Evaluation of Diagnodent Accuracy in Detecting Approximal Caries in Primary Molars

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Abstract

Introduction: Detection of caries lesions on approximal surfaces of posterior teeth is difficult, since wide contact points hamper direct visual inspection. Due to the importance of the early detection of dental caries, the aim of this study is to compare the performance of different methods (visual, bitewing radiography and DIAGNOdent) in detecting approximal caries in primary molars. **Methods:** Thirty six children were selected from patients referred to the pediatric dentistry department of Shahid Sadoughi University of Medical Sciences, Yazd, Iran. Two examiners evaluated 229 approximal surfaces of primary molars using: visual inspection, radiography and a pen-type laser fluorescence device (DIAGNOdent) for the presence of proximal caries. The surfaces were evaluated by 2 other examiners for the presence of white spots or cavitations. Sensitivity, specificity and accuracy (percentage of correct diagnosis) were calculated for each method. The area under the receiver-operating characteristics curve (A z) was calculated for DIAGNOdent device. The inter-examiner reproducibility was calculated using the intra-class correlation coefficient (ICC values) for laser Fluorescence and agreement coefficient for visual and radiographic methods. **Results:** At white-spot threshold, a DIAGNOdent device presented better performance. At cavitation threshold the radiographic method demonstrated higher sensitivity than visual inspection and DIAGNOdent device. In this threshold, all methods presented high specificities

Conclusions: A DIAGNOdent device performs better in white spot threshold. However, radiography shows better performance in detecting more advanced approximal caries lesions.

Key-words: Laser Fluorescence, DIAGNOdent, Proximal caries, Radiography.

Introduction

Dentists usually rely on visual, tactile and radiographic methods to detect dental caries[1]. Caries in inter-dental surfaces are frequently detected by bite-wing radiography[2-4], but this method has got some limitations. Radiographic images cannot reliably show the real depth of the lesions and are not appropriate for detection of the initial stages of enamel caries. Exposure to X-ray is another concern with radiography (2).

Visual method has shown a high specificity, though low sensitivity and reproducibility for detection of proximal caries compared to other methods (1,2,5).

International Caries Detection and Assessment System (ICDAS) is introduced for standardization and improvement of dental caries detection by visual method[6]. This system is expected to increase the sensitivity and reliability of this method. Some studies on detection of occlusal caries have found this international system highly valuable during recording of results by visual method[7,8]; although using ICDAS index for diagnosis of approximal caries by visual method is not valuable (2,5).

Recently, the need for more conservative treatments and procedures to suppress and inverse the decay-producing process has led to considerable efforts to develop technologies for early detection of dental caries. One of the new technologies to achieve this goal is using pen-type laser fluorescence device (LF-pen). This device provides a quantitative method for detection of occlusal and approximal caries (5,9,10).

Novaes et al. assessed bitewing radiography and LF-pen and showed a similar efficacy for detection of approximal caries, but Lussi et al. found laser fluorescence to be superior to radiography in detection of proximal caries in permanent teeth.

Most studies on detection of caries by LF-pen have assessed occlusal caries (11, 14).There are few in vivo studies on detection of approximal caries especially in primary molars (2, 16), on the other hand in vitro reconstruction of contact areas in posterior teeth is not a precise method, so we decided to compare different methods of caries detection, i.e. visual, bitewing radiography and laser fluorescence for detection of approximal caries in primary molars in an in vivo study.

Materials and methods

The research protocol was approved by the Ethical Committee of Yazd medical university (protocol≠ p/17/1/21967). This in vivo diagnostic cross sectional study was performed on 36 children referred to the pediatric dentistry department of Shahid Sadoughi University of Medical Sciences, Yazd, Iran. Patients were referred for dental examinations or therapeutic procedures. After primary examinations, children 5-10 year-old who fulfilled the inclusion criteria (according to the forms filled by the parents) entered the study. An informed consent was obtained from the parents. Examinations were performed on approximal surfaces of the primary molars.

Those with the following conditions were excluded from the study: approximal restorations, hypoplastic pits, extensive approximal caries completely destroying the marginal ridge, extensive caries on smooth or occlusal surfaces, and lack of adjacent tooth.

Eventually, 229 approximal surfaces were assessed. Caries lesions on approximal surfaces were assessed by visual, radiographic and laser fluorescence methods. All evaluations were performed by two dentists. Each examiner separately assessed the surfaces and recorded the results. Both examiners were blinded to the results of each other. Before beginning the study, aforementioned diagnostic methods were performed on two children as pilot samples and these two children did not include in the study.

Before examinations, approximal surfaces were cleaned by dental floss, prophylactic paste, and rubber cup. Initially in order to assess the visual method, approximal surfaces were evaluated after cleansing under sufficient illumination. Each surface was first assessed when it was wet and then it was dried by air pressure and assessed again.

ICDAS index was used for recording the visual results [Ismail et al., 2007].

