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A Pilot Study of a Modified Radiographic Technique for Detecting Early Proximal Cavities

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Key Words

Approximal caries · Bitewing radiography · Caries detection · Caries diagnosis · Proximal caries

Abstract

Diagnosing the necessity of cavity preparation in demineralized proximal areas has been considered as a challenge in restorative treatment planning. The purpose of this study was to investigate the clinical performance of a modified radiographic technique for the detection of proximal cavities. The sample consisted of 44 proximal surfaces in 38 dental students. The patients had radiolucent proximal lesions restricted to the inner half of enamel or the outer third of dentine in bitewing radiographs, and there was doubt regarding the presence or absence of cavities in the approximal areas. The suspected surfaces were then examined by secondary bitewing radiographs which were taken after pressing radiopaque material into the proximal areas. Finally, orthodontic elastic separators were placed in the contact areas to provide enough space for direct visual and tactile examination, thus detecting any proximal cavity (reference standard). The sensitivity, specificity and accuracy of the modified bitewing radiography were calculated against the reference standard. Overall, 7 surfaces presented caries cavities according to the reference standard. All proximal radiolucencies observed in the inner half of enamel and 46% of those extended to the outer third of dentine were not cavitated when evaluated by direct visual and tactile examination. The sensitivity, specificity and accuracy of bitewing radiography with opaque material for detecting proximal cavities (n = 7) were 86, 100 and 98%, respectively. The tested radiographic technique displayed good validity in this pilot study for detecting proximal cavities in posterior teeth and should be further investigated.

Diagnosis of early proximal caries in posterior teeth is a difficult task in restorative treatments. Visual inspection has low sensitivity in detecting proximal caries in early stages of development [Hintze et al., 1998; Newman et al., 2009] so most clinicians rely on bitewing radiographs which, however, expose patients to ionizing radiation. In the clinical settings, it is important to distinguish between cavitated and noncavitated proximal lesions because, as long as the tooth integrity has not been compromised in the caries process, remineralization treatments with fluoride or other prophylactic agents are capable of restoring the minerals lost during lesion formation and even of making the tooth more resistant to further caries development [Buchalla et al., 2002; Cury and Tenuta, 2009; Rehder Neto et al., 2009].

Although bitewing radiography has a higher sensitivity than visual examination for diagnosing proximal caries [Hintze et al., 1998; Newman et al., 2009], it is still deficient

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in differentiating enamel demineralization from cavitation. Several authors [de Araujo et al., 1996; Hintze et al., 1999; Tan et al., 2002; Heymann et al., 2012] demonstrated that a great amount of proximal radiolucencies confined to enamel or the outer half of dentin in bitewing radiographs are noncavitated and can be treated with remineralization measures. On the other hand, it has been proposed that administrating a topical intraoral contrast agent can be useful in radiographic imaging of dental caries, diagnosing or monitoring periodontal disease or evaluating the three-dimensional shape of dental canals before root canal therapy [WIPO: patent application WO/2012/151464]. We worked on the assumption that pressing an opaque material to the contact area before taking a bitewing radiograph can overcome the shortcomings of bitewing radiography in detecting cavitated proximal lesions and help the clinician to diagnose lesions that are indeed in need of restorative intervention. The aim of this study was to investigate, for the first time, the clinical performance of a modified radiographic technique using radiopaque material in the contact area for the detection of cavitated approximal lesions.

Subjects and Methods

In a recall program, dental students at the School of Dentistry of Mashhad University of Medical Sciences who had had posterior bitewing radiographs taken within the previous month were asked to refer to the Department of Restorative Dentistry for further examination of the caries process. All bitewing radiographs had been taken under the same standardized conditions at the Department of Radiology of Mashhad Dental School. From the 132 students who had initial bitewing radiographs, 38 patients with 44 radiolucent lesions in proximal surfaces of posterior teeth were selected. The lesions were judged under a lightbox by the first author to be located in the inner half of enamel or the outer third of dentin. In the clinical examination, the teeth with radiolucent lesions were in contact with the neighboring teeth, and there was some doubt regarding the presence or absence of cavities in the approximal areas. Teeth with marginal ridge discontinuity or obvious carious lesions on occlusal or smooth surfaces, such as those with restorations in approximal surfaces or showing hypoplastic pits, were excluded from the study. The study protocol was approved by the Ethics Committee of Mashhad University of Medical Sciences, and an informed consent was obtained from each participant after explaining the purpose of the research.

