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ACCURACY OF DIAGNODENT IN DETECTING THE DEPTH OF PROXIMAL CARIOUS LESIONS

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ABSTRACT

Background: The diagnosis of hidden caries extending deeply into dentine with intact enamel is based on digital radiograph (RVG) and is considered a difficult procedure, which needs more analysis of the affected teeth.

Aim: The purpose of the present study was to determine the accuracy of laser fluorescence (DIAGNOdent) and the conventional method (bitewing radiograph) in identifying the depth of the proximal carious lesions in posterior teeth *in vivo*.

Materials and methods: Forty proximal lesions were identified in 26 patients aged between 20-45 years old, who were recruited from the out clinic of Umm Al-Qura Dental Teaching Hospital. Following initial clinical examination, the patients were subjected to two diagnostic methods: The first one is a bitewing digital radiograph using GXS - 700 Gendex with exposure time of 0.32 second and patients with scores from 1 to 3 were selected. The second method was carried out using the DIAGNOdent device to take the reading of demineralization existing in proximal surfaces. Only teeth with readings representing actual cavitation were included. Cavity preparations were performed to the selected carious lesions according to the extension of the caries, then axial cavity depths were measured, and teeth were restored using bonded resin composite restorations.

Results: Statistical analysis revealed a significant positive correlation between DIAGNOdent and RVG ($R= 0.868$; $p< 0.05$). Also, there were positive correlation between cavity depth and DIAGNOdent ($R= 0.998$; $p< 0.01$) as well as between cavity depth and RVG ($R= 0.798$; $p< 0.05$). The strongest correlation was detected between cavity depths with DIAGNOdent compared to RVG.

Conclusion: The current study suggests that the score of DIAGNOdent has higher correlation with the cavity depth and it could present a better sensitive and specific tool for the diagnosis of proximal caries. Further studies are needed to measure the sensitivity and specificity of laser florescence.

KEYWORDS: Cavity depth, DIAGNOdent, Digital radiographs, Proximal caries.

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INTRODUCTION

Detection and diagnosis of dental caries in its early stage decrease the chance of unrecoverable loss of tooth structure. Conventional examination for detection of occlusal caries is principally done using visual inspection and tactile sensation while; radiographs are the primary method for proximal caries diagnosis. Radiographic examination has great value in detecting caries lesions especially when they are not clinically visible but in low caries population resulted from fluoride usage, the surface of enamel does not break down, making the caries detection harder [1].

The ideal diagnostic approach for detecting proximal caries should aim to detect the early pathologic changes in the dental tissues [2]. However, the diagnosis of hidden caries outspreading beneath the dentino-enamel junction with intact enamel is a more obstinate procedure that needs more comprehensive examination of the affected teeth[3,4]. For detection of proximal caries, Bitewing Radiographic examination is the traditionally used method but with the limitations of radiation and inaccuracy of representing the lesion size and it is also fallacious for non-cavitated lesion [5,6].

As these methods give satisfactory results in detection of cavitated lesions but they are –most of the time- insufficient for the detection of un cavitated lesions besides, they don't give accurate information about the depth of the lesion, it was mandatory to develop new methods to aid in better diagnosis [1].

Laser fluorescence (LF) is lately introduced as an option for caries detection. DIAGNOdent (DD) is a LF-based device, capable of discriminating caries lesions from sound tissues based on the difference of fluorescence displayed by the two different structures when subjected to a red and infrared spectrum. The fluorescence is transformed into a numerical scale, and the deeper the lesion, the higher the value displayed by the device [7-9]. This system has a range of 0 to 99 where value 0 indicates a sound tooth structure and the number increases with the degree of destruction. It is described as an effective approach to detect initial lesions without cavitation [10-13].

DIAGNOdent has been subject to both in vitro and in vivo studies to check its accuracy. The reported results are conflicting while as some studies have reported well to excellent performance while others reported equal results to visual examination[14-17].

