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Clinical performance of a new laser fluorescence device for detection of occlusal caries lesions in permanent molars

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ABSTRACT

Objectives: To determine the clinical performance of a laser fluorescence device (DIAGNOdent pen, KaVo) to discriminate between different occlusal caries depths (D_0–D_{1-4}; D_{0-2}–$D_{3,4}$) in permanent molars.

Methods: In this prospective, randomized two-centre-study 120 sound/uncavitated carious sites in 120 patients were measured after visual and radiographic caries assessment. In cases of operative intervention ($n = 86$), the lesion depths after caries removal were recorded (reference). In cases of preventive intervention ($n = 34$), the sites were reassessed visually/radiographically after 12 months to verify the status assessed before (reference). The discrimination performance was determined statistically (Mann–Whitney test, Spearman's rho coefficient, and areas under the receiver operating characteristic curves (AUCs)). Sensitivities (SE) and specificities (SP) were plotted as a function of the measured values and cut-off values for the mentioned thresholds suggested.

Results: Sound sites ($n = 13$) had significantly minor fluorescence values than carious sites ($n = 107$) ($P < 0.0001$) as had sites with no/enamel caries ($n = 63$) compared to dentinal caries ($n = 57$). The AUCs for the same discriminations were 0.92 and 0.78 ($P < 0.001$). For the D_0–D_{1-4} threshold, a cut-off at a value of 12 (SE: 0.88, SP: 0.85) and for the D_{0-2}–$D_{3,4}$ threshold at 25 (SE: 0.67, SP: 0.79) can be suggested. A moderate positive correlation between the measurements and the caries depths was calculated (rho = +0.57, $P = 0.01$).

Conclusion: Within this study, the device's discrimination performance for different caries depths was moderate to very good and it may be recommended as adjunct tool in the diagnosis of occlusal caries.

1. Introduction

In its early stages, caries detection and diagnosis is often difficult. A correct diagnosis is required in order to apply appropriate preventive measures or operative procedures. While in most industrialized nations there has been a substantial decline in caries prevalence in children, much attention has now been drawn to monitoring of the early stages of the carious process.[1] The occlusal fissures in children and adolescents are most prone to developing caries, and

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should therefore be screened frequently.[2] The visual appearance of initial caries has recently been described and scored using the ICDAS system.[3,4] In addition to visual inspection, non-destructive methods using optical instruments may be used in order to detect early changes in enamel indicating caries. Quantitative light-induced fluorescence (QLF) has been proven to be a useful, but time-consuming adjunct tool to aid caries diagnosis.[5] A laser fluorescence (LF) device (DIAGNOdent 2095, KaVo, Biberach, Germany) has also been shown to be of additional clinical value in the detection of occlusal caries. Changes in the optical properties of the mineral are caused by an increased pore volume in demineralised enamel.[6] It has been suggested that LF detects substantially more fluorophores within these pores than within unaltered, healthy enamel.[7,8] Recently, a new laser fluorescence device has been introduced (DIAGNOdent pen, KaVo, Biberach, Germany)[9] with proven reproducibility *in vitro*.[10,11] This prospective, randomized two-center-study (reported according to the CONSORT statement[12]) aimed to determine the clinical performance of LFpen in detecting occlusal caries lesions in permanent molars.

It has been reported that readings from LF devices are more indicative of the quality of the enamel surface rather than giving quantitative information that indicates the actual depth of the carious lesion.[13,14] Furthermore, the threshold values as reported by Lussi and Hellwig[9] *in vitro*, have not yet been verified *in vivo*. Therefore, the aim of this study was to test the ability of the LFpen to differentiate between carious and non-carious enamel and between enamel and dentinal caries and the capacity to predict lesion depth. Appropriate cut-off values and intra- and inter-examiner reliability and the repeatability would be measured. The null hypothesis I was that it is not possible to distinguish between the presence ($D_{1–4}$) or absence (D_0) of occlusal caries in permanent molars with the DIAGNOdent pen (LFpen). Null hypothesis II was that it is not possible to differentiate between caries-free enamel, enamel-only caries ($D_{0–2}$) and dentinal caries ($D_{3,4}$). Null hypothesis III was that it is not possible to predict the depth of caries as determined by the measured fluorescence values.

2. Materials and methods

2.1. Participants

Voluntary participants were recruited from the Department of Preventive, Restorative and Paediatric Dentistry, University of Bern, Switzerland and the Department of Restorative Dentistry, Periodontology and Paediatric Dentistry, University of Munich, Germany. Ethical approval (Bern No. 71/05, Munich No. 258-05) and participants and/or parental informed written consent were obtained. Measurements were performed by four experienced, calibrated dentists from the above institutions. Inclusion criteria for the participants (≥6 years old) were the presence of a minimum of one permanent molar with at least one occlusal sound or macroscopically uncavitated carious site. Exclusion criteria included patients who were uncooperative, those with disabilities, severe systemic diseases and those with language difficulties. Further exclusion criteria included enamel anomalies, such as hypomineralisation or hypoplasia or any intrinsic or extrinsic staining, any restorations or fissure sealants as well as the presence of amalgam fillings, gold or steel crowns in adjacent teeth. No compensation was provided to either the study participants or investigators.

2.2. Interventions and follow up

The assigned occlusal sites were cleaned (Prophyflex, KaVo), rinsed and air-dried followed by a visual assessment of the caries status using dental light and mirror (Table 1). If clinically indicated, digital bitewing radiographs were taken or already available recent radiographs were used (Sidexis, Sirona, Bensheim, Germany) and the presence of possible radiolucencies determined (Table 1). Based on the visual and radiographic findings, the decision was made for operative or preventive intervention. Thereafter, measurements with the DIAGNOdent pen (occlusal tip) were carried out.[9] After calibration with a ceramic standard, the fluorescence of a sound spot on the coronal part of the buccal surface was recorded (zero value). The tip was then moved along the occlusal fissure system and moved around in order to measure the fluorescence from the slopes of the fissure walls and the peak value recorded. The whole procedure was then repeated. For statistical analysis, the mean of the two peak values minus the mean of the two zero values was used. If operative intervention was indicated, the lesion was opened with a fissurotomy bur (SSWhite, USA), the caries removed using a round bur and the extent of the lesion determined by inspection and probing (reference, Table 1). This was followed by an appropriate restorative therapy. In cases where no operative intervention was indicated, the measurement site was recorded (description or photograph) and a sodium fluoride varnish applied (Duraphat, Colgate, NY, USA). After

Table 1 – Criteria used for visual and radiographic examination and actual lesion depth after caries removal

Visual examination	Radiographic examination	Lesion depth after caries removal or recall
Occlusal sites		
No caries detectable (V_0)	No radiolucency or radiolucency in enamel ($R_{0–2}$)	No caries (D_0)
Enamel caries, white surface (V_1)		Enamel caries (D_1, D_2)
Enamel caries, brown surface (V_2)		
Dentinal caries (V_3)	Radiolucency in the outer half of dentine (R_3)	Superficial dentinal caries (D_3)
	Radiolucency in the inner half of dentine (R_4)	Deep dentinal caries (D_4)
–	No radiograph	–