REVIEW ARTICLE

Recent Advances In Dental Caries Diagnosis: A Review

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ABSTRACT

Dental caries, a progressive bacterial damage to teeth, is one of the most commondiseases that affects 95% of the population and is still a major cause of tooth loss.Recent years have seen an increase in research activity surrounding diagnostic methods, particularly in the assessment of early caries lesions. The use of technologies as adjunct to clinical visual examination for caries diagnosis will facilitate preventive care in dentistry to lower treatment cost as well as reduce the cost and time for testing potential anticaries agents. In recent years, the early diagnosis of dental caries has gained importance as conservative dentistry is kept in the forefront. Especially in pediatric patients, the dentist should focus on the early detection of dental caries and minimally invasive treatment options. The conventional caries detection methods often fail to detect initial enamel lesions that have not progressed to cavitation. For this reason, various new techniques have been developed aiding early detection of caries. The aim of this review is to give general information about recent caries detection methods and to mention their benefits when used in conjunction with conventional methods.

Keywords: anticaries, pediatric, cavitation, caries detection

INTRODUCTION

Early detection and diagnosis of dental caries reduces irreversible loss of tooth structure, the treatment costs and the time needed for restoration of the teeth. Dental caries often initiates at the fissures in the occlusal surface of the tooth. Conventional examination for caries detection is primarily done using visual inspection, tactile sensation, and radiographs. While these methods give satisfactory results in detection of cavitated lesions, they are usually inadequate for the detection of initial lesions. Because of these deficiencies, new detection methods have been developed to aid better diagnosis. General criteria for an ideal caries detection method include following.

- Ideal caries detection method should capture the whole caries progress, from the earliest stage to the cavitation stage,
- It should be accurate,
- It should be precise,
- It should be easy to apply,
- It should be useful for all surfaces of the tooth including caries adjacent to restorations,
- It should assess the activity of the lesion,
- It should be sensitive, allowing lesions to be detected at early stages.[1,2]

RECENT ADVANCEMENTS IN CARIES DETECTION METHODS

a. RADIOGRAPHS

Radiographic examination has great value in detecting caries lesions especially when they are not clinically visible. In low caries population, as a result of fluoride use, the surface of enamel does not break down, making the caries detection harder. In recent years, the incidence of such lesions has increased dramatically[3]. According to studies, bitewing radiography has been proven to be an effective method in the detection of proximal caries and hidden caries [4].

1. DIGITAL RADIOGRAPHY

Digital radiography has offered the potential to increase the diagnostic yield of dental radiographs. It has manifested itself in subtraction radiography. A digital radiograph is comprised of a number of pixels. Each pixel carries a value between 0 and 255, with 0 beingblack and 255 being white.The values in between represent shades of grey, and it can be quickly appreciated that a digital radiograph, with a potential of 256 grey levels has significantly lower resolution than a conventionalradiograph that contain millions of grey levels.[5]

2. DIGITAL SUBTRACTION RADIOGRAPHY

Digital subtraction radiography (DSR) is a more advanced image analysis tools. Thismethodallowsto distinguish small differences between subsequent radiographs that otherwise would have remained unobserved because of over projection of anatomical structures or differences in density that are too small to be recognized by the human eye. Digital subtraction radiography has been used in the assessment of the progression, arrest, or regression of caries lesions.The basic premise of subtraction radiology is that two radiographs of the same object can be compared using their pixel values. The value of the pixels from the first object is subtracted from the second image. If there is no change, the resultant pixel will be scored 0; any value that is not 0 must be attributable to either the onset or progression of demineralisation, or regression. When there is caries regression, the outcome will be a value above zero (increase in pixel values). In case of caries regression, the result is opposite and the outcome will be a value below zero (decrease in pixel values).[6]Subtraction images therefore emphasise this change and the sensitivity is increased.[7,8]

b. NOVEL VISUAL TECHNIQUES

1. FIBER OPTIC TRANSILLUMINATION

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The light transmission index of decayed and sound tooth are different[9]. Sound enamel is formed of densely packed hydroxyapatite crystals. When this structure is disrupted, in the presence of demineralization, the photons of light are scattered resulting in an optical disruption [10]. When we examine the carious tissues with fiber optic device, we observe dark shadows along the dentinal tubules as it has lower light transmission index compared with the sound tooth structure[9]. The best utilization of the fiber optic transillumination (FOTI) device is for evaluating the depth of occlusal lesions (if the caries has reached to the dentin or not) and for the detection of the proximal lesions[11].

