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Recent methods for diagnosis of dental caries in dentistry

A Project Submitted to

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Certification of the supervisor

I certify that this project entitled “Recent methods for diagnosis of dental caries in dentistry “ was prepared by the fifth-year student Fatima Hammad Rakad under my supervision at the College of Dentistry/University of Baghdad in partial fulfillment of the graduation requirements for the Bachelor Degree in Dentistry.

Supervisor's name

Date

Dedication

Firstly and lastly, all gratefulness and faithfulness thanks and praises are to "Allah" God of the world.

I want to dedicate my graduation project to my family especially my parents, who supported and encouraged me and my friends .I would like to thank supervisor Lecturer Yasameen Hasan Motea for her continuous guidance ,time advice and support.

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Introduction

Dental caries is an infectious microbiologic disease of the teeth that results in localized dissolution and destruction of calcified tissues **(Theodore M.R., 2014)**. Development of caries require interaction between plaque microorganism, susceptible tooth, substrate and time.

The infection results in loss of tooth minerals that begins on the outer surface of the tooth and can progress through the dentin to the pulp, ultimately compromising the vitality of the tooth. There are number of risk and modifying factors which affect the mineral equilibrium in one direction or another, i.e. towards remineralization or demineralization.**(Holt RD.,l 2001)** There has been remarkable progress in the reduction of dental caries over the past 30 years. Changes have been observed not only in the prevalence of dental caries, but also in the distribution and pattern of the disease in the population. Specifically, it has been observed that the relative distribution of dental caries on tooth surfaces has changed, and the rate of lesion progression through the teeth is relatively slow for most people. The use of fluoride in public water supplies, in toothpaste, and in professional dental products, improved oral hygiene, and increased access to dental care have played major roles in this dramatic improvement. Nevertheless, dental caries remains a significant problem. Finding an accurate method for detecting and diagnosing any disease has been the goal of the healing arts since the time of Socrates.

Early diagnosis of the caries lesion is important because the carious process can be modified by preventive treatment so that the lesion does not progress. If the caries disease can be diagnosed at an initial stage (e.g. white spot lesion) the balance can be tipped in favor of arrestment of the process by modifying diet, improving plaque control, and appropriate use of fluoride**(Michele Baffi Diniz and Jonas de Almeida, 2012)**.Using non-invasive quantitative diagnostic methods it should be possible to detect lesions at an initial stage and subsequently monitor lesion changes over time during which preventive measures could be introduced.A diagnostic method for dental caries should allow the detection of the disease in its earliest stages and for all pathologic changes attributable to the disease to be determined from early demineralization to cavitations**(Stooky GK and Jackson RD, 1999)**.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. Although, no single method is currently developed that will allow detection of caries on all tooth surfaces, these technologies have the potential to offer higher specificity and sensitivity with respect to caries detection and quantification as well as to facilitate the development of more effective preventive interventions**(Stooky GK and Jackson RD, 1999)**.

General criteria for an ideal caries detection method include following: (**Garg A and Biswas G, 2014).**

- 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 stage.

Aim of study

The aim of this project is to review the definition of dental caries, risk factors for caries, methods of caries detection, types of conventional method including (visual inspection, tactile sensation, radiograph and caries detecting dyes), types of novel diagnostic systems (digital imaging, fiber optic transillumination, digital imaging fiber optic transillumination, subtraction radiography, fluorescence, carbon dioxide laser, electrical conductivity measurements, ultrasonics, micro air abrasion, and tuned aperture computed tomography).

1. Risk Factors for caries

Table 1: Risk and modifying factors for caries Primary risk factors

Saliva	-Ability of minor salivary glands to produce saliva -Consistency of un stimulated (resting) saliva -pH of un stimulated saliva -Stimulated salivary flow rate - Buffering capacity of stimulated saliva
Diet	-Number of sugar exposures per day -Number of acid exposures per day
Fluoride	-Past and current exposure
Oral biofilm	-Differential staining -Composition -Activity
Modifying factors	-Past and current dental status -Past and current medical status -Compliance with oral hygiene and dietary -advice Lifestyle -Socioeconomic status

2. Caries detection methods

Caries detection methods should be capable of detecting lesions at an early stage, when progression can be arrested or reserved, avoiding premature tooth treatment by restorations .

