre el uso de la radiografía interproximal en adolescentes, evaluando la evidencia que respalda los parámetros utilizados para su indicación y para la determinación del intervalo de tiempo prescrito entre tomas sucesivas para el diagnóstico de caries. **Metodologia:** Se realizó una revisión sistemática de la literatura en 2022/23, en idioma Español, Inglés y Portugués identificando publicaciones clasificables como "guías", "directivas" o "directrices" para el uso de radiografías bitewing. Dos revisores consultaron MEDLINE, LILACS, SCOPUS y Google Scholar. Se utilizó la Evaluación de calidad de guías para la investigación y evaluación AGREE II. **Resultados:** Se incluyeron seis guías y cinco documentos. Cinco de las guías cumplen el dominio 1 de AGREE II, pero ninguna incluyó opiniones/preferencias de los pacientes. Mayormente utilizan la opinión de expertos, un lenguaje adecuado y claro. Solo dos miembros de la guía declaran no tener conflictos de intereses. Mientras ADA 2012, AAPD 2017, EAPD 2019, ITALIA 2019 sugieren utilizar la presencia de lesiones de caries/evaluación de riesgo como indicador de radiografía en la primera consulta, los demás no presentan indicador o la indican en todos los pacientes, señalando edades claves. La frecuencia varía según valoración de riesgo y presencia de lesión de caries. **Conclusión:** No existe consenso sobre los parámetros a ser utilizados para la indicación/momento y frecuencia de examen radiográfico, sin embargo, condenan su uso indiscriminado. La frecuencia debe establecerse en relación con las condiciones basales y los factores determinantes presentes. Frecuencias menores de 12 meses requieren justificación.

Palabras clave: Caries dental/diagnóstico, Radiografía dental, Radiografía Interproximal, Adolescentes.

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Indicação de radiografias interproximais em adolescentes: uma revisão sistemática de diretrizes clínicas.

Resumo: **Objetivo:** identificar e analisar as diretrizes atuais sobre o uso da radiografia interproximal em adolescentes, avaliando as evidências que sustentam os parâmetros utilizados para sua indicação e para a determinação do intervalo de tempo prescrito entre disparos sucessivos para o diagnóstico de cárie. **Metodologia:** Foi realizada uma revisão sistemática em 2022/23, em espanhol, inglês e português, identificando publicações classificáveis como "guias", "diretivas" ou "diretrizes" para o uso de radiografias interproximais. Dois revisores consultaram a MEDLINE via PubMed, LILACS, SCOPUS e Google scholar. Foi utilizada a Avaliação de Qualidade das Diretrizes para Pesquisa e Avaliação II (AGREE II). **Resultados:** Foram incluídas seis diretrizes e cinco documentos. Cinco das diretrizes cumpriram o domínio 1 do AGREE II, mas nenhuma incluiu as opiniões/preferências dos pacientes. Utilizam principalmente a opinião de especialistas e uma linguagem adequada e clara. Membros de apenas duas diretrizes declaram não ter conflitos de interesse. Enquanto ADA 2012, AAPD 2017, EAPD 2019, ITALIA 2019 sugerem utilizar a presença de lesões de cárie/avaliação de risco como indicador radiográfico na primeira consulta, os demais não apresentam indicador ou indicam para todos os pacientes, indicando idades-chave. A frequência varia de acordo com avaliação de risco e presença de lesão de cárie. **Conclusão:** Não há consenso sobre os parâmetros a serem utilizados para indicação/tempo e frequência do exame radiográfico, porém condenam seu uso indiscriminado. A frequência deve ser estabelecida em relação às condições basais e aos fatores determinantes presentes. Frequências inferiores a 12 meses carecem de justificativa.

Palavras-chave: Cárie dentária/diagnóstico, Radiografia dental, Radiografias interproximais, Adolescentes.

Introduction

Caries diagnosis is the most common activity in both public and private clinical practice [1]. For this reason, it is pertinent to assess the consequences of using different diagnostic tools on patients, the associated risks, and their cost-effectiveness [2].