Fibre optic transillumination uses high intensity white light that is presented through a small aperture in the form of a dental handpiece. The tip is 0.5mm;light source is by a 150 watt halogen lamp set at maximum intensity. The probe is applied perpendicular to the buccal and lingual surfaces and its position and angulation varied to obtain maximum light scattering through the lesion. The decrease of transmission is interpreted by the observer, traditionally as an ordinary rating scale.

Shadow depth scaleScore 0 = sound

Score 1 = shadow in enamel

Score 2 = shadow in dentine

2. DIGITAL IMAGING FIBER OPTIC TRANSILLUMINATION (DIFOTI)

DIFOTI is based on the same principle as FOTI, and uses visible light (wavelength range between 450 and 700 nm) to transilluminate the tooth along with a charge coupled device (CCD) camera. DIFOTI can capture real time images from the occlusal or buccal and lingual surfaces. DIFOTI was developed in an attempt to reduce the perceived short comings of FOTI by combining FOTI and a digital CCD camera. Images captured in camera are sent to a computer for analysis using dedicated algorithms.[12,25]

c. FLUORESCENT TECHNIQUES

1. QUANTITATIVE LIGHT-INDUCED FLUORESCENCE (QLF)

This technique uses argon laser (488 nm) with a filtered blue light source. Fluorescence of tooth structure is due to the presence of chromophores within the enamel. Sound and carious enamel have differences in fluorescence due to the loss of chromophores. Carious enamel results in increase in light scattering and consequently the less fluorescence. In this technique, blue light is used to irradiate the surface of the tooth and the resultant fluorescent image is captured in a computer. QLF shows demineralization or incipient lesions as a dark spot. Caries and plaque appear red in color, indicating a bacterial presence. The images can be stored, measured and quantified in terms of shape of an area.[1,26]

The QLF equipment is comprised of a light box containing a xenon bulb and a hand piece, similar in appearance to an intraoral camera, light is passed to the hand piece via a liquid light guide and the hand piece contains the band pass filter.[13,27] Live images are displayed via a computer and accompanying software enables patient’s details to be entered and individual images of the teeth of interest to be captured and stored. QLF can image all tooth surfaces except inter- proximally. Once an image of a tooth has been captured, the next stage is to analyze any lesions and produce a quantitative assessment of the demineralization status of the tooth.[13,28]

Digital Fiber Optic Transillumination Imaging method is the combination of the FOTI anda digital camera in order to reduce the shortcomings of FOTI.[14,29]

d. LASER-INDUCED FLUORESCENCE

1. DIAGNODENT

DIAGNODENT contains a laser diode (655 nm, modulated, 1 mW peak power) as the excitation light source, and a photo diode combined with a long pass filter (transmission > 680 nm) as the detector. The excitation light is transmitted by an optical fiber to the tooth, and a bundle of 9 fibers arranged concentrically around it serves for detection. The long pass filter absorbs the backscattered excitation and other short wavelength light and transmits the longer wavelength fluorescence radiation. To eliminate the long wavelength ambient light also passing through the filter, the laser diode is modulated, and only light showing the same modulation characteristic is registered. Thus, the digital display shows quantitatively the detected fluorescence intensity (in units related to a calibration standard).

The emitted light reaches the dental tissues through a flexible tip. As the mature enamel is more transparent, this light passes through this tissue without being deflected. In contact with affected enamel, this light will be diffracted and dispersed. The latter is able to excite either the hard dental tissue, resulting in the tissue autofluorescence, or fluorophores present in the caries lesions. These fluorophores derived from the products of the bacterial metabolism and has been identified as porphyrins. The emitted fluorescence by the porphyrins is collected by nine concentric fibers and translated into numeric values, which can vary from 0 to 99. Two optical tips are available: tip A for occlusal surfaces, and tip B for smooth surfaces. This device has shown good results in the detection of occlusal caries; however, it might not be used as the only method for treatment decision-making process[15,16]

2. LED FLUORESCENCE

This method detects differences in the reflection and refraction of infrared energy from red light-emitting diode (LED) that is carried by a fiber optic cable to a tooth. The presence of a carious lesion will lead to changes in these properties. Another fiber optic cable serves as a photodetector that transmits the captured light to a microprocessor, which compares the signals to defined parameters.[17,30]

e. ELECTRICAL CONDUCTIVITY MEASUREMENTS

Because of its high mineral content, sound enamel is a good electrical insulator. Demineralization process results in the formation of pores and saliva fills these pores forming a conductive pathway for electric current[18]. The electrical conductance increases as the pores get larger meaning that demineralization is directly proportional with electrical conductance[9,31].

