ORIGINAL ARTICLE

METHODS FOR CARIES DETECTION: AN OVERVIEW

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ABSTRACT

It is critical to detect caries as early as possible to reverse / halt the carious process or to restore the tooth in a most conservative manner. The conventional caries detection methods may fail to detect early carious lesions. Therefore, efforts have been underway to develop more sophisticated caries detection systems. Various caries detection systems are discussed in this review. The evidence supporting new systems is currently limited. This brief review describes available technology and research supporting its use. Each system have its own indications and benefits. It can be recommended that the systems such as Laser Fluorescence, Quantitative Light-Induced Fluorescence (QLF) and Digital Image fiber-Optic Trans-illumination (DiFOTI) do facilitate earlier detection of enamel caries.

Key Words: *Caries detection, Laser Fluorescence, DiFOTI, QLF, Electronic Conductance Measurements, Digital radiography.*

INTRODUCTION

Although the prevalence of dental caries has globally declined considerably, it still remains a problem of great magnitude.[1,2] Occlusal and proximal surfaces are considered to be the most likely sites for the development of carious lesions.[1-3] Occlusal surfaces of molars are even more susceptible due to anatomical factors.[3,4] Dental caries is a dynamic process consisting of periods of demineralization and re-mineralization of enamel. As the balance tilts towards demineralization, frank cavitation consequently results. All these interactions take place in a complex biofilm overlying the tooth surface. The biofilm comprises of a pellicle as well as oral microflora.[5,6]

It is important that caries are detected as early as possible to reverse/halt the carious process where ever possible and, to restore the tooth in a most conservative manner. The conventional caries detection methods such as visual inspection, tactile sensation (with explorer tip) and radiographs may fail to detect early carious process. Therefore, efforts have been underway to develop sophisticated systems for early caries detection (Table 1).

A caries detection system must be capable of initiating and receiving signals as well to interpret the strength of the signals in a meaningful way.[6] The purpose of this paper is to review the techniques and systems available in this area.

Visible Light - Enhanced Visual Techniques

Enhanced Visual Techniques are based upon the phenomenon of light scattering. Three techniques; Fiber-Optic Trans-illumination (FOTI), Quantitative Light-Induced Fluorescence (QLF) and Digital Image fiber-Optic Trans-illumination (DiFOTI) are mostly used (Table 1). These techniques utilize different light sources; high intensity and visible lights which have several disadvantageous such as reflection of light over the tooth surface, underlying dentine shade, and saliva layer refraction.[7,8] FOTI is a useful technique for diagnosing proximal caries (Fig 1a) Enamel and optical disruption can occur by penetrating photons of light through densely packed hydroxyapatite crystals. Fluorescence (green and red) is a phenomenon by which an object is excited by particular wavelength of light and fluorescent (reflected) light is of a larger wavelength.[6] The QLF is usually employed in detecting a range of lesions, and is most promising of the new technologies in the caries detection (Fig 1c & d). It has been reported that QLF offers the advantage of closer correlation with changes in mineral content.[9] Clinical efficacy of enhanced white light has been reported for early detection of caries lesions.[10]

Electronic Conductance Measurements

Every substance possesses its own electrical signature; i.e. when a current is passed through the substance, the properties of the substance dictate the degree to which that current is conducted.[6] Condition in which the substance is stored or physical changes

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to the structure of the substance will have an effect on this conductance.[6] ECM dental caries detection systems generally consist of a "Probe" from which the current is passed, a "Substrate", typically a tooth, and a contra-electrode, usually a "Metal bar" held in the patient's hand.[11] Measurement can be taken either from enamel or exposed dentine surfaces. Electronic caries detectors employ a single, fixed-frequency alternating current which attempts to measure the "bulk resistance" of tooth tissue (Fig 2).[6] When measuring the electrical properties of a particular site on a tooth, the probe is directly applied to a site, typically a fissure, and the site's resistance is measured.[11]

There are also some physical factors that affect ECM results; these factors include temperature of the tooth, thickness of the tissue, and the hydration of the material.[6] A clinical trial on root caries suggested that dentine may be a more suitable tissue for ECM.[11,12] There is also a good evidence to suggest that ECM is capable of longitudinal monitoring and, clinicians may use the device to monitor attempts at re-mineralization, till root caries lesions are possible arrested.[11] Another application of electronic monitoring of caries is Electrical Impedance Spectroscopy (EIS). Unlike ECM which uses a fixed frequency (23 Hz), EIS scans a range of electrical frequencies and provides information on capacitance and impendence.[11,13] This process provides the potential for more detailed analysis of the structure of the tooth including the presence and extent of caries.[11,14]