Considering these facts, this study aimed to measure whether a correlation exists between the depth of the carious lesion with both laser fluorescence readings and digital radiographs in vivo. Additionally, the present study investigated the correlation between both methods. A better understanding of the correlations between the cavity depths with both techniques could provide a better and/or early diagnostic protocol for hidden proximal dental caries and more conservative treatment approaches.

AIM OF THE STUDY

This study aimed to deduce the correlation between clinical cavity depth and laser fluorescence measurement compared to digital radiographs. The following null hypotheses were tested: (1) there was no correlation between depth of the proximal carious lesions and the readings of the laser fluorescence device and (2) there was no correlation between laser fluorescence measurement and digital radiography score.

MATERIAL AND METHODS

Study design and ethical approval

The current study was clinical study carried out at the specialty clinics of the Dental Teaching Hospital, Umm-Al-Qura University after obtaining ethical approval from the Biomedical Research Ethics Committee of the University (HAPO-02-K-012-2021-02-562).

Sample size

Number of cavities were calculated using an online calculator by setting the power at 80% and the values for the mean (3.53) and SD (2.36) for the control group, based on previous study [18].

Carious lesions selection:

Forty lesions were identified in patients with age range between 20 - 45 years who were presented in the out clinic seeking restorative treatment. Teeth were selected according to the following criteria: 1) fully erupted permanent molars and premolars, 2) no visible cavitation in proximal surfaces, 3) caries must represent a primary lesion that has been diagnosed clinically as active caries and 4) the teeth must be free of any existing restorations. Teeth with occlusal restorations, occlusal fissure sealants, and hypoplastic pits, frank occlusal cavitation resulting from caries attack or symptoms of pulpitis were excluded. The teeth were visually sound or had various stages of non-cavitated carious lesions on proximal surfaces were selected.

Clinical Examination

a) Visual Examination

All examinations were conducted under standard conditions. Each tooth included in the current study received visual and tactile examinations with a standard explorer as follows: After drying the tooth with compressed air, the area of the suspected lesion was evaluated from the occlusal aspect using direct and reflected light. The visual appearance of the lesions was recorded using the criteria shown in (Table I)[19]. Only score 0, 1, and 2 scores were included.

The Visual Classification System of dental caries:

Score	Criteria
0	No or slight change in enamel translucency after prolonged air drying (>5s)
1	Opacity or discoloration hardly visible on a wet surface, but distinctly visible after air-drying.
2	Opacity or discoloration distinctly visible without air-drying.
3	Localized enamel breakdown in opaque or discolored enamel and/or greyish discoloration from the underlying dentin.
4	Cavitation in opaque or discolored enamel exposing the dentin.

b) RVG examination:

All clinically detected carious lesions were examined with the bitewing digital radiography and this was accomplished using an intra-oral sensor held by a special holder, the bitewing radiographs were taken digitally (GXS-700 Gendex) with exposure time of 0.32 second as recommended by the manufacturer. Radiographs were examined and recorded using the radiographic scoring system presented in (Table II) [19]. All scores except 0 and 4 were included.

The criteria used in the Radiographic Scoring System of dental caries:

Score	Criteria
0	No radiolucency visible
1	Radiolucency visible in the enamel
2	Radiolucency visible in the dentin but restricted to the outer third of the dentin
3	Radiolucency extending to the middle third of dentin
4	Radiolucency in the pulpal third of dentin.

c) Laser fluorescence Measurements:

The selected teeth were measured using DIAGNOdent pen (Fig. 1). It was used to take the reading of demineralization existing in proximal surface. The DD generates a laser beam with a wavelength of 655 nm. The DD probe has two

different types of tip: a cone-shaped tip for the diagnosis of fissure caries; and a broad tip for the diagnosis of smooth surface caries, which was used in the present study. Assessment of the teeth with the laser fluorescence system was held according to the manufacturer's instructions as follows: after isolation and dryness of the tested teeth, the pen was calibrated (first calibration) using the calibrating plate supplied with the device (Fig. 2). Then the fluorescence of a sound spot on the facial surface of an intact upper incisor was measured for each patient to provide a baseline measure for each patient (second calibration) (Fig. 3).

