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Caries Diagnostic Techniques in Pediatric Dentistry

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Abstract: During the past few decades, changes have been observed not only in the prevalence of dental caries, also in the distribution patterns of the disease and the rate of progression of caries. These changes have implication on predicting the caries risk, diagnosis, and management of incipient lesions. New strategies were introduced to provide improved detection, risk assessment and diagnosis and to create improved method to arrest or reverse the non-cavitated lesion while improving the management of cavitated lesion

Keywords: Caries Diagnosis, Pediatric dentistry

Introduction

The child patient presents a challenge to the dentist, who must solve the problems of today with an eye to the future and the dental health of an adult. The proper management of dental caries in clinical practice requires an accurate clinical diagnosis. Accurate diagnosis can only be achieved by systematic and methodical collection of data. At the clinical dental practice level, caries diagnosis also has a significant impact since it rules treatment decisions. The diagnosis of early caries lesions has been considered the cornerstone of cost-effective health care delivery and quality of dental care. Early diagnosis of the caries lesion is important because the carious process

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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. 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. [1]

Caries detection is entering a new era, with technologies capable of both detecting lesions at an earlier stage of development and quantifying the impact of non invasive professional fluoride treatments such as fluoride varnishes. There are several different instruments available on the market that may be able to assist with the early detection of caries. Currently available technology and improvements in the future will enhance accuracy in detection of caries improving the oral health of the public. This literature review focuses on various caries diagnostic techniques in pediatric dentistry compiling all the conventional caries detection modalities and the recent advances along with the future perspective taking into consideration the recommendation and precautions to be taken for a child patient.

A] Traditional methods

i. Patient complaint
ii. Clinical examination
iii. Visual - Tactile examination
iv. Tooth separation
v. Dental floss/tape
vi. Radiographic examination

B] Based on X rays

i. Digital radiography
ii. Digital Image enhancement
iii. Digital subtraction radiography
iv. Tune aperture computed tomography
v. Computer aided diagnosis

C] Based on light

i. Laser fluorescence measurement (DIAGNODENT)

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ii. Quantitative light induced fluorescence (QLF)
iii. Digital imaging fibre optic transillumination (DIFOTI)

D] Based on electrical current

i. Electrical conductance measurement
ii. Electrical impedance measurement
iii. Alternating current impedance spectroscopy

E] Recent Advances

i. Xeroradiography
ii. Dyes (Procion)
iii. Endoscopic filtered fluorescence
iv. Ultrasonic Imaging

i. Patient History

Knowing certain factors pertaining to the patient's history can assist in the diagnosis of caries and identification of high risk patients. Such factors include age, gender, fluoride exposure, smoking habits, alcohol intake, medications, dietary habits, economic and educational status, and general health, increased smoking, alcohol consumption, use of medication and sucrose intake result in increased risks for caries development. Poor general health also increases the risk. However, past caries experience is the best predictor of future caries activity.[2]

ii. Clinical Examination

General information regarding inadequate salivary functioning. Plaque accumulation, inflammation of soft tissues, poor oral hygiene, cavitated lesions, and existing restorations also are instructive in determining potential risk to caries development. Assessing individual tooth surface for cavitation is crucial. If cavitation has occurred, usually restorative, intervention is required. However, examination of tooth surfaces for cavitation must be accomplished judiciously, primarily using visual assessment of discoloration, translucency, or opacity.[3]

iii. **Visual and Tactile Diagnosis**

In 1924, Greene Verdiman Black suggested the use of sharp explorer. If there was a "catch" then the surface was counted as decayed. Simon 1956, Gilmore 1982, Marzouk

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1985 and Studervant 1985, all supported the use of explorer for caries detection. Visual-Tactile method - A mouth mirror & sharp Probe; A mouth mirror & blunt Probe; Light, a mouth mirror & Blunt Probe.[2]

iv. **Tooth Separation**

Use of Orthodontic elastic separators for temporary tooth separation; for diagnosis of approximal smooth surface caries; Definitive assessment of extend and depth of the lesion.

