Diagnostic Values of Laser Fluorescence Device Compared to Other Techniques in Occlusal Caries Detection

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Abstract:
Objective: The aim of the present study was to compare the performance of laser fluorescence (LF) method with other conventional diagnostic techniques in detection of small occlusal caries in permanent teeth.

Materials and Methods: Prior to this in vitro diagnostic study, a pilot study assessed intra-examiner reliability and reproducibility. The occlusal surfaces of 90 extracted human premolars were examined with four diagnostic methods: probing, visual inspection, bite-wing (BW) radiographs, and LF. The teeth were then sectioned for the purpose of histological examination. The data were analyzed using SPSS 15 software, and sensitivity, specificity and other diagnostic criteria of the techniques were calculated.

Results: The intra-examiner reproducibility for probing and also radiographic techniques was 100%. The corresponded figure for LF (88%) was more than visual inspection (82%). The highest level of validity of the examiner turned out to be in probing technique (76.9%). Sensitivity of visual inspection, probing, and LF methods was 84.8% and 81.1%, respectively. Probing and visual inspection showed the highest specificity (97.5% and 94.9, respectively) and efficiency (92.2% and 90%, respectively) among the methods.

Conclusion: Specificity and efficiency of LF method were lower compared to those of other methods. Among all the investigated methods, the most efficient methods in the diagnosis of small occlusal caries in permanent teeth were probing and visual inspection, respectively.

Key Words: Diagnosis; Dental Caries; Lasers

INTRODUCTION
It is necessary for dental professionals to adopt reliable detecting systems in discerning and identification of carious from sound teeth. During the last two decades, many impressive developments have taken place in the diagnostic methods of caries, and various effective tools have been offered to dentists. Existing conventional methods, according to numerous studies, hardly diagnose occlusal caries of fissures [1-4]. Occlusal surfaces are still exposed to caries while extensive use of fluoride has resulted in a significant decrease of caries in smooth surfaces [5]. A proper diagnosis of oc-
clusal caries lesions in initial stages is of great importance in choosing either noninvasive preventive measures or restorative procedures. The answer to the question of “How does the sealing of fissures affect its bacterial flora?” has been the subject of various studies resulting in different conclusions. However, all researchers unanimously have emphasized that it is not wise to leave the microorganisms, which have the potentiality to generate caries, with no preventive intervention [6].

Caries detection is possible through a variety of methods including a range of conventional visual examination, radiography, and tactile inspection, to some newer noninvasive, instrument-based measurement techniques like fiber-optic trans-illumination (FOTI), videoscope, digitized radiographs, infrared laser fluorescence (LF) and the measurement of the electrical conductance of dental tissues [7]. The infrared laser fluorescence was developed mainly to detect coronal caries, particularly on occlusal pits and fissures, and has been reported to present good accuracy and reproducibility, even better than those of radiographic examination [8].

The most important diagnostic values, which are used for the evaluation of a diagnostic method, are as follows: sensitivity (ability to correctly identify decayed surfaces), specificity (ability to correctly identify sound surfaces), efficiency (the probability that test results and the gold standard agree), Positive Predictive Value (PPV; the capability of a test to predict the absence of a lesion), Negative Predictive Value (NPV; the capability of a test to predict the presence of a lesion), False Positive (FP; the number of healthy persons who have tested positive) and False Negative (FN; the number of patients who have tested negative). An ideal diagnostic method should possess high sensitivity and specificity in order to accurately diagnose sound and decayed teeth [9].

Several in vitro studies, comparing some conventional methods with LF, have been performed on the diagnosis of occlusal caries [10-15]. Pereira et al [12] found that the performance of LF in the detection of occlusal enamel caries in permanent teeth was not statistically different from that of visual inspection. Attrill and Ashley [13] applied LF on deciduous teeth under in vitro conditions and reported that the new diagnostic method did not perform better than visual inspection. Some other investigations recommend that LF should be used for monitoring occlusal caries lesions [13-15]. For instance, an in vitro study carried out by Reis et al [15] showed that LF presented higher specificity and accuracy at the threshold of D3 (demineralization extended to the middle third of dentin).

Souza-Zaroni et al [7] in a study on 47 human extracted molars compared the validity and reproducibility of various combinations of methods for occlusal caries detection, and concluded that combination of visual examination, laser fluorescence and radiographic examination resulted in the best accuracy. They also emphasized that the knowledge background of the examiners influenced their ability to detect carious lesions and affected interexaminer reproducibility [7].

The aim of the present study was to compare the performance of laser fluorescence (LF) method with other conventional diagnostic techniques in detection of small occlusal caries in permanent teeth.

MATERIALS AND METHODS

Ninety unrestored human premolars, extracted within a 6-month period and stored in 0.5% thymol solution, were selected for the study by a senior researcher who did not participate as an examiner. As in our study we chose the young premolars, which were extracted for orthodontic purposes, the selected teeth exhibited varying degrees of primary occlusal caries or apparent absence of carious lesion.