The use of bitewing radiography, or interproximal radiography (IR), is widely accepted by clinicians as a diagnostic complement for the detection of caries lesions on clinically inaccessible surfaces, dentin occlusal caries, and treatment planning and monitoring. The combined use of visual-tactile clinical examination and radiography for caries diagnosis increases the sensitivity of the diagnostic method, i.e., the probability of correctly identifying a patient with caries lesions. This represents a significant benefit to clinicians, allowing them to implement, if possible, nonoperative or less invasive treatments more frequently [3, 4]. However, the use of radiography in the diagnostic process has some disadvantages. First, we must consider the lack of information on the dynamics of the caries process (activity). This is only possible by taking two or more identical radiographs over time and comparing lesion progression. Secondly, the information provided by radiographic imaging is unable to differentiate a cavitated lesion from a non-cavitated one [1, 5-8]. Last but not least, there is an implicit health risk associated with the use of ionizing radiation.

The marked decrease in the prevalence and progression of caries lesions in young populations, regularly exposed to fluoride, as well as the consideration of the possible damage to health caused by ionizing radiation, have led to a reflection and re-evaluation of the indications for radiographic examination, mainly in children and adolescents [8-10].

In recent decades, several guidelines have been developed to assist in identifying those patients who could truly benefit from radiographic examination, all of which state that routine use of radiographs is unacceptable [11]. We cannot ignore the possibility of some adverse effects from X-rays, regardless of the administered dose. The risk is age-related and can be multiplied by two or three in adolescents and children up to 10 years of age, respectively [12]. Exposure to ionizing radiation requires justification, which is demonstrated by the benefits it provides to diagnosis, and always requires a signed informed consent form. The acronym ALADAIP (As Low As Diagnostically Achievable being Indication-oriented and Patient-specific) summarizes the need to individualize the indication for radiography according to patient characteristics [13].

Goodwin *et al.* (2017), in a systematic review of guidelines aimed at determining the timing and interval between bitewing radiographs, concluded that the existing recommendations on the frequency of bitewing radiographs and the age at which the first radiograph should be taken are highly varied and, in general, have not been debated or accepted by professionals [11]. Considering the existence of updates or new guidelines published after this work, the objective of this systematic review is to analyze the current clinical guidelines on the use of interproximal radiographs (IR) in adolescents, evaluating the indications and recommended time interval between taking them. In addition, we intend to discuss the scientific evidence that supports these parameters and their applicability in clinical practice.

Materials and methods

A systematic review of the literature as conducted in 2022/23, in Spanish, English and Portuguese to identify publications classified as guides/directives/directives for the use of IR during the diagnosis of caries in adolescents. According to the World Health Organization (WHO), adolescence includes the period of human growth and development that occurs after childhood and before adulthood, between 10 and 19 years of age [14].

For the electronic search, the databases consulted were MEDLINE, via PubMed, LILACS, SCOPUS, and Google Scholar. Specialized books and citations found in the selected articles were reviewed.

The descriptors used were: “Dental radiography AND (guideline OR indication) AND (diagnosis OR diagnostic imaging) AND adolescents”. Initially, two reviewers (LA – AF) assessed the identified publications and selected them by title and abstract. The final decision to include the papers was made after reading the entire selection.

Each guideline was also analysed, for three independent reviewers (LA, AF, YI) previously trained, according to the Appraisal of Guidelines for Research and Evaluation II (AGREE II), which assesses the methodological rigor and transparency of guidelines development [15].

The researchers were trained in theory. Individual registration forms were created, and each of the domains and their scores were defined. In case of disagreement, the results were compared and resolved by discussing the case together.

