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CASE STUDY

DETECTION OF DENTAL CARIES –A REVIEW

***Ravishankar Periyasamy, Krithika Chandrashekar, Preethi Nandagopal, Nivedha Avoodaiappan and Mutum Sangeeta Devi**

Thai Moogambigai Dental College and Hospital, India

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ABSTRACT

Dental caries is a progressive microbial damage to teeth that affects 95% of the population. There is currently no highly sensitive and specific clinical means for detection of dental caries at its early stage. Detection of early caries in enamel would be of significance since it is possible to reverse the process of decay therapeutically at this stage. Caries diagnosis continues to be a challenging task for dental practioners. Hence, the purpose of the present article is to review the various methods of diagnosing dental caries.

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INTRODUCTION

Caries diagnosis is one of the most basic diagnostic skills that oral healthcare professionals must learn. The basic principle in detection of dental caries is detection of mineral loss in teeth by visual, radiographic or other methods. It is important to consider that most of the research on caries detection has focused on occlusal caries and smooth surface caries (Zandona *et al*., 2012), andthat many studies rely on screening examinations without intraoral radiographic capability. (Bader *et al*)

Ethics of caries diagnosis

According to American Dental Association (ADA), Dentists should do no harm to his or her patient. Should enhance their caries detection skill. Avoid placing restoration in teeth with early demineralized enamel lesions. (Bravo *et al*., 1997) The ideal approach is to begin with the most simple, or least invasive and work up to more sophisticated techniques. The first method is visual with the help of mouth mirror and explorer. (Braga *et al*., 2010)

Caries detection methods

1.Visual method

ADA has categorized dental caries as initial, moderate, severe, as follows (Fisher *et al*., 2012):

No caries	– Sound tooth surface with no lesion
Initial enamel caries	- Visible non cavitated or cavitated lesion limited to enamel
Moderate dentin caries	– Enamel breakdown or loss of root cementum with non cavitated dentin
Severe dentin caries	– Extensive cavitation of enamel and dentin

In 2002 International caries detection and assessment system (ICDAS) proposed a classification system for dental caries, which continues to remain the leading international system for caries diagnosis even today (ICDAS 2013)

ICDAS code

0 - Sound tooth surface
1 - First visual change in enamel
2 - Distinct visual change in enamel
3 - Localized enamel breakdown due to caries with no visible dentin
4 - Underlying dark shadow from dentin (with or without enamel breakdown)
5 - Distinct cavity with visible dentin
6 - Extensive distinct cavity with visible dentin.

Caries detecting dyes

Basic fuchin red stain was used to aid in differentiation of two layers of carious dentin. In the year 1972 due to the potential

Corresponding author:* **Ravishankar Periyasamy,
Thai Moogambigai Dental College and Hospital, India.

carcinogenicity basic fuchin stain was replaced by acid red solution (Kuboki *et al*., 1983). The dye was used to stain infected tissue. It was advocated as a painless caries removal technique. But this technique was laborious as it involved multiple dye application and removal and used slowed speed bur. It is clearly established that these dyes do not stain bacteria but instead stain organic matrix of less mineralized dentin .The routine use of these dyes without understanding their distinct limitations will lead to excessive removal of total sound structure resulting in mechanical exposure of pulp. Dye staining and bacterial penetration are independent phenomenon which significantly limits the usefulness of these dyes for diagnostic purposes. Dyestaining is not good indicator for the presence or absence of bacteria in dentin and lacks the necessary specificity for the accurate detection of carious dentin. (Dorothy McComb *et al*., 2000)

Intraoral radiography

The history of dental radiography begins with the discovery of the x- ray. (Zangooei booshehry *et al*., 2010) Radiography is useful for the detection of dental caries because the caries process causes tooth demineralization. The lesion appears darker than the unaffected portion and may be detected in radiographs. Posterior bitewing radiographs are useful x-ray projections for detecting caries in interproximal and occlusal surfaces of premolar and molars. Now, the purpose of carious lesion detection, intra oral radiography is a standard procedure and is essential for diagnosing inter proximal caries. But, intraoral radiography has considerable limitations including low sensitivity to detect early caries and occlusal caries, cervical burn out and Mach band effect. (Tubert-Jeannin *et al*., 2004)

Extraoral radiography

Extra Oral Radiography (EOR) Extraoral radiographic techniques for proximal caries detection have been studied and proven to be inferior to intraoral techniques (Clifton *et al*., 1998). Radiographic imaging of oral anatomy consists primarily of viewing 3-D structures collapsed onto a two-dimensional (2-D) plan.

Microtomography

X-ray microtomography is a miniature version of computerized axial tomography with a resolution in order of micrometres (Daataselaar *et al*., 2003). It has the ability to accurately measure the linear attenuation coefficient. From this, the mineral concentration can be computed.Using microtomography we can form three dimensional images of hard tissues.