2.1 Conventional Methods Used in Diagnosis of Dental Caries

2.1.1 Visual Inspection

It is one of the most common diagnosis methods implemented by dentists.This method is based on the use of a dental mirror, a sharp probe and a

3-in-1syringe and requires good lighting and a clean/dry tooth surface**(Ekstrand and Ricketts, 1997).** In order to make an accurate assessment, the teeth should be clean, dry and examined under a light source. In visual examination, changes in tooth structure such as; enamel dissolution, white spot lesions, discoloration, surface roughness and presence of cavitation are assessed. When illuminated, the carious tissues scatter the light and make enamel look whiter and opaque. This is due to increased porosity caused by demineralization. Similarly, when dentin undergoes demineralization, a shadow is observed under the intact enamel. When caries progress, the surface breaks down and a cavitation is formed **(Garg Aand Biswas G, 2014). (Sheehy ECand Brailsford SR, 2001)** On the other hand, there are some questions about the use of dental explorer to probe suspected carious lesions**.(Hamilton,2005)** reported that until to the time those facts emerge from acceptable long-term clinical trials, dentist should feel comfortable using the dental explorer to probe suspected carious lesions**.**

The International Caries Detection & Assessment System (ICDAS)– the system was developed and introduced by an international group of researchers (cariologists and epidemiologists) to provide clinicians, epidemiologists, and researchers with an evidence-based system for caries detection **(Pitts, N.,2004).** This method was devised based on the principle that the visual examination should be carried out on clean, plaque-free teeth, with carefully drying of the lesion ⁄ surface to identify early lesions. According to this system, the replacement of the traditional explorers and sharp probes with a ball-ended periodontal probe would avoid traumatic and iatrogenic defects on incipient lesions (**Ismail and Sohn,2007).**

ICDAS is a two-digit identification system. Initially, the status of the surface is described as un restored, sealed, restored or crowned. After that, a second code is attributed to identify six stages of caries extension, varying from initial changes visible in enamel to frank cavitation in dentine. **(Ismail, A.I.and Sohn, W.; 2007).**

(Table2):ICDAS caries severity codes.

Code	Code Description
0	Sound tooth surface
1	First visual change in enamel seen only after prolonged drying
2	Distinct visual change in enamel
3	Localized enamel breakdown in opaque or discolored enamel, dentin visible
4	Dentinal shadow (not cavitated into dentin(
5	Distinct cavity with visible dentin
6	Extensive distinct cavity with visible dentin

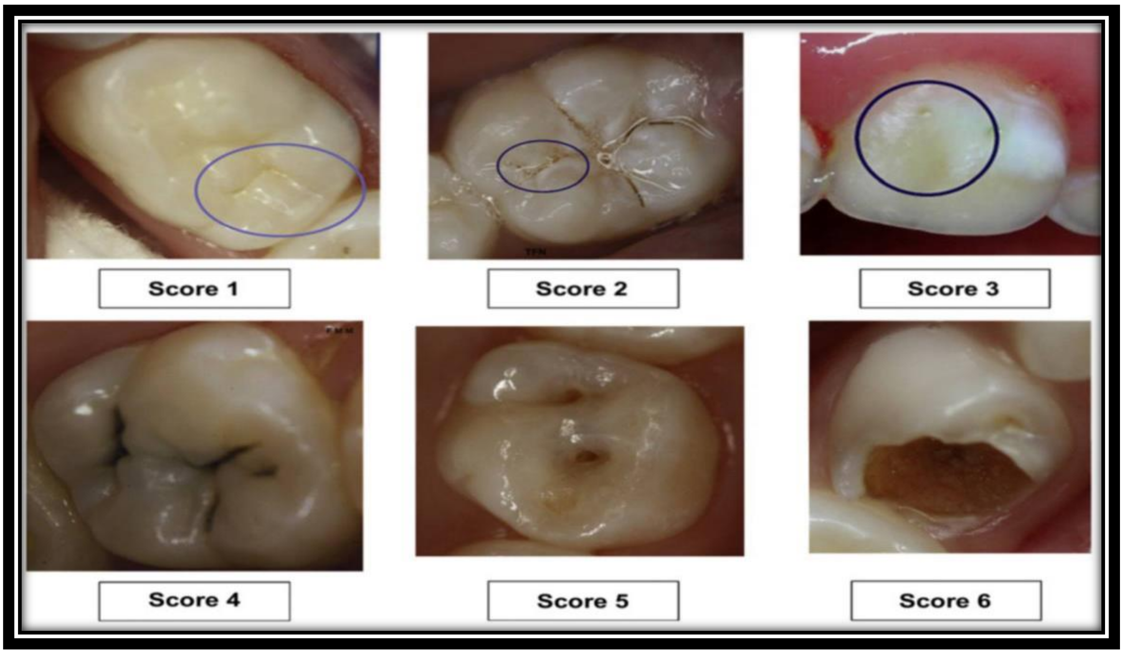

Figure 1: Description and clinical examples of each code of ICDAS system.

2.1.2 Tactile Sensation

The explorer and the dental floss are used for tactile examination but the use of an explorer is not preferred because **(Zandona AFand Zero DT,2006).**

1.Sharp tip of the explorer can produce traumatic defects on the enamel surface.

