Detection of early occlusal caries of the first permanent molar using different techniques
(An in vivo study)

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ABSTRACT

Background: Molars and premolars are considered as the most vulnerable teeth of caries attack, which is related to the morphology of their occlusal surfaces along with the difficulty of plaque removal. different methods were used for early caries detection that provide sensitive, accurate preoperative diagnosis of caries depths in order to institute suitable protective procedures and avoid early tooth management by restoration. The aim of the present study was to evaluate the clinical sensitivity and specificity rates of DIAGNOdent and visual inspection as opposed to the ICDAS for detection of initial occlusal carious lesions in noncavitated first permanent molars.

Materials and Methods : the present study examined 139 occlusal surface of the first permanent molar pooled from fifty patients aged 8-9 years by three methods. The selected criteria include one occlusal site per tooth (first permanent molars) with carious lesions range from 0 to 3 according to ICDASII (gold standard) visual criteria then the clinical sensitivity and specificity of visual inspection according to Ekstrand *et al.*in 1997 and DIAGNOdent were performed. .

Results: the highest correlation was found between the ICDASII and DIAGNOdent. The sensitivity of the DIAGNOdent for the enamel caries detection (D_1) was better than that of visual inspection. The sensitivity and the specificity for the DIAGNOdent at D_3 threshold were better than the D_1 threshold and the visual inspection method.

Conclusion: DIAGNOden pen can be used as a tool for early caries detection in cases of difficult diagnosis that provide good additional sensitivity to the visual inspection.

KEYWORDS: dental caries, diagnosis, early detection, DIAGNOdent, ICDASII. **(Received: 15/8/2018; Accepted: 1/10/2018)**

INTRODUCTION

Caries detection is still a difficult task, since there might be carious lesions involving dentin underneath apparently undamaged surfaces [(1)]. As the prevalence of occlusal carious lesions has been augmented, a detection of the non-cavitated carious lesions by clinicians, according to the progression and clinical characteristic of the carious lesions, has become complicated [(2,3)]. Estimations showed that in children and adolescents, more than 75% of the carious lesions were developed in occlusal pit and fissures [(4)]. While early detection of caries is very important for prevention, the diagnosis of these lesions is sometimes challenging for the dentists due to the morphology of occlusal pit and fissures [(5)]. None of the traditional methods of caries diagnosis fulfills this requirement and they are highly subjective. A visual examination alone has low sensitivity for detection of incipient carious lesions even though the specificity is high. Tactile examination of dental caries has been criticized because of the possibility of transferring microorganisms from one site to another leading to the fear of further spread of the disease in the same oral cavity [(6)]. Additionally, using an explorer can lead to irreversible traumatic defects in remineralizable incipient carious lesions [(7)]. Radiographs are generally recommended for detection of proximal carious lesions and they are of inadequate usefulness in the diagnosis of incipient occlusal caries. Moreover, they are associated with health hazards of radiation [(8)] and show underestimation of the lesion size [(9)]. An effort to overwhelm these restrictions is the formation of thorough visual criteria, such as the International Caries Detection and Assessment System (ICDAS) [(10)]. The use of detailed and certified criteria enhances the visual examination performance in the finding of carious lesions [(11)].

ICDAS II take in to account the early visible signs of the carious lesions like opacities, brown discolorations, enamel breakdowns or microcavities without an obvious cavity. These visual signs have recognized to be good pointers for the presence of enamel and/or dentin lesions [(12, 13)].

The ICDAS was developed in 2002 by an international group of researchers (cariologists and epidemiologist) based on a systematic evaluation of the available caries detection systems to provide the clinicians, epidemiologists, and researchers with a system that is based on evidence for caries detection. This system allow standardization for data

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collection and it would better comparability among studies [10, 14, 15, 16].

In 2003, ICDAS-I system was developed based on the importance of examining the clean, plaque-free teeth, with careful drying of the tooth surface to identify early lesions by visual inspection methods. This system entails the replacement of the traditional sharp probes with a ball-ended ones to avoid the traumatic effect on the incipient lesions. Later on, in 2005, this system was adjusted and the ICDASII was created at the ICDAS workshop in Baltimore. The upgrading involved an interchange of codes 3&4 to make sure that this system would represent the increased severity in caries [10, 15].

Though, even with this well-described criteria, the system is still subjective. Therefore, objective and quantitative tools, such as diode laser fluorescence (LF), which was developed to detect the occlusal carious lesions based on laser induced fluorescence in which the carious lesions fluorescent more strongly than the sound tooth when agitated by laser light of a specific wavelengths [17, 18].

