International Journal of Innovative Research and Advanced Studies (IJIRAS)
Volume 6 Issue 5, May 2019

ISSN: 2394-4404

Optical Diagnostic AIDS In Endodontics - A Review

Dr. Anil. K. Tomer

Professor and Head, Department of Conservative Dentistry & Endodontics D.J. College of Dental Sciences and Research, Modinagar, Ghaziabad, Uttar Pradesh, India

Dr. Panna Mangat

Professor Department of Conservative Dentistry & Endodontics D.J. College of Dental Sciences and Research, Modinagar, Ghaziabad, Uttar Pradesh, India

Dr. Afnan Ajaz Raina

Dr. Megna Bhatt

Dr. Hysum Mushtaq

Dr. Ayush Tyagi

Post Graduate Student, Department of Conservative Dentistry & Endodontics D.J. College of Dental Sciences and Research, Modinagar, Ghaziabad, Uttar Pradesh, India

Dr. Faizan Bin Ayub

Post Graduate Student, Department of Orthodontics & Dentofacial Orhtopedics, D.J. College of Dental Sciences and Research, Modinagar, Ghaziabad, Uttar Pradesh, India

Abstract: Endodontics has seen a major a remarkable growth in relation to diagnostic aids. For a successful treatment outcome, one needs to correctly diagnose the disease. Recently new diagnostic aids have come up with a more reliable outputs. The aim of this review therefore is to assess the usefulness of some optical diagnostic aids and techniques used in endodontic therapy to make the correct pulpal diagnosis.

I. INTRODUCTION

Diagnosis is often derived from personal and cognitive experiences. Good diagnosticians use past experience, based on knowledge and diagnostic tools. To become a successful diagnostician, one must develop a number of assets. The most important of these are knowledge, interest, intuition, curiosity, and patience.

Once the status of the patient's general health has been established, a dental history follows. This is best developed by following the time-honored formula of determining the chief complaint- the reason the patient is seeking care. It is usually documented in the patient's words, or in the case of a young minor, the parent's or guardian's words. This verbal description of the problem is often aided by hand gestures and the patient pointing to a general area of discomfort. After obtaining the chief complaint, the examination process is continued by obtaining a dental history of the present illness enlarging on this complaint with questions about the present dental illness, relating the history of past dental illness to the chief complaint, and combining this with information about the patient's general health (medical history) and the examination results- which follow a logical sequence, from the general to the specific, from the more obvious to the less obvious, from the external to the internal. The results of the examination, along with information from the patient's history, will be combined with the clinical testing to establish the diagnosis, its differential diagnosis formulate a treatment plan, and determine the prognosis.

II. OPTICAL METHODS

FIBER-OPTIC TRANSILLUMINATION

- ✓ Fiber optic transillumination works under the principle that since a carious lesion has a lowered index of light transmission, an area of caries appear as a darkened

ISSN: 2394-4404

shadow that follows the spread of decay through the dentin. Fiberoptic consists of halogen lamp and a rheostat to produce a light of variable intensity. The 150 watt lamp generates a maximum light intensity of 4000 lx at the end of 2mm diameter cable.

- ✓ Two attachments are used: a plane mouth mirror mounted on a steel cuff and a fiberoptic probe of 0.5mm diameter so that it can be placed in the embrasure region. It produces a narrow beam of light for transillumination. A rheostat is set to give a light of maximum intensity. For examination, the tip of the probe is placed in the embrasure immediately beneath the contact point of the proximal surface to be examined either on the buccal or lingual surface depending on the tooth.
- ✓ The basis for FOTI is that the decayed tooth material scatters light more strongly, and thus has a lower index of light transmission than a sound tooth structure. This 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

ADVANTAGES

- ✓ No hazards of radiations
- ✓ Simple and comfortable for the patients
- ✓ Lesions which cannot be diagnosed radio-graphically can be diagnosed by this method.
- ✓ Not time consuming

DISADVANTAGES

- ✓ Permanent records are difficult to maintain
- ✓ It is subjected to inter and intra observer variations.
- ✓ Difficult to locate the probe in certain areas.[2]

DIGITAL IMAGING FIBER-OPTIC TRANSILLUMINATION - DIFOTI

Developed by Schneidermann et al, Images of teeth are obtained using visible light via fiber optic transillumination. Light propagates from the optic fiber through the tooth to a non-illuminated surface (usually the opposite surface). The images are acquired by a digital electronic CCD camera. The acquired data are sent to a computer for analysis and stored in a database for comparative review of images overtime. DIFOTI operates with an intense band of white light that covers the entire visible spectrum and literally shines through the tooth from any angle above the gum line.

BENEFITS OF DIFOTI

- ✓ Has the potential to enable dentists to detect demineralization on all tooth surfaces.
- ✓ It can also be used to inspect the integrity of the tooth for fractures, decalcification and wear and integrity of amalgam, composites, sealants, orthodontic bands.
- ✓ Eliminates or reduces the intra – and inter examiner variation of visual detection using FOTI.
- ✓ As the digital images can be viewed instantaneously, DIFOTI enables to truly educate a patient during an examination and discuss recommended treatment options.
- ✓ Can monitor the progress of chemical caries control measures.
- ✓ The images can be stored on a PC database, printed or transmitted over the internet.