2.The cariogenic bacteria may be transferred from one tooth surface to another.

3. Probing may cause cavitation and fracture in the incipient lesions.

4. Explorers have low sensitivity resulting in undetected lesions.

If the explorer catches or resists removal when moderate pressure is applied, and when this is accompanied by one of the following:

- Softness at the base of the lesion.
- Opacity adjacent to the pit or fissure.
- The enamel is softened adjacent to the pit and fissure, we can conclude that the area is carious. **(Tandon S.,2006)**, proposed the use of dental floss for the detection of caries. When there is food packing between the teeth and the floss is frayed when passed through the contact area, this might be the indication of caries **.**

2.1.3 Radiography

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 **(Sawle RFand Andlaw RJ., 1988).** According to studies, bitewing radiography has been proven to be an effective method in the detection of proximal caries and hidden caries **(Bloemendal Eand de Vet HCW, 2004).** Besides its advantages, radiographs also have some limitations too. For this reason, it is advisable to use clinical evaluation along with radiographic imaging. The disadvantages of radiography are as follows: **(Garg Aand Biswas G, 2014)**

•Proximal contacts are overlapped.

•The lesion depth may appear to be increased due to angulation and this may lead to false diagnosis.

•Occlusal lesions may not be detected because of the superposition of the buccal and lingual cusps.

•The real cause of the radiolucency can’t be determined whether it is due to caries, resorption or wear.

•The superficial demineralization of the buccal and lingual surfaces may seem like proximal caries.

•Active and arrested caries can’t be distinguished in the radiographs.

•Radiographs may give false positive results due to a phenomenon called “Mach band effect.”.

In this perceptual phenomenon, the contrast between the dark and lighter areas has increased, resulting in a dark demarcation band. This effect causes formation of a radiolucent area in dentin enamel junction.

•Cervical burn out is another optical phenomenon where a wedge shaped radiolucent area is seen between the bone and the cemento-enamel junction. This effect is due to tissue density and the low penetration of X-rays at the cervical region.

Despite the disadvantages, radiographs are the most commonly used diagnosis tool and with the development of new techniques many of the problems are solved **(Sikiri VK.,2010).**

2.1.4 Caries Detecting Dyes

Caries indicator dyes are non-specific protein dyes that stain the organic matrix of less mineralized dentin, including normal circumpulpal dentin and sound dentin in the area of the amelo-dentinal junction. The purpose of their study was to compare the accuracy of diagnosis of carious lesions in the occlusal pit, fissure, and groove system of lower molars. Various dyes such as silver nitrate, methyl red have been used to detect carious sites by change of color.The dye is purported to stain only infected tissue and is advocated for a "painless" caries removal technique without local anesthetic. The technique is laborious, as it is guided by staining, involves multiple dye application-and-removal repetitions and requires the use of a slow- speed bur. There are two layers of decalcification in carious dentin. The first one is the soft and infected layer which doesn't have the capacity of remineralization. The second one is hard, intermediately decalcified and has the ability of remineralization **.(Young DA.,2002)** In 1972, it was suggested that caries- detector dyes could help differentiate infected dentin from affected dentin. However,Although there are opinions stating the benefit of caries detection dyes, there are also opinions that dyes can lead to over-reduction in the dentin **(Tandon S.,2009).**

Most clinical investigations have concluded that, caries detection dyes don't stain bacteria but stain the less mineralized organic matrix. In a study of **(Demarco FF,1998)**they suggested that dye remnants that remained on the walls of the cavity may cause a decrease in the shear bond strength between the composite restorations and the enamel.

Figure 2: caries detection dyes.

2.2 Novel diagnostic systems

2.2.1 Digital Imaging

Digital image is an image composed of a series of sensors and pixels distributed orderly **(Garg Aand Biswas G, 2014).** The advantages of digital imaging over conventional radiography is as follows:(**Garg Aand Biswas G, 2014).**

- The radiation dose is approximately 60-90% lower.
- The image receptor is often larger.
- The image is immediately available.
- The image can be electronically transferred.
- Magnification, contrast, brightness can be adjusted.
- There is no need for processing solutions protecting the environment and lowering the costs.

In an in vitro study comparing the capacity of conventional radiographic imaging with digital imaging systems in detection of proximal caries, it was concluded that these two systems provided similar results, showing no significant difference over another. It is highly recommended to use digital imaging as the radiation dose is significantly lower **(Castro VM, Katz JO ,2007).**

Figure 3; digital imaging.

2.2.2 Fiber OpticTransillumination

The light transmission index of decayed and sound tooth are different **(Tandon S.,2009).** 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**(Iain AP.,2006).** 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 **(Tandon S.,2009).** 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 **(Pretty IA, Esktrand KR,2016).**It is simple, noninvasive, painless procedure that can be used repeatedly with no risk to the patient.