The tip of the laser device was placed on the test site (the marginal ridge) of the suspected carious side perpendicular to the long axis of the tooth and rotated around a vertical axis until the highest fluorescence (the peak value) reading was found [20]. All suspected surfaces were measured twice, and the average was determined (Fig. 4).

Cavity preparation

Following the completion of visual examinations, radiographs and DD measurements, cavity preparations were done, and clinical cavity depths were taken as follows, proximal lesions were accessed occlusally from the marginal ridges with a sterile carbide round bur, any remaining carious dentine was excavated with a spoon excavator, as a sharp instrument has proved reliable in differentiating carious and sound dentine, and explorer was used to check for remaining soft dentine.

Cavity depth determination and restoration

Axial cavity depths were measured by using gutta-percha cones size 30, which is bended by a tweezers to be extended from the contact area of the adjacent tooth to the deepest point axially in the prepared cavity (extension of the caries), then the bended gutta-percha was measured by periodontal probe (Fig. 5). Then teeth were restored using bonded resin composite restorations.

Statistical analysis

The data was analyzed using SPSS (version 22, IBM, Corp., Chicago, IL, USA). Pearson's test was used to measure the correlations between DD readings, radiograph scores and cavity depth. $p < 0.05$ was considered statistically significant.

Fig. (1) DIAGNOdent device

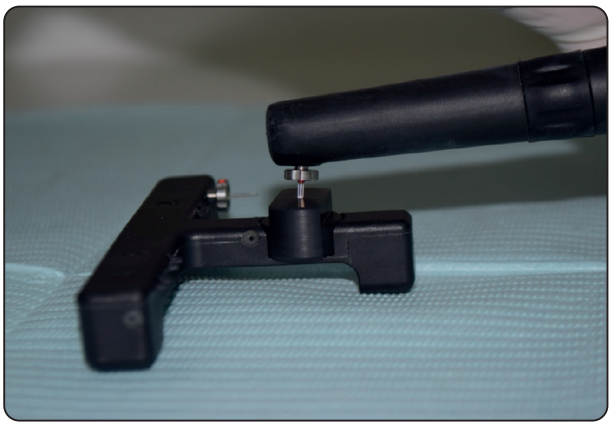

Fig. (2) Calibrating plate (1st calibration)

Fig. (3) Baseline measure (2nd calibration)

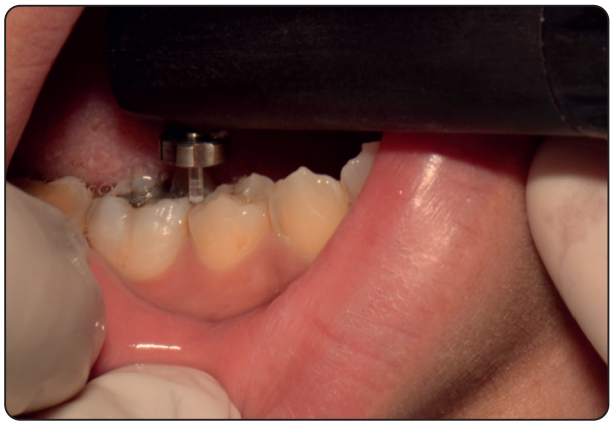

Fig. (4) The peak value measurement

Fig. (5) Cavity depth determination

RESULTS

Forty lesions were identified in 26 patients (Table I), there was a significant positive correlation between DD and radiograph readings (R = 0.868; p < 0.05) (Fig. 6). Also, there were significant positive correlations between cavity depth with DD (R= 0.998; p < 0.01) and radiograph scores (R= 0.798; P < 0.05) (Table II, Figs. 7&8).