v. **Radiography**

With the discovery of X – rays by Roentgen in 1895, radiography has been used to detect Dental caries primarily used for detecting lesions on proximal surfaces and for occlusal surface lesions, once progressed into dentin. As caries process proceeds, the mineral content of Enamel & Dentin decreases with the resultant decrease in attenuation of X – ray beam as it passes through the teeth and this area appears radiolucent on the radiograph.[3]

1) **Periapical View-** Periapical views are used to record the crowns, roots, and surrounding bone. Film packs come in three sizes: 0 for small children (22 X 35 mm); 1, which is relatively narrow and used for views of the anterior teeth (24 X 40 mm); and 2, the standard film size used for adults (31 X 41 mm) [45]
2) **Bitewing View-** Bitewing (inter proximal) views are used to record the coronal portions of the maxillary and mandibular teeth in one image. They are useful for detecting inter proximal caries and evaluating the height of alveolar bone. Size 2 film usually is used in adults; the smaller size 1 is preferred in children. In small children size 0 may be used. A relatively long size 3 also is available.

3) **Occlusal View -** Occlusal film is more than three times larger than size 2 film (57 X 76 mm) It is used to show larger areas of the maxilla or mandible than may be seen on a periapical film. These films also are used to obtain right angle views to the usual periapical view. The name derives from the fact that the film usually is held in position by having the patient bite lightly on it to support it between the occlusal surfaces of the teeth.[4]

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i. DIRECT DIGITAL RADIOGRAPHY:

It consists of charged coupled devices (CCD) and complementary metal oxide semiconductors (CMOS). The intensity of the x-ray beam is measured directly by light sensitive elements. The output of the elements is fed to the computer as an electric signal and is digitized in the frame grabber.[5-6]

CCD: These were invented in 1970's by BELL lab. They consist of thin wafer silicon crystals arranged in rectangular lattice. They consist of an array of light sensitive/ x- ray sensitive pixels. Each pixel has thousands of photoelectric cells that generate voltage in proportion to amount of light/ x- rays striking them. The Covalent bonds between Silicon atoms are broken by 1.1V. The Resultant electronic image is converted to digital image by analog to digital converter in the form of 256 gray shades. [6]

ii. THE RVG SYSTEM

The system comprises four main components: an x-ray set with special timer, an intra-oral sensor, a display processing unit and a printer.

iii. DIGITAL IMAGE ENHANCEMENT

The diagnostic performance of dentists in diagnosing small carious lesions from film radiographs and digital radiographs was investigated by Verdonschot et al. 1992. It was demonstrated that the diagnostic performance from film radiographs exceeded that from unenhanced digital radiographs. When the diagnostic task was to discriminate between 'caries' and 'no caries', enhanced radiographs performed equally well. With the decision cut-off between 'dentinal caries' and 'no dentinal caries', the sensitivity was statistically significantly superior to that of radiographs, but this enhancement was also associated with a statistically significant reduction in specificity. [12]

iv. SUBTRACTION RADIOGRAPHY [6]

It is a procedure in which time 1 digital image of a specific anatomic area is subtracted from time 2 image of the same anatomic area to get an image of between the two areas. Digitalization achieved by taking a picture of radiograph in a video camera. This is fed on computed imaging device digitizer. Two such radiographs with identical exposure are used. First Image – Reference image and subsequent image for comparison. The reference image, displayed on screen and subsequent image is superimposed. The difference b/w original & subsequent image will show as dark bright areas, which are interpreted readily

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v. TUNED APERTURE COMPUTED TOMOGRAPHY (TACT) [7]

Tuned aperture computed tomography (TACT), more generalized application of the principles of tomosynthesis, may help to improve accuracy in caries diagnosis because of its three-dimensional (3-D) or pseudo-three-dimensional capabilities. TACT reconstruction provides the ability to sample slices of anatomy at varying levels within a structure. Similarly, pseudo-tridimensional representations of an object, known as pseudoholograms, can be generated by sequentially displaying two-dimensional image frames from different angles. TACT is a relatively new technology. Similarly, the TACT radiographic data acquisition scheme is subject to numerous variation and few restrictions. The selection of the most appropriate projection geometry and angular disparity to be used is dependent on the diagnostic task.

vi. COMPUTER AIDED RADIOGRAPHIC METHOD [8]

Variation between observers in interpretation of radiographs is well known. Development of Computers has made possible use of automated procedures to overcome the shortcomings of human eye.

