Lasers for Caries Detection: Does this Method Perform well on Occlusal and Proximal Surfaces?

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_Abstract

Caries diagnosis has become a major challenge in dentistry due to recent modifications in lesion characteristics and patient behaviour. Novel methods have been developed in order to aid visual and radiographic examinations for caries detection. This review focuses on the performance of laser-induced fluorescence devices (DIAGNOdent and the DIAGNOdent pen) that have been studied in the past decade. Both devices are based on the measurement of back-scattered fluorescence from bacterial metabolites present in the caries lesion. Occlusal and proximal surfaces can be assessed and lesion severity can be quantified using these methods. Based on the literature, both devices can be considered auxiliary methods for caries diagnosis, i.e., as a "second opinion" in the treatment decision-making process.

_Introduction

Dental caries is an important global public health problem. Its detection is a key element in the prevention and treatment of lesions, and is a difficult task in dentistry.[3] Therefore, early diagnosis is fundamental for the establishment of a treatment plan that is effective but as conservative as possible, in order to reduce the involvement of tooth structures in restorative procedures when indicated.

Due to the widespread use of fluorides, which promote superficial remineralisation that seems to delay cavitation, incipient occlusal lesions have become difficult to detect. The difficulty of precise detection is also related to other factors, such as the complex anatomy of pits and fissures[25] and the superposition of structures in radiographic evaluations. Additionally, the changes in lesion morphology could lead to the presence of occlusal dentine caries under a fissure which seems intact to the naked eye.

In general, an early caries lesion in enamel is clinically observed as a white spot lesion caused by acids from dental plaque. This incipient lesion progresses slowly and may be remineralised without requiring operative intervention.[22, 26] White spots are opaque because their crystals have altered physical and chemical properties, and the spatial configuration of the crystals is different from that of normal enamel. The presence of water means that light is reflected off the enamel surface differently for an initial carious lesion than for a sound surface. The early detection of smooth surface caries lesions is important for appropriate management of caries, i.e., to avoid premature tooth restoration treatment but allow the

Fig. 1a


Fig. 1b


Fig. 1c

Fig. 1a_DIAGNOdent 2095.
Fig. 1b_Tip A for occlusal surfaces.
Fig. 1c_Tip B for smooth surfaces.

caries to be monitored over time.

Caries lesions on proximal surfaces are difficult to detect with visual-tactile examination unless the lesion is relatively advanced and considerable loss of tooth structure has occurred.[5, 6] Bitewing radiographs have been recommended to aid and improve the diagnosis of proximal caries lesions. However, this method is of limited value during diagnosis and might lead to an underestimation of lesion size. An alternative system that permits better detection and monitoring of such lesions would be of great use to clinicians and researchers.


Fig. 2a

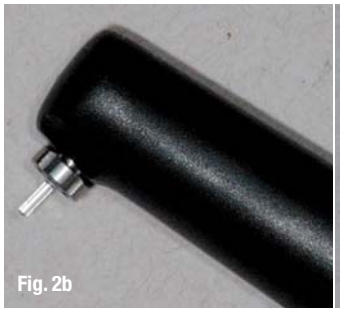
Fig. 2b


Fig. 2c

Fig. 2a_DIAGNOdent 2190 (DIAGNOdent pen).
Fig. 2b_Cylindrical tip for occlusal surfaces.
Fig. 2c_Wedge-shaped tip for proximal surfaces.

The difficulty in detecting caries has led to an increase in the research and development of new diagnostic methods. In recent years, a number of novel techniques such as electrical conductance measurements and fluorescence-based methods have become available to accompany traditional methods of caries detection.[12] In the present review, a brief explanation of laser-induced fluorescence devices and their performance in evaluating occlusal and proximal surfaces will be given.

_Laser-induced fluorescence methods

The first laser fluorescence device (DIAGNOdent, KaVo, Biberach, Germany) was developed in 1998. It is a laser-based instrument that emits light at 655 nm from a fibre optic bundle and is able to capture the fluorescence emitted by oral bacterial metabolites present in the caries lesions; this yields a quantitative measurement of caries development. This device is based on the principle that carious tissue fluoresces more strongly than sound tissue. A photodetector quantifies the emitted fluorescence that passes through the filter and displays a real-time (moment) and a maximum (peak) value. Changes in emitted fluorescence register as an increase in the digital number displayed on a monitor. This new method allows quantifiable, non-invasive examination of the tooth surface, therefore favouring early detection of lesions so that preventive measures may be adopted to prevent caries progression.[25]

More recently, a new laser fluorescence device (DIAGNOdent 2190, KaVo, Biberach, Germany) has been tested for the detection of both occlusal and proximal caries. This system functions on the same principle described above .[17, 18] In the LFpen device, the excitation and the emission of fluorescence follow the same solid fibre tip, but in opposite directions.[17] This is the main difference from the first device, which uses different fibres for excitation and emission.[19] To enable the user to place the probe on mesial and distal surfaces at the facial and oral sides of front and posterior teeth, the tip must be able to rotate about its long axis. A knob allows turning around the tip and a red point on it indicates the light direction.