TABLE I: Cavity depths in relation to radiographic scores:

Score	1	2	3	Total
Cavity depth	≤ 1.5	1.5 - 2.5	2.5 - 3.5	
Patient No.	6	12	8	26
Caries lesions No.	13	15	12	40

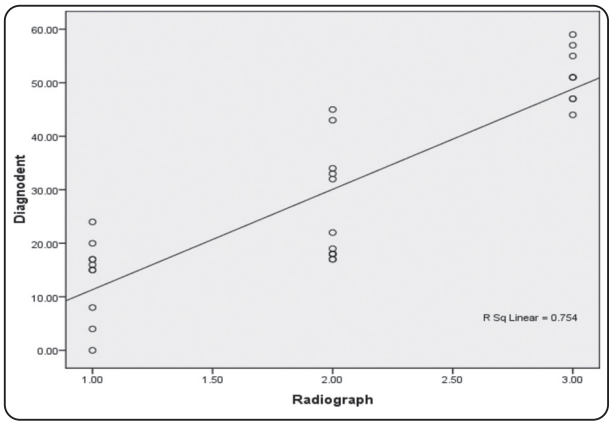

Fig. (6) The correlation between DD and radiograph

TABLE II: Pearson's correlation between both DD, Radiograph scores and cavity depth.

Correlation		Radiograph	DD
Cavity depth	R value	0.648	0.807
	p value	< 0.05	< 0.01

DD= DIAGNOdent, R value = Pearson's correlation and p value = level of significance.

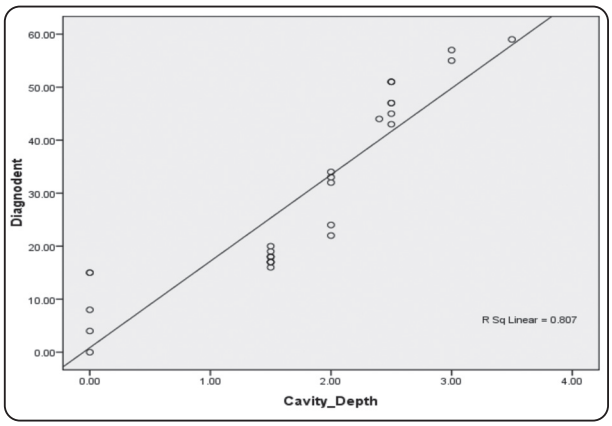

Fig. (7) The correlation between DD and cavity depth.

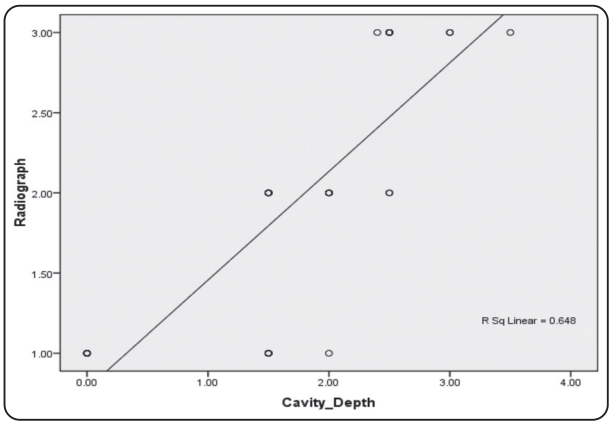

Fig. (8) Correlation between radiograph and cavity depth.

DISCUSSION

Proximal non-cavitated carious lesions still represent a clinical challenge to dentists and the diagnosis of most of that kind of lesions depends mostly on radiographic examination together with explorer and visual examination. However, with these traditional tools, dentists are not able to reach accuracy and 100% positive result as they could mix stain with hidden carious lesion. The development of a non-invasive technique, which could detect early demineralization beneath the intact enamel surface, is one of the desirable aims of the dental researchers [21,22].