The AGREE document contains 23 items organized into six separate domains: "Scope and Purpose," "Stakeholder Engagement," "Rigor of Development," "Clarity of Presentation," "Applicability," and "Editorial Independence." In addition, the overall assessment (overall quality and recommendation) was analyzed, which includes two ratings. Each of the 23 items and the two items in the overall assessment are rated on a Likert scale from 1 to 7, where 1 represents strongly disagreement and 7 represents strongly agreement. Percentages are generated from this rating.

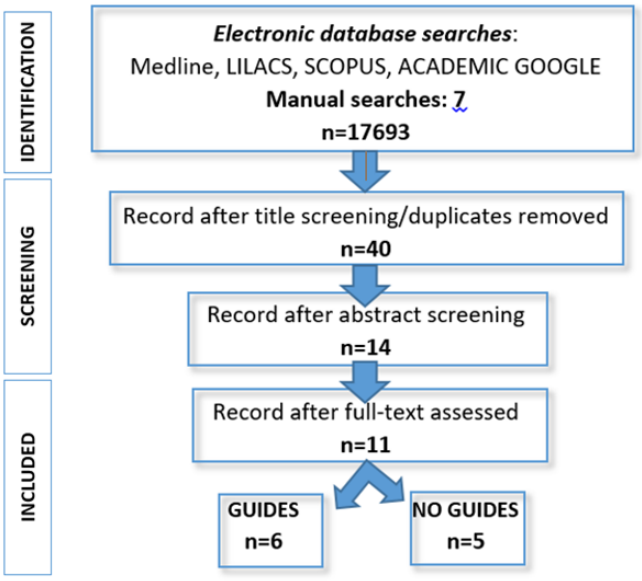

Figure 1. *Search flowchart*

Results

The search strategy resulted in 17693 artícles (17,400 from Google Scholar; 235 from PubMed; 51 from SCOPUS; 3 from LILACS; 4 from libros), of which only 40 were considered after title reading (only the most recent version of guides was used for assessment). After reading the abstracts, 26 articles were discarded. Finally, after reading the full text, 11 publications were selected (see Figure 1).

Six guidelines were included in this review, four European (two from the United Kingdom, one from Italy and one from member countries of the European Academy of Pediatric Dentistry (EAPD))[16-19] and two from the United States of America (USA) [20,21].

Five articles containing guidelines or recommendations on the use of radiographs for the diagnosis of caries lesions in children and adolescents were also included [22-25]. Although these publications do not present a structure corresponding to a guideline, they provide well-founded recommendations for the indication of the use of IR and guidelines for establishing the frequency of subsequent radiographic examination.

Quality assessment

None of the guides declares to have used the AGREE I or II principles. Notwithstanding, five of the guidelines comply adequately (>75%) with domains 1 (Scope and Purpose)[17-21]. Domain 2 (Stakeholder Engagement) consists of three items: Composition of the guideline development team; vision and preferences of the target population; and definition of the target population. Patient opinions or preferences were not included in any of the guidelines.

However, the EAPD and the National Clinical Guideline for Children's Oral Health Services in Canterbury recommend explaining to parents/carers and patients the benefits of taking an

X-ray[12,17]. Regarding Domain 3 (rigor of development), four of the guides include a search strategy for the evidence that supports the recommendations [18-21] while the others use methodologically incomplete search strategies and a wide range of references. The EAPD and Italian guides were generated at the request of expert workshops[18-19]. Domain 4 (Clarity of Presentation) addresses the language, structure, and format of the guideline. While the language is appropriate and clear in all of the selected guidelines, only two present a reader-friendly structure[16, 19]. None of the guidelines describe the existence of potential barriers or alternatives to the recommended techniques (Domain 5).

Three documents include information regarding other possible complementary tools for the clinical diagnosis of caries to be used, such as tooth separation in cases of proximal lesions, fiber optic transillumination (FOTI) and digital fiber optic transillumination (DIFOTI)[16,18,19].

Regarding Domain 6, only two of the guidelines present a declaration of no conflict of interest from their authors[18,19]. The quality scores (%) awarded to the selected guidelines, for each domain requested by AGREE II are presented in Table 1.