Digital radiography

This is another possible aid in diagnosis and detection of dental caries. The diagnostic performance of these enhanced radiographs is at least as good as conventional radiographs.[11,15] However, digital radiographs need lower radiographic dose and thus offer additional benefits than the diagnostic yield; and in addition, the digital images can also be archived and replicated with ease.[6]

One of the most promising technologies in this regard is that of radiographic subtraction which has been extensively documented for the detection of caries and assessment of bone loss.[11,16] The basic idea of subtraction radiography is that the two radiographs of the same object are compared using their pixel values. Recent advances in software have enabled the two images to be correctly aligned and then subtracted.[6,17] The advancement may also facilitate the introduction of this technology into mainstream practice, where such alignment algorithms could be translated into soft wares for displaying digital radiographs.[11,18] An example of a subtraction radiograph is shown in Fig 3. The efficacy of digital radiographs in approximal caries detection has been reported.[11,18]

Laser Fluorescence Measurement

As stated above, conventional methods of diagnosing dental caries such as manual probing and radiographic evaluation are often ineffective in detecting early enamel defects as they may be too small or inaccessible to the diagnostic tool.[19] Additionally, manual probing has the potential of stimulating caries development due to the iatrogenic damage caused by the explorer.[19] Although radiographs (bitewing and periapical x-rays) are effective in revealing advanced stages of decay, they are unsuccessful in detecting early caries, especially in the anatomically complex fissure areas.[19] Fortunately, with the advent of the laser fluorescence systems such as DIAGNOdent, dentists can now successfully detect the presence of occlusal decay and properly manage the tooth structure as necessary.[19]

DIAGNOdent (DD) [Kavo, Germany] device utilizes LASER Fluorescence Measurement method with a 655 nm diode laser that is capable of detecting non-cavitated, occlusal pit-and-fissure caries as well as smooth surface caries at the earliest possible stage.[19] Unlike the QLF system, the DD does not produce an image of the tooth; instead it displays a numerical value on two LED displays.[11] It has a pen hand-piece that is suitable for diagnosis of dental caries without radiographs, and any mechanical damage to the tissues (Fig 1b). The DD uses a low power laser onto the tooth and, based on the tooth's fluorescence, provides a number that is interpreted as to the suitability for restoration. As the laser light is propagated into the site, two-way hand-piece optics allows the unit to quantify the reflected laser light energy.[20] Healthy tooth structure displays little or no fluorescence resulting in very low scale readings on the display. However, carious tooth structure displays fluorescence proportional to the degree of caries, resulting in elevated scale readings on the display. Use of laser fluorescence device provides results that are more consistent with tactile examination comparing with other methods.

A number of studies have been carried out about efficacy of DD.[21-23] The DD device is capable of diagnosing dental caries which are not visible clinically or even radiographically. Laser Fluorescence pen has also shown better reproducibility for caries in primary and permanent teeth and higher accuracy in detecting approximal caries lesions than bitewing radiographs in primary and permanent teeth.[24,25] The study has recommended that laser fluorescence pen should be used as an adjunct method for approximal caries detection. The DD laser pen is more accurate in determining when teeth are free of occlusal caries than LED based device.[22,23] The DD has also been shown to be applicable for caries diagnosis during caries removal.[21] Though, DD has