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 scale

Score 0 = sound

Score 1 = shadow in enamel

Score 2 = shadow in dentine

Zandoná AF, Zero DT(2006) Enamel lesions appear as gray shadows and dentin lesions appear as orange-brown or bluish shadows**. Pine CM(1996)** In an in vitro study, FOTI, performed along with visual examination, had higher specificity both for enamel and dentinal lesions and had a better correlation with histology.

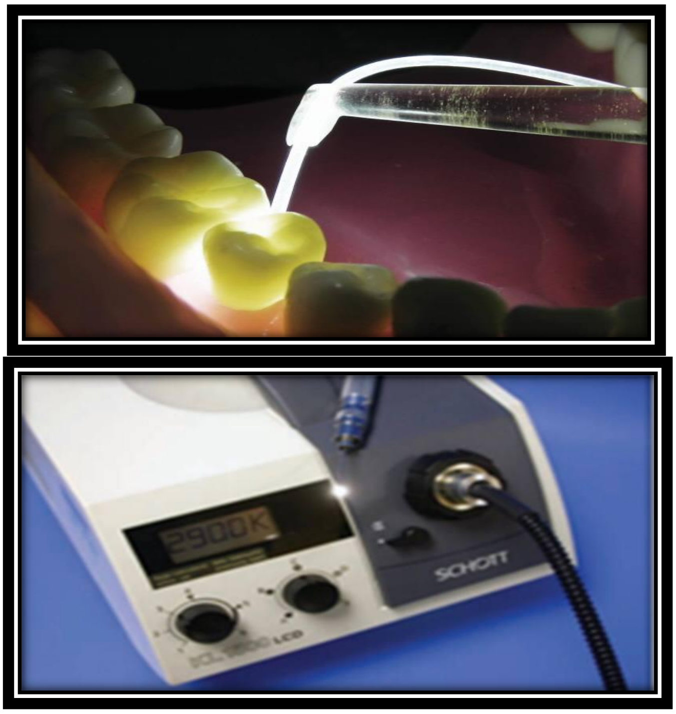

Figure 4; A_fiber optic transillumination. B_Fiber optic transillumination device.

Advantages:

1. Lesions which cannot be diagnosed radiographically can be diagnosed.

2. No radiation hazard.

3. Comfortable to the patient.

Disadvantages:

1. FOTI is not possible in all locations of carious lesions.

2. can not detect small lesions.

2.2.3. Digital Imaging Fiber Optic Transillumination (DIFOTI)

is a relatively new methodology that was developed in an attempt to reduce the perceived shortcomings of FOTI by combining FOTI and a digital CCD camera(charge coupled device). Images captured by the camera are sent to a computer for analysis using dedicated algorithms. The use of the

CCD allows instantaneous images to be made and projected, and images taken during different examination can be compared for clinical changes among several images of the same tooth over time**(Stooky GKand Jackson RD,1999).**

According to studies, this method is non-invasive, doesn't use ionizing radiation and it is more sensitive than X-rays in detecting early demineralizations **(Karlsson L,2010).**

Also, the images obtained by this method can be saved and viewed later, the properties of the lesions can be examined by increasing the contrast of the image. This method is useful in detecting changes like fractures and fluorosis **(Bin-Shuwaish Mand Dennison JB,2008).**However, Caution must be taken, when interpreting a proximal DIFOTI image that is taken at a view similar to that of a conventional bitewing radiograph. Although, the images may look similar, proximal lesions can be detected using DIFOTI only by careful angulation, remembering that the resulting image is that of a surface or what is near the surface. This also may explain why the DEJ is not always seen with conventional radiography, when the incident beam is transmitted through the entire tooth, often masking early changes in the surface. However, this method is much better for evaluating lesion depth at the proximal surface. In addition, another possible drawback of DIFOTI is the inability to quantify lesion progression, even though images can be compared over time **(Young DA.,2002).** One in- vitro study indicated that the method has higher sensitivity than does a radiographic examination for detecting lesions on interproximal, occlusal and smooth surfaces **(Schneiderman A and ElbaumM,1997).**.

Figure 5; DIFOTI.