For radiographic evaluation, bitewing radiographs were taken from dental surfaces including maxillary and mandibular primary molars (device was set on 70Kv, 80mA and 0.3 exposure time), using 22×35mm Kodak films and bitewing film preservative (XCP).

After radiography, caries in each surface were recorded using the criteria previously described [Ekstrand et al., 1997].

Surfaces were assessed by laser fluorescence LF-pen (DIAGNOdent, Kavo, Biberach, Germany) as well. A tip for approximal surfaces was used for evaluation. Laser was first calibrated on the porcelain reference of the device and then on the healthy teeth. Afterwards, the tooth contact area was dried by air for 5 seconds and DIAGNOdent tip was placed first near proximal area of buccal and the lingual surfaces. The score was read each time and the largest score was recorded by each examiner.

After recording the results of three diagnostic methods, in order to use a standard reference method, it was necessary to separate the contact area of primary molars so as the teeth be separated at least $0.5 - 1$ mm from each other. In this condition, it is possible to accurately define the amount of caries in approximal

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surfaces. So we used orthodontic separators between primary molars for 7 days. After this period, the contact area was cleaned by dental floss and was examined again using a mirror and a probe. The results of the evaluations were categorized in 3 groups:

0- Intact and healthy surface: without any change in enamel lucency and absence of surface discontinuity after air drying.
1- Presence of white spot lesions: White or brown discoloration in dried or wet surfaces without surface discontinuity.
2- Cavitation: loss of surface integrity clearly observed or observed after using a probe.

When there was inconsistency between two examiners, surfaces were assessed once more to reach to a common opinion.

Proximal surfaces were considered as statistical units which were assessed for comparison between different diagnostic methods.

Sensitivity, specificity and accuracy were calculated for each method and each examiner separately using defined cut-off points.

Receiver operating characteristic (ROC) curves were drawn for data extracted from LF-pen diagnostic method and the area under the ROC curve (A-z) was calculated. Then agreement coefficient for radiography and visual method was measured and inter-examiner reliability was evaluated by using intra-class correlation coefficient.

Results

After assessment of data from the standard method, 87 surfaces (38%) were sound, but 84 (36.7%) and 58 (25.3%) showed white-spot lesions and cavitation, respectively.

Table 1 compares the results of visual method with the standard method.

In table 2, results of radiographic method are compared with standard method.

All surfaces showing radiolucency in the middle third of dentin (score 3) were found to have cavity.

The best cut-off point for LF-pen device in this study included: Sound surfaces: 0-5, white-spot: 6-15, cavitation: ≥16.

The Az value for laser method was 0.97 and 0.98 for the first and second examiners, respectively, which shows a high efficiency for this method. High ICC value (0.99) in LF-pen method and high agreement coefficient (0.96 for radiography and 0.90 for visual method) showed a high inter-examiner reliability for these three methods. As table 3 shows, in white-spot category, the sensitivity of LF-pen device by both examiners was significantly higher than other methods.

The sensitivity of visual method was lower than other two methods, although its specificity in white-spot category was higher than other methods. Totally, all three methods in this category have got a high specificity (tables 3). In the cavitation category, the specificity of radiography was significantly higher than LF-pen.

The highest accuracy for detection of caries in approximal surfaces was observed in LF-pen, radiography and visual methods, respectively.

Table 1. Frequency of visual scores by ICDASII index and results from standard method, by two examiners.

Visual scores	Reference standard			Total
	Sound	White spot	cavitation	
Examiner 1				
0	87	80	7	174
1	0	1	0	1
2	0	1	0	1
3	0	0	3	3
4	0	2	39	41
5	0	0	9	9
Examiner 2				
0	87	80	6	173
1	0	0	0	0
2	0	2	0	2
3	0	0	9	9
4	0	2	35	37
5	0	0	8	8
Total	87	84	58	229

Table 2. Frequency of radiographic scores and results from standard method, by twoxaminers

Radiographic scores	Reference standard			Total
	sound	White spot	cavitation	
Examiner 1				
0	80	23	0	103
1	6	55	5	66
2	1	6	23	30
3	0	0	23	23
4	0	0	7	7
Examiner 2				
0	79	25	0	104
1	7	51	5	63
2	1	8	34	43
3	0	0	14	14
4	0	0	5	5
Total	87	84	58	229

Table3. Sensitivity, specificity and accuracy of caries detectio by each examiner (1 and 2) for all methods (visual inspection, DIAGNOdent and radiography)

