Indian Journal of Dental Sciences.
March 2016
Issue:1, Vol.:8

www.ijds.in

Review Article

Indian Journal of Dental Sciences

E ISSN NO. 2231-2293 P ISSN NO. 0976-4003

Diagnosis Of Dental Caries Conventional V/S Recent Methods

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Submission : 3rd July 2014

Accepted : 12th November 2015

Quick Response Code

Abstract

Dental caries is a major dental disease affecting a large proportion of the inhabitants of the world. There are practically no geographic areas in the world whose inhabitants do not exhibit some evidence of dental caries. It affects persons of both genders in all races, all socioeconomic strata and every age group. It impairs the quality of life for many people causing pain and discomfort. The loss of tooth structure leading from dental caries results to compromised function of tooth which further affects ability to eat and enjoy the full range of dietary choices. Patient care can be improved with detection at the earliest stage. The present review studied the various diagnostic aids introduced in the recent times and their merits and demerits in diagnosing the disease.

Key Words

Diagnosis, Dental Caries, Radiography, Conventional, Recent Methods.

Introduction

Dental caries is one of the most commonly occurring diseases worldwide. The word 'caries' is derived from Latin word, meaning 'rot' or decay. It is similar to the Greek word 'Ker' meaning 'death'.[1]

The last few decades have witnessed huge developmentsin the prevention and management ofdental caries. In spite of this, well over three quartersof the world's population suffer from untreatedcaries. In developing countries the prevalenceof untreated caries ranges from 30% to 90%in 12-year-old children, while in adults aged 35–44years, between 55% and 95% have untreated caries. This problem is in no way unique to developingcountries since even in industrialized countries disadvantaged sectors of the community receivelittle or no dental care.[2]

Patient care can be improved with detection at the earliest stage.[3] During early stage of the disease the process is reversible and can be arrested i.e. a noninvasive intervention can convert a lesion from an active to inactive state. Appropriate diagnostic techniques are necessary to support such decisions about management of the individual lesions.[4]

In recent years, various techniques have been explored to address the need for better detection tools to aid dentist in the diagnosis of early caries like digital radiography, digital imaging, fibro-optic transillumination, electroconductivity measurements, impedence electroscopy, laser fluorescence, ultrasound, terahertz imaging etc.[3]

Visual Examination

Visual examination is the most commonly used method for detecting caries lesions, because it is an easy technique that is routinely performed in clinical practice. It includes looking for cavitation, surface roughness, opacification and discoloration. The visual examination is conducted in a dry, well-illuminated field.[5]

Visual examination has presented high specificity (proportion of sound sites correctly identified), but low sensitivity (proportion of carious sites correctly identified), and low reproducibility; the latter because of its subjective nature.[3]

C E Ketley & R D Holt in 1993 compared the visual and radiographic diagnosis of occlusal caries in first permanent molars and in second primary molars and found that visual examination alone is not a reliable method for detection for dental caries. When radiographs were used together with visual examination the status of 82% of first permanent molars and 91% of second primary molars were correctly classified.[3]

Tactile Sensation

An explorer is used to scrape away any plaque from the area in question, as plaque is a precursor for the occurrence of caries. When non-cavitated lesions (white or brown spots) are found, the tip of the explorer is used to determine the texture of the surface through minute vibrations felt when moving the tip of the explorer at an angle of 20-40 degrees across the surface. Thus, it can be established whether or not the demineralization is an active lesion.[6]

Pickard (1961) has suggested the use of floss for the detection of caries. When there is history of food-packing between the teeth, the fraying of a piece of dental floss, when it is passed through an apparently normal contact area points out that the area is the site of early carious detection.[3]

Lussi A. in 1997performed a study to evaluate Validity of diagnostic and treatment decisions of fissure caries. It was concluded that the use of an explorer does not improve the validity of the diagnosis of fissure caries when compared to that of a visual inspection alone.[4]