2.2.4 Subtraction Radiography

This technique is extensively used for detection of caries and assessment of bone loss in periodontology **(Iain AP.,2006)** .Digitalization is done by taking a picture of the radiograph with a high-quality video camera. This image is transferred to a computer imaging device named as digitizer. Two standardized radiographs exposed to same amounts of beam are superimposed using a software. The difference between the two images looks as dark bright areas **(Garg Aand Biswas G,2014).**

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).13Subtraction images therefore emphasise this change and the sensitivity is increased **(van der Stelt,2008).**

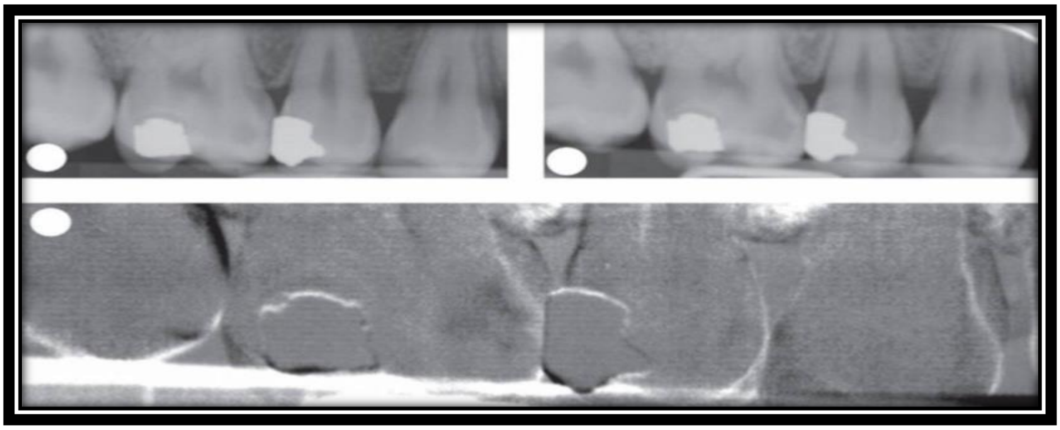

Figure 6: Example of a subtraction of two digital bitewing radiographs: (a) Radiograph showing proximal lesion on mesial surface of first molar; (b) Radiograph taken 12 months later; (c) The areas of difference between the two films are shown as black, that is, in this case the proximal lesion has become more radiolucent and hence has progressed.

2.2.5 Fluorescence

Two methods have been developed based on the fluorescence of the organic components of teeth; they are quantitative light-induced fluorescence [QLF (QLF-clin, Inspector Research Systems BV, Amsterdam, Netherlands)] which uses an arc lamp with a wavelength of 290-450 nm and DIAGNOdent (KaVo Dental laser fluorescence pen, DIAGNOdent pen, Lake Zurich) which uses infrared light and has a 655 nm wavelength **(Zandona AFand Zero DT,2006).**

2.2.5.1 DIAGNOdent

This system has a range of 0 to 99. The value 0 indicates the healthiest state of the tooth. It is an effective method in detecting initial lesions without cavitation. It’s also useful for measuring different decalcification values in different surfaces of the tooth. The fiber optic probe directed onto the occlusal surface of the tooth emits a light of wavelength 655 nm. The changes caused by demineralization are converted into numeric values and displayed on the screen. The surface to be examined must be clean because dental calculus, plaque and discoloration may cause false results **(Garg Aand Biswas G,2014).**

According to studies carried on permanent teeth it is indicated that DIAGNOdent has high sensitivity and low specifity. Having a high sensitivity means that the tool is suitable for caries detection but having low specifity means a higher rate of false positive results are obtained. Therefore, it is recommended to use DIAGNOdent in combination with other techniques **(Costa AMand Paula LM,2008).**

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 **(Hibst, Rand Paulus,2001)**.The emitted fluorescence by the porphyrins is collected by nine concentric fibers and translated into numeric values, 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.

Recently, a device called DIAGNOcam was proposed to the market. This technology uses a laser diode of wavelength 780 nm for transillumination of teeth. Carious tissues absorb lighter than their surroundings and a digital camera is used for monitoring the images. The caries tissues appear as dark spots. According to a recent study, the results obtained by DIAGNOcam were better correlating with the clinical results when compared with DIAGNOdent **(Marinova-Takorova Mand Anastasova R,2014).**

Another new technology is DIAGNOdent pen (KaVo Dental, Biberach, Germany). This device works with the same principle as DIAGNOdent and it comes with two different sapphire fiber tips: A cylindrical tip and a conical tip. In a study comparing DIAGNOdent and DIAGNOdent pen in detecting occlusal caries it was found that this new device gives comparable results with DIAGNOdent **(Lussi Aand Helwig E.,2006).**

Figuren7; The DIAGNOdent device.