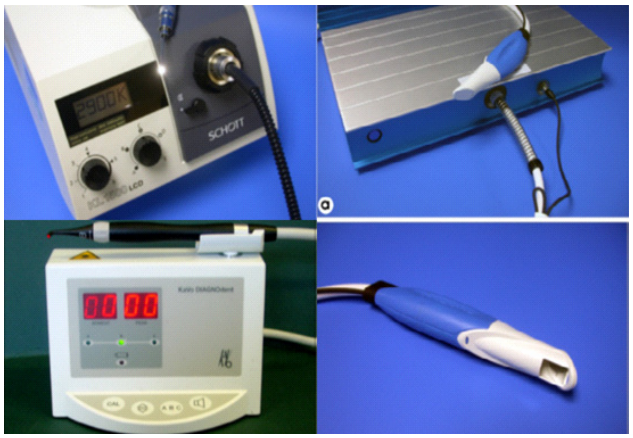

Fig 1: a: FOTI Equipment; b: DIAGNOdent device; c & d: QLF Systems

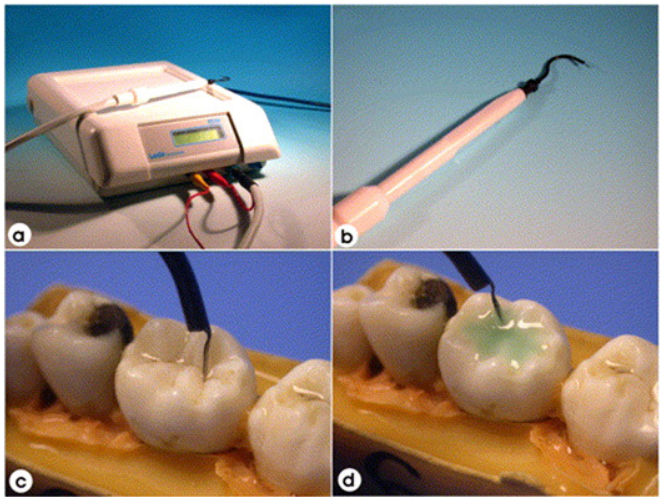

Fig 2: ECM device and its application. a; the machine b; the hand piece c; site specific measurement technique d; surface specific measurement technique

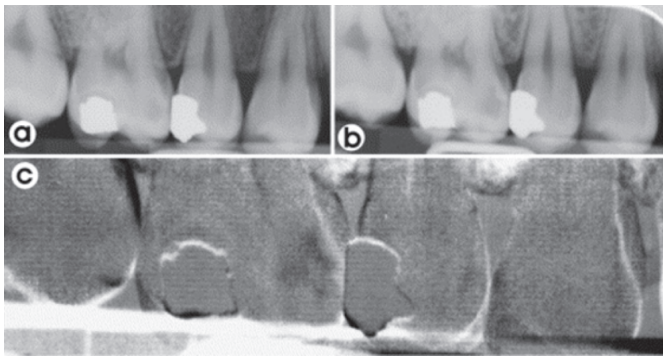

Fig 3: Example of a subtraction of two digital bitewing radiographs. (a) Radiograph showing proximal lesion on mesial surface of first molar, (b) follow up radiograph taken 12 months later, (c) the areas of difference between the two films are shown as black, i.e. in this case the proximal lesion has become more radiolucent and hence has progressed.

TABLE 1: SOME NEW METHODS OF CARIES DETECTION

Medium	System
Visible Light	Fiber-Optic Trans-illumination (FOTI) Quantitative Light-Induced Fluorescence (QLF) Digital Image Fiber-Optic Trans-illumination (DiFOTI)
Electrical Current	Electrical Conductance Measurement (ECM)
X-Rays	Digital radiography
Laser Light	Laser Fluorescence Measurement (DIAGNOdent)
Ultrasound	Ultrasound Caries Detector

a value as an easy-to-use and noninvasive method of detecting hidden caries on occlusal surfaces; its inability to determine the depth of the carious lesions has also been mentioned.[2,9,26] Some recent studies claim that fluorescence-based intra-oral devices do not contribute to a better detection of early carious lesions.[27,28] Nevertheless, these caries diagnostic tools can be used in conjunction with the International Caries Detection and Assessment System (ICDAS), a relatively new technique for the measurement of dental caries developed from the systematic reviews of literature on the clinical caries detection system and other sources.[29]

Ultrasound Caries Detector

UCD was first suggested over 30 years ago, however, development of this method has been slow.[11] The principle is that images of tissues can be collected by reflected sound waves. A number of studies have been undertaken using ultrasound in caries detection with various levels of success. A study reported that ultrasound caries detection (UCD) could discriminate between cavitated and non-cavitated approximal lesions.[6,30] It has also been documented that UCD reduced patient exposure to ionizing radiation and improved caries detection; and that it had higher sensitivity and lower specificity than the radiographs in diagnosis of approximal caries.[31] Some researchers have used ultrasound method in determination of thickness changes in enamel.[14,32]

Dentist play an important role as the leader of dental team. This leadership role is critically tied to the fact that dental clinicians retain the sole right of diagnosis and thus the devices and approaches described in this paper serve only to augment the diagnostic skills of the clinician.[11] The responsibility of making the decision about absence or presence of a carious lesion, degree of its severity and activity rests with the dentist.

Conflict of Interest Statement

The authors declare no commercial interest in any of the products mentioned in this review.

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