Based on the differences in the electrical conductance of carious and sound enamel two instruments were developed and tested in 1980's.

i) **Vangaurd electronic caries detector**manufactured by Massachusetts Manufacturing Corp., Cambridge, Mass, USA. Electrical conductivity is expressed numerically on a scale from 0 to 9. The machine displayed a frowning face that indicated extensive demineralization or the smiling face that indicated a sound site. This device is no longer available commercially.

ii) **Caries meter L.** manufactured by two companies-GC international corp, leven, belgium and Onuki dental corp, ltd, japan. Each measurement site is moistened with saliva to ensure proper contact between the electrode and the tooth. The Caries Meter L uses colored lights to indicate caries extent.

- Green - sound
- Yellow-enamel caries
- Orange-dentinal caries
- Red-caries reaching the pulp

The system is painless, and safe for the patient. X-rays can be avoided and the diagnosis/checkup offers the patient insight into his or her oral hygiene.The measurement system fits in (with) the existing routine and neither special knowledge nor extra time is required. It may become part of the checkup that is performed by the assistant or dental hygienist.

3. ELECTRONIC CARIES MONITOR (ECM)

The ECM device employs a single, fixed-frequency alternating current which attempts to measure the 'bulk resistance' of tooth tissue[19,32] This can be undertaken at either a site or surface level. When measuring the electrical properties of a particular site on a tooth, the ECM probe is directly applied to the site, typically a fissure, and the site measured. During the 5 s measurement cycle, compressed air is expressed from the tip of the probe and this results in a collection of data over the measurement period, described as a drying profile that can provide useful information for characterizing the lesion.[20,21]

f. ULTRASONICS (ULTRASOUND CARIES DETECTOR)

Sound waves can be used for the detection of caries. Ultrasound can detect lesions easily because the travel time of ultrasonic pulses differ in sound and demineralized enamel tissues .[22]This method is considered promising in detecting early enamel lesions because the white spot lesions confined to enamel produce no detectable or weak echoes whereas deeper lesions produce substantially higher amplitudes[23]

The technique is easy to perform and may show the presence, exact size, shape, content and vascular supply of endodontic lesions in the bone. The echographic probe, covered with a latex protection and topped with the echographic gel, should be moved in the buccal area of the mandible or the maxilla, corresponding to the root of the tooth of interest.

Ultrasonic system is composed of a transducer (probe) & an ultrasonic precision thickness gauge.The contact transducer is of the right angle type with a 1.5mm tip contact diameter, 11MHz nominal center frequency with a removable plexiglass delay tip. The delay line tip of the contact transducer is at a right angle so that it could be inserted or used in restricted height areas. These high frequency focused delay line transducers are compatible with any ultrasonic instrument capable of displaying a return echo at depths as minute as 0.010inches. The useful range is from 0.010 to 0.25 inches approximately.[24.]

g. ENDOSCOPE

The flexible and semi-flexible endoscopes can be very valuable addition to the armamentarium. The endoscope is flexible due to special Nitinol coating. The optical part which is 0.9 mm of diameter, is a piece of equipment that enables the practitioner a magnification of up to 20X with clear picture with wide angle. A 2.7mm lens diameter, a 70º angulation, and a 3 cm long rod-lens are recommended for surgical endodontic visualization and a 4mm lens diameter, a 30º angulation, a 4 cm long rod-lens are recommended for non-surgical visualization through an occlusal access opening.[9,18]

CONCLUSION

It is clear from the above discussion that the differences in caries presentations and behavior in different anatomical sites make it unlikely that any one diagnostic modality will have adequate sensitivity and specificity of detection of carious lesions for all sites; a combination of diagnostic tools will help us diagnose lesions earlier and detect failing restorations sooner, all to avoid more costly, destructive dental procedures and truly take dentistry into the preventive rather than reactive mode.

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