Guideline content

Tables 2 and 3 describe the year of publication of the document/update, author, country, and parameters used for the indication or frequency of repetition of radiographic examinations in the guidelines and articles with directives or recommendations for radiographs, respectively.

Most of the documents analyzed reject the indiscriminate use of X-rays and promote the concept of prescription based on patient needs [17, 21]. The patient's ability or capacity to cooperate was considered in two guidelines and one document [18, 19, 25].

Table 1. *Qualitative evaluation of the selected guides. The percentages for each domain suggested by AGREE II are shown*

	SCOPE AND PURPOSE	STAKEHOLDER INVOLVEMENT	RIGOUR OF DEVELOPMENT	CLARITY OF PRESENTATION	APPLICABILITY	EDITORIAL INDEPENDENCE
2010: UK Child Oral Health Services Clinical Directors Group	27.8%	16.7%	15.6%	38.9%	12.5%	10%
2012: USA ADA Council on Scientific Affairs	**95%**	50%	36.3%	**72.2%**	16.7%	10%
2012: SCOTISH Dental Clinical Effectiveness Programme. Oral Health Assessment and Revie Dental Clinical Guidance.	**77.8%**	39%	36.3%	55.6%	13.9%	10%
2017: USA AAPD Council on Scientific Affairs	**88.9%**	50%	55%	**77.8%**	12.5%	10%
2019: ITALY Ministry of Health	**100%**	55.6%	**96.3%**	**72.2%**	37.5%	25%
2019: EUROPE EAPD	**100%**	44.4%	**64.4%**	**85.2%**	16.7%	55%

Indication of initial radiography for the diagnosis of caries

The indication for IR for caries diagnosis at the first dental consultation varies widely among the selected guidelines, as shown in Table 2. While the Scottish guideline does not describe criteria for indicating radiography at the first consultation, the UK National Clinical Guideline for Children's Oral Health Services proposes using it in all patients without previous radiographic examinations in order to determine the baseline caries risk status [16,17]. Although the other four guidelines propose analyzing risk and activity as criteria for indicating radiography, they are actually based only on the presence of caries lesions [19-21] or when the presence of caries is suspected [18].

The five selected documents (Table 3) contain guidelines for indicating radiography at the first consultation and show wide variations. While Méjare (2005) and Steiner *et al.* (2011) propose indicating radiographs at specific ages (11-12 / 15-16 and 7/15 years, respectively) [22, 23], Cordeiro *et al.* (2010) propose assessing the risk of caries (anamnesis) and the presence of active lesions [25]. Other authors indicate radiographs at the first consultation

Table 2. *Criteria indicated by the guidelines for the indication of initial interproximal (IR) radiography and recommendations for the frequency of subsequent exams.*

