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Validation of quantitative light-induced fluorescence-digital (QLF-D) for the detection of approximal caries *in vitro*

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ARTICLE INFO

Article history:
Received 2 January 2015
Received in revised form
14 February 2015
Accepted 17 February 2015

Keywords:
Approximal caries
Caries detection
Quantitative light-induced fluorescence-digital
International Caries Detection and Assessment System
Radiography

ABSTRACT

Objectives: Detection of approximal caries lesions can be difficult due to their anatomical position. This study aimed to assess the ability of the quantitative light-induced fluorescence-digital (QLF-D) in detecting approximal caries, and to compare the performance with those of the International Caries Detection and Assessment System II (ICDAS II) and digital radiography (DR).

Methods: Extracted permanent teeth ($n = 100$) were selected and mounted in pairs. The simulation pairs were assessed by one calibrated dentist using each detection method. After all the examinations, the teeth ($n = 95$) were sectioned and examined histologically as gold standard. The modalities were compared in terms of sensitivity, specificity, areas under receiver operating characteristic curves (AUROC) for enamel (D1) and dentine (D3) levels. The intra-examiner reliability was assessed for all modalities.

Results: At D1 threshold, the ICDAS II presented the highest sensitivity (0.80) while the DR showed the highest specificity (0.89); however, the methods with the greatest AUC values at D1 threshold were DR and QLF-D (0.80 and 0.80 respectively). At D3 threshold, the methods with the highest sensitivity were ICDAS II and QLF-D (0.64 and 0.64 respectively) while the method with the lowest sensitivity was DR (0.50). However, with regard to the AUC values at D3 threshold, the QLF-D presented the highest value (0.76). All modalities showed to have excellent intra-examiner reliability.

Conclusions: The newly developed QLF-D was not only able to detect proximal caries, but also showed to have comparable performance to the visual inspection and radiography in detecting proximal caries.

Clinical significance: QLF-D has the potential to be a useful detection method for proximal caries.

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http://dx.doi.org/10.1016/j.jdent.2015.02.010
0300-5712/

1. Introduction

As it was realized that dental caries process is dependent on the balance between pathological factors and protective factors, and that caries progresses when the pathological factors predominate while the caries can be arrested or reversed when the protective factors predominate, the treatment principles for caries lesions gradually shifted towards preventive treatment of enamel lesions where the lesions can have an opportunity to reverse.[1–3] In order to implement the preventive therapy, caries lesions need to be detected at their early stage. However, early detection of caries can be difficult, especially approximal caries, due to their anatomical position. It was found that 75% of approximal lesions are in the contact area and 25% are beneath the contact area, which makes visual detection complicated.[4] Hence, approximal lesions are normally detected when the weakened marginal ridges break down and become cavitated.[5] Therefore, it is likely to underestimate the number of approximal carious lesions with visual examination only. Radiographic examination is another common method for detection of approximal lesions, yet it has been known that radiographic examination often detects caries lesions at advanced stage, which have already passed the scope of remineralization interventions. Furthermore, the use of ionizing radiation, which exposes patients to risk, leads into consideration of alternative methods for detection of approximal lesions.

Since the performance of visual examination in detection of early approximal caries lesions is inadequate, enhanced visual scoring systems have been developed. One of them is International Caries Detection and Assessment System (ICDAS), which has been reported by number of studies that it is an accurate and reproducible method to detect early lesions and also to detect longitudinal changes in lesions.[6–8] The ICDAS is also theoretically applicable to approximal smooth surfaces,[9] and the use of ICDAS for approximal caries has been evaluated in a few studies.[10,11]

Another potential method for approximal caries detection is a newly developed device called quantitative light-induced fluorescence-digital Biluminator™ (QLF-D). This device is an upgraded version of the first product, the QLF device (Inspektor™ Pro, Inspektor Research Systems BV, Amsterdam, The Netherlands), with a modified filter set (D007; Inspektor Research Systems BV, Amsterdam, The Netherlands), and the principle of this device is based on auto-fluorescence of teeth. When a tooth with demineralization is excited by a visible light of 405 nm from the QLF, there is loss of fluorescence from the demineralized part, and the QLF is able to detect and quantify the change in demineralization,[12,13] and early studies have shown that this device has high sensitivities and specificities.[12,14,15] Other than quantitatively detecting mineral loss, the QLF is also able to detect endogenous porphyrins produced by oral bacteria and present as red fluorescence, and the detected red fluorescence is found to be associated with caries risk.[16,17] The QLF-D is upgraded to enhance these characteristics of the QLF. Since the results of the previous studies can be interpreted in terms of QLF only, there is a need to investigate the ability of the QLF-D in detecting caries lesions.

In order to assess performances of detection methods, clinical studies are ideally required. However, it is difficult to conduct such clinical studies because there are many confounding factors to be considered and the extraction of teeth is required for the gold standard. Therefore, the present study was conducted *in vitro*. The aims of the study were to assess the ability of the QLF-D in detection of approximal caries at different stages, compared with histology examination, and to compare its performance with those of other detection methods such as ICDAS and digital radiography.

2. Materials and methods

2.1. Sample selection

A total of 100 permanent molar and premolar teeth without enamel hypoplasia or dental fluorosis were selected from a pool of extracted permanent human teeth from Yonsei University, with ethical approval from the Institutional Review Board for Clinical Research in Yonsei Dental Hospital (IRB 14-0067). Prior to the extraction, informed and written consent was obtained from all the study participants. After teeth were extracted, they were immediately collected in specimen jars containing distilled water first, and then the teeth were carefully cleaned of soft tissues and calculus, and frozen at −20 °C until used.[18]

Before the teeth were examined using different detection methods, the stored teeth were unfrozen, and selection of teeth was performed. Proximal surfaces with extensive cavities involving more than half of the proximal surface were excluded. Each tooth was given an identification number that was maintained throughout the study.

2.2. Preparation of simulation pairs

Pairs were formed with marginal ridges in contact to simulate the oral relationship with resin (Ortho-jet, Lang Dental Mfg. Co., Inc., USA) in putty (DuoSil Putty set, Bukwang, Busan, Korea), and they were stored individually in containers of distilled water. Each sample was removed from the container, scored and replaced in the container.

2.3. Examiner standardization

All the examinations were performed by one calibrated dentist. The examiner was experienced in the use of QLF-D for caries detection and quantification. For the ICDAS, the examiner had a 90-min training session through the e-learning program prior to the examination. The training for radiographic scoring involved discussion of the radiographic scoring system with a dental professional who was specialized in radiology, and if there was any uncertainty, it was discussed to consensus.

2.4. Detection methods

Three caries detection methods were applied. ICDAS II, digital radiography, and quantitative light-induced fluorescence-digital Biluminator™ (QLF-D).