The teeth were carefully cleaned using rotary
bristle brush, normal saline and pumice powder to remove deposits of calculus, plaque or debris that could interfere with the results, and then the examination sites were specified by a marker. The teeth roots were then cast by transparent acrylic resin and were coded by 4-digit numbers, and they were randomly put in netted dishes containing 0.9% saline solution for dampening the samples and simulating the oral cavity environment.

The visual inspection was performed on dry, clean surfaces with visualization under the direct dental unit light with a distance of 20 centimeters. The status of each sample was determined on the basis of diagnostic criteria of Table 1 and the degree of 3 was considered as dentinal caries. The teeth were protected against dehydration during the study.

One week later and with a random rearrangement of the samples, the teeth were examined in a similar condition by an explorer (Hu-friedy double end EXD5, USA). The instances of catching were considered as decay.

Two weeks later and with a random rearrangement, the samples were evaluated by the LF device (DIAGNOdent, Kavo, Biberach, Germany), according to the manufacturer’s specifications. For each individual tooth, the device was calibrated prior to every operator’s evaluation by holding the selected probe tip (cone-shaped tip A, indicated for fissures areas) against the ceramic plate of the device. Afterwards, the probe tip was placed perpendicularly on the suspicious site with light contact. The tip was slowly rocked in a pendulous motion so as to thoroughly scan the nearby periphery of the site at various angles. The specified sites were examined for three times, the corresponded figures were read, and the highest value was recorded. The values of higher than 26 were considered as dentinal caries (Table 1).

For the bitewing radiography, the Planmeca (PROSTYLE INTRA, Finland) equipment, with a 35-centimeter localizer, was adjusted on the time of 0.35 of a second and the fixed dis-

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**Table 1. Criteria used in this study for different diagnostic methods.**

<table>
<thead>
<tr>
<th>Diagnostic Method</th>
<th>Grades</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual Method</td>
<td>Grade 0- No change or slight change in enamel translucency after prolonged drying</td>
</tr>
<tr>
<td></td>
<td>Grade 1- Thin stain or visible white opacity after drying</td>
</tr>
<tr>
<td></td>
<td>Grade 2- Discoloration or visible white opacity without drying</td>
</tr>
<tr>
<td></td>
<td>Grade 3- Opaque discoloration with grayish shadow indicating the presence of undermined enamel</td>
</tr>
<tr>
<td>Probing Inspection</td>
<td>Not getting caught by the explorer</td>
</tr>
<tr>
<td></td>
<td>Getting caught by the explorer</td>
</tr>
<tr>
<td>Radiography</td>
<td>Lack of visible radiolucency</td>
</tr>
<tr>
<td></td>
<td>Confined to enamel radiolucency</td>
</tr>
<tr>
<td></td>
<td>Visible radiolucency in DEJ and dentine</td>
</tr>
<tr>
<td>Laser Fluorescence</td>
<td>0 to 15= Lack of caries or preliminary enamel lesions with no need to dentistry treatment</td>
</tr>
<tr>
<td></td>
<td>15-30= Enamel caries or lesions extended to the dentin-enamel junction with the need of preventive intervention with the consideration of caries risk</td>
</tr>
<tr>
<td></td>
<td>Higher than 30= Dentin caries with the need of reparative interventions</td>
</tr>
<tr>
<td>Histology</td>
<td>D0- Absence of enamel demineralization or, a thin opaque strip</td>
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<tr>
<td></td>
<td>D1- Enamel demineralization extended to 50% of enamel</td>
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<tr>
<td></td>
<td>D2- Demineralization extended to 50% of enamel to the beginning of dentin</td>
</tr>
<tr>
<td></td>
<td>D3- Demineralization extended to one third of middle dentin</td>
</tr>
<tr>
<td></td>
<td>D4- Demineralization extended to one third of internal dentin</td>
</tr>
</tbody>
</table>
tance of 5 centimeters between the tube and the film’s (Kodak D-speed, Kodak Ltd, Hemel Hempstead, UK) surface. The samples were all radiographed on the same day and the films were developed immediately following exposure by means of an automatic processor (GENDEX, Clarimat 100, USA). Then, the visible radiolucency in DEJ and dentin were recorded.

The examiner’s accuracy in the procedure was evaluated by means of a pilot study with 18 teeth prior to the main study. The examiner studied each of the teeth individually using the four diagnostic techniques at two separated times with a time interval of two weeks. The teeth were also examined using histopathology method as the gold standard.

The data were analyzed by SPSS 15 software and the diagnostic values of each method including sensitivity, specificity, efficiency, PPV, NPV, FP and FN were determined. Kappa statistics also served for the intra-examiner reproducibility and validity.

RESULTS

The intra-examiner reproducibility for probing and also radiographic techniques was 100%. The corresponded figure for LF (88%) was more than visual inspection (82%). The highest level of validity of the examiner turned out to be in probing technique (76.9%).