2.2.5.2 Quantitative Light Induced Fluorescence

This technique is based on the principle that as the mineral content of the tooth changes the auto fluorescence of the tooth changes also. The light scatters much faster in carious tissues compared to sound dental tissues, shortening the pathway of the light in the lesion and decreasing the absorption and fluorescence in this area. This means that, the scattering of the light is used for evaluating the mineral loss related with the lesion

(Stookey GK.,2004). The QLF method can also be used in measuring the red fluorescence from microorganisms in plaque. The value of red fluorescence can be used in the evaluation of oral hygiene, assessment of the plaque on the dentures, detection of the infected dentin and detecting the leakage of a sealant or caries at the margin of a restoration **(Karlsson L.,2010).**The QLF method was suggested as an efficient technique not only for the detection early caries but also monitoring the progression of a lesion or remineralization process **(Stookey GK.,2004).**

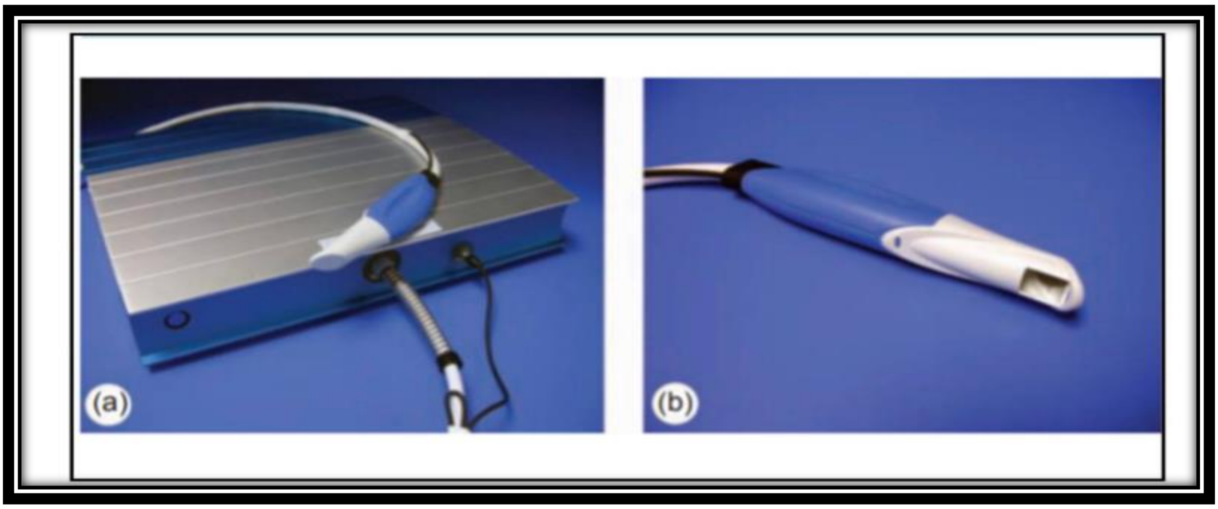

Figure 8: Quantitative light-induced fluorescence Equipment: (a) The unit light box, demonstrating the handpiece and liquid light guide; (b) A close- up of the intra-oral camera featuring a disposable mirror tip that also acts as an ambient light shield.

Principle: Autofluorescence of the tooth alters as the mineral content of the dental hard tissue changes. When teeth are illuminated with high intensity blue light, they will start to emit light in the green part of the spectrum. 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. 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. The

QLF method can also measure and quantify the red fluorescence (RF) from microorganisms in plaque **(Angmar-Mansson Band ten Bosch JJ.,2001)**.

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.

Angmar-Mansson Band ten Bosch JJ(2001) Live images are displayed via a computer and accompanying software enable spatient'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.

2.2.6 Carbon Dioxide Laser

The reason of the application of carbon dioxide laser as a diagnostic tool is because the subsurface of the carious lesion has more organic compounds than the adjacent sound tissues. When carbon dioxide laser is applied to an incipient lesion, the organic contents evaporate leaving a black carbonized residue behind whereas the inorganic substance of sound enamel containing minimum amount of water is less affected by the laser beam **(Sikiri VK.,2010).**More clinical studies should be carried out in order to understand the efficacy of carbon dioxide laser.