Year: country board	Guideline	Selection Criteria at Baseline Examination	Frequency Criteria
2010: UK Child Oral Health Services Clinical Directors Group	**National Child Oral Health Services Clinical Guideline**	Interproximal radiographs should be taken in caries-free individuals to establish the risk of initial caries (including new patients in whom previous radiographs are not available). No specific threshold for risk classification is supplied.	Patients with active caries lesions (cavitated or no): within 12 months. Low risk children should have radiographies at key aged: 11/12 years old. No specific threshold for risk classification is supplied
2012: USA ADA Council on Scientific Affairs	**Dental radiographic examinations: recommendations for patient selection and limiting radiation exposure.**	New Patient being evaluated for oral diseases: Individualized radiographic exam may be indicated: positive historical findings (remineralization monitoring) and positive clinical signs/symptoms (Large or deep restorations; deep carious lesions).	Patient with clinical caries or at increased risk for caries: at 6-12 month intervals. Patient without clinical caries and not at increased risk for caries: at 18-36 month intervals. Use ADA Caries Risk Assessment forms over 6 years of age for caries risk classification.
2012: Scotland Scottish Dental Clinical Effectiveness Programme Group.	**Oral Health Assessment and Review** *Dental Clinical Guidance*	Does no describe	High risk: every 6 months until no new or active lesions are apparent. Moderate risk: every 12 months until no new or active lesions are apparent. Low risk in mixed dentition: every 12 – 18 months. Low risk in permanent teeth: ≥24 months as long as it remains of low caries activity. Specific threshold for risk classification is supplied.
2017: USA AAPD Council on Scientific Affairs	**Prescribing Dental Radiographs for Infants, Children, Adolescents, and Individuals with Special Health Care Needs**	New Patient being evaluated for oral diseases: Individualized radiographic exam may be indicated: positive historical findings (remineralization monitoring) and positive clinical signs/symptoms (Large or deep restorations; deep carious lesions).	Patient with clinical caries or at increased risk for caries: at 6-12 month intervals. Patient without clinical caries and not at increased risk for caries: at 18-36 month intervals. Use ADA Caries Risk Assessment forms over 6 years of age for caries risk classification.
2019: ITALY Ministry of Health	**National guidelines for dental diagnostic imaging in the developmental age.**	In all patients, when carious lesions are suspected in permanent teeth, particularly for caries risk patients. No definition of high caries risk patient is supplied.	Does no describe
2019: EUROPE EAPD	**Best clinical practice guidance for prescribing dental radiographs in children and adolescents: an EAPD policy document.**	Patients with caries lesions (cavitated or noncavitated). The risk and activity should be assessed at regular intervals to prescribe initial radiographs. No indication of risk or caries activity methods are supplied.	On basis of the age and the most progressed proximal caries lesion identified on the latest radiographic caries assessment Age 10-12: probably no indication age 13-16: no caries: 3-5 years every 2 years in presence of enamel lesions every 1-2 years with caries beyond EDJ every 1 year with dentine caries age >16: no caries: 5-10 years every 3 years in presence of enamel lesions every 1-2 years with caries beyond EDJ every 1 year with dentine caries

Table 3. *Criteria indicated in the selected documents for the indication of initial interproximal (IR) radiography and recommendations for the frequency of subsequent exams.*

Year: country author	Document	Selection Criteria at Baseline Examination	Frequency Criteria
2005: SWEDEN Ingegerd Mejàre	**Bitewing examination to detect caries in children and adolescents: When and how often?**	Key ages. 8-9 years 11-12 years 15-16 years	Annual examination should be considered if: ≥ 1 approximal dentine lesions or restored approximal surface and ≥ 3 approximal enamel lesions Any unrestored approximal dentine lesions or a recently restored approximal neighbouring surface. Low risk: every 2/3 years.
2007: BRAZIL Caroline de Oliveira Langlois, Célia Regina Winck Mahl , Vania Fontanella	**Diretrizes para a indicação de exames radiográficos em odontologia. Guidelines for prescribing dental radiographs**	Surface cannot be visually examined (independent of caries risk) or in presence of signs or symptoms of disease.	**Based on caries risk.** High/moderate risk: every 12 months until no new or active lesions are apparent. Low risk: every 24 months or in longer periods if the risk remains low. No specific threshold for risk classification is supplied.
2007: USA Larry Jenson; Alan W. Budenz; John Featherstone; Francisco J. Ramos-Gomez; Vladimir Spolsky; and Douglas Young.	**Clinical Protocols for Caries Management by Risk Assessment**	Not describe.	Based on risk assessment (visible cavities; radiographic penetration of the dentin; radiographic approximal enamel lesions (non in dentine); white spots on smooth surface and restorations last 3 years). The presence of any factors likes high risk. Low risk: between 24-36 months. Moderate risk: between 18-24 months. High risk: between 6-18 months (until no cavitated lesions are present) Extreme high risk (High risk plus dry mouth or special needs): every 6 months until no cavitated lesions are present.
2010: BRAZIL Rita de Cássia Loiola Cordeiro Fabio Cesar Braga de Abreu-e-Lima	**Indicadores de radiografías en Odontopediatria.** **(Manual de referencia para procedimientos clínicos en Odontopediatria. ALOP)**	After the clinical examination and previous Rx analysis. The presence of lesions is considered Key ages: 8/9; 12/16 years	**Based on caries risk:** Low risk: every 2/3 years. High risk: every 1 year.
2011: ZURICH Marcel Steiner; Saskia Bühlmann; Giorgio Menghini; Carola Imfeld; Thomas Imfeld.	**Caries risks and appropriate intervals between bitewing x-ray examinations in schoolchildren.**	Key ages.	Based on caries experience. Without caries experience: after 8 years (last school year). With caries experience: initial interval of 1 year. If, after 1 or 2 years, no development of the lesions can be detected, an extension of the interval is recommended.