The study included 26 (59.1%) premolar and 18 (40.9%) molar teeth. Each suspected tooth was cleaned by water slurry of pumice, and the contact area was flossed. A radiopaque material was then placed in the contact area and pressed to the proximal surface of the suspected tooth by using a stainless steel dental matrix band which was moved in a sweeping motion in the occlusogingival and buccolingual directions. The opaque material was prepared for each individual in a creamy consistency by mixing zinc oxide powder BP (Associated Dental Products Ltd., UK) with a sialography solution (meglumine compound 76%; Darou Pakhsh, Tehran, Iran). The buccal and lingual surfaces of the tooth were then cleaned with cotton rolls and a secondary bitewing radiograph was taken. A Planmeca intraoral X-ray machine (model PM 2002; Planmeca Oy, Helsinki, Finland) was used to take radiographs using intraoral E-speed films (30.5 × 40.5 mm; Kodak, Carestream Health Inc., Rochester, N.Y., USA) and bitewing holders to provide standardized projection geometry. The apparatus operated at a voltage of 66 kV and an intensity of 8 mA, and the exposure time was set to 0.2 s. The focus-to-film distance was approximately 40 cm. The films were manually processed for development.

The secondary bitewing radiographs were then assessed under a lightbox by an oral and maxillofacial radiologist (H.H. Zarch), and the passage of the opaque material through the boundary of the tooth was recorded as the presence of cavitated lesion (fig. 1). The investigator rated the bitewing radiographs under the same conditions 1 week later to determine intraexaminer reproducibility.

The Reference Standard

After performing the radiographic examination, orthodontic separators (Ortho Technology, Tampa, Fla., USA) were placed in the contact area using a separating pliers (Ortho Technology) and allowed to remain for at least 48 h to provide adequate space between the teeth, thus making direct visual and tactile examination of the proximal area possible. The rings were removed in the next visit; the proximal surfaces were cleaned with dental floss and then assessed by a dental mirror and a pigtail explorer (Hu-Friedy, Chicago, Ill., USA). The examination was carried out by a restorative dentist (M. Akbari) who was not aware of the previous radiographic evaluation. The restorative dentist classified the surfaces as follows:

Score 0: enamel surface is either sound or shows noncavitated caries lesion defined as white or brown discoloration without enamel discontinuity.

Score 1: enamel surface shows cavitated caries lesion defined by loss of enamel integrity during visual or tactile examination with a dental explorer.

Statistical Analysis

Intraclass correlation coefficient analysis was used to evaluate the intraexaminer reliability of radiographic assessment. Sensitivity, specificity and accuracy (the percentage of correct diagnosis in all samples including cavitated and noncavitated surfaces) of the modified bitewing radiography were calculated against the reference standard. A confidence interval (CI) of 95% was assumed.

Results

Overall, 13 surfaces (29.5%) had radiolucent lesions confined to the outer third of dentine and the remaining radiolucencies (70.5%) were diagnosed to be restricted to the inner half of enamel. The frequency of proximal cavities according to bitewing radiography with opaque material and direct visual and tactile examination (reference

