Comparison of three methods for detection of carious lesions in proximal surfaces versus direct visual examination after tooth separation

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The present study aimed to compare clinical, fiber-optic transillumination and bite-wing radiographic assessment of carious lesion depth in contacting proximal surfaces with the results obtained by direct visual inspection after tooth separation of the respective surfaces. It is suggested that when a carious lesion is diagnosed as non-cavitated by clinical examination or restricted to enamel by FOTI or radiographic examinations in a population of children with low caries prevalence, dentists should adopt a preventive approach.
J Clin Pediatr Dent 28(1): 59-62, 2003

INTRODUCTION

The increased understanding about the dynamic nature of the carious process and the efficacy of noninvasive methods of arresting lesion progression in recent years has changed the criteria for the treatment of proximal carious lesions.[1] Now, it has been suggested that the management of dental caries nowadays should be determined by an evaluation of the rate of lesion progression and the presence or absence of enamel surface cavitation instead of focusing solely on the radiographic depth of a carious lesion.[2]

When posterior teeth are in normal anatomical contact, it is difficult to estimate the presence of a cavitation by clinical examination or by bite-wing radiography. Therefore, other methods were developed as an alternative to these exams such as fiber-optic transillumination (FOTI). In this technique, an intraoral fiber-optic light probe is placed through the contact point of proximal surfaces, which are examined using the transmitted light viewed from the occlusal surface.[3] The principle behind FOTI is that a carious lesion presents a lower index of light transmission than a sound surface. Thus, carious lesions appear as dark shadows following the external outlines of the lesion when dental surfaces are transilluminated.[3]

Regarding the radiographic method, no radiolucent appearance conclusively defines which of the diagnosed lesions are cavitated or not, although studies state that there is a positive correlation between depth of the lesion and probable presence of a cavity.[4-6] As in FOTI, no shaded area characterizes with certainty a cavitated or noncavitated lesion, but rather provides an indication of a possible presence.[7-9]

In cases in which the diagnosis is doubtful, elastomeric separators can be used to produce temporary tooth separation, since they allow direct inspection of proximal sites. The method is non-destructive, reversible and inexpensive, and may be a useful aid in the diagnosis and management of some lesions.[10,11]

The literature presents a moderate number of studies evaluating the performance of diagnostic methods for the identification of proximal caries lesions in posterior teeth.[2,4,7,12] However, the relationship between the depth of the lesion visualized by clinical, radiographic and FOTI examinations and probable presence of a cavitation has not been fully investigated.

In view of these considerations, the purpose of the present study was to compare clinical, fiber-optic transillumination (FOTI) and bite-wing radiographic assessment of carious lesion depth in proximal surfaces with the results obtained by direct visual inspection after tooth separation.

MATERIAL AND METHODS

The sample was composed by 70 schoolchildren with low caries prevalence (DMFT = 1.4), aged 13 to 15 years (mean age 14 years) from a school located in the city of Iracemápolis, SP, Brazil. Children, parents and schoolteachers were informed of the purpose of the study prior to its initiation. The clinical selection criterion was that the posterior contacting surfaces should be without fillings. The available surfaces were

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assessed by three examiners (A, B and C) independently and each one was responsible for just one diagnostic method to avoid bias in the results of the examinations.

Before starting the clinical study, three examiners (A, B and C) standardized the scores for proximal caries. They used all examination method codes and registration criteria in extracted teeth and in teeth *in situ* for the calibration.

The proximal surfaces between the two premolars, between second premolars and first molars and between the first and second molars were examined.

For the clinical visual examination, all children were examined in a dental chair with the aid of a dental lamp, a 3-in-1 syringe and a mirror. All patients received a thorough dental prophylaxis before the examination. A WHO-621 periodontal probe (Trinity, Campo Mourão, PR, Brazil) was used only to examine surface contour and remove adherent debris. Surfaces were kept dry with cotton rolls, compressed air and a suction apparatus. Examiner A performed the visual examination with no input from the other observers and methods. Codes and criteria used were: code 0 = sound, code 1 = non-cavitated lesion (white spot and discolored lesions), code 2 = cavitated carious lesions.

Following the visual examination, all posterior surfaces were examined with FOTI (Fiber-Lite(PL 800 series, Lawrence, MA, USA; with a probe 0.5 mm in diameter) by examiner B. During the FOTI examination, the dental lamp and room lights were turned off and only a wall-mounted, standard radiographic view box illuminated the room. The tip of the fiber-optic probe was positioned beneath the contact point of the proximal surfaces to be examined and the surfaces were kept dry, similar to the visual examination. Next, the marginal ridge was viewed from the occlusal surface. The following codes and criteria were used: 0 = no shadow, 1 = shadow restricted to enamel, 2 = shadow reaching dentine.