DIAGNOdent, is a handheld diode laser device operated on a battery, based on the quantification of the fluorescence. DIAGNOdent make use of a 655-nm diode laser excitation light source that is modified to distinguish it from ambient light. Carious lesions fluoresces more than 680 nm when facing this light and this fluorescence is identified and measured by the DIAGNOdent unit [19, 20].

The aim of the present Clinical study was to evaluate the clinical sensitivity and specificity rates of DIAGNOdent and visual inspection as opposed to the ICDAS for the detection of initial occlusal caries in noncavitated first permanent molars.

MATERIALS AND METHODS
Sample selection:
This study involved 139 first permanent molars teeth pooled from 50 children aged between 8-9 years attending the Department of Pedodontics and Preventive dentistry, at College of Dentistry/ Baghdad University.

Teeth with carious lesions range from 0 to 3 in visual assessment using a six-grade index of International Caries Detection and Assessment System (ICDAS) were selected.

Teeth having carious lesions of the proximal, buccal or lingual surfaces, fillings, fissure sealants, hypoplasia, fissure stain, orthodontic bands were not included in the sample.

The examination was performed after a signed consent was gotten from the parents or the guardians of the patients earlier than the start of examination.

Clinical examination:
The occlusal surface of all the teeth were cleaned first with pumice slurry and expansively washed with water for 10 sec. [21]. The selected criteria include one occlusal site per tooth (first permanent molars) with carious lesions range from 0 to 3 according to ICDASII (gold standard) visual criteria [figure 1]. Then the clinical sensitivity and specificity of visual inspection and DIAGNOdent were performed.

Score	Clinical description of occlusal pits and fissures.
0	no evidence of caries after prolonged air-drying (5 seconds) (sound tooth)
1	First visual changes in enamel seen only after air-dry the tooth for 5 seconds (D_1)
2	Distinct visual changes in enamel seen when tooth is wet (D_2)
3	Localized enamel breakdown (D_3)
4	Underlying dark shadow from dentin with or without localized enamel breakdown
5	Distinct cavity with visible dentin(less than 50% of the tooth)
6	Extensive distinct cavity with visible dentin involve more than 50% of the tooth

Figure (1): ICDAS II criteria [22]

Visual examination:

Visual examination was performed when the patients positioned in the dental chair after the teeth had been cleaned, using a dental light, triple syringe and a plane buccal , according to the criteria proposed by Ekstrandetal[23]as shown in figure 2.

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Laserfluorescence(DIAGNOdent): The last method for caries detection was laser fluorescence measurement with the DIAGNOdent device (DIAGNOdent 2190, KaVo, Biberach, Germany) so it does not influence the previous subjective methods. The device was first calibrated on ceramic disc standard (Figure 3) and then calibrated for each patient at the start of the examination on sound tooth enamel to provide the zero value (according to manifacture instructions) which was subtracted from the final measurement of the accusedtooth

Statistical Analysis:Data were analyzed using the SPSS program (version 25). In all analysis, a *P* value < 0.05 was considered significant. Spearman correlation coefficient and receiver operator characteristic curve were used to analyze the data. The sensitivity and specificity were obtained for each mehtod in comparition to ICDAS II   .

score	interpretation	Visual examination
0	sound	No or slight change in enamel after prolonged air-drying (>5 s)
1	Enamel caries(D_1)	Opacity or discoloration hardly visible on wet surface but distinctly visible after air-drying; opacity or discoloration distinctly visible without air-drying
2	Caries in the outer half of the dentine(D_3)	Localized enamel breakdown in opaque or discolored enamel and/or grayish discoloration from the underlying dentine
3	Caries in the inner half of the dentine(D_4)	Cavitation in opaque or discolored enamel exposing dentine

Figure (2): Visual inspection according to Ekstrand criteria [23]

Fig. (3) Ceramic disc standard calibration

RESULTS

One hundred thirty nine teeth were examined and divided to groups according to ICDAS II criteria for non-cavitated lesion from which 38.1% was diagnosed as sound (score 0), 26.6% as outer half of enamel caries (score 1), 15.8% as inner half of enamel caries (score 2) and 19.4% as dentinal caries (score 3) as shown in table 1.These groups used as validation for the other methods (visual inspection and DIAGNOdent).