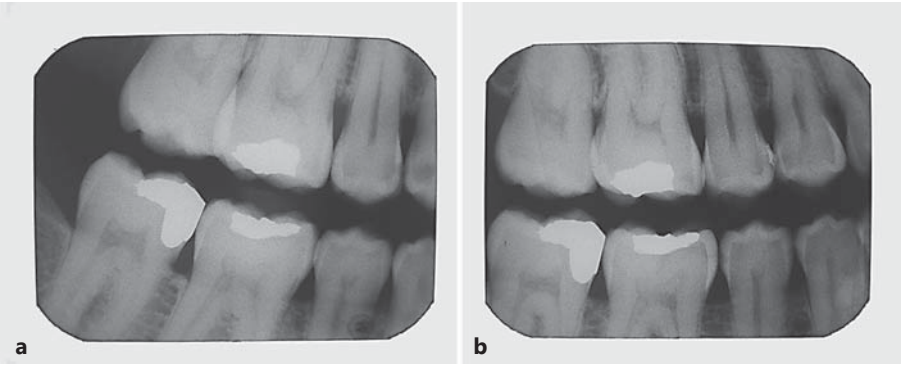

Fig.1. a A conventional bitewing radiograph. **b** The bitewing radiograph of the same patient taken with the use of opaque material. Note the passage of the radiopaque material into the mesial surface of the upper second premolar.

Table 1. The frequency of sound/demineralized and cavitated proximal surfaces as detected by bitewing radiography with opaque material and by visual and tactile examination (reference method)

	Sound/demineralized surface, n (%)	Cavitated surface, n (%)	Total, n (%)
Bitewing radiography with opaque material	38 (86.4)	6 (13.6)	44 (100)
Reference method	37 (84.1)	7 (15.9)	44 (100)

method) are presented in table 1. The reference method revealed that 7 (16%) surfaces presented caries cavities and 37 (84%) were either sound or had noncavitated caries lesions (table 1). None of the proximal radiolucencies observed in the inner half of enamel was cavitated. All cavitated surfaces had radiolucent lesions extending to the outer third of dentine. The sensitivity, specificity and accuracy of the modified radiographic approach were found to be 86% (95% CI: 42–99%), 100% (95% CI: 88–100%) and 98% (95% CI: 93–102%), respectively, for detecting smooth surface cavities in posterior teeth with limited radiolucent areas. The intraexaminer reliability (reproducibility) of the tested technique was found to be very high, giving an intraclass correlation coefficient value of 0.928.

Discussion

The performance of a modified radiographic technique was investigated, for the first time, in this study for the detection of proximal cavities. Bitewing radiography was used as a screening method for patient selection to more closely simulate the clinical situation when the clinician may have doubt concerning conservative versus invasive treatment of teeth with limited radiolucent lesions in approximal areas. In the present study, all of the proximal lesions observed in the inner half of enamel and about half of those extended to the outer third of dentine were not cavitated, which is consistent with the findings of previous authors [de Araujo et al., 1996; Hintze et al., 1999; Tan et al., 2002]. The diagnosis of smooth surface caries with modified bitewing technique showed high reproducibility.

Bitewing radiography is the most commonly used method for diagnosing proximal caries and displays moderate-to-high specificity for detecting enamel or dentine lesions in proximal areas [Heymann et al., 2012]. The sensitivity of bitewing radiography for proximal caries detection is dependent on caries extension, as it is more sensitive in detecting dentinal than enamel lesions. Bitewing radiography, however, shows deficits in representing enamel surface integrity, as the presence of proximal radiolucencies in bitewing radiographs is not always indicative of cavitation [Peker et al., 2009; Heymann et al., 2012]. In this study, the opaque material was inserted into the proximal contact area before taking radiographs so as to counteract the limitation of bitewing radiography in representing proximal surface integrity and to help the clinician in the treatment decision-making process in order to clarify whether the surface is cavitated or not. Considering the high specificity of this approach, it could be used as a valid diagnostic aid to prevent unnecessary cavity preparation, but further studies with greater sample size are required to prove its efficacy and practicality in the dental office.