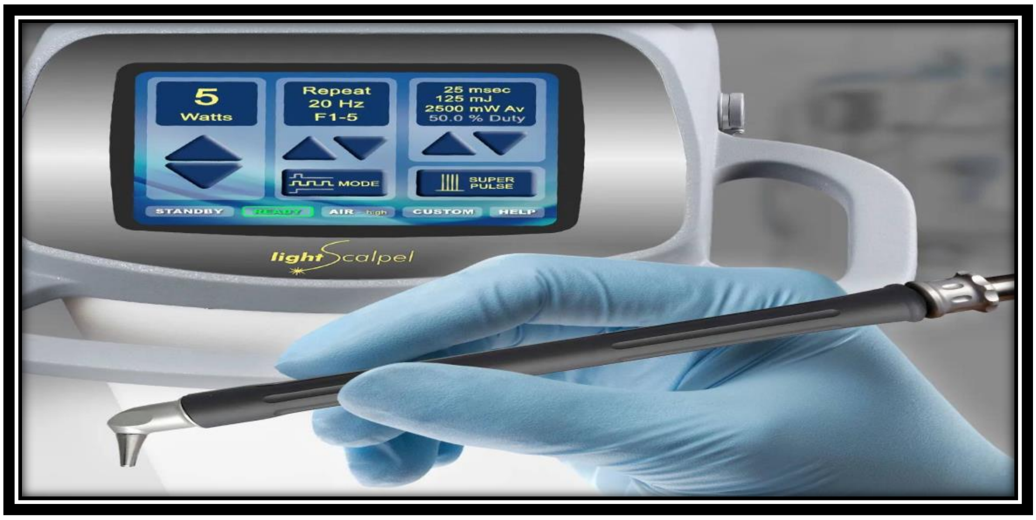

Figure 9; carbon laser device.

2.2.7 Electrical Conductivity Measurements

Because of its high mineral content, sound enamel is a good electrical insulator. **(Verdonschot EHand Rondel P,1995)** In its simplest form, caries can be described as a process resulting in an increase in porosity of the tissue (enamel or dentine). This increased porosity results in a higher fluid content than sound tissue and this difference can be detected by electrical measurement by decreased electrical resistance or impedance.Demineralization process results in the formation of pores and saliva fills these pores forming a conductive pathway for electric current**(Sikiri VK.,2010).** The electrical conductance increases as the pores get larger meaning that demineralization is directly proportional with electrical conductance **(Tandon S.,2009).**

Ekstrand KRand Ricketts DN(1998) For example, dentine is more conductive than enamel. In dental systems, there is generally a probe, from which the current is passed, a substrate, typically the tooth, and a contra-electrode, usually a metal bar held in the patient's hand. Measurements can be taken either from enamel or exposed dentine surfaces.

Figure 10; The electronic caries monitor device.

2.2.7.1Vangaurd 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 **(Tandon S.,2009).**

Figure 11; vanguard electronic caries.

2.2.7.2 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 **(Tandon S.,2009).**

. The Caries Meter L uses colored lights to indicate caries extent.

*Green-sound

*Yellow-enamel caries

*Orange-dentinal caries

*Red-caries reaching the pulp

Figure 12; caries meter L device.

2.2.7.3 Electronic caries monitor (ECM)

The ECM device employs a single, fixed-frequency alternating current which attempts to measure the 'bulk resistance' of tooth tissue **(Longbottom**

Cand Huysmans MC.,2004) 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. It is generally accepted that the increase in porosity associated with caries is responsible for the mechanism of action for ECM, **(Huysmans MCand Longbottom C, 2000)** There are number of physical factors that will affect ECM results. These include the temperature of the tooth, **(Huysmans MCand Longbottom C,2000)** the thickness of the tissue, **(Wang Jand Sakuma S A,2000)** the hydration of the material (i.e. one should not dry the teeth prior to use) and the surface area. **(Longbottom Cand Huysmans MC.,2004)** The ECM readings may range between -0.70 and 13.20 indicating increased conductance .

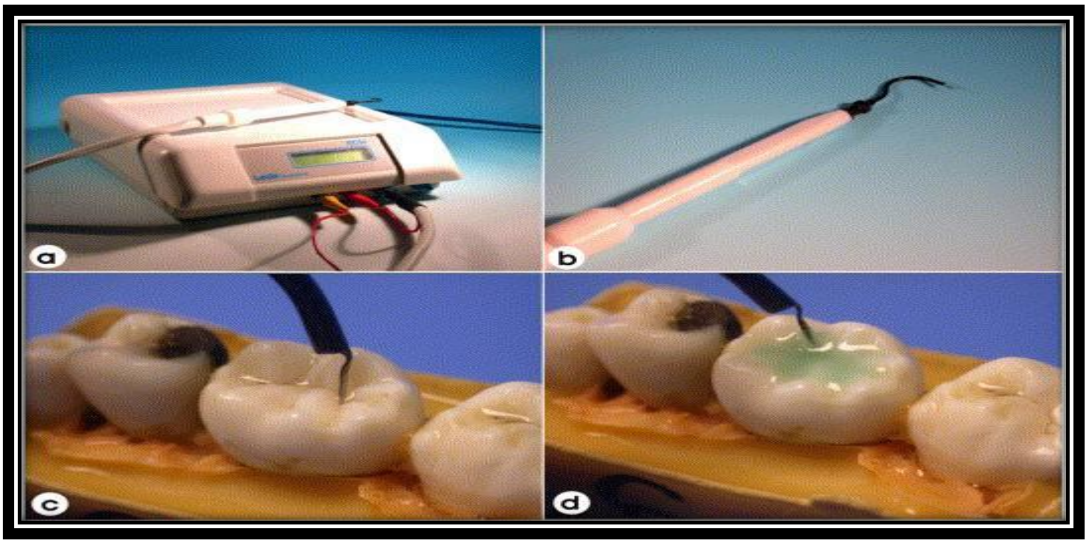

Figure 13: The Electreonic Caries Monitore device (version 4) and its clinical application: (a) The machine; (b) The handpiece; (c) Site-specific measurement technique; (d) Surface-specific measurement technique.