The spearman correlation coefficient between the methods was done and the ICDAS II was used as a gold standard method for comparison. The results as shown in table 2 and 3. The ROC curve analysis used where the y-axis represents the sensitivity of the test at different thresholds and the x-axis represent the (1-specificity). The area under the ROC curve represents the accuracy of the test.

Visual inspection with area under the curve was (0.627) which indicates poor accuracy to detect the enamel caries, while for the DIAGNOdent ,the AUC was (0.773) which indicated that it was fair technique for detection the enamel caries as in figures (4&5)

Table (1): Frequency distribution of each ICDAS criteria

Score	Frequency	Percent
0	53	38.1
1	37	26.6
2	22	15.8
3	27	19.4
Total	139	100.0

Table (2): correlation between ICDAS and DIAGNOdent

Diagnostic techniques	Spearman's rho	DIAGNOdent
ICDAS	Correlation coefficient	0.881
	Sig.	0.000
	No.	139

Table (3): correlation between ICDAS and the visual inspection.

Diagnostic techniques	Spearman's rho	Visual inspection
ICDAS	Correlation coefficient	0.825
	Sig.	0.000
	No.	139

For the dentinal threshold, the AUC of the visual inspection was (0.745) indicating that it was a fair method to detect the caries while the DIAGNOdent AUC was equal to (0.934) which indicated that it was an excellent technique to detect the caries as shown in figure 6 and 7. The results of the sensitivity and specificity of each technique was shown in table (4) at the enamel threshold (D_1) and dentinal threshold (D_3). For the visual inspection, the sensitivity at the D1 threshold was only 36% means that there were many cases with early enamel caries diagnosed as sound, but when the caries reached the dentine the sensitivity increased. So this method should be accompanied by another more accurate method to detect the hidden caries.

Concerning the DIAGNOdent, the sensitivity at the D_1 was(70%) which was better than that for the visual inspection means some cases with early enamel caries missed by visual inspection and diagnosed as sound will be detected by DIAGNOdent, the specificity at D_1 was significant (90%). At the D_3 threshold, the sensitivity was good (85%) with excellent specificity (94%) so the DIAGNOdent was a good method for dentinal caries detection.
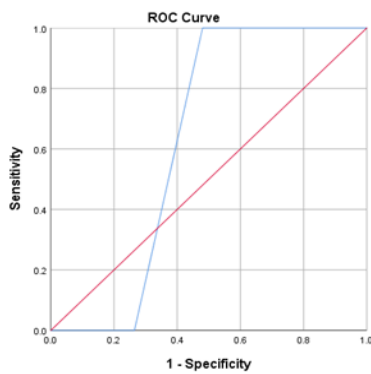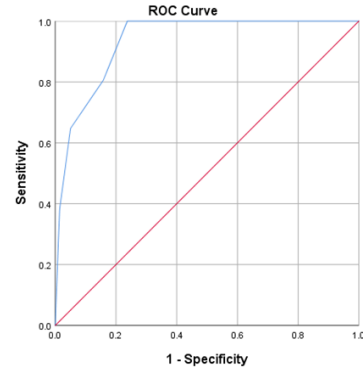

Fig. (4) ROC curve of the visual inspection at the enamel threshold
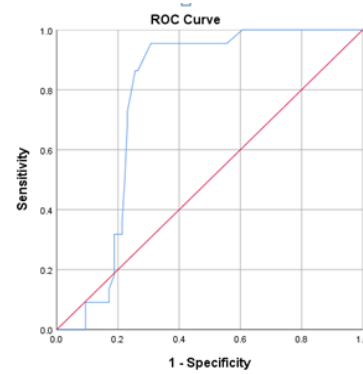
Fig. (5) ROC curve of the DIAGNOdent at the enamel threshold
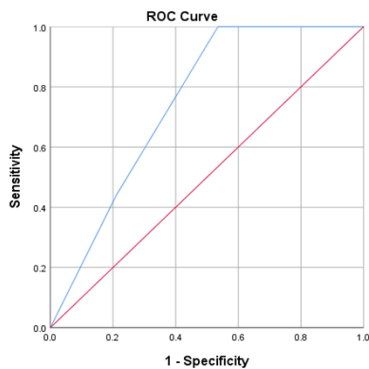
Fig. (6) ROC curve of the visual inspection at the dentinal threshold

Fig. (7) ROC curve of the DIAGNOdent at the dentinal threshold

Table (4): The sensitivity, specificity and accuracy for each technique at D1 threshold and D3 threshold:

Diagnostic technique	Cut off point	sensitivity	specificity
Visual inspection	D_1	36%	64%
	D_3	70%	67%
DIAGNOdent	D_1	70%	90%
	D_3	85%	94%

DISCUSSION

Visual examination methods is still the most widely used in the dental clinics for the detection of carious lesions [11, 24] but it is a subjective method[25] that can be affected by the examiners' experience of the diagnostic criteria [26]. So the need for objective quantitative method for early caries detection is the main goal to enable the reversal of the carious process at the early stage by the application of preventive measure before the cavitations develops.