Transverse microradiography

Transverse microradiography (TMR) TMR or contact-microradiography is accepted method used to assess de- and re- mineralization of dental hard tissues in studies(13).In TMR, the tooth sample to be investigated is cut into thin slices (about 80 μm and 200 μm for dentine samples). A microradiographic image is made on high resolution film X-ray exposure of the sections together with a calibration step wedge. The microradiogram is digitized by a video camera or photomultiplier. The mineral can be calculated from the gray levels of the images of section. Parameters of interest are mineral loss, lesion depth, ratio or average loss of mineral content in the lesion area. With mineral details of approximately 2-3 μm can be detected. The time required for making 5 scans plus evaluation is 3-4 minutes.

Longitudinal microradiography

Longitudinal Micro Radiography (LMR) LMR is a method to determine mineral loss in a tooth slice (Daatselarr *et al*., 2003). Mineral content is computed by performing measurements of the optical density of the microradiogram and comparing these values with that of an aluminum step wedge. In TMR, a transversal slice of the tooth is created, LMR is based on longitudinal slices. The LMR system is automated. Scanning the sample is performed using a scanning table and all calculations are performed automatically.

Tuned Aperture Computed Tomography (TACT)

Tuned Aperture Computed Tomography (TACT) images makes it possible to view three-dimensional objects in tomosynthetic radiographs. TACT overcomes the current limitations of conventional dental technologies and increases the 3-D information (Webber *et al*., 1997). It is significant in diagnosis and management of dentoalveolar diseases and abnormalities. With TACT, the patient has to remain motionless during each individual exposure. The time between exposures is determined by convenience, diagnostic task, and economics.

Computer- Aided Radiographic Method (CARM)

Computer-aided radiographic method exploits the measurement potential of computers in assessing and recording lesion sizeproximal carious lesions (Albrektsson *et al*., 2001) it diagnosis and evaluates with the aid of histologic database, allowing graphic visualization of the size and progression of the lesion.

Electrical caries monitor

Electrical caries monitor (ECM) is based on the principle thatevery 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. (Stookey *et al*., 1999) 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. 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 .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. 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. This process provides the potential for more detailed analysis of the structure of the tooth including the presence and extent of caries.

Ultrasound caries detector

Ultrasound Caries Detector (UCD) was first suggested over 30 years ago, however, development of this method has been

slow. The principle is that images of tissues can be collected by reflected sound waves. UCD reduces patient exposure to ionizing radiation and improved caries detection; and had higher sensitivity and lower specificity than the radiographs in diagnosis of proximal caries. (Kausar Parveen *et al*., 2015)

Visible light

A) Fiber-optic transillumination (FOTI) is a caries detection technique is based on the fact that carious enamel has a lower index of light transmission than sound enamel (Lynch *et al*., 2005) Light is absorbed when the demineralization disrupts the crystalline structure of enamel and dentin. This gives that area a darkened appearance. This method of caries detection uses a light source, to illuminate the tooth. Caries or demineralized areas in dentin or enamel appear as darkened areas. This effect can be achieved with a fiber optic illuminator, which is readily available at the handpiece coupler of the dental operatory and has been used for detection of proximal and occlusal caries. Posterior proximal caries can be diagnosed with the light probe positioned on the gingiva below the cervical margin of the tooth, whereby the light passes through the tooth structures and proximal decay produces a dark shadow on the occlusal surface. It is useful for proximal and occlusal lesions; its sensitivity and specificity are not sufficient for detection of very early caries. Besides, it is not quantitative and therefore not useful as a caries monitor over time.

B) Digital imaging fiber-optic transillumination is a digitized and computed version of the FOTI. While FOTI was designed for detection of proximal and occlusal caries, digital imaging fiber-optic transillumination DIFOTI is used for detection of both incipient and frank caries in all tooth surfaces. DIFOTI uses white light to transilluminate and instantly creates a high-resolution digital image. The carioustooth scatters and absorbs more light than sound structures. A single fiber-optics illuminator in the mouthpiece delivers light to one of the tooth's surfaces. Light travels through layers of enamel and dentin, and gets scattered in all directions, usually the opposite surface. The light is then directed through the mouthpiece to a miniature electronic charge coupled device CCD camera in the handpiece. The camera digitally images the light emerging from either the smooth surface opposite the illuminated surface or the occlusal surface. These images are displayed on a computer monitor and stored on the hard drive for easy retrieval for comparative review of images over time. Image acquisition is controlled with software. Images of the teeth can be viewed by the clinician and patient, and hence used for patient education and motivation.

C) Quantitative light-induced fluorescence, (QLF) - This is a prominent diagnostic system in dentistry. The quantitative light-induced fluorescence QLF technology was introduced in 1995 and was quickly used to monitor caries lesions over time (E. de Josselin de Jong *et al*., 1995). QLF uses the natural fluorescence of the teeth, which is determined by the light absorption and scattering properties of the teeth, to discriminate between caries and surrounding sound enamel. The autofluorescence of tooth tissue decreases with demineralization and QLF measures the percentage fluorescence change in demineralized enamel with respect to surrounding sound enamel and relates it to the amount of mineral lost during demineralization. It is based on the principle that a demineralized tissue limits the penetration of light due to excessive scattering of photons entering the lesion with consequent limitation to the chance of a photon being absorbed and fluorescence remitted. Furthermore, excessive scattering in carious tissue prevents the light entering the tissue from reaching the DEJ and dentin where the chance of absorption by a fluorophore for fluorescence remittance is a magnitude higher. Photonstravels in sound enamel and reach dentin and along their path may be absorbed by a fluorophore leading to excitation of fluorescent photons.