So far, great attempts have been made in the development of diagnostic adjuncts that have higher accuracy than tactile examination and bitewing radiography in detecting proximal lesions. Recent studies focused on the performance of a laser fluorescence apparatus (DIAGNOdent pen; KaVo, Biberach, Germany) and reported relatively high diagnostic accuracy for this device as a screening method for diagnosing smooth surface caries [Novaes et al., 2009, 2010, 2012b; Chen et al., 2012], although some authors claimed that visual-tactile examination was still the superior strategy regarding the choice of treatment [Baelum et al., 2012; Mendes et al., 2012]. It is not possible to compare the performance of the novel radiographic technique with other methods of proximal caries detection used in previous studies because of the differences in the inclusion criteria. To be included in this study, the teeth should have limited radiolucent lesions in approximal surfaces of posterior teeth in the preliminary bitewing radiographs. We did not use the modified bitewing technique for screening proximal surface caries because the preparation and insertion of the opaque material may be time-consuming and uncomfortable for the patient as well as for the clinician. Furthermore, the conventional bitewing radiography can indicate the necessity of cavity preparation in most cases, depending on the caries incidence of the population. The modified radiographic technique should be reserved for those cases that have radiographic lesions extending to the outer third of dentin where there is doubt regarding the necessity of preparing the tooth for restoration or taking a wait-and-see policy. The exposure to ionizing radiation is certainly a health hazard concern, which can be minimized by using the digital radiographic technique.

We verified the presence of proximal cavities at least 2 days after temporary tooth separation, which provided enough space to allow direct visual and tactile examination of the contact areas. Novaes et al. [2009, 2012a] assumed that tooth separation with orthodontic rubbers was not a perfect but a functional validation method in primary teeth, which provided spacing narrower than 1.0 mm between primary molars. Hintze et al. [1998], however, believed that tooth separation did not have enough reliability to be used as validation for other diagnostic methods in detecting approximal cavitations. In the clinical conditions, the criterion to decide whether to go through conservative versus invasive treatment is the presence of cavitation. Therefore, gentle tactile examination with an explorer after tooth separation can be considered as a suitable and conservative approach to determine the need for operative interventions in approximal surfaces of posterior teeth. Placing rubber separators between the proximal surfaces of permanent teeth, however, may be painful and uncomfortable for the patient. Another disadvantage is the necessity for future examination of the surface within 1–7 days following elastic insertion. The applicability of this approach may be dependent on the duration of separator retention in the contact area and may also be affected by the thickness of the rubber ring.

In populations with low caries activity, it may take a long time for an initial caries lesion to progress into a lesion that requires restorative intervention. In the clinical conditions, a false-negative diagnosis may be of little consequence if the frequency of examination is high and the rate of caries progression is slow [Bader and Shugars, 2004]. In contrast, a rise in the false-positive diagnosis would be associated with unneeded treatment and iatrogenic damage to the tooth structure [Bader and Shugars, 2004]. Therefore, the specificity of a caries diagnostic device can be considered as more important than its sensitivity in populations with low caries prevalence. It is believed that for caries diagnostic modalities, sensitivity should be at least 75% and specificity should be over 85% [Karlsson, 2010]. In this study, the sensitivity (86%) and specificity (100%) were above these values. However, due to the limited number of cavities (n = 7) detected in this pilot study, these values are afflicted with some uncertainty and should be interpreted with caution. Therefore, the modified radiographic technique should be further investigated as a supplemental method in cases where proximal lesions had been identified by preliminary bitewing radiographs in order to permit the differentiation of these lesions into cavitated and noncavitated ones. This approach can prevent unnecessary restorative intervention and reduce treatment costs, although watchful waiting and remineralization therapy may be required to gain the optimal result.

A limitation of this study was the small sample size and the lack of access to a perfect validation tool in the clinical settings. Further clinical studies with larger sample size should be designed to investigate the validity, reliability, applicability and patient acceptance of bitewing radiography with opaque material for the detection of proximal cavities.

Conclusions

Bitewing radiography with opaque material showed high intraexaminer reproducibility in detecting cavities on approximal surfaces of posterior teeth.

The sensitivity, specificity and accuracy of bitewing radiography with opaque material were found to be high for detecting proximal cavities in this pilot study, and thus this approach should be further investigated as an adjunct in the decision-making process to indicate the necessity of cavity preparation.