Radiographs

The purpose of radiographic examination is to detect lesions that are clinically hidden from a careful clinical-visual examination, such as when an adjacent tooth prevents the dentist from seeing an approximal lesion. The radiographs also help to estimate the depth of lesion in dentin.[4]

In a study by Huysmans MC, Longbottom Cand Pitts N. in 1998 comparing bitewing radiography with visual inspection showed that bitewing radiography had higher sensitivity and lower specificity than visual inspection.[7]

But radiographs are not reliable means of detecting caries because of overlapping of contacts, overestimation of depth of lesion and also because of two dimensional representation of three dimensional object.

Matalon S, Feuerstein Oand Kaffe Iin 2003compared the bitewing radiography with ultrasonic imaging for detection of approximal caries and they found that bitewing radiography had lower sensitivity and specificity than ultrasonic imaging.[8]

Xeroradiography

It was introduced as a diagnostic aid in dentistry in 1968 when Lapinskene & Lapinskenereported that some dental structures were better defined on periapical xeroradiographs than on conventional films.[9] The main characteristics of xeroradiographic technique are the ability to have both positive and negative prints together.[10]

Xeroradiography is considered to be superior for caries detection than conventional radiography because of edge enhancement feature. Edge enhancement facilitates the visualization of very small structure and areas of minor differences.[11] Edge enhancement means differentiating areas of different densities especially at margins or edges.[10]

Besides the automatic processing in less than 25 seconds and elimination of dark room the system did not gain much popularity because of the electric charge which causes discomfort to patient and also the image artifacts are more.[10]

White SC et al in 1988performed a study comparing the xeroradiography and conventional D and E films for the detection of proximal carious lesions and they concluded that all the three tests performed the same and there was no essential difference between the diagnostic techniques.[12]

Wenzel A. et al in 1991 compared four diagnostic techniques; visual inspection, conventional radiography, xero radiography and digital radiography for the detection of non-cavitated occlusal defects. The result showed that digital radiographic method was the most sensitive method among all, detecting 70 percent of all the carious lesion and xeroradiography was no superior to other 2 methods i.e. visual inspection and conventional radiography.[13]

Digital imaging

Digital imaging eliminates the need of chemical processing and no hazardous waste is formed in the form of lead foils and processing chemicals.[11] The digital radiographs provides various possibilities of manipulating the radiographic image, reduced radiographic exposure and allowing the radiographic image to be easily obtained, stored and transmitted consisted of an important advancement in the area of imaging diagnosis.[14]

Beside all the advantages the digital imaging sensor is larger and stiff so may cause discomfort in some patients.[14]

Antonio Carlos Pereira et al in 2009compared the three radiographic techniques for the detection of occlusal caries in permanent molars. They observed that no additional diagnostic performance was there in case of digital radiography as compared to conventional radiography.[15]

In an another study by Farida Abesi et al in 2012 comparing the diagnostic accuracy of digital and conventional radiography for the detection of non-cavitated approximal dental caries, the researchers found that diagnostic accuracy of digital imaging was similar to that of conventional radiography.[16]

Electric Resistance

Radiographic techniques are unable to detect the defect unless there is 40% demineralization of tooth structure.[11] Therefore, defects like incipient lesion go undetected by these methods. Electric resistance method was developed in order to eliminate these disadvantages. This method works on the principle that sound tooth enamel is a good electric insulator due to its high inorganic content. Caries or enamel demineralization results in increased porosity. Saliva fills these pores and forms conductive pathways for electric current. The electric conductivity is hence directly proportional to the amount of demineralization that has occurred.[10]

The electrical impedance values between each portion of tooth and mucous membrane is depicted. The electrical impedance is indicated by four colored lights: green, yellow, orange, red. When a potential of less than one volt is applied, the resistance of above 600,000 ohms indicates that the tooth is caries free. A resistance below 250,000 ohms indicates that caries involving the dentine is present.[10]

Besides the ability to detect the caries at early stage there are various factors that may affect the electric measurements for example the porosity, thickness and hydration of tissue.

