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An *in vivo* comparison of radiographic and clinical examination with separation for assessment of approximal caries in primary teeth

ABSTRACT

Aim To compare *in vivo*, clinical examination (CE) and bitewing radiographs (BW) for the detection of cavitations and initial approximal lesions in deciduous molars with validation after temporary separation (TS) and direct visual examination (DE) of the approximal surfaces.

Methods Thirty children aged 4 to 8 years without visual cavitations or restorations and with at least one approximal contact. Two calibrated examiners evaluated 355 surfaces of primary molars, which were then validated through TS and DE.

Results Of the 280 surfaces considered sound by CE, 24.6% were cavitated after separation. Comparing BW and DE, it was observed that, when the radiolucency involved the inner half of dentin, 68.4% of lesions were cavitated. The sensitivity and specificity of CE and BW were 0.14 and 0.43, and 0.80 and 0.75, respectively.

Conclusions DE identified a greater number of pre-cavitated lesions and cavities. BW were useful for detection of decayed surfaces, but with low specificity for diagnosis of sound surfaces, while detection of sound or decayed approximal areas by means of CE alone was not possible. The combination of methods was effective in obtaining an accurate diagnosis of caries in the primary dentition.

Keywords Bite-wing radiography; Clinical examination; Dental caries diagnosis.

Introduction

The combination of a large area of approximal contact between primary molars, and the physical-chemical structure of enamel and dentin of deciduous teeth favour the onset and rapid progression of the caries lesion, which can compromise the integrity of the pulp tissue [Araújo et al., 1996]. In order to make treatment decisions it is important to know whether an approximal caries lesion can be arrested by improvement of the patients' oral hygiene and the use of fluorides or if operative treatment is unavoidable [Kielbassa et al., 2006].

Over the years, the literature described a number of methods to diagnose caries lesions in approximal surfaces, such as visual inspection with or without dental probe, bitewing radiographs, direct or indirect clinical examination (through impressions) after tooth separation [Newbrun, 1985; Deery et al., 2000] and fluorescence-based methods [Novaes et al., 2009]. Efforts have been made to develop a diagnostic method that aims at detecting incipient caries lesions, which have become increasingly common, and present a risk of remaining "hidden" and progress slowly [Wenzel and Verdonchot, 1994].

Visual inspection can be considered as one of the most common methods for dental caries diagnosis. However, its application for diagnosis of approximal lesions is limited due to the difficulty of direct examination of these areas [Pitts and Longbottom, 1983; Pitts, 1991; Hopcraft and Morgan, 2005].

Bitewing radiographs are considered the most useful method [Rimmer and Pitts, 1990; Galcerá-Civera, 2007], nevertheless, its low sensitivity for diagnosis of incipient lesions [Verdonchot and Rondel, 1995; Silva Neto et al., 2008] and the occurrence of technical problems that may increase the dose of ionizing radiation, particularly problematic in children [Marthaler and Germann 1970; Peers, 1993; Matalon et al., 2003; Mendes et al., 2012], encouraged the development of other methods, such as direct visual examination of impressions or casts of approximal surfaces after elastomeric separation [Seddon, 1989; Araújo et al., 1992; Pitts and Rimmer, 1992; Danielsen et al., 1996; Lunder and von der Fehr, 1996; Hintze et al., 1996] in cases where the diagnosis is still doubtful.

This method has many advantages: it reduces the number of radiographs taken, allowing direct visual access to the approximal surface, is reversible and has a low cost [Stokes, 1988; Rimmer and Pitts, 1990]. However, the results of its application in paediatric dentistry are still rare and conflicting [Pitts and Rimmer, 1992; Araújo et al., 1996].

Thus, the aim of this study was to compare *in vivo* the clinical examination and bitewing radiographs for detection of pre-cavitated and cavitated approximal lesions in deciduous molars with validation after temporary separation and direct visual examination of the approximal surfaces, in order to select the most effective method

among those included in the study for early diagnosis of approximal dental caries in the primary dentition through assessment of sensitivity and specificity values.

Materials and methods

Ethical approval and subject selection

the study was approved by the Research and Ethics Committee of the Fluminense Federal University (Protocol CEP CMM/HUAP n° 07/00). The procedures, possible discomforts or risks, as well as possible benefits were fully explained to the parents of the children involved and informed written consent was obtained from all the participants prior to the investigation.

The study sample consisted of 30 children of both genders, with age ranging from 4 to 8 years, selected at random from patients attending the Fluminense Federal University Pediatric Dentistry Clinic in the city of Niterói, Brazil, who fulfilled the following criteria: presence of approximal bilateral contact in primary molars in both arches and no cavitations or restorations clinically detectable.