Two posterior bite-wing radiographs were taken in each side of the mouth of all patients using Kodak Ektaspeed Plus film (Kodak, Rochester, New York, USA) and film holders (Indusbello, Londrina, Paraná, Brazil). Film was developed in an automatic processor (Gendex GXP, Gendex Corporation, Illinois, USA). Examiner C examined all pictures randomly through a view box with 2x magnification. The following codes and criteria were used: code 0 = sound, code 1 = radiolucency in outer half of enamel, code 2 = radiolucency in inner half of enamel, code 3 = radiolucency in outer one-third of dentine, code 4 = radiolucency in inner two-thirds of dentine.

From the 1.680 surfaces examined in the 70 schoolchildren, 199 were considered as presenting carious lesions by at least one observer or one diagnostic method. Only these surfaces were scheduled for tooth separation. Those surfaces that were considered sound by all the methods were excluded from the study sample.

The direct visual inspection after tooth separation (DVITS) of proximal surfaces was performed with elastic orthodontic separators (G&H Wire Company, Greenwood, USA) placed between posterior contacts to establish a final diagnosis. The rings were removed 24 hours later and the surfaces were cleaned by dental floss and dried before examination. Next, three examiners joined to decide the caries diagnosis of surfaces. They used the same criteria as the clinical visual exam.

The visual, radiography and FOTI examinations were repeated in a randomly selected sub-sample (10%) of children in order to test intra-examiner reproducibility using kappa values[13] about 2 weeks after the exams had finished.

RESULTS

Kappa values for intra-observer agreement were 0.79 for the visual exam, 0.83 for FOTI and 0.85 for radiographic examination. Fleiss[13] suggested that Kappa statistics equal to 0.75 or over represent excellent agreement. Table 1 presents a comparison of clinical visual examination results with that obtained by DVITS.

Of the 120 surfaces recorded as sound (score 0), 84 (70%) presented noncavitated lesions and 15 (12.5%) presented cavitated carious lesions, resulting in a high proportion of false negative diagnoses. Of surfaces recorded as carious without cavitation (score 1), 5 (7.3%) were validated as cavitated. In surfaces visually found to exhibit carious lesions with cavitation (score 2), the diagnosis was confirmed in 8 (72.7%) of the cases.

Table 2 presents a comparison of FOTI examination results with the status recorded by DVITS.

Of the 126 surfaces recorded as sound (score 0), 97 (77%) presented noncavitated lesions and 9 (7.1%) presented cavitated carious lesions. Of the 67 surfaces recorded as shadow in enamel (score 1), 43 (64.2%) were noncavitated and 16 (23.9%) were cavitated, which demonstrates good positive prediction of the method. Of the 6 surfaces recorded as presenting shadow in dentine (score 2), 3 were noncavitated and 3 were cavitated. Of the 171 lesions detected by DVITS, only 65 (38%) of these were confirmed by FOTI examination.

Table 3 presents a comparison of radiographic examination results with their status recorded by DVITS.

Table 3 shows that in cases where the radiolucency reached the inner half of enamel (code 2) 67.6% of the lesions did not exhibit cavitation. Of surfaces with radiolucency in the outer one-third of dentine (code 3) and in the inner two-thirds of dentine (code 4) 46.1% and 100%, respectively, were cavitated. As radiolucency became deeper in the direction of the dentine, the percentage of cavitated lesions increased.

Table 1. Visual examination scores compared with DVITS.

	Direct Visual Inspection after Tooth Separation			
	Sound	Carious		Total
		No cavitation	Cavitation	
Clinical scores	n	n	n	n
0	21	84	15	120
1	6	57	5	68
2	1	2	8	11
Total	28	143	28	199

Table 2. FOTI examination scores compared with DVITS.

	Direct Visual Inspection after Tooth Separation			
	Sound	No cavitation	Cavitation	Total
FOTI scores	n	n	n	n
0	20	97	9	126
1	8	43	16	67
2	0	3	3	6
Total	28	143	28	199

Table 3. Radiographic examination scores compared with DVITS. Direct Visual Inspection after Tooth Separation

	Sound	No cavitation	Cavitation	Total
Radiographic scores	n	n	n	n
0	13	56	04	73
1	11	56	05	72
2	2	25	10	37
3	2	5	06	13
4	0	0	4	4
Total	28	143	28	199

Table 4. Clinical studies showing the percentage of cavitated approximal lesions in permanent teeth in relation to different scores.