Lussi et al in 1995performed a study to investigate the accuracy of electric resistance method as compared to conventional bite wing radiography in detecting occlusal pit and fissure caries. A high rate of false positive readings was observed in case of electric resistance method.[17]

Huysmas et all in 1998 compared electric resistance device with visual inspection and bitewing radiography for diagnosis of occlusal caries. No significant difference was found in detection of caries by electric resistance and conventional bitewing method. However, visual inspection was found to be least sensitive method among all three.[18]

Fiberoptic Transillumination (FOTI)

FOTI was developed by Friedman and Marcus in 1970 for detection of proximal lesions. Fiber-optic transillumination is an enhanced visual technique that uses the principle of illuminating teeth to detect the presence of caries.[19]

The principle behind transilluminating teeth is that demineralized areas of enamel or dentine scatter light more than sound areas. Incipient caries appear as darker areas in the resultant images, which are obtained during screening.[19]

It is a diagnostic method by which visible light is transmitted through the tooth from an intense light source, e.g. from a fine probe with an exit diameter of 0.3-0.5 mm. If the transmitted light revels a shadow when the tooth is observed from the occlusal surface this may be associated with the presence of a carious lesion.[6]

For examination, the tip of probe is placed in the embrasure immediately beneath the proximal contact point of a surface to be examined either on the buccal or the lingual surface depending upon the tooth. The marginal ridge is viewed from the occlusal surface.[10]

The device has a limited use only for detection of proximal lesion not for secondary caries.

Verdonschot et al in1992 performed an in vivo study to compare the efficacy of three diagnostic system; conventional radiography, electric resistance and

FOTI. It was found that sensitivity levels of FOTI have been shown to vary between 50 and 85%.[19]

Vaarkamp et al in 2000 compared the conventional bitewing radiography with FOTI in detecting approximal carious lesions. The FOTI was found to be more sensitive diagnostic technique as compared to Bitewing radiography.[20]

Digital Imaging Fiber-Optic Transillumination (DIFOTI)

This is a recent innovation to fiber optic transillumination introduced by Electro-Optical Sciences, Irvington, New York.[21]

The user-friendly DIFOTI system consists of consists of 2 handpieces (one for occlusal surface and one for smooth and interproximal areas), a disposable mouthpiece, a foot pedal for selecting the image of interest from the live picture and a computer to store the resulting image.[10]

Schneiderman A. et al in 1997 compared DIFOTI with visual inspection in diagnosing occlusal, approximal and smooth surface lesions. The result showed that DIFOTI was more sensitive method in detecting carious lesions.[21]

Young et al in 2005 performed a study comparing DIFOTI with F speed radiographic film in determining the depth of proximal lesions and concluded that DIFOTI was not a reliable method for the depth determination of approximal lesions. F speed films were superior in measuring the depth of carious lesion.[22]

Fluorescence

FOTI method could not detect the carious lesion present below the gingiva; also it did not offered higher sensitivity than bitewing radiography in detecting approximal lesions. The fluorescence of dental hard tissues has been known for a very long time (Benedict, 1928).[21]

The difference between the fluorescence of sound tooth tissues and that of caries lesion can be made visible by the quantitative laser- or- light induced fluorescence (QLF) and by the DIAGNOdent method.[21]

DIAGNOdent (KaVo Biberach, Germany)

Principle of DIAGNOdent: The fluorescent light is measured and its intensity is an indication of the depth of the carious lesion. The intensity of the fluorescent light is displayed as a number ranging from 0-99, with 0 indicating a minimum and 99 a maximum of fluorescent light.[21]

Operation- The tip of the device is placed against the tooth surface and the laser light penetrates the tooth. Further, the tip for approximal surfaces is constructed in a way that it is able to reflect the light of excitation and detection laterally.[21]