For both devices, the manufacturer's instructions indicate that it is necessary to perform a standard calibration on a porcelain object with known fluorescence (standard calibration). An additional calibration against a sound spot on the buccal surface should also be performed, allowing the automatic subtraction of the zero value from the site of interest (individual calibration).[7, 8, 11] However, some authors[13, 14, 16, 18] have chosen to measure a sound spot on buccal surface to obtain the zero value of fluorescence and perform the subtraction manually (zero value subtraction) after lesion assessment.

The studies that evaluated individual calibration are controversial. While Braun et al.[8] suggested that the individual calibration should be performed because a difference of 6 units was found in the LF assessments, Braga et al.[7] did not find any influence of the calibration procedure on the performance of the device in primary teeth. Recently, Rodrigues et al.[24] observed a decrease in sensitivity of DIAGNOdent performance when zero value subtraction was used. The authors concluded that the DIAGNOdent readings may be performed without zero value subtraction without cut-off's adjustment. For the DIAGNOdent pen, however, the absence of the zero value subtraction changed both the sensitivity and specificity and should not be eliminated.

_Performance on occlusal surfaces

Rodrigues et al.[25] compared different methods for caries detection in occlusal surfaces. DIAGNOdent showed higher specificity and lower sensitivity than the values found by Lussi and Hellwig[18], while the DIAGNOdent pen showed lower specificity and practically the same sensitivity when compared to these values. Another comparison of the DIAGNOdent device, visual examination and radiographic examination was recently performed in vivo. The authors concluded that the DIAGNOdent device may be a useful supplement to visual examination, and its diagnostic performance seems to be well-suited for occlusal caries detection.[2] Another in vivo study demonstrated that the DIAGNOdent device performs well in detecting dentine caries lesions.[10]

Additionally, a high value of fluorescence may indicate caries or changes in the physical properties of the

Fig. 3a-d_Calibration procedure: (a) and (b) standard calibration; and (c) and (d): individual calibration with DIAGNOdent (occlusal tip) and DIAGNOdent pen (proximal wedge-shaped tip), respectively.
Fig. 4_Assessment of an occlusal surface using DIAGNOdent.
Fig. 5_Assessment of a proximal surface using the DIAGNOdent pen (image reproduced from Neuhaus et al.).[20]

tooth structure, such as the presence of calculus, disturbed tooth development or mineralisation. Neither device performs well on stained surfaces, which can generate false-positive results.

A systematic review[3] showed that the DIAGNOdent device tended to be more sensitive than the visual method in detecting occlusal dentinal caries. This means that a larger proportion of true lesions were detected. However, the method was less specific in that the DIAGNOdent also identified a larger proportion of sound sites as being carious (false-positive results) than did the visual method. Furthermore, the device was less sensitive and more specific in detecting enamel lesions than in detecting dentinal caries; i.e., the performance of this device in enamel is worse than in dentin. For this reason, this device may be best used as an auxiliary method for occlusal caries detection.

Other limitations of both devices are that the clinician must move the tip around the test site until the highest value is obtained in order to avoid false assessments. This ensures that the tip picks up the highest value present in the fissure wall, where the carious process often begins. The calibration procedure using a ceramic standard should also be performed, as described above.

_Performance on proximal surfaces

Data concerning the performance of the DIAGNOdent devices on proximal surfaces are limited. The first device identifies proximal caries with high sensitivity but low specificity. In addition, the readings on proximal surfaces are not as reproducible as readings taken on occlusal surfaces.[26,27] This could be due to the fact that the tip made for the first device does not penetrate the proximal surface well, if at all.

Therefore, a special tip for the DIAGNOdent pen was developed for use on proximal surfaces. Its small width (0.4 mm) and unique shape, which allows better penetration into the proximal space and accurate light reflection, enable better assessment of these areas.[4] Lussi et al.[17] showed that this device accurately assesses proximal surfaces in vitro, indicating that this new system might be a useful tool in detecting proximal caries. Because of the reproducibility of readings taken with this device, it could be used to monitor caries regression or progression on proximal surfaces.

Novaes et al.[21] assessed primary teeth in vivo and also found that both the DIAGNOdent pen and radiographic methods presented similar performance in detecting the presence of cavitations on proximal surfaces.

_Other applications

DIAGNOdent devices have been also studied in other clinical situations, e.g., for the detection of recurrent caries[4,5], residual caries during excavation[15], caries around orthodontic brackets[1], root caries[28] and caries under sealants.[9,23]

_Conclusions

Based on the literature, DIAGNOdent devices perform well on occlusal and proximal surfaces. However, they cannot be considered as standalone diagnostic tools, but instead should be used as a second opinion during the caries diagnosis process. Finally, while using the laser-induced fluorescence devices, clinicians should understand the concepts of caries risk, activity, detection, diagnosis and assessment to determine the best treatment for each individual patient._

The Literature list can be requested from the author.

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