Herein, we investigated the use of laser florescence in the diagnosis of proximal non-cavitated caries *in vivo*. We also measured the correlations between the DD readings with the digital radiographic method and the depth of cavities. In the present investigation, both null hypothesizes were rejected.

Results showed significant positive correlations between DD scores with those of radiographs and with the depth of cavities. The strongest correlations with the depth of cavities were observed with DD readings followed by the radiograph scores. These results suggest that DD could provide an alternative method to traditional tools for the diagnosis of hidden carries, which could be more sensitive and specific.

Unfortunately, the studies investigating the performance of DD caries detection *in vivo* are few and the clinical extrapolation of *in vitro* results may be not accurate. [23-26] Thus, *in vivo* studies are required for validating the use of laser in detection of proximal caries for permanent teeth, because most of the previous studies have been carried out on primary teeth or on permanent teeth but under *in vitro* settings [27, 28].

The DD readings have been shown to be more reliable in determination of lesion depth than visual inspection or bitewing radiography in a clinical study conducted by Alkurt et al, 2007 [29] where they compared laser fluorescence measurements with conventional methods for occlusal caries detection, these results were similar to those obtained in the present investigation and are in agreement with it.

In another *in vivo* study which evaluated the use of DD for the quantification of occlusal dental caries, the authors concluded that DD readings were weakly correlated with lesions depth and volume [30]. Nonetheless, they have suggested that DD could be used as an adjunct aid in the caries diagnosis and treatment planning process. One possible explanation for the differences between our findings and the previous study could be related to the methods used for the determination of the lesions' depth and volume.

Mepparambath et al, 2014 compared DD and bitewing radiography in detection of proximal caries in primary teeth *in vivo* where they demonstrated a strong association between the DD and the bitewing radiography ($p < 0.001$), which was in agreement with the present investigation [31]. Another in *vitro study* compared and evaluated DD with visual and radiography for the detection of occlusal caries. Their results showed that the visual examination and DD had a better performance than radiography [32]. Diniz et al, 2015 conducted an *in vitro* study where they measured the performance of pen type laser fluorescence device and bitewing radiographs for the detection of proximal caries in permanent

and primary teeth in which they reported that the bitewing radiography method exhibited lower correlation coefficients than DD reading in the primary teeth [33].

Furthermore, Alwas-Danowska et al, 2002 concluded that, DD was suitable for detecting small enamel lesions rather than deep dentinal lesions [34]. In a more recent study conducted by Luczaj-Cepowicz et al, 2019 who assessed the extent of early carious lesions using the International Caries Detection and Assessment System (ICDAS) II and DIAGNOdent pen compared with micro CT examination in an in vitro study, where they concluded the diagnostic efficiency of the DIAGNOdent pen [35].

Our findings correlate with the a forementioned studies as they showed a significant positive correlation of DD scores either with the cavity depth or with the radiograph findings. Hence, further studies with larger number of patients and different types of caries are required to measure the diagnostic performance of DD in the diagnosis of hidden caries.

CONCLUSION

According to the data provided, it can be concluded that; There was a direct correlation between cavity depth and DIAGNOdent readings throughout the whole study. While, for the relationship between cavity depth and digital radiographic scores there was also a direct relationship between them but not throughout the whole study it was just restricted to scores (2) and (3) but not in detecting initial caries (score1). Therefore, from this study, DIAGNOdent values stipulated a better blend of sensitivity and specificity when equaled with other diagnostic tools in detecting both enamel and dentin caries.

LIMITATION AND FUTURE RECOMMENDATION

Although this study has provided some useful information to our understanding of the value of laser fluorescence in assessing proximal caries, it has some limitations. The relationship between DIAGNOdent values and multiple carious lesions in the same tooth still unclear and needs further investigation. Moreover, the validity and reliability of the used laser device in measuring the size of the lesion need more *in vivo* studies.

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