for all patients regardless of the risk of caries[26] or do not provide selection criteria for patients who could benefit from radiographic examination [24].

Frequency of indication of radiographic examination

The authors of the reviewed studies use different criteria and time intervals (frequencies) for prescribing X-rays in adolescents, even in the same country or geographic region. The Italian guideline is the only one that does not describe the criteria for establishing a frequency of X-ray examinations [18].

The British, Scottish, and American guidelines determine the intervals between radiographic examinations based on multivariate models for caries risk assessment, with different classifications and indicators. At the same time, they emphasize the need to assess the presence of caries lesions. The first does not describe a specific threshold for risk classification [17], and the American guidelines use risk checklists designed for children over 6 years of age [20, 21].

The Scottish guidelines establish specific cutoff points, classifying individuals as high, moderate, and low risk. Differences were detected in the criteria used to establish risk categories, as well as variations in the recommended intervals for repeat radiographic examinations within the same risk category. For low-risk patients, the interval varies between 12 and 36 months[17, 20, 21] and between 6 and 12 months for high-risk patients[16,17,20, 21].

The EAPD guidelines propose using data from the first radiograph, combined with key age groups: 10-12; 13-16; and >16 years. From the first radiograph onward, patients are classified according to the severity of their caries lesions to establish the frequency of radiographic examinations: absence of caries lesions,

caries lesions in enamel, lesions up to the dentin-enamel junction, and lesions in dentin. Patients in the late mixed dentition (10-12 years) would not benefit from repeated radiographic examinations due to physiological exfoliation of the primary dentition. The frequency ranges from annual examinations (patients >13 years with dentin caries) to 5-10 years (patients >16 years without caries lesions).

Méjare (2005) and Steiner *et al.* (2011) base their indications on the presence of caries lesions[22, 23]. Méjare (2005) considers the extension and severity of the diagnosed lesions to establish the frequency between radiographic examinations. He proposes an annual check-up for patients with the presence of caries lesions (≥1 proximal lesion in dentin or restored proximal surface and ≥3 proximal lesions in enamel) and no earlier than two years for patients with no experience of caries. Meanwhile, Steiner *et al.* use multivariate models for the assessment of caries risk with different classifications (high/moderate/low and extremely high/high/moderate/low) and intervals that vary according to the presence of new caries lesions [24,26]. Cordeiro *et al.* (2010) established the frequency of radiographic taking at key ages (5; 8/9; 12/16) and based on the risk diagnosis (low and high) that is linked to the presence of active caries lesions [25].

Discussion

Clinical guidelines are "statements systematically developed to assist health care professionals and patients in making decisions about appropriate medical care in specific clinical circumstances" [27]. For this reason, they should provide clear and concise instructions about which diagnostic tests to order and how to provide the maximum health benefit with the minimum risk.

The analysis carried out in this study shows a lack of consensus regarding the use of X-rays for the initial diagnosis of patients with caries lesions. This situation raises doubts among clinicians as to their correct use. At the same time, considerable variability was detected, even within the same geographical region.