Source of light i.e. the diode laser emits light at 655 nm wavelength. Light is transported to the angulated tip within a central fiber. Around the central fiber, additional fibers are concentrically arranged to collect the fluorescent light from the dental hard tissue. The reflected and the ambient lights are eliminated by a filter.[10]

Attrill DC & Ashley PF in 2001 compared the accuracy and repeatability of three diagnostic systems (DIAGNOdent, visual and radiographic) for occlusal caries diagnosis in primary molars. They concluded that the DIAGNOdent was the most accurate system tested for the detection of occlusal dentine caries in primary molars.[10]

DIAGNOdent have shown good intra-examiner reproducibility in vitro and in vivo, indicating that equipment measured consistently (Lucci et al., 2001, 2006; Tranaeus et al., 2004). This means that the DIAGNOdent can be used for monitoring the carious process.[21]

QUALITATIVE LIGH-INDUCED FLUORESCENCE (QLF) is a new method for oral health assessment, providing additional visual information about caries and bacterial activity. With QLF real-time fluorescent images are captured into the computer and stored in an image database. Optional quantitative analysis tools enable the user to quantify parameters like mineral loss, lesion depth, lesion size, stain size and severity with high precision and repeatability.[6]

Itis based on the principle that the auto fluorescence of the tooth alters as the mineral content of the dental hard tissue changes. Increased porosity due to a subsurface enamel lesion scatters the light either as it enters the tooth or as the fluorescence is emitted, resulting in a loss of its natural fluorescence. Bjelkhagen et al. Sundström et al (1981) developed the technique of qualitative light fluorescence based on this optical phenomenon.[19]

The changes in enamel fluorescence can be detected and measured when the tooth is illuminated by violet-blue light (wavelengths 290–450 nm, average 380 nm) from a camera hand piece, following image capturing using a camera fitted with a yellow 520 nm high pass filter(QLF; Inspektor Research Systems, Amsterdam, the Netherlands). The image is captured, saved, and processed: it is first converted to black-and-white so that thereafter the lesion site can be reconstructed by interpolating the grey level values in the sound enamel around the lesion.[10]

Tranaeus Set al performed an in vivo study in 2001 to evaluate the repeatability and reproducibility of QLF in quantification of natural incipient lesions. The in vivo repeatability and reproducibility results of QLF were found to be excellent.[23]

In a study by Shi XQ, Tranaeus Sand Angmar-Månsson Bin 2001, QLF was found to be more sensitive in detecting smooth surface caries as compared to DIGNOdent, also it was found that QLFoffers the advantage of closer correlation with changes in mineral content.[24]

Ultrasonic Imaging

It is a technique based on sound waves that acquires images in real time without the use of ionizing radiation.[10]

In order for sound waves to reach the tooth they must pass first through a coupling mechanism, and a number of these have been suggested, but those with clinical applications include water and glycerine.[19]

A number of studies have been undertaken using ultrasound, with differing levels of success. A study by Bab et al (1997)reported that ultrasonic device could discriminate between cavitated and non-cavitated inter-proximal lesion.[19]

Another study by Çalı#1;kan Yanıkoğlu F. et al in 2000concluded that ultrasonic evaluation is a sensitive method for the detection of the natural white spot carious lesions and can differentiate the changes in elastic properties of enamel numerically.[25] Despite encouraging findings, no further, research has been undertaken using the device.

Mini-D

Another new caries detection portable device based on fiberoptic principle has been developed by Necks Technologies inc. (Canada)[26]

It is easy to use and requires no calibration.[21] It works on the principal of difference in optical behavior inside the tooth related to change in the tooth structure.

