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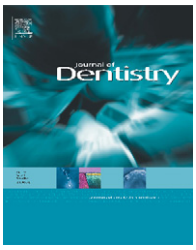

In vitro performance of different methods in detecting occlusal caries lesions

J. Gomez [a,b,*], C. Zakian [a], S. Salsone [c], S.C.S. Pinto [d], A. Taylor [a], I.A. Pretty [a], R. Ellwood [a]

[a] The University of Manchester, School of Dentistry, Colgate-Palmolive Dental Health Unit, Williams House, Manchester Science Park, Lloyd Street North, Manchester M15 6SE, United Kingdom

[b] Caries Research Unit UNICA, Dental Faculty, Universidad El Bosque, Cra. 7B Bis No. 132-11, Bogota, Colombia

[c] Doctorate School of Science and Technique "Bernardino Telesio", Department of Physics, Università della Calabria, via Pietro Bucci, 87036 Arcavacata di Rende, CS, Italy

[d] Department of Dentistry, Ponta Grossa State University, Avenida Gal. Carlos Cavalcanti 4748, Campus Universitário Em Uvaranas, Ponta Grossa 84030-900, Parana, Brazil

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ABSTRACT

Early caries detection is essential for the implementation of preventive, therapeutic and intervention strategies within general dental practice.

Objective: The aim of this study was to compare the in vitro performance of the International Caries Detection and Assessment System (ICDAS), digital photographs scored with ICDAS (ICDAS photographs), fibre-optic transillumination (FOTI), optical coherence tomography (OCT), SoproLife® camera and two implementations of quantitative light-induced fluorescence a commercial (QLF-Inspektor Research systems) and a custom (QLF-Custom) system, to detect early and intermediate occlusal lesions.

Methods: One hundred and twelve permanent extracted teeth were selected and assessed with each detection method. Histological validation was used as a gold standard. The detection methods were compared by means of sensitivity, specificity, areas under receiver operating characteristic (AUROC) curves for enamel and dentine levels and with the Spearman's rank correlation coefficient against histology.

Results: For any enamel or dentine caries detection, the AUROC curves ranged from 0.86 (OCT) to 0.98 (ICDAS and ICDAS photographs, SoproLife® camera) and at the dentine level from 0.83 (OCT) to 0.96 for FOTI. The correlations with histology ranged between 0.65 (OCT) and 0.88 (ICDAS and FOTI). Under in vitro conditions, the assessed detection methods showed excellent intra-examiner reproducibility. All the methods were strongly correlated with histology ($p < 0.01$) except OCT which showed a moderate correlation (0.65).

Conclusion: Even though all methods present similar performance in detecting occlusal caries lesions, visual inspection seems to be sufficient to be used in clinical practice for detection and assessment of lesion depth. Other methods may be useful in monitoring caries lesion behaviour.

* *Corresponding author at*: The University of Manchester, School of Dentistry, Colgate-Palmolive Dental Health Unit, Williams House, Manchester Science Park, Lloyd Street North, Manchester M15 6SE, United Kingdom. Tel.: +44 161 232 4705.
E-mail address: juliana.gomez@postgrad.manchester.ac.uk (J. Gomez).

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1. Introduction

Early detection of carious lesions is highly desirable for the implementation of preventative strategies, such as fluoride remineralisation therapies, when lesions have the greatest opportunity for reversal or arrest.[1,2] Detection of occlusal caries and the evaluation of the lesion depth have frequently been highlighted as a diagnostic problem. Visual and radiographic examinations are the most commonly used methods for caries detection but radiographs are unable to diagnose early enamel caries lesions reliably.[2] When an occlusal lesion is detected on a bitewing radiograph, the lesion may have already reached the middle third of dentine and hence beyond the scope of remineralisation interventions.[3]

In response to this diagnostic dilemma, enhanced visual scoring systems reflecting the disease process have been developed. However, the conclusion of two systematic reviews in 2001 determined that the current evidence of reliability and reproducibility for visual and visual/tactile detection systems was weak.[4,5] These findings led, in part, to the development of the International Caries Detection and Assessment System (ICDAS). The system is evidence based and intends to develop better diagnosis, prognosis and clinical management at the individual and population levels.[6] ICDAS has shown to be an accurate and reproducible method to detect early lesions and also to detect changes in longitudinal follow-up.[7–10]