Software has been developed for automated interpretation of digital images and this software is integrated in the system. Example: In Trophy 97 system, an artificial intelligence software (Logicon caries detector) is integrated

Radiographic Selection Criteria

The decision to perform radiography is taken on the basis of complete evaluation and examination of the patient. Dental radiography is done when there is either a suspicion of a disease; or a left untreated disease that threatens the health of the teeth. Hence, the decision to use radiography should be based on professional judgment. Selection criteria include symptoms that allow the dentist to determine who can benefit from radiography.

Two criteria are important when deciding on radiography to be; the dental evolution stage;the risk of dental caries

Effective dose

The effective dose for common dental radiography varies ranging from around 1.5μSv for intraoral radiographs to between 2.7 to 24μSv for panoramic radiography. Particular attention should be paid to children because they are more susceptible to radiation risk than adults. There are some specific criteria and guidelines to aid the dentist in determining the need for dental radiographs. Needless to say, special attention should be applied for pediatric patients due to their

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markedly higher radiation sensitivity.

Radiation Rate in Dental Radiography for Children

According to scientific data, the maximum virtual ray that one person can receive per year is 5,000 µSv So, if a person falls below this limit, there is nothing to worry. Ordinary dental radiography only radiates about five millimetres in the mouth and jaw. Therefore, if more than 1,000 radiographs of this type are taken, there is a risk of complications. Each person naturally absorbs approximately 350 µSv of radiation from the surrounding environment annually. Therefore, taking into account the environmental rays, each person can even take radiographs up to 70 times a year from all teeth. Radiation doses to ordinary people from various sources are 2.5 µSv/year, out of which, 15 percent of the radiation contribution is from radiation sources of medicine.

1) LASER CARIES DETECTION[14]

The Diagnodent device: This is based on commercial development of laser fluorescence. It is a chair side battery powered quantitative diode LF device. The unit emerges light of 655nm wavelength through the descendent optic fibre from the hand held probe with beveled tip and fibre optic eye. Both organic and inorganic molecules in the tooth absorb the light, and fluorescence within the infrared spectra.[9]The emitted and back-scattered ambient light is collected through the tip and passed through ascending fibres to photo-diode detector. The back-scattered short wavelength ambient light is absorbed by band pass filter in front of diode detector. To discriminate the fluorescence from the ambient light, the laser diode is modulated. By amplifying the modulated portion of the signal, the ambient light is suppressed. [11]

2) **QUANTITATIVE LIGHT INDUCED FLUORESCENCE [9]**

Mineral loss caused by carious destruction of tooth can be detected and measured as change in fluorescence of tooth substance when exposed to laser light. Light interacts & Dental hard tissues in different ways a) Reflection; b) Scattering; c) Transmission; d) Absorption; e) Absorption with fluorescence. Electrons in lower status are moved to a higher status and when they fall back to the original situation, energy is emitted in the form of light called fluorescence. The cause of Enamel fluorescence is unclear may be due to organic components, Proteinic Chromophores and apatite (Spitzer & Ten Bosch – 1976). In sound enamel, path lengths are long with a high probability that the photons will hit a chromophore. So fluorescence is relatively intense. Demineralization results in loss of auto fluorescence.

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3) FIBRE OPTIC TRANSILLUMINATION (FOTI) [9]

Was initially designed for detection of proximal caries (Friedman & Marcus in 1970)By this method caries or demineralized areas in dentin or enamel will be shown as darkened areas. Because light is absorbed more and lower index of light transmission, since decay process disrupts the crystalline structure of Enamel or Dentin which gives the area more darkened appearance. Fiber optics consists of halogen lamp, rheostat to produce light of variable intensity. The 150-watt lamp generates maximum light intensity of 4500 lx at the end of 2mm diameter cable.