In histological assessments of the 90 teeth, 11 of them showed caries at D3.

Sensitivity, specificity, efficiency, positive and negative predictive values, false positive and false negative values are displayed in Table 2. The highest efficiency value was provided by probing system (92.2%). LF presented the highest value of false positive (15.2%), whereas, the highest value of false negative belonged to the radiographic technique (72.7%).

DISCUSSION

The present study comparing performance of laser fluorescence method with other conventional diagnostic techniques in detection of occlusal caries showed slightly lower values of efficiency for LF method compared to other methods (visual inspection, probing, and radiography). This might be due to the high frequency of false positive diagnoses in LF technique. It seems that the high rate of undecayed teeth in our samples, which were selected among the teeth extracted for orthodontic purposes have increased the values of the diagnostic criteria of all methods.

In an in vitro study by Lussi and Francescut [14] on 95 deciduous molar teeth, the techniques of visual inspection, visual inspection with magnification, visual inspection with light pressure probing, BW radiography and LF were compared to each other and caries extension were assessed by histological methods. The highest obtained sensitivity score in that study belonged to LF (82%), whereas in our study, the sensitivity scores of visual inspection, probing and LF technique were equal (54.5%). The calculated specificity scores for laser in both studies were nearly similar, 84.8% in our study and 85% in Lussi and Francescut study [14]. In addition to morphological difference between deciduous and permanent teeth, a probable reason for the difference in the results of the two studies might resulted from different classifications and

Table 2. Diagnostic values of four methods in diagnosing caries in occlusal surfaces of premolar teeth.

<table>
<thead>
<tr>
<th>Diagnostic Method</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>NPV</th>
<th>PPV</th>
<th>FN</th>
<th>FP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual Method</td>
<td>54.5</td>
<td>94.9</td>
<td>93.8</td>
<td>60</td>
<td>45.5</td>
<td>5.1</td>
</tr>
<tr>
<td>Probing Inspection</td>
<td>54.5</td>
<td>97.5</td>
<td>93.9</td>
<td>75</td>
<td>45.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Laser fluorescence</td>
<td>45.5</td>
<td>96.2</td>
<td>92.1</td>
<td>35.7</td>
<td>54.5</td>
<td>11.4</td>
</tr>
<tr>
<td>Radiography</td>
<td>27.3</td>
<td>88.6</td>
<td>90.5</td>
<td>50</td>
<td>72.7</td>
<td>3.8</td>
</tr>
</tbody>
</table>

NPV=Negative Predictive Value, PPV=Positive Predictive Value, FN= False Negative, FP= False Positive
thresholds (D2 or D3) for caries diagnosis.
In the research by Reis et al [15], the visual method was compared to LF on 110 areas of 57 third molar teeth in vivo and in vitro, and then the samples were sectioned. The study showed that specificity and efficiency of LF in the threshold of D3 was more than that of visual method, while visual method represented higher intra-examiner reproducibility (88%) compared to the other method. The results of their study showed that in in vitro environment, LF had the highest specificity value in the threshold of D3 [15]. In our in vitro research also, the specificity of LF technique turned out to be 84.8%, which is close to the result of Reis, study. However, in our study the specificity of visual inspection method was higher than that of LF technique (94.9%).

Another notable finding in the present study was the high frequency of false positives diagnoses (15.2%) for LF device. This finding is in agreement with Reis’s et al [15]. Recent evidence has shown that LF device tends to over score discolored sites. As professional cleaning with rotating brushes cannot remove intrinsic or extrinsic stains or discoloration in the fissure system, this could be the source of high rate of false positives obtained with LF and the consequent reduction in specificity [7]. Thus, it seems that LF may overestimate the number of caries and may eventually lead to overtreatment.

A research by Lussi et al [17] indicated that type of storage solution (thymol, formalin, etc) within the period of 5 months of storage may affect the amount of the scattered fluorescent reflectance from the tooth. However, after that period, fluorescent goes back to its normal level. Since our study was performed after storing the teeth in thymol solution for 6 months (which is more than the effective 5 months reported by Lussi et al [17]), the storing time can not be considered as an intervening factor.

Despite the high values of sensitivity and specificity reported for tactile inspection in the present study, irreversible damage to sound enamel and micro-organisms transmission in this diagnostic method will still remain the main concern [5,14]. Therefore, seeking new methods for caries detection with more accuracy and less adverse effects is still an important priority and is open for further research. It is worth mentioning that results of the present study confirmed the ideality of the visual method. Since molar teeth possess a relatively more complex morphology, and more likely need preventive resin restoration or pit and fissure sealant therapy compared to premolars, it is suggested that further research in future focus on molar teeth.

CONCLUSION
Specifity and efficiency of LF method were lower compared to those of other methods. Among all the investigated methods, the most efficient methods in the diagnosis of small occlusal caries in permanent teeth were probing and visual inspection, respectively.

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REFERENCES