

Performance of a laser fluorescence device in detecting occlusal caries in vitro

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Abstract

The aim of this study was to compare the validity of the measurements of the laser fluorescence device, KaVo DIAGNOdent, with the result of polarized light microscopy in the detection of occlusal fissure caries in extracted third molars and premolars. Forty-three extracted third molars and premolars which had macroscopically intact occlusal surface were selected. The DIAGNOdent measurements of the occlusal test site were recorded by two observers at intervals of 2 days. The teeth were then sectioned at the specified test sites for histological examinations.

Prepared specimens were evaluated under the polarized light microscopy and all images were scored with the caries classification of D1 (sound and fissure lesion in the half of the outer enamel), D2 (enamel decay) and D3 (dentin decay) level (gold standard). Value of specificity for the detection of enamel caries at D1 level was 0,72 and sensitivity values at D2 and D3 levels were 0,66 and 1, respectively. The present study indicates that the DIAGNOdent provides not only almost perfect agreement but also sufficient repeatability at D1, D2, D3 levels and better specificity at D1 level as well as lower sensitivity at D2 level and excellent sensitivity at D3 level.

Key words: caries detection, laser fluorescence, occlusal caries, polarized light microscopy.

Introduction

The contemporary approach to clinical management of dental caries is based on the detection of the presence of the disease in early stage, when any hard tissue changes are minimal. Treatment is based on non-invasive measures to arrest the disease process and reverse the hard tissue damage.

Today there is an increasing concern regarding so – called “hidden” occlusal caries: carious lesions which develop beneath macroscopically intact fissures and are difficult to detect by conventional visual, tactile and radiographic techniques.

Since early caries detection is not simple, a new system has been developed in the monitoring of early caries lesions. This system based on laser fluorescence is the DIAGNOdent*. This system is designed to capture increase fluorescence in the occlusal or proximal areas of the tooth [6,7, 12].

Changes in the tooth substances associated with progression of the carious process are reflected in an increased amount of fluorescent light [5]. The cause of this increased level of fluorescence was the presence of chromophores associated with bacteria present in the infected tooth structure. A numerical value is assigned to the degree of fluorescence as an indicator of the extent of caries [6,7].

Objective

The aim of this study was to establish morpho-clinical correlation between the results obtained with Diagnodent device and the histological aspects of carious lesion in polarized light microscopy and stereomicroscopy.

Material and method

Forty-three extracted third molars and premo-

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lars which had macroscopically intact occlusal surface (10 impacted third molars with completed root formation, 20 premolars extracted in orthodontic purposes and 13 premolars with different grades of mobility) were surgically removed without any damage. The teeth were stored in 10% buffered formalin immediately following extraction and had none of the following: occlusal restorations; fissure sealants; developmental defects; and frank cavitation, i.e. cavitation visible on initial examination.

All teeth had been pooled within an interval of less than 1 month and stored in physiological saline solution. They were then thoroughly rinsed with water, cleaned with a tooth brush and pumice and dried with paper tissues in order to obtain optimal conditions for laser detection.

The measurements of the occlusal test site were made by using laser fluorescence device DIAGNOdent. At the specific wavelength (655-nm) that the DIAGNOdent laser operates, clean healthy tooth structure exhibits little or no fluorescence, resulting in very low scale readings (D1 > 0–13) on the display. The presence and extend of carious lesions were classified as follows: sound fissures and enamel fissure lesions (D1), enamel caries (D2) and dentinal caries (D3). According to the caries level, carious tooth structure exhibits fluorescence in elevated scale readings (D2 > 14–19) and (D3 > 20) [8].

A tapered fibre optic probe (Tip A) has been specially designed for the detection of fissure caries. The laser probe scans over the fissure in question and has to be inclined to the right and to the left over the main fissures to ensure that the tip picks up the fluorescence from the slopes of the fissure walls, where the carious process often begins. The maximum value is shown by the appliance as a 'peak' value.

The observers were asked to record DIAGNOdent peak value on the charts above the drawings on the same day. Two days later, each measurement was repeated on the same test site of differently enumerated teeth to ensure that the observers did not recall the previous result.

Teeth were then sectioned for histological examination. Teeth were hemi-sectioned in a mesial–distal direction through the fissure pattern with a high-speed drill and fine diamond bur.

The specimens were submerged in water and examined using a polarized light microscope. Stereomicroscopy allows the study of tridimensional images. This qualities are based on large fields of interpretation and the large distances

between 92 mm -286 mm, with a magnification from 1,95 to 225 x.

For the otical study in stereomicroscopy was used Olympus microscope SZ x 7 and Olympus camera with 2,5 x digital zoom and 3 x optical zoom.

Specificity was defined at D1 level and sensitivity was calculated at D2 and D3 level.

Results

Results obtained with Diagnodent device revealed: out of 43 apparently sound teeth: 18 had values between 2 and 12 (D1), 13 values between 14 and 20 (D2), 12 values over 20 (D3).

Four of the specimens were damaged during the histological preparations so they were not evaluated. After histological examination, 25 teeth were sound, 10 teeth had enamel caries and 8 teeth were shown to have dentinal caries.

From the 10 surfaces with enamel carious lesions histologically distinguished in stereomicroscopy, 6 presented at the examination with Diagnodent device values between 14–20 (D2) (*fig.1, 2*) and 4 values between 20–32 (D3) (*fig.3, 4*).

The relationship between the histological assessments and DIAGNO-dent values are given in *Table 1*. The calculation was performed using cut-off limits representing values 0–13: absence of caries or outer lesion of the enamel (D1); values 14–19: presence of enamel caries (D2); values >20 dentinal (D3) caries.