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References

Bader JD, Shugars DA: A systematic review of the performance of a laser fluorescence device for detecting caries. J Am Dent Assoc 2004;135:1413–1426.

Baelum V, Hintze H, Wenzel A, Danielsen B, Nyvad B: Implications of caries diagnostic strategies for clinical management decisions. Community Dent Oral Epidemiol 2012;40:257–266.

Buchalla W, Attin T, Schulte-Monting J, Hellwig E: Fluoride uptake, retention, and remineralization efficacy of a highly concentrated fluoride solution on enamel lesions in situ. J Dent Res 2002;81:329–333.

Chen J, Qin M, Ma W, Ge L: A clinical study of a laser fluorescence device for the detection of approximal caries in primary molars. Int J Paediatr Dent 2012;22:132–138.

Cury JA, Tenuta LM: Enamel remineralization: controlling the caries disease or treating early caries lesions? Braz Oral Res 2009;23(suppl 1):23–30.

de Araujo FB, de Araujo DR, dos Santos CK, de Souza MA: Diagnosis of approximal caries in primary teeth: radiographic versus clinical examination using tooth separation. Am J Dent 1996;9:54–56.

Heymann HO, Swift EJ, Ritter AV: Sturdevant's Art and Science of Operative Dentistry. St Louis, Mosby, 2012, pp 92–104.

Hintze H, Wenzel A, Danielsen B, Nyvad B: Reliability of visual examination, fibre-optic transillumination, and bite-wing radiography, and reproducibility of direct visual examination following tooth separation for the identification of cavitated carious lesions in contacting approximal surfaces. Caries Res 1998;32:204–209.

Hintze H, Wenzel A, Danielsen B: Behaviour of approximal carious lesions assessed by clinical examination after tooth separation and radiography: a 2.5-year longitudinal study in young adults. Caries Res 1999;33:415–422.

Karlsson L: Caries detection methods based on changes in optical properties between healthy and carious tissue. Int J Dent 2010;2010:270729.

Mendes FM, Novaes TF, Matos R, Bittar DG, Piovesan C, Gimenez T, Imparato JC, Raggio DP, Braga MM: Radiographic and laser fluorescence methods have no benefits for detecting caries in primary teeth. Caries Res 2012;46:536–543.

Newman B, Seow WK, Kazoullis S, Ford D, Holcombe T: Clinical detection of caries in the primary dentition with and without bitewing radiography. Aust Dent J 2009;54:23–30.

Novaes TF, Matos R, Braga MM, Imparato JC, Raggio DP, Mendes FM: Performance of a pen-type laser fluorescence device and conventional methods in detecting approximal caries lesions in primary teeth – in vivo study. Caries Res 2009;43:36–42.

Novaes TF, Matos R, Raggio DP, Imparato JC, Braga MM, Mendes FM: Influence of the discomfort reported by children on the performance of approximal caries detection methods. Caries Res 2010;44:465–471.

Novaes TF, Matos R, Celiberti P, Braga MM, Mendes FM: The influence of interdental spacing on the detection of proximal caries lesions in primary teeth. Braz Oral Res 2012a;26:293–299.

Novaes TF, Matos R, Raggio DP, Braga MM, Mendes FM: Children's discomfort in assessments using different methods for approximal caries detection. Braz Oral Res 2012b;26:93–99.

Peker I, Toraman Alkurt M, Bala O, Altunkaynak B: The efficiency of operating microscope compared with unaided visual examination, conventional and digital intraoral radiography for proximal caries detection. Int J Dent 2009;2009:986873.

Rehder Neto FC, Maeda FA, Turssi CP, Serra MC: Potential agents to control enamel caries-like lesions. J Dent 2009;37:786–790.

Tan PL, Evans RW, Morgan MV: Caries, bitewings, and treatment decisions. Aust Dent J 2002;47:138–141, quiz 182.

WIPO: Patent application WO/2012/151464. http://patentscope.wipo.int/search/en/detail.jsf?docId=WO2012151464&recNum=51&docAn=US2012036444&queryString=%22oligosaccharide%22&maxRec=21681.