In this study, the highest spearman correlation was found between the DIAGNOdent and the gold standard method used (ICDASII) and this was in agreement with results of the previous studies [27-30]. In the other hand, this was in contrast to another in vitro study performed by Chong *et al*. [31] Compared the DIAGNOdent with radiograph in extracted premolars found that the Spearman rank correlation (Sp) for the DIAGNOdent was Sp =0.444 which reflected a poor correlation between the DIAGNOdent and the radiograph. Which disagree with the present study .This variation could be due to the differences in methodology as the previous study used radiograph as the standard reference and the in vitro condition of the premolar teeth might affect the DIAGNOdent results.

The sensitivity mean the ability to detect the caries, for the visual method at D_1 threshold it was only 36% sensitive. This low sensitivity reflecting that many cases of enamel caries would be overlooked and wrongly diagnosed as sound.

The specificity of visual inspection at the enamel threshold was 64% indicating that this method could recognize the sound teeth with little false positive results. For the dentinal caries threshold (D_3), this method was 70% sensitive and 67% specific, which mean that when the caries progressed more deeply, the visual inspection would be better for detecting the carious teeth, those mostly requiring restorations or it would be wrongly diagnosed the caries as an enamel caries. Therefore, visual inspection is a useful method for caries diagnosis, but it should be accompanied by a more accurate method due to its low sensitivity that might lead to possible missing of hidden caries.

For the DIAGNOdent, the sensitivity at the enamel threshold was 70% which was better than the visual inspection to detect the caries, while the specificity was excellent (90%) at enamel threshold this mean that it recognize the sound teeth with minimum false positive results.

The dentinal threshold sensitivity and specificity was (85%; 94%) respectively, demonstrating that DIAGNOdent was a good accurate method mainly for the detection of dentinal caries and performed better at D_3 threshold, which in accordance to the previous literatures [32-34].

However, other studies found that DIAGNOdent led to a greater possibility of false-positive diagnosis than the visual method [35-37] this might be due to the presence of deposits such as stain, plaque, calculus, tooth paste, disturbed tooth development, or mineralization all these might increase the fluorescence value and the sensitivity which produce more false-positive result.

CONCLUSION

- DIAGNOdent Pen was superior to the visual inspection method in terms of sensitivity and specificity;
- DIAGNOdent showed stronger correlation to the ICDAS II (gold standard method) than the visual inspection.

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الخلاصة

المقدمة: الأضراس والضواحك هي الأسنان الأكثر تعرضًا للتسوس وذلك يتعلق بمظهر أسطح الإطباق وصعوبة إزالة الصفيحه الجرثومية. كان الهدف من هذه الدراسة هو تقييم طرق مختلفة سريريا (DIAGNOdent القلم والتفتيش البصري) للكشف المبكر عن تسوس الأسنان التي توفر تشخيص أكثر حساسية ودقة عن أعماق التسوس لوضع تدابير وقائية كافية وتجنب علاج الأسنان المبكر من خلال الترميم.

الطريقة: فحصت هذه الدراسة 139 سطح إطباقي من الضرس الدائم الأول من خمسين مريضًا (8-9 سنوات) أولاً وفقًا لمعايير ICDAS II ثم الفحص البصري وأخيرًا باستخدام قلم الليزر (التشخيص). بعد تسجيل النتائج ، تم استخدام ICDAS II كمعيار ذهبي للتحقق من صحة القياس.

النتائج: تم العثور على أعلى ارتباط بين ICDAS وقلم الليزر. كانت حساسية تشخيص الكشف عن تسوس المينا (D1) أفضل من الفحص البصري. كانت حساسية وخصوصية التشخيص في عتبة D3 أفضل من عتبة D1 وطريقة الفحص البصري.

الاستنتاج: يمكن أن يكون قلم الليزر أداة مفيدة لكشف التنخر في حالات التشخيص الصعب ويوفر حساسية إضافية جيدة للفحص البصري.