Examination methods

A total of 355 surfaces were examined clinically and radiographically by two calibrated examiners. The calibration was performed both in teeth in situ with a similar group and in extracted teeth.

For the clinical examination, a plain mouth mirror (Duflex, SSWhite®, Rio de Janeiro, Brasil) and a number 5 dental probe (Duflex, SSWhite®, Rio de Janeiro, Brazil) were used to assess the caries status after dental prophylaxis with pumice and water. The following codes were used [Rimmer and Pitts, 1990]: 0 – no proximal caries lesion; 1W – white spot; 1B – brown/black spot; 1M – enamel defects/ fluorosis.

For the radiographic examination, 2 posterior bitewing radiographs, positioned using a Kwik-Bite film holder (Hawe-Neos®, Kerr-Hawe, Bioggio, Switzerland), were taken for each patient using Kodak Insight radiographic films (22 x 35 mm, Eastman Kodak®, Rochester, NY, USA) all with same batch number and a Spectro 70x model X-ray unit (Dabi-Atlante®, Ribeirão Preto, Brazil), operating at 70KVp and 8 mA with a 0.3 second exposure time. The exposed films were processed in batches in an automatic processor (Durr AC245, Durr Dental, Bietigheim, Germany)

with freshly prepared Kodak developer and fixer at 28 °C according to the manufacturer's instructions. The X-rays were viewed separately from the clinical examination by the two examiners independently, who were blinded with regard to the clinical data, on a backlit screen with a x2 magnification viewer (Lumagny, model n° 7547, Hong Kong) in a dark environment whose light was limited to the radiographic film size by one board paper mask, and the radiographic lesion depth was evaluated by the same calibrated examiners according to the scores [Ekstrand et al., 1997]:

- R0. No visible radiolucency
- R1. Radiolucency visible in the enamel
- R2. Radiolucency visible in the dentine, but restricted to the outer 1/3 of dentine
- R3. Radiolucency extending to the middle 1/3 of the dentine
- R4. Radiolucency in the inner 1/3 of dentine.

In case of discordant grading a consensus rank was agreed. Subsequently, the surfaces were submitted to elastomeric separation for diagnostic validation. Orthodontic rubber rings (EL-400, Dental Morelli®, São Paulo, Brazil) were placed around the contact points for seven days and a 0.8 to 1 mm space in the proximal area was thus obtained. After separation, the surfaces were cleaned with water spray and dental floss (Oral B, Belmont, USA) and evaluated by means of direct visual inspection and the lesions were scored as cavitated and sound.

Statistical analysis

Statistical analysis was performed using SPSS software (SPSS for Windows 11.5.1; SPSS Inc., Chicago, IL, USA). The sensitivity and specificity values for each diagnostic method were also determined. Cohen's Kappa test was employed to check the inter-examiner reproducibility.

Results

The inter-examiner reproducibility values of the radiographic and clinical exams (Kappa's value) were 0.81 and 0.84, respectively. The comparison of clinical examination and direct visual inspection after separation is shown in Table 1. It was observed that 69 (24.6%) of the 280 surfaces considered sound (score 0) by clinical examination were cavitated. Table 2 shows the comparison of radiographic examination and direct visual

Direct visual inspection	Clinical examination codes								TOTAL	
	0		1W		1B		1M			
	n	(%)	n	(%)	n	(%)	n	(%)	n	%
Cavitated	69	(24.6)	0	(0)	-	-	-	-	69	19.4
Sound	211	(75.4)	75	(100)					286	80.6
TOTAL	280	(100)	75	(100)					355	100

TABLE 1 Clinical examination compared to direct visual inspection after tooth separation.

Direct visual inspection	Radiographic scores										Total	
	R0		R1		R2		R3		R4			
	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	n	%
Cavitated	0	(0)	6	(5.3)	12	(30)	12	(34.3)	39	(68.4)	69	19.4
Sound	109	(100)	108	(94.7)	28	(70)	23	(65.7)	18	(31.6)	286	80.6
TOTAL	109	(100)	114	(100)	40	(100)	35	(100)	57	(100)	355	100

TABLE 2 Radiographic examination compared to direct visual inspection after tooth separation.