4) DIGITAL FIBRE OPTIC TRANSILLUMINATION: (DIFOTI)

Is a new methodology, developed to reduce the shortcomings of FOTI by combining FOTI & Digital camera. Illumination is delivered on tooth surface by Fibre optics, which acts as light source. The resultant change in light distribution is captured by camera and sent to computer for analysis Use of Digital Camera allows instantaneous image. Used to compare clinical changes between several images of the same tooth over time.

1. **ELECTRICAL CONDUCTANCE MEASUREMENT (ECM):** Magitot gave this idea in 1987. The entire occlusal surface is first covered with a conducting medium. Conductivity from occlusal surface to ground electrode is measured in a probe. An increase in conductivity is due to development of microscopic demineralized cavities within enamel, which are filled with saliva.[15]
2. **ALTERNATING CURRENT IMPEDANCE SPECTROSCOPY (ACIST):** This characterizes the electrical properties of a tooth and lesion to monitor and quantify change. If alternating current is applied on a tooth bathed in saliva, ionic current will flow. This method measures the size of pores. Repeated measurement over time to see whether pores are getting bigger or smaller and subsequently whether caries is progressing or reversing.[9]

Recent Advances

1) Xeroradiography: Xeroradiography which is a method of imaging uses the xeroradiographic copying process to record images produced by diagnostic X-rays. It differs from halide film technique in that it involves neither wet chemical processing nor the use of dark room. The imaging method was discovered by an American physicist, Chester Carlson in 1937. Pogorzelska-Stronczak became the first to use xeroradiograph to produce dental images with extraoral dental use in cephalometry, sialography, and panoramic xeroradiography. [10]

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2) Dyes: Dyes are used 1) To visualize a subject from its routine background. 2) To discriminate the subject from others.[13]

3) Procion: Staining becomes irreversible because dye reacts with N2 & OH-groups of enamel and acts as fixative.

4) Calcein: This dye makes complex with calcium and remains bound to lesion.

5) Fluorescent dye: EgZyglo ZL-22 used in In -vitro study but not suitable for in-vivo. Dye is made visible by illumination.

6) Brilliant Blue: Has been used to enhance the diagnostic quality of FOTI

7) Endoscope: This technique based on observing the fluorescence that occurs when tooth is illuminated in blue light of wavelength ranging 400 – 500 nm. Difference is seen in the fluorescence of sound enamel and carious enamel. When this fluoresced tooth is viewed through a specific broadband gelatin filter, white spot appears darker than enamel. A white light source can be connected to an endoscope by fibreoptic cable so that teeth can be viewed without a filter. This is called "White Light Endoscopy". [9]

8) Videoscope: A camera integrated to Endoscope is called as Videoscope. A miniature colour video camera is mounted to metal mirror holder. It is designed in such a way that image of the surface of enamel can be viewed directly over T.V Screen. [9]

9) Ultrasound or Ultrasonic Imaging: This method utilizes a sonar device in which beam of waves is directed against tooth surface and reflected wave is picked up by appropriate receiver.[11]

Conclusion

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. 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. The diagnostic method of choice depends on the purpose of the examination. Apart from the occult fissure lesion penetrating deeply into the dentin, difficulties in clinical detection and registration arise not with the advanced lesion but primarily with the early lesion (confined to the outer enamel), the non-cavitated lesion of dentin, recurrent caries (around the margins of restorations), and subgingival root caries.

The general trend in clinical examination is away from reliance on gentle probing with a

sharp explorer, toward meticulous visual inspection (sharp eyes and a blunt probe) for early detection of non-cavitated lesions. Various innovative devices designed for dental caries detection have shown a range of accuracy with regard to specificity and sensitivity compared to traditional visual and radiographic examination. No single device or method alone is sufficient to adequately diagnose carious lesions in all sites. A combination of diagnostic methods and devices greatly increases the ability to detect caries in its earliest stage which will allow for a preventive treatment approach rather than more costly and invasive operative interventions.

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