Table 1. The relationship between the histopathological assessments and DIAGNOdent values

Diagnostic test DIAGNOdent	Gold standard Histological examination			
	D1	D2	D3	T
(D1) 0–13	18	0	0	18
(D2) 14–19	7	6	0	13
(D3) >20	0	4	8	12
T	25	10	8	43

The histological examination was shown to be 100% repeatable.

DIAGNOdent could not differentiate between sound surfaces and those with lesions in the outer half of the enamel, these two were combined.

Of seven teeth which appeared D1 histologically, DIAGNOdent reading gave readings of D2 (14–19). Four of six teeth had histological enamel caries but showed readings of D3 with DIAGNOdent.

Histological dentin caries did not differ from the results of DIAGNOdent.

This study predicted the probability that when histological caries was confined to enamel, the cut-off limits were between 19 and 26 (D2) and in dentin they were more than 27 (D3). Values of specificity for the detection of caries level was 0,72 at D1 level and sensitivities at D2 and D3 level were 0,60 and 1, respectively (Table 2).

Table 2. Specificity and sensitivity for DIAGNOdent

Results	Percentage
Specificity D1	72
The value of sensitivity for D2	60
The value of sensitivity for D3	100



Figure 1. Occlusal surface with deep fissures and plaque deposits, stereomicroscopy, x 32.



Figure 2. Morfometry of occlusal surface with deep fissured and plaque deposits, stereomicroscopy, x 32.



Figure 3. Stereomicroscopy of a carious lesion diffused under amelo-dentinal junction, polytopic lyses of enamel and dentin nearby carious lesion, x 32.



Figure 4. Occlusal surface with multiple defects of fissural compounds, reactionary hypermineralization adjacent to the carious lesion, stereomicroscopy, x 8.

Discussion

The modern clinician's aim should be to diagnose caries before caries cavitation occurs. Early diagnosis of occlusal caries and the initiation of more effective treatment presents a considerable challenge [9,13,15]. Much attention has been paid to the possible use of lasers for early caries detection. [9]. This study was conducted on third molars which were obtained in less than 1 month time and stored in physiological saline solution to prevent the effect of storing solution and time [4].

Contrary to present study, the material used in other in vitro DIAGNOdent studies consisted of extracted molar and/or premolar teeth of unknown history.

Therefore, the number of teeth selected in this study was limited ($n=43$). Ten of the selected teeth were impacted third molars. Since the impacted third molars had comparatively poorly matured enamel, the measurements of high DIAGNOdent might have been influenced by incomplete eruption, but this cut-off limit was not obviously associated with histological caries.

So that impacted third molars could be examined to establish 'gold standards' for sound fissures.

Ten impacted teeth had a minimum DIAGNOdent score of 4 and maximum 14 but never had 0. This finding had been in agreement with the result of longitudinal diagnosis of just erupted first molars [10].

Erupted premolars (25) without macroscopic breakdown exhibited also minimum reading of 4.

Based on the result of this study, numerical scale readings of device were defined as follows: 3–18, no caries, or histological enamel caries limited to the outer half of enamel thickness; 19–26, histological caries extending beyond the outer half, but confined to the enamel; 27–99, histological dentinal caries.

It is clear that the cut-off limits obtained in this study are quite different from those of the earlier in vitro studies [7, 12], but almost in agreement with recent clinical studies [8, 11]. An explanation may be provided by the in vivo mimetic characteristic of the storage solution and time used in the present study.

It is obvious from Table 2 that the use of DIAGNOdent to detect caries at D1 threshold showed substantial specificity (0,72). The results were roughly in accordance with the literature. In an in vitro study of natural decay of occlusal fissure enamel, the specificities of DIAGNOdent were (0,72–0,78) [7]. In another in vitro study (Shi et al., 2000) with micro radiography as the gold standard, the laser device had a specificity of 0,95 [12].

In this study, DIAGNOdent showed perfect sensitivity value (1,00) at D3 level supported by other recent studies. One of these evaluated the DIAGNOdent system in vitro and diagnosis was

confirmed by micro radiography and showed higher diagnostic accuracy in the detection of dentinal caries than in enamel [12].

Attrill and Ashley (2001) found that the sensitivity values of the DIAGNOdent system for the detection of occlusal caries extending into dentine in extracted primary molars was 0,77–0,80 [2].

DIAGNOdent showed a high sensitivity (0,95) for detection of caries when the cut-off limit was between sound fissures and caries in enamel and dentin. For the diagnosis of enamel decay (D2) on occlusal surfaces a previous study had compared DIAGNOdent device with electronic caries monitor (ECM) in an in vitro study with histological measures as the gold standard. It found higher sensitivities (0,76 – 0,84) for DIAGNOdent than the value found in the present study (0,66) (with a cut-off 14–19) [3].

High sensitivity for dentin caries (at D3 threshold) with good specificity for sound fissures and lesions in the outer half of the enamel (at D1 threshold) indicates that this diagnostic method can accurately detect both dentin caries and sound fissures.

Although this experiment was carried out in vitro, and therefore some care must be taken into account to interpret these results for in vivo condition, the ability of the device to detect dentinal lesions before substantial tissue loss would allow considerable changes in the treatment decision strategy.

Good specificity for enamel caries detection (recognizing sound surfaces) would have significant influence on the overall use of prevention techniques.

Conclusion

This in vitro study revealed that the DIAGNOdent device has high diagnostic validity for the detection of sound surfaces and the dentinal caries. DIAGNOdent provides not only almost perfect agreement but also sufficient repeatability at all levels and good specificity at D1 level, and lower sensitivity at D2 level than D3 level in extracted third molars.

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