Diagnodent

This is a laser fluorescence system that detects changes in the tooth structure due to demineralization (Lussi *et al*., 1999). These structural changes cause an increase in the fluorescence at specific excitation wavelengths. The intensity of the fluorescence depends upon the wavelength of the light as well as the structure and condition of hard dentinal tissues. Wavelength of655 nm laser beam via a central fiber is transported to the tip of the device and into the tooth. When the incident light interacts with tooth substance, it stimulates fluorescent or luminescent light at longer wavelengths. The intensity of fluorescence is a function of the degree of demineralization or bacterial concentration in the probed region. Diagnodent operates on the premise that a high level bacteria reading indicates a probability of having a decalcified enamel structure. Hence, one weakness of this technology is that all bacteria, not only caries-related bacteria, produce fluorescence. Alot of organic and nonorganic materials such as stains, plaque and calculus, food, and even the tooth itself can cause fluorescence. (Bennett *et al*., 2009)

Optical coherence tomography

Optical coherence tomography (OCT) can produce an image of tissue microstructure of the caries lesion to show the changes within, and therefore can be compared both qualitatively and quantitatively with histological methods such as microcomputed tomography and transverse microradiography, the current gold standard for measuring demineralization. OCT technology is an imaging modality that provides a tool for noninvasive evaluation of tissue microstructure by providing high spatial resolution and real-time, twodimensional depth visualization (Amaechi *et al*., 2003). OCT creates a two-dimensional map of the tissue microstructure by illuminating the tissue with lowpower near infrared (NIR) light, collecting the backscattered light, and analyzing the intensity. OCT is based low coherence interferometry. Based on the principle the highest quality image information is in the portion of the detected light that is relatively unscattered and therefore travels the most direct path through the tissue. Although the first application of low coherence interferometry in the biomedical optics field was for the measurement of the eye, since then OCT has been used to provide images of tooth structures. Following the modification of the system to produce polarization-sensitive OCT (PS-OCT), the application of OCT in dentistry has widened covering in vitro images of dental caries.

Cone beam computed tomography

The application of cone beam computed tomography (CBCT) in dental caries diagnosis has not been widely studied. The investigation to apply in caries diagnosis stems from its numerous advantages when compared to all current forms of x-ray imaging. Radiation dose is similar to a quarter panoramic

Table 1. Advantages and Disadvantages of caries detecting method

Method	Advantage	Disadvantage
Visual	1. Quick. 2. Easy. 3. Inexpensive.	1.Lesions can go undetected 2. Proximal caries maybe missed.
Radiographs	1.Non-invasive 2.Widely available 3. Can detect established caries and periapical lesions.	1. Sensitivity in detecting early caries lesions is low. 2.Radiation exposure
Dye	1.Can detect infected dentin	1.Carcinogenic
Electrical caries monitor	1. Potential for monitoring lesion progression, arrest, ordemineralization. 2.Senstivity and specificity is high	1. Time consuming.
Ultrasound	1.No exposure to radiation 2.High sensitivity	1. Low specificity in detection of proximal caries.
Foti (fibre optic transillumination)	1. Examination can be done with operating light.	1. Sensitivity and specificity are not sufficient for detection of early caries.
Dfoti (digital imaging fibre optic transillumination)	1. Images are displayed on a computer monitor. 2.Can be stored in hard drive 3. Easy retrieval for comparative review.	1. Cannot indicate the depth of lesion penetration.
Qlf (quantitative light induced fluroescence)	1.Applied in clinical trials, research, patient education 2. Canmonitor demineralization of teeth in vitro.	1.Cannot differentiate between decay and hypoplasia 2. Inability to detect interproximal lesions.
Diagnodentlaser	1. Reliability of the device is high. 2. High sensitive and specific values. 3. Both occlusal and proximal caries can be detected.	1. Moderate correlation with mineral loss. 2.Device is expensive 3. Device tips are delicate.
Oct (optical coherent tomography)	1.Image early enamel caries in extracted teeth and root lesions 2. High image quality	
Cbct (cone beam computed tomography)	1.Multiplanar imaging	1. Artifacts 2. High radiation than IOPA radiographs

image or five dental x rays using high-speed film. CBCT scanners are more accurate than dental periapical films or panoramic x rays. While there is clearly less radiation used to generate a panoramic image, the amount of information it renders is less accurate and not as useful when compared to the three-dimensional images of a CBCT scan. (Sonick *et al*., 1994)

Conclusion

There are various methods in detection of dental caries at its early stage. A thorough knowledge of each of these techniques including their principles, advantages and disadvantages is necessary to select the most appropriate technique in a given situation. A combination of diagnostic tools is most likely to be successful in the detection of early Dental caries that can facilitate prompt intervention to avoid more costly, destructive dental procedures.

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