Diagnosis of dental caries

Tooth caries is chronic, progressive, and bacterial diseases. The main characters of tooth caries are the changes in color, shape, and quality of tooth hard tissue. The typical pathological changes have important reference value for caries diagnosis. At present, the methods for dental caries diagnosis are mainly based on clinical inspection and X-ray examination. However, it is difficult to identify early caries which is in the hidden area of the tooth. Prevention is at its most effective when detection is early within the natural history of the dental caries. The failure to detect early caries, leaving those detectable only at the deep enamel, or cavitated stage, has resulted in poor results and outcomes for remineralization therapies. Therefore, the ability to monitor early lesions and determine if they have indeed arrested or stabilized is also key to ensuring that effective prevention can become commonplace in general dentistry.

Diagnosis is a decision process and is informed by, initially, detection of a lesion and should be followed by an assessment of the patient's caries risk, which may include the number of new and past caries lesions, diet, presence or absence of modifying factors (salivary flow, mutans streptococci counts, oral hygiene), and qualitative aspects of the disease such as color and anatomical location. These detection systems are therefore aimed at augmenting the diagnostic process by facilitating either earlier detection of the disease or enabling it to be quantified in an objective manner. The problem of diagnosis is related to sensitivity versus specificity.

Detection systems of caries

- visual and tactile examinations
- Radiographic techniques
- Electrical current measurement (electronic resistant method)
- Fiber Optic Transillumination (FOTI and DiFOTI) (Enhanced visual techniques)
- Fluorescent techniques
- Other techniques like Dyes, Ultrasound techniques, Photo-thermal Radiometry.

Visual and tactile examinations

Visual inspection, the most widespread caries detection system, is subjective. Assessment of features such as color and texture are qualitative in nature. These assessments provide some information on the severity of the disease. They are also limited in their detection threshold, and their ability to detect early, noncavitated lesions restricted to enamel is poor. Carious lesions come in various sizes, surface features and colors. The vast majority of carious lesions are detected by dentists using visual methods. The use of accompanying tactile examination is not recommended because rigorous probing of lesions can lead to cavitation and deep bacterial invasion. The use of a blunt probe, ideally a periodontal probe, can be used to detect differences in surface roughness. Detection of initial caries by sharp probe may lead to cavity formation which reducing the chance of remineralization of intact surfaces. Tactile examination using explorers allows for detection of roughness, soft floors, frank cavitation, white spot lesion as non cavitated. Good dryness is recommended while detection of initial lesion. A clinical caries examination performed according to these principles takes about 5–10 min, depending on the caries status of the patient. Caries on proximal contact area is difficult to be examined by inspection and probing. Dental floss can be used as a convenient method. The floss will be torn if caries is present. Examination with floss can be misled by dental calculus. Different types of separators can be used as orthodontic rubber rings for several days as diagnostic aids. The effectiveness of a visual–tactile caries examination depends strongly on the caries diagnostic level used. When non-cavitated diagnoses are included in the classification, the diagnostic yield of the visual–tactile caries examination is greater than that of radiographic examination

Benefits of visual and tactile examinations

- Is quick and easy to perform.
- Does not need expensive equipment.

Radiographic techniques

Radiographic examination (traditional and digital) can be helpful in locating proximal caries and undermining caries and secondary caries. It can also be used to

assess the proximity of caries to pulp chamber. It is non-invasive technique in caries diagnosis. Periapical and bite-wing radiographs are commonly used for clinical assessment of caries. Using bite-wing radiographs raise the sensitivity of the diagnosis if obvious dentin caries activity to be detected but can be inaccurate if diagnosing enamel occlusal caries activity. Radiolucency on hard tissue due to demineralization is identified as carious lesion. Digital radiography has offered the potential to increase the diagnostic yield of dental radiographs, it also offers a decrease in radiographic dose and thus offer additional benefits than diagnostic yield. Digital images can also be archived and replicated with ease. Using digital radiographs offers a number of opportunities for image enhancement, processing, and manipulation. One of the most promising technologies in this regard is that of radiographic subtraction, which has been extensively evaluated for both the detection of caries and also the assessment of bone loss in periodontal studies. Miss diagnosis by radiograph can occur as a result of superimposition, angulation of cone, difficulty of film position.

The intervals between bitewing examinations should be based on individual risk assessment. Annual examinations should be considered in the following situations:

• age 5–7: one or more approximal dentin lesion or several approximal enamel lesions in primary molars

• age 7–12 (mixed dentition): a permanent first molar with approximal caries, half through the enamel or several approximal lesions in primary molars

• age 12–13: – one or more approximal dentin lesion or restored approximal surface – three or more approximal enamel lesions – any unrestored approximal dentin lesion – a recently restored approximal neighboring surface.

The degree of caries risk should be reassessed individually by considering the number of new lesions, and progression of existing lesions, as well as other relevant risk factors. The interval to the next bitewing examination is adjusted accordingly. Intervals shorter than 1 year are seldom indicated. A 6-month interval is, however, advocated if several approximal dentin lesions are left unrestored. This applies to children and young adults.