Working: It uses infrared and red light emitting diodes(LEDs) and a fiber optic to distribute light to the observed area present at the probe tip. A second fiber opticcollects light from the observed area to a photodetector that measures returned collected light. This photo detector thentransmits the signal to a microprocessor that compares signallevels with defined parameters. When the result is positive,the processor deactivates the third green LED and pulses at ahigher intensity than the red LED. When the detection isnegative i.e., healthy tooth area, the green LED is dominant resulting in a green illumination when healthy structure is detected. A buzzer also beeps with different frequencies to indicate the intensity of demineralization detected.[27]

The device is light weight, easy to use, pen sized, cordless that can be used as an aid for clinicians to quickly locate and diagnose caries.[13] The Mini-D can be used for approximal caries detection during the examination by slightly angling and moving the probe along the marginal ridge just over the vulnerable approximal area.[27]

However, this device can give false positive signals in cases of teeth with growth malformations in the enamel or the dentin, teeth with thick, dark stains, hypermineralization, hypocalcification, dental fluorosis, and atypically shaped teeth due to alteration in the translucency of enamel caused by these conditions. The device cannot be used on composites or amalgams but can be used to check the marginal ridges of occlusal amalgams.[27]

Carbon Dioxide Laser

Lasers can be used in the visible regions as a tool for the detection of carious lesions. Radiation of wavelength 10.6 micro meter- the most commonly used for carbon dioxide laser is strongly absorbed by water to the extent that it can be vaporized instantaneously. The fact that most biological tissue contains large quantities of water makes them vulnerable to destruction by irradiation from a laser beam of such a wavelength. The water in tissues is vaporized leaving a residue of carbon based material.[10]

Photo-vaporization by a carbon dioxide laser of this organic material in the incipient carious lesion will leave a carbonized residue, which will appear black. At low power levels and short interaction times, the inorganic substance of sound enamel with minimum water content will be much less affected by carbon dioxide laser beam.[8]

Benedetto et al in 1988 studied the diagnostic efficacy of carbon dioxide lasers in detecting incipient pit and fissure lesion and they found that carbon dioxide laser made the lesions more visible as there was charring of incipient lesions due to low carbon content of the carious enamel.[28]

In another study by Longbottom et al in 1993 the carbon dioxide laser was found to be a very effective means for caries detection. The study was performed on fifty extracted human molars and premolars which were first tested by carbon dioxide laser and then after subjected to histological analysis. No false positive results were detected.[29]

Micro Air Abrasion

The air abrasion system provides advantage of detecting as well removal of the carious lesion simultaneously. The study of the use of air abrasion technology for dental applications initiated by Dr. Robert Black in the 1940's was successfully introduced in1951 with the Airdent air abrasion unit (S.S. White).[30] It was developed as an alternative to slow-speed, belt driven hand pieces used at that time.[21]

This method is of particular advantage in examining darkened areas in the bottom of pits and grooves.[21] Whenever the clinical, radiographic, and patient risk factors make pit and fissure caries suspect, air abrasion can be used to remove the organic debris and determine if caries is present. Use of burs for this procedure would remove far more sound enamel than the few micrometers removed with air abrasion.[30]

Rodrigues et al in 2000 performed a study to assess the influence of cleaning pits and fissures with an aluminum oxide air abrasion system on the detection of occlusal caries in primary teeth using laser fluorescence (LF) and visual examination. The findings suggest that cleaning pits and fissures with aluminum oxide air abrasion increased the accuracy of LF and visual examination for detection of occlusal caries in primary teeth.[31]

Optical Coherent Tomography (OCT)

Principle and Working: The principle of OCT is similar to B-mode ultrasound imaging, except that OCT uses near infrared (NIR) light instead of sound. First demonstrated in1991, OCT creates a two-dimensional map of the tissue microstructure by illuminating the tissue with lowpower NIR light, collecting the backscattered light, and analyzing the intensity. OCT is based on confocal microscopy and low coherence interferometry. Based on the principle that the highest quality image information is contained in the portion of the detected light that is relatively unscattered and therefore travels the most direct path through the tissue, OCT uses low coherence interferometry to selectively remove the component of backscattered signal that has been multiply scattered, resulting in very high resolution images.[32]