2.2.8 Ultrasonics (Ultrasound Caries Detector)

The principle behind the technique is that sound waves can pass through gases, liquids and solids and the boundaries between them.Images of tissues can be acquired by collecting the reflected sound waves. In order for sound waves to reach the tooth they must pass first through a coupling mechanism, usually water and glycerine **(Hall Aand Girkin JM.,2004).**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 **(Çalışkan and Yanikoğlu F,2000)** .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 **(Tandon S.,2009).**

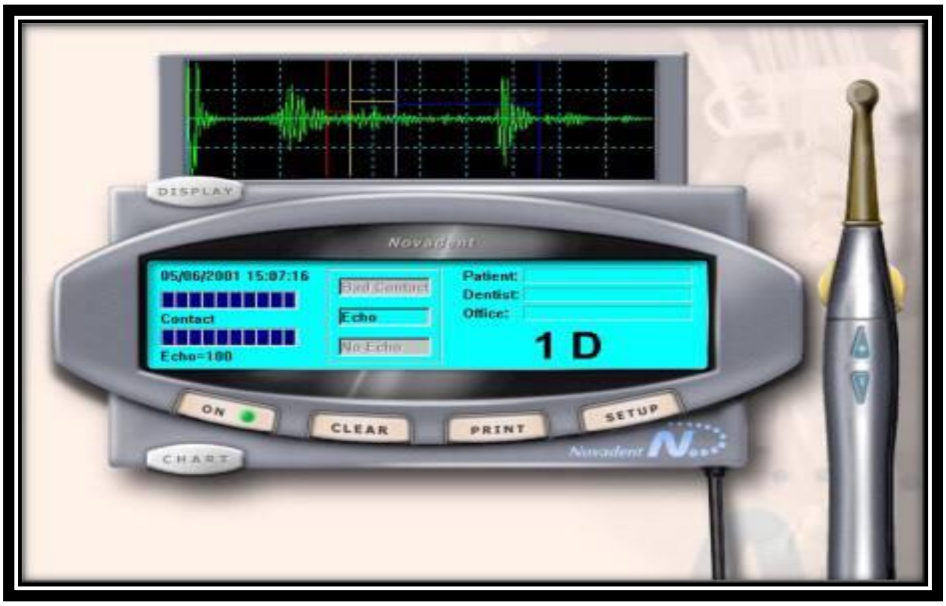

Figure 14; ultrasound caries detector.

2.9 Micro Air Abrasion

This method allows the examination of dark areas in the bottom of the pits and fissures. If a darkened area is considered as decay, the abrasion technology is used to deliver alumina particles to the suspicious area. If this darkened area is stain or organic plug, it will be cleaned by abrasion leaving the sound tissue behind **(Tandon S.,2009).** Usually after the bursting of the particles the underlying decay masked by the stain is revealed. This undetected caries may even be a deep lesion. Further application of abrasion can be used to remove the caries until the healthy tooth structure is revealed **(Goldstein REand Parkins FM.,1995).**

Figure 15; micro air abrasion.

2.2.10 Tuned Aperture Computed Tomography

This technique was recently introduced and is still under development. The image produced with this technique is the three-dimensional image of the original object. Detection of demineralization and vertical root fractures is possible with this method **(Dobhal Aand Agarwal A,2011**)Compared to present detection tools used, tuned aperture computed tomography (CT) has a promising future for the detection of recurrent caries. It is possible to slice the coronal anatomy into pieces and observe the interested region. The main advantage of this technique is that it offers the examination of individual projections of an area **(Tandon S.,2009).**

Figure 16; Tuned Aperture Computed Tomography.

3. Conclusion

The emerging biofilm science is changing how the dental profession looks at dental caries as a disease model. This more accurate, but also more complex, picture of dental caries anticipates the need for new technologies to better assess, detect, and diagnose signs of disease presence, progression, and activity levels. By early and accurate identification of dental caries, medical model therapies and minimally invasive surgical procedures provide patients with the best predictable treatment outcomes possible today. Tomorrow they may provide the answers to the prevention-oriented profession G.V. Black envisioned so many years ago .The caries detection tools aim the early detection of caries and prevent the progression of caries from demineralization to cavitation. None of the mentioned techniques alone are sufficient for diagnosis of dental caries. In the future, with the development of the diagnostic tools, small changes in the tooth structure will be detected and the dental structures will be protected by implementing preventive treatments.

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