An apparent decrease in caries prevalence, attributable to increased fluoride bioavailability in the oral environment, is marked by the polarization of dental caries disease and accompanied by a slowing of lesion progression rates. This translates into a shift in the distribution pattern of lesions [28]. There are disparities in the rates of caries onset and progression between and within populations. This is due to differences in sociodemographic and behavioral conditions that interact with the etiology of dental caries 8. The surfaces most affected by caries in adolescents are the occlusal surfaces of molars and the proximal surfaces of premolars and molars. Once the contact points have been established, direct visual access to the proximal surfaces is difficult, limiting diagnostic accuracy, particularly in early caries lesions. Although various complementary diagnostic methods exist, bitewing radiography is widely used.

The combined use of visual-tactile diagnosis (VDT) accompanied by two IRs is the most widely used method in daily clinical practice.

It is traditionally considered the "state of the art" for the detection of caries lesions on clinically inaccessible proximal surfaces and occlusal caries lesions in dentin [3, 7]. The justification for its use is the increased diagnostic sensitivity on these surfaces [3, 4]. Despite this, its routine use is considered unacceptable. Based on the principles of radiation protection for children and adolescents (justification, optimization, and limitations), the prescription of an X-ray should be individualized, with specific justification and preceded by a clinical examination [19, 25].

The visual method should be the first choice for caries detection. This is a low-cost tool that requires no equipment, is faster, has acceptable sensitivity, is capable of distinguishing active from inactive lesions, and poses no inherent risk[29-31]. The use of other complementary diagnostic methods does not adequately reflect the integrity of the tooth surface or the presence of caries (Baelum, 2010).

Despite its widespread acceptance, DVT has a low sensitivity (SE) (ability to detect true positives) for proximal lesions (0.3) and a moderate sensitivity for initial lesions on occlusal surfaces (0.78). At the same time, a moderate-high specificity (SP) (ability to detect true negatives) is observed, regardless of the lesion surface and severity (0.92-0.99) [2, 5, 32]. The low SE determines an underestimation of lesions, which is between 30 and 60%, limiting the possibility of early detection of initial caries lesions and their non-operative approach and leaving severe lesions (with dentin involvement) both occlusal and proximal without operative treatment [5,6,33,34,37, 38].

The conditions under which the visual diagnosis must be made (clean, dry and illuminated field) added to the use of detailed and validated indices seems to improve the accuracy of the diagnostic method (its sensitivity) [32]. Only the Scottish guide emphasizes the importance of using caries detection systems with these characteristics such as the International Caries Detection System: ICDAS [35, 16].

In order to increase the diagnostic sensitivity of DVT (mainly in early caries lesions) and reduce the risk of ionizing radiation, different complementary methods are being investigated and used (electrical conductivity (EC), fiber optic transillumination (FOTI), quantification by light-induced fluorescence (QLF) and infrared laser-induced fluorescence (DIAGNOdent) [19]. The systematic review of the literature, published in 2013, showed that there is a great variation for both SE and SP, highlighting the results of electrical conductivity (EC) and quantitative light-induced fluorescence (QLF). However, its high cost and lack of availability in health services does not make its widespread use possible 36. Several guidelines recommend the combined use of DVT and radiography[11,37]. The reviewed documents recommend prescribing radiographs on an individual basis, with specific justification for each patient, followed by a clinical examination, consideration of the patient's dental history, age, and risk assessment. However, there is no consensus among the documents analyzed regarding the appropriateness of prescribing radiographs for adolescents attending a first consultation in daily practice as a diagnostic complement to visual-tactile examination. Furthermore, some

documents do not specify indicators[16, 24] and others suggest always taking x-rays to all patients at the first consultation[17,18] without providing guidelines. Evidence on the benefit of x-rays is scarce and contradictory, even in populations with the same caries experience or in similar regions. While some studies in high-risk populations conclude that there is no benefit in indicating x-rays [33], others show evidence for indicating them to all patients at the first consultation [4, 37].

