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

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Abeer M. Hassan, B.D.S, M.Sc. (2)

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 (Di) was better than that of visual inspection. The sensitivity and the specificity for the DIAGNOdent at Di threshold were better than the Di threshold and the visual inspection method.

Conclusion: DIAGNOdent 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 \(^\text{(10, 14, 15, 16)}\).

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 \(^\text{(10, 15)}\).

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 \(^\text{(17, 18)}\).

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 \(^\text{(19, 20)}\).

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. \(^\text{(21)}\). The selected criteria include one occlusal site per tooth (first permanent molars) with carious lesions range from 0 to 3 according to ICDASI (gold standard) visual criteria [figure 1]. Then the clinical sensitivity and specificity of visual inspection and DIAGNOdent were performed.

<table>
<thead>
<tr>
<th>Score</th>
<th>Clinical description of occlusal pits and fissures.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>no evidence of caries after prolonged air-drying (5 seconds) (sound tooth)</td>
</tr>
<tr>
<td>1</td>
<td>First visual changes in enamel seen only after air-dry the tooth for 5 seconds (D1)</td>
</tr>
<tr>
<td>2</td>
<td>Distinct visual changes in enamel seen when tooth is wet (D2)</td>
</tr>
<tr>
<td>3</td>
<td>Localized enamel breakdown (D3)</td>
</tr>
<tr>
<td>4</td>
<td>Underlying dark shadow from dentin with or without localized enamel breakdown</td>
</tr>
<tr>
<td>5</td>
<td>Distinct cavity with visible dentin( less than 50% of the tooth)</td>
</tr>
<tr>
<td>6</td>
<td>Extensive distinct cavity with visible dentin involve more than 50% of the tooth</td>
</tr>
</tbody>
</table>

**Figure (1): ICDAS II criteria \(^\text{(22)}\).**

**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 Ekstrand et al. \(^{(23)}\) as shown in figure 2.

**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 manufacture instructions) which was subtracted from the final measurement of the accused tooth.

**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 method in comparison to ICDAS II.

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

**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>
<thead>
<tr>
<th>Score</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
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<tbody>
<tr>
<td>0</td>
<td>53</td>
<td>38.1</td>
</tr>
<tr>
<td>1</td>
<td>37</td>
<td>26.6</td>
</tr>
<tr>
<td>2</td>
<td>22</td>
<td>15.8</td>
</tr>
<tr>
<td>3</td>
<td>27</td>
<td>19.4</td>
</tr>
<tr>
<td>Total</td>
<td>139</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Table (2): correlation between ICDAS and DIAGNOdent

<table>
<thead>
<tr>
<th>Diagnostic techniques</th>
<th>Spearman's rho</th>
<th>DIAGNOdent</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICDAS</td>
<td>Correlation coefficient 0.881</td>
<td>Sig. 0.000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Diagnostic techniques</th>
<th>Spearman's rho</th>
<th>Visual inspection</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICDAS</td>
<td>Correlation coefficient 0.825</td>
<td>Sig. 0.000</td>
</tr>
</tbody>
</table>
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 (D₁) and dentinal threshold (D₃). 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 D₁ 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 D₁ was significant (90%). At the D₃ threshold, the sensitivity was good (85%) with excellent specificity (94%) so the DIAGNOdent was a good method for dentinal caries detection.

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

<table>
<thead>
<tr>
<th>Diagnostic technique</th>
<th>Cut off point</th>
<th>sensitivity</th>
<th>specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual inspection</td>
<td>D₁</td>
<td>36%</td>
<td>64%</td>
</tr>
<tr>
<td></td>
<td>D₃</td>
<td>70%</td>
<td>67%</td>
</tr>
<tr>
<td>DIAGNOdent</td>
<td>D₁</td>
<td>70%</td>
<td>90%</td>
</tr>
<tr>
<td></td>
<td>D₃</td>
<td>85%</td>
<td>94%</td>
</tr>
</tbody>
</table>

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
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 (25-30). 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 D1 threshold it was only 36% sensitive. This low sensitivity reflecting that many cases of enamel cavities 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 cavities threshold (D3), 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 D3 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 الأطباق وصعوبة إزالة الصفيحة الجرثومية. كان الهدف من هذه الدراسة هو تقييم طرق مختلفة سريريا (DIAGNOdent) للتشفير المبكر عن تسوس الأسنان التي توفر تشخيص أكثر حساسية ودقة عن أعمق التنكسات ووضع دراسة وقائية للتصفح وعلاج الأسنان المبكرة من خلال الترميم.

الطريقة: فحصت هذه الدراسة 139 سطح أطباق الأسنان في الأقران الأول من خمسين مريضا (8-9 سنوات) أولاً وفقًا لمعايير ICDAS II ثم الفحص البصري وأخيرًا باستخدام قلم الليزر (التشخيص). بعد تسجيل النتائج، تم استخدام ICDAS II كمقياس دقيق للتحقق من صحة الفيال. النتائج: تم العثور على أعلى ارتباط بين ICDAS II وقلم الليزر. كانت حساسية تشخيص التسوس من النوع D (أفضل من الفحص البصري) وخصوصية التشخيص في عتبة D (أفضل من عتبة D) ودراسة ICDAS II وطريقة الفحص البصري.

الاستنتاج: يمكن أن يكون قلم الليزر أداة فعالة لتشخيص التسوس في حالات التشخيص الصعب ويوفر حساسية إضافية جيدة للفحص البصري.

DIAGNOdent pen and CarieScan PRO for the detection and assessment of occlusal caries in primary molar teeth. Clinical oral investigations. 2014 Apr 1;18(3):737-44.