Otis et al in 2000developed a dental OCT system which consists of a computer, a compact light diode light source, a photo detector and a hand piece that scans a fiberoptic cable over the oral tissues.[28]

Laser light of wavelength that the enamel is readily transparent to is used such as 840-1310 nm. It passes into tissue and the emerging light is detected in relation to its phase, which is a measure of the distance that it has travelled.[10]

OCT showed promising results in detection of incipient root caries in a study by Ameachi BT et al in 2004 for the quantification of root surface caries using optical coherent tomography and microradiography.[33]

Holtzman et al in 2010 compared OCT method with conventional methods for detecting caries under the pit and fissure sealants. They found that OCT was much better in diagnosing caries beneath the commonly used dental sealants as compared to visual inspection and radiographic evaluation.[34]

Magnetic Resonance Imaging (MRI)

Principle: MRI (Magnetic resonance imaging) makes use of the magnetic properties of certain atomic nuclei. An example is the hydrogen nucleus (a single proton) present in water molecules, and therefore in all body tissues. The hydrogen nuclei behave like compass needles that are partially aligned by a stronger magnetic field in the scanner. The nuclei can be rotated using radio waves, and they subsequently oscillate in the magnetic field in the scanner while returning to equilibrium. Simultaneously they emit a radio signal. This is detected using antennas (coils) and can be used for making detailed images of body tissues.[11]

MRI is also feasible for looking at dental carious lesions in three dimensions and no artifacts are created by metallic restoration on this exam. But it is difficult to distinguish the hard tissues of the tooth within MRI scans due to their scarce water content. To overcome these problems a new MRI technique has been developed very recently: the SWIFT (Sweep Imaging with Fourier Transformation) technique. With this technique the presence and extension of carious lesion can be seen in detail. This method is extremely effective in ex- vivo evaluations, while it still needs to be perfected for in-vivo applications.[35]

MRI has advantages of providing 3D image but image distortion occurs in case of metal object in the field of view. Also, the device itself is very expensive.[10]

Idiyatullin Din 2011studied the diagnostic ability of SWIFT MRI system. They found that MRI was not even able to detect the carious lesion but also the extent of the lesion was made visible.[36]

Another in vitro study by Bracher et all in 2013. MRI showed an accuracy rate of 97% as compared to conventional radiographic methods which showed an accuracy rate of 85%.[37]

Cone Beam Computerized Tomography (CBCT)

MRI technique is unable to detect the carious lesions adjacent to the metallic restorations. Because any metallic object leads to distortion of the image.[11] CBCT can prove a better alternative in cases where secondary caries are suspected beneath metallic restorations.

CT is radiographic technique, usually using film, designed to image a slice or plan of images. It uses an x-ray tube and radiographic film rigidly connected and capable of moving about a fixed axis or fulcrum, which is located within the body's plane of interest (focal plane). Since, the introduction of CBCT and MRI, which has superior contrast resolution, CT is used less frequently.[10]

CBCT appears to be the best prospect for improving the detection and depth of caries in approximal and occlusal lesions.Recent work with benchtop-based local or limited CBCT (LCT) systems has demonstrated the potential for caries detection and depth characterization by high-resolution systems.[37]

Certain limitations of CBCT are:[37]

- Noise: Because radiation from the source is transmitted through tissues in the body, the receptor receives non-uniform information from radiation scattered in many directions; this is termed as noise.
- Radiation is attenuated when passing through dense objects (such as non precious alloys in metal restorations, crown)
- High cost of CBCT technology

Zhi-ling Zhang et al in 2011performed a study to compare the CBCT imaging with radiographic film and phosphor plates for detection of proximal caries. They found that CBCT performed better as compared to other two diagnostic aids.[38]

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Source of Support : Nill, Conflict of Interest : None declared