FOTI is a widely accepted method for caries detection and has been extensively used to detect proximal caries for which it is particularly suited.[11] The literature reporting the performance of FOTI detecting caries lesions on occlusal surfaces is not extensive.[12,13] Recent developments in visual scoring system such as ICDAS may be enhanced when FOTI is added.[14]

Non-invasive methods have been developed as potential diagnostic aids for clinicians – principally by facilitating the detection and quantification of early lesions. Quantitative light-induced fluorescence (QLF) is one such system based on the measurement of fluorescence loss following enamel demineralisation.[14] This method has shown high sensitivities and specificities in detecting enamel lesions.[15–17] Another method based upon the imaging and auto-fluorescence of dental tissues to detect caries is the SoproLife® camera.[18] The literature on SoproLife® is limited to preliminary results only.

OCT is a high-resolution, non-invasive imaging technique that constructs cross-sectional images of internal biological structures.[19] This technology is based on the principle of optical interferometry using a low coherence light source that is split into two beams, which then are reflected back, one from the investigated tissue and the other from a reference mirror, and combined together to create an interference pattern that contains depth-information from the sample.[20] Previous studies have shown that OCT has the potential to detect and quantify demineralisation based on an increase light scattering from porous structures within the tooth in in vitro caries-like models.[21,22] However, these simple models did not reflect the complexity of natural lesions; in particular they were not subsurface lesions.[22] Previous studies have shown the potential use of OCT to detect and quantify demineralisation based on an increase light scattering from porous structures within the tooth using in vitro caries-like models.[20,21,23]

The aim of this in vitro study was to compare the performance of ICDAS, FOTI, QLF (Custom and Inspektor Pro systems), SoproLife® camera and OCT in detecting early to intermediate occlusal caries.

2. Methods

2.1. Sample

A total of 112 permanent molar and premolar teeth stored in distilled water with thymol 0.1% were selected from a pool of extracted teeth from the Indiana Oral Health Research Institute, School of Dentistry, Indiana University with appropriate ethical approval from the local Ethics Committee. The occlusal surfaces were selected to provide a range of lesions ICDAS 0–4. The teeth were pooled before collection and no patient data were associated with the samples. The teeth were cleaned with water and a toothbrush and air-dried for 5 s before each detection procedure. For each tooth one examiner (JG) defined a region of interest (ROI) on the occlusal surface for assessment using each of the methods. The occlusal surfaces on the selected teeth were photographed and the ROI indicated with a rectangle shape on a power point file. Teeth were allocated an identification number that was maintained throughout the study. Seven caries detection methods were applied; ICDAS, ICDAS photographs, FOTI, OCT, QLF (Custom and Inspektor) and SoproLife. The examinations were repeated in a subsample of teeth after 7 days (30% repeat).

2.2. Examiners

One examiner performed all the examinations, except for the FOTI assessment where the scores were compared and a consensus decision was taken in case of disagreement.

2.3. Examination methods

2.3.1. ICDAS/FOTI

The ROI on the teeth was assessed using the ICDAS criteria[10] (Table 1) by an examiner (JG) trained by an ICDAS trainer, with the aid of a WHO probe and air syringe. The examination sites were also scored visually using FOTI by two examiners (JG, RPE). The FOTI tip (0.5-mm) was placed perpendicular to the buccal and the lingual surface. The intensity of the halogen lamp (150 W) of the FOTI equipment (Schott Fibre Optics, Doncaster, UK) was set to the maximum. Scores were

Table 1 – Criteria used for ICDAS and FOTI.

	ICDAS	FOTI
0	Sound	No shadow
1	First visual change in enamel	Thin-grey shadow into enamel
2	Distinct visual change in enamel	Wide-grey shadow into enamel
3	Localised enamel breakdown	Shadow <2 mm in dentine
4	Underlying dentinal shadow	Shadow >2 mm in dentine