Electrical current measurement

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. The Electronic Caries Monitor (ECM) device employs a single, fixed-frequency alternating current, which attempts to measure the 'bulk resistance' of tooth tissue. A number of physical factors also will affect ECM include the temperature of the tooth, the thickness of the tissue, the hydration of the material, and the surface area. A major advantage of ECM is to present objective readings which have the potential for monitoring lesion progression, arrest, or remineralization.

Fiber Optic Transillumination (FOTI and DiFOTI)

The basis of visual inspection of caries is based upon the phenomenon of light scattering. Sound enamel is comprised of modified hydroxyapatite crystals that are densely packed, producing an almost transparent structure. The color of teeth, for example, is strongly influenced by the underlying dentin shade. When enamel is disrupted, for example in the presence of demineralization, the penetrating photons of light are scattered (that is, they change direction, although do not lose energy), which results in an optical disruption. In normal, visible light, this appears as a 'whiter' area called white spot. This appearance is enhanced if the lesion is dried; the water is removed from the porous lesion. Water has a similar refractive index (RI) to enamel, but when it is removed and replaced by air, which has a much lower RI than enamel, the lesion is shown more clearly. This demonstrates the importance of ensuring the clinical caries examinations are undertaken on clean, dry teeth. Fiber-optic transillumination (FOTI) is a diagnostic method by which visible light is transmitted through the tooth from an intense light source, for example from a fine probe with an exit diameter of 0.3–0.5 mm. If the transmitted light reveals a shadow when the tooth is observed from the occlusal surface this may be associated with the presence of a carious lesion. The narrow beam of light is of crucial importance when the technique is used in the premolar and molar region. For optimal performance the probe should be brought in from the buccal or lingual aspect at an angle of about 45 degrees to the approximal surfaces pointing apically, while looking for dark shadows in the enamel or dentin.

Shadows are best noticed when the office light is switched off. Although transillumination is a simple, fast and cheap supplementary method well known to most practitioners for diagnosing approximal caries in the anterior teeth, the fiber-optic method has never become broadly accepted for detection of lesions in approximal surfaces in the premolar and molar regions. The sensitivity has been shown to vary between 50 and 85%, with higher values for dentin lesions than for enamel lesions. Although the specificity of the method has also been reported to be high, over 95%, it remains to be documented that FOTI adds substantially to the clinical caries examination for detecting lesions. FOTI is used to detect lesion in anterior area, it is adjuvant to visual and radiographic examination but its limitation as failure sometimes in the detection of very small lesions.

Digital Imaging Fiber Optic Transillumination (DIFOTI) is used for detection of both incipient and frank caries in all tooth surfaces, fractures, cracks and secondary caries around restoration. This is a digitized and computed version of the FOTI.

DIFOTI uses white light to transilluminate each tooth and to instantly create high-resolution digital images of the tooth. It is based on the principle that carious tooth tissue scatters and absorbs more light than surrounding healthy tissue. Decay near the imaged surface appears as a darker area against the more translucent brighter background of surrounding healthy anatomy.

Fluorescent techniques

Quantitative Light-induced Fluorescence Technique (QLF)

QLF is light emission phenomenon of biological structure. The autofluorescence of dental tissue decreases in demineralization of the tissue. Quantitative light induced fluorescence devices use high-intensity halogen lamp (blue light 488 nm) to stimulate the tooth to emit the fluorescence in green spectrum. This reflected light is detected by spectrum and recorded in computer and demineralization is quantified. QLF is a visible light system that offers the opportunity to detect early caries and then longitudinally monitor its progression or regression. It may also be able to image plaque, calculus and determine if a lesion is active or not and predict the likely progression of any given lesion. Fluorescence is a phenomenon by which an object is excited by a particular wavelength of light

and the fluorescent (reflected).

QLF has inability to detect or monitor interproximal lesions and is limited to measurement of enamel lesions several hundred micrometers depth.

Laser fluorescence - DIAGNODent

It is another device employing fluorescence to detect the presence of caries. Using a small laser, the system produces an excitation wavelength of 655 nm, which produces a red light. This is carried to one of two intra-oral tips: one designed for pits and fissures, and the other for smooth surfaces. The tips both emits the excitation light and collects the resultant fluorescence. The device doesn't produce an image of the tooth, it displays a numerical value. The device is aimed in detection of occlusal and smooth surface lesions. The threshold between occlusal caries limited to enamel and caries into dentin was found to be around 18 under humid conditions. Clinically visible white spot lesions are measurable with this device. However, very initial lesions, with no fluorophores from bacteria present, are not captured by the DIAGNOdent. The same registration under dry conditions led to higher cut-off point. The intensity of the fluorescent light is displayed as a number ranging from 0 to 99, with 0 indicating a minimum and 99 a maximum of fluorescent light.

A new version of the method was designed named DIAGNODent pen permits assessment of both occlusal and proximal surfaces. The device works on the principles of the old version but the design is different. After excitation, the tip collects the fluorescence and translates it into a numerical scale from 0-99.

For both DIAGNOdent devices, careful tilting on occlusal surfaces around the spot to be measured is crucial for adequate detection.