Author	Radiographic scores				
	0	1	2	3	4
Rugg-Gunn, 1972	1.0	20.6	47.0	100.0	100.0
Bille & Thylstrup, 1982	0.0	13.0	20.0	52.0	100.0
Thylstryp *et al*., 1986	31.0	7.0	12.0	52.0	88.2
Pitts & Rimmer, 1992	0.0	0.0	10.5	40.9	100.0
de Araujo *et al*., 1992	nr	13.0	26.0	90.0	nr
Akpata *et al*., 1996	0.0	0.0	19.3	79.1	100.0
Lunder & von der Fehr, 1996	nr	nr	30.4	65.2	nr
Hintze *et al*., 1998*	1-2.6	0-4.9	3.3-8.3	21.8- 42.1	44.4 -100
Ratledge *et al*., 2001	nr	nr	nr	85.0	nr
Mialhe *et al*., 2002	5.4	6.9	27.0	46.1	100.0

nr = not registred

* In this study, four observers examined the same surfaces with the same diagnostic method and the authors did not differenciate between scores 3 and 4

DISCUSSION

Direct visual inspection of proximal surfaces after tooth separation remains the most sensitive method to diagnosis the clinical appearance of carious proximal surfaces *in vivo* situation. The technique is simple and acceptable to most patients. Although it should not be a substitute for routine radiographic examination, it can be considered an important auxiliary diagnostic method. The diagnostic yield of the DVITS method could be judged by the increased numbers of lesions revealed when proximal surfaces could be visualized directly. In the present study, about 59% of the lesions detected by DVITS were not confirmed by clinical examination. Our findings agreed with the data obtained by de Araújo *et al.*[14] who verified that mechanical separation was more effective in diagnosing 51% of the incipient carious lesions compared to a clinical examination without tooth separation using previous radiographic detection as reference.

Under the 11 surfaces recorded as carious lesions with cavitation by the clinical examination before separation, 8 (72.7%) were identically assessed after separation. This value was smaller than that obtained by de Araújo *et al.*[14] who found 100% of agreement among the examinations. It was larger than that obtained by Hintze *et al.*[8] who verified an average of 57% in agreement among the examinations and Danielsen *et al.*,[15] who verified 53.3% of agreement among the examinations.

In relation to the FOTI examination, under the surfaces with a shadow confined to enamel, 64.2% had noncavitated carious lesions, while 23.8% had cavitated lesions diagnosed after tooth separation. These findings agree with the data presented by Hintze *et al.*,[8] which verified on average 66.6% of surfaces with a shadow confined to enamel had noncavitated carious lesions while 21 to 46% were cavitated. If a shadow was visualized in dentine, 50% of the surfaces presented noncavitated lesions while 50% presented a cavitated one. In clinical practice, this means that when a shadow can be visualized in enamel and/or dentine when transilluminated, there is a high probability that a carious lesion is present in proximal surfaces.

In recent years, it has been suggested that restorative treatment should ideally be instituted only when a cavitated proximal carious surface is present.[1,2] In spite of a consensus of opinion that the larger the depth of radiolucency observed in the radiographic examination the larger the probability of a cavitated lesion,[4-6] some studies (Table 4) have verified that less than 50% of the radiolucency reaching the outer third of dentine was cavitated. Our results were close to the data presented by Thylstrup *et al*.[16] Pitts and Rimmer[6] and Hintze *et al*.[8] since only 46.1% of radiolucency reaching the outer one-third of dentine was cavitated.

It is important to discuss these results in view of the wide disparity in criteria for initiation of restorative proximal caries based on radiographic appearance.[17-19] Mejàre *et al*.,[18] who investigated the radiographic proximal threshold for restorative treatment in a group of Swedish dentists, observed that 42% of those responding selected an operative intervention for radiographic lesions when they reached the outer third of the dentine. These findings differ from results obtained by Tan *et al*.,[19] who investigated a group of Australian dentists. Approximately 100% of the sample selected an invasive approach for a lesion, which reached the outer 1/2 of dentine. It seems that the majority of dentists still prefer to institute invasive treatments despite the decline in caries incidence and the development of various noninvasive strategies to control dental caries effectively.

The results of the present study provide evidence that could help dentists in making a decision to adopt a preventive approach when a carious lesion is diagnosed to be noncavitated by clinical examination or restricted to enamel by FOTI or radiographic examinations in a population of children with low caries prevalence, thereby avoiding over treatment. The use of temporary tooth separation was considered an effective method for confirming the diagnoses of dental caries and the integrity of approximal surfaces.

ACKNOWLEDGEMENTS

This investigation was supported by FAPESP (Proc. 99/11941-1).

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