Diagnostic methods	TP	FP	TN	FN
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Clinical examination	40	46	35	234
Radiographic examination	229	17	52	57

TABLE 3 True-positive (TP), false-positive (FP), true-negative (TN) and false-negative (FN) values for Clinical and Radiographic examination.

inspection after separation. Of the 109 surfaces classified radiographically as R0, 100% were considered as clinically sound, of the 114 surfaces scored as R1, 94.7% were sound, and of the 40 surfaces scored as R2, 70% were sound. Regarding the caries lesions extending to the middle 1/3 of the dentin (R3) a cavitation was found in 12 of 35 cases (34.3%), whereas in caries lesions scored as R4 a cavitation was found in 39 of 57 cases (68.4%). The sensitivity and specificity of the clinical and radiographic examination were 0.14 and 0.43, and 0.80 and 0.75, respectively, as shown in Table 3.

Discussion

Several *in vitro* and *in vivo* studies have been performed to assess the best diagnostic method of dental caries in approximal surfaces, however, the results of *in vitro* studies do not take into consideration the conditions found in clinical management of the patient [Marthaler and Germann, 1970]. Thus, this *in vivo* study was developed with the aim to provide additional data to the current literature on methods for validating the diagnosis of approximal caries in primary teeth, a subject poorly studied in the literature that mainly addresses the mixed and permanent dentitions.

Despite of the sample size, that may have limited the study, the results showed an underestimation of the prevalence of approximal caries lesions by clinical examination alone, as direct visual inspection after separation was more accurate than conventional clinical examination, since 24.6% of the approximal caries lesions remained undetected by clinical examination alone

(Table 1). Similar results were obtained by other authors [Rimmer and Pitts, 1990; Deery et al., 2000]. Besides, the clinical examination alone showed lower specificity (0.43) and sensitivity (0.14) values than the radiographic method in this sample (0.75 and 0.80, respectively) (Table 3). These data agree with those of the literature [Araújo et al., 1992; Russell and Pitts, 1993; Hopcraft and Morgan, 2005; Galcerá-Civera et al., 2007].

With reference to the comparison of radiographic examination and direct visual inspection after separation, it was observed that when the radiolucency was visible in the enamel (R1), only 5.3% of the lesions were cavitated (Table 2). On the other hand, considering R2, R3 and R4 scores, it was noted an increasing number of cavitated lesions (30%, 34.3% and 68.4%, respectively), suggesting that radiography is not the most indicated method to detect incipient lesions confined to enamel, being more effective for lesions that have already reached the DEJ. These data also agree with the literature [Pitts and Rimmer, 1992; Akpata et al., 1996; Araújo et al., 1996; Lunder and von der Fehr, 1996; Hopcraft and Morgan, 2005; Silva Neto et al., 2008]. Thus, radiographic examination is more specific than sensitive regarding incipient lesions [Pitts and Rimmer, 1992; Van Rijkom and Verdonschot, 1995].

Despite the availability of different caries detection methods, none of them present high sensitivity values. Mendes et al. [2012] showed in their study that adjunct radiographic and laser fluorescence methods offer no benefits to the detection of caries in primary teeth in comparison to visual inspection alone. This is an indication, from the clinical point of view, that the best caries detection approach still relies on a combination of techniques allied to the dentist's knowledge and clinical judgment [Silva Neto et al., 2008]. According to Novaes et al. [2009], the temporary separation is more efficient in primary teeth, since they are less firmly anchored in the alveolar bone and easier to move than permanent teeth and then it could be used as a validation method for dental caries diagnosis in paediatric dentistry.

Based on the results of the present study, the radiographic examination can be of value as an auxiliary method for diagnosis of approximal caries in the primary dentition, mainly for cavitated carious lesions, but it is not

a trustworthy method for detection of incipient lesions. In these cases, when an accurate diagnosis is questioned, the use of orthodontic rubber rings associated with direct visual inspection is a helpful diagnostic method for validation of incipient carious lesions in children.

Conclusions

Within the limitations of this study, the following conclusions may be drawn.

1. It can be concluded that clinical examination after separation identified a greater number of pre-cavitated lesions and cavities than conventional clinical examination and bitewing radiographs.
2. The radiographs were perfectly capable of diagnosing decayed surfaces, but with low specificity for diagnosing sound surfaces, while the clinical examination alone was not able to detect which areas were sound or decayed.
3. The probability of a radiolucency in the bitewing radiograph corresponds to a cavitated lesion was higher according to the depth of this image.
4. The combination of methods was effective in obtaining an accurate diagnosis of caries in the primary dentition, and the use of orthodontic rubber rings to obtain a temporary separation in case of questionable carious lesions may be an important adjunct to increase the diagnosis of early approximal caries in children.

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