Similar inconsistencies can be found in the literature regarding low-risk populations. While some indicate the use of IR at the first consultation [37], others show evidence indicating the use of radiographs at key ages linked to the active eruption of permanent molars [37,38], or not. The systematic review of the literature published by Apps *et al*. in 2020 evaluates the diagnostic efficacy of intraoral radiographs and the evidence supporting the indication of radiographs in children. It was conducted in support of the creation of the EAPD guideline and concluded that there is not enough high-quality evidence for the use of intraoral radiographs in children [39].

Although guidelines propose using caries risk and activity as criteria for prescribing radiographs for the diagnosis of basal caries, few studies investigate individual indicators for prescribing radiographs. A study conducted in 9-year-old children with the aim of establishing individual indicators for prescribing radiographic examinations found that the best predictor was the clinician's judgment, but its accuracy was low [38]. Carvalho *et al*. (2020) established the following group of indicators for prescribing x-rays at the first consultation in patients between 16 and 32 years of age: caries activity, D1MFS ≥17, and frequent soft drink consumption. The grouping of these indicators for the presence of radiographically detected lesions showed high sensitivity (0.84–0.91) and moderate specificity (0.64–0.73) for all surfaces and diagnostic thresholds studied (diagnosis of both cavitated and non-cavitated caries) [4]. At the same time, a cross-sectional study carried out in a Uruguayan adolescent population at high risk of caries could not correctly identify those adolescents who could benefit from taking x-rays for caries detection at their first consultation despite the higher number of lesions identified when using IR 40. This keeps the discussion alive and encourages the continuation of studies that allow us to efficiently manage the use of x-rays for diagnostic purposes.

Different parameters are used to determine the time interval between successive radiographic examinations, but few are based on the prevalence of caries lesions[22,23], their progression rates and the diagnostic accuracy of the imaging techniques in question [22,23]. The ADA, AAPD and the British and Scottish guidelines recommend taking into account the patient's risk assessment when establishing the frequency between successive imaging examinations. However, the evidence for caries risk assessment and caries lesion prediction is limited and contains a high degree of uncertainty [41, 42]. Two systematic reviews were conducted to assess the ability of multivariate models and individual risk factors to identify future caries development in children and adolescents [42, 43]. The results obtained show limited validity.

Risk assessment is a valuable tool for establishing the frequency of health checks, but it is not valid for determining the

frequency of repeat radiographs. The Italian guideline does not use risk assessment. The author considers that patients identified as "high caries risk" could be subject to a more "aggressive" diagnostic approach regarding the radiographic examinations to be performed [18].

Baseline caries experience was the most frequently used individual risk factor to predict caries incidence [43]. The risk of developing caries is highest during the years immediately following eruption[44, 45]. Caries lesion progression varies according to the surface and tooth involved, as well as the depth of the lesion at onset. Progression through dentin is greater than that through enamel and sound surfaces. Méjare *et al.* (1999) demonstrated that 75% of initial caries lesions survived a median of 6.3 years without penetrating the enamel thickness. Meanwhile, lesions diagnosed in the inner half of the enamel take an average of 4.8 years to advance to the outer half of the dentin. For proximal enamel lesions, progression from the outer half of enamel to the inner half takes an average of 8 years. In 10% of patients, these lesions may progress within 2.5 years. Fifty percent of lesions in the outer third of the dentin progress to the inner third within 3.1 years, but in 20% of the population, they do so within 1 year [44]. These data show that caries lesion progression varies widely according to the patient's caries activity.

Conclusion

There is no consensus on the parameters to be used for indicating and repeating radiographic examinations within the guidelines and articles analyzed in this review. However, the evidence reviewed condemns its indiscriminate use and emphasizes that it should always be based on the patient's needs.

The reviewed papers suggest prescribing radiographs according to the patient's risk diagnosis using different classification criteria, while also highlighting the importance of assessing caries activity. Furthermore, some documents highlight the use of key ages as an indicator of radiography to be considered in adolescents.

The frequency should be determined based on baseline conditions and determining factors. A repeat radiograph frequency of less than 12 months requires justification.

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