Diagnostic Methods		Visual inspection		DIAGNOdent		Radiography	
		Examiner1	Examiner 2	Examiner 1	Examiner 2	Examiner 1	Examiner 2
White spot	Sensitivity (%)	2.8 (0.7-4.9)	2.8 (0.7-4.9)	79 (75-83)	82 (78-86)	65 (59-71)	66 (60-72)
	Specificity (%)	100 (99-100)	100 (99–100)	95 (93-97)	94(92-96)	92(89-95)	90 (87-93)
	Accuracy (%)	61 (55-67)	71 (67-75)	87 (83-91)	90 (87-93)	82 (78-86)	79 (75-83)
Cavitation	Sensitivity (%)	87.9 (83-91)	89 (85-93)	82 (78-86)	82 (78-86)	91 (88-94)	91 (88-94)
	Specificity (%)	100 (99-100)	100 (99-100)	99 (98-100)	99 (98-100)	98 (96-100)	98 (96-100)
	Accuracy (%)	61 (55-67)	71 (67-75)	87 (83-91)	90 (87-93)	82 (78-86)	79 (75-83)

*the numbers inside the brackets are calculated with a 95% confidence coefficient

Discussion

In preventive dentistry which is now regarded as an important issue, early diagnosis of enamel lesions, especially in children, is important and can help their dental health. So, nowadays there is a tendency to newer techniques which may lead to timely diagnosis of primary caries.

According to the results, DIAGNOdent had a higher sensitivity in white-spot threshold for detection of primary lesions comparing other methods, but in cavitation threshold bitewing radiography showed a significant higher sensitivity; although all three methods showed similar specificities. This was different from the results of Bahrololoomi el al. study in which the specificity of DIAGNOdent was less than two other methods (17).

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There is controversy about this issue in different studies (2, 5, 16, and 17). Braga et al. in an in vitro study on primary molars found that visual-tactile methods have a higher sensitivity and specificity comparing radiography and laser fluorescence; although the latter methods showed a high efficacy for detection of advanced caries (2, 6). The study of Bahrololoomi et al. showed that Visual examination was the first choice for diagnosis of incipient caries. But in suspicious cases, radiography or laser DIAGNOdent can be used as adjunct procedures.

In the current study, laser fluorescence in white-spot threshold and radiography in cavitation threshold were more efficacious. The inconsistency with Braga study is probably due to the different methods used in the studies.

In in vitro studies, visual method has been shown to be more efficacious for detection of approximal caries, because in clinic, observation of discoloration and approximal caries through marginal ridge in the mouth is difficult, but in in vitro studies this limitation is relatively overcome (5). But there is no difference between in vivo and in vitro studies regarding the diagnosis of caries in the occlusal groove of molars [18].

In a study conducted by Lussi et al. laser fluorescence was more efficacious in detection of approximal caries in permanent molars in both initial and advanced lesions. The results of this study are consistent with the current study in initial caries lesions. But Lussi et al. worked on permanent teeth and in an in vitro situation, so the results cannot be extrapolated to primary teeth.

Novaes et al. assessed the detection of approximal caries in primary molars in an in vivo study. Consistent with the results of the current study, the specificity of all three methods in both initial and advanced lesions was high; although the sensitivity of laser fluorescence and radiography in white-spot threshold was low which was against the results we found in the current study (2). Totally Novaes et al. showed that laser fluorescence is not significantly superior to radiography for detection of approximal caries in both caries lesions[2].

We found that visual method has a low sensitivity and high specificity which was consistent with most previous clinical studies (1, 2, 16).

In the current study, the sensitivity of visual method in cavitation threshold was very similar to other two methods, but Bader et al. and Novaes et al. found that the sensitivity of this method in cavitation threshold was significantly lower (1,2).

Newer studies have used ICDAS II for standardization of the stages for detection of caries by visual method[6]. Higher sensitivity and specificity is expected for this method when ICDAS II is used. Some

studies have shown the value of this index for detection of occlusal caries (7, 8). We didn't find a considerable development by using of this index for detection of approximal caries comparing previous studies which was consistent with the results of Novaes et al. study (1).

In the current study, inter-examiner reliability of visual method was relatively similar to other methods, which is probably due to the use of this index, but the accuracy of visual method for detection of approximal caries was lower than other methods.

In the study of Novaes et al. using ICDAS II resulted in a higher inter-examiner reliability which has been considered as an advantage of this index(2). But totally it can be concluded that in spite of the high value of this index for detection of occlusal caries (7,8), its use for detection of approximal caries in primary molars was not advantageous, but due to the lack of a more efficacious index, it has been used for detection of approximal caries in molars in different studies.

Some researchers believe that the method of separation of teeth is not reliable (3, 19); although these studies were conducted on permanent teeth and separation of primary teeth is simpler than permanent teeth[19]. Although this gold standard method is not ideal, according to the results of the current study and the study by Novaes et al. it is an efficacious method[2]. Inspite of the precision of histologic methods in measurement of lesions depth, its use is impossible in in vivo studies. The difference between in vivo studies can be attributed to the lack of an ideal gold standard.

Conclusion

In this study, laser fluorescence showed a higher efficacy for detection of approximal caries in primary molars in white-spot lesions, but in more advanced lesions, DIAGNOdent was not more efficacious than radiography.

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