DISADVANTAGES

- ✓ A proximal lesions can be picked up by using DIFOTI only by careful angulation
- ✓ Does not measure lesion depth since the resulting image is that of a surface or what is near the surface
- ✓ Inability to quantify lesion progression, even though images can be compared over time.
- ✓ With the greater sensitivity and somewhat lower specificity there is real possibility of over diagnosis
- ✓ Accentuates the surface difference between less dense mineral and normal tooth mineral even more so than radiography because of its greater sensitivity.
- ✓ Does not detect caries which is a subsurface phenomenon in early stages, it detects surface changes to visible light. It is upto the clinician to interpret these images and come up with a clinical diagnosis.

III. QUANTITATIVE LIGHT FLUORESCENCE

- ✓ QLF is a dental diagnostic tool for in-vivo and in-vitro quantitative assessment of dental caries lesions, dental plaque, bacteria activity, calculus, staining, and tooth whitening. 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. QLF™ uses the principle of fluorescence to reveal dental caries. In QLF this light is not induced by X-rays or other ionizing radiation but by visible or near ultraviolet radiation. The fluorescence of tooth tissue has been known for a very long time. Spectra have been given by many authors. Three types of fluorescence have to be distinguished.
- ✓ The first is the blue fluorescence that is excited in the near ultraviolet.
- ✓ The second is the yellow and orange fluorescence excited in the blue and green.
- ✓ The third is the fluorescence in the far red and near infrared that has recently received much attention for quantitative non- image diagnosis of caries lesions.

LASER AUTO FLUORESCENCE

- ✓ Visible light within the blue green region has been used as a light source for the development of smooth surface and fissure caries at an early stage (Bjelkhagen et al.,1982).

- ✓ The tooth is illuminated with a broad beam of blue green light of 88 nm wavelengths from an argon ion laser and the fluorescence observed in the540nm range. This fluorescence of enamel occurring in the yellow region is observed through yellow high pass filter to exclude the tooth scattered blue light. Demineralised areas appear dark in this region.
- ✓ Healthy tooth fluoresces differently from that of carious tissues impregnated with fluorescent dyes.
- ✓ Demineralised tissues absorbs dyes like Fluorol TGA, sodium fluorescence etc. This is referred to as dye enhanced laser fluorescence.

DIAGNODENT

- ✓ DIAGNOdent contains a laser diode (655 nm, modulated, 1 mW peak power) as the excitation light source, and a photo diode combined with a long pass filter (transmission > 680 nm) as the detector. The excitation light is transmitted by an optical fiber to the tooth, and a bundle of 9 fibers arranged concentrically around it serves for detection. The long pass filter absorbs the backscattered excitation and other short wavelength light and transmits the longer wavelength fluorescence radiation. To eliminate the long wavelength ambient light also passing through the filter, the laser diode is modulated, and only light showing the same modulation characteristic is registered. Thus, the digital display shows quantitatively the detected fluorescence intensity (in units related to a calibration standard).

FUNCTION OF THE DIAGNODENT

- ✓ The DIAGNOdent measures laser fluorescence within tooth structure. As the incident laser light is propagated into the site, two-way handpiece optics allows the unit to simultaneously quantify the reflected laser light energy.
- ✓ At the specific wavelength that the DIAGNOdent laser operates, clean healthy tooth structure exhibits little or no fluorescence, resulting in very low scale readings on the display.
- ✓ However, carious tooth structure will exhibit fluorescence, proportionate to the degree of caries, resulting in elevated scale readings on the display of the DIAGNOdent.
- ✓ An audio signal allows the operator to hear changes in the scale values, enabling focus on the patient and not solely on the device.

USE OF THE DIAGNODENT IN DAILY CLINICAL PRACTICE

- ✓ Generally, teeth to be assessed should be cleaned and dried to present optimal conditions for regular visual inspection, which should be the first diagnostic step. Thorough cleaning is a prerequisite for accurate caries detection.
- ✓ Drying makes decalcifications visible. It lowers the refractive index of the intercrystalline spaces, from 1.33 for wet demineralized tooth surfaces to 1.0 for dried demineralized tooth surfaces, thus making the opaque appearance of the decay clearly visible (Basting and Serra, 1999).
- ✓ If there is doubt about the status of health at any particular site, then more sensitive equipment should be used. This approach allows the dentist to combine the advantages of higher specificity and speed of clinical inspection with the higher sensitivity of the new devices. After enamel is dried, light-scattering is increased, and a lower fluorescence can be measured (Al-Khateeb *et al.*, 2002).
- ✓ In contrast, the performance (specificity, sensitivity) of the DIAGNOdent on dry tooth surfaces is not significantly different from that on moist surfaces. Further research is needed to investigate the exact influence of dehydration on DIAGNOdent readings, especially when caries is longitudinally monitored.
- ✓ The assessment of a tooth by means of the laser fluorescence system occurs as follows:
- ✓ After calibration with a ceramic standard, the fluorescence of a sound spot on the smooth surface of the tooth is measured to provide a baseline value. This value is then subtracted electronically from the fluorescence of the site to be measured.
- ✓ The laser system DIAGNOdent is useful on occlusal sites (tip A) and on smooth surfaces (tip B). Fluorescence measurements on approximal surfaces are hindered by the dimensions of both tips. To achieve the maximum extension of caries on occlusal surfaces, one must tilt the instrument around the measuring site. This ensures that the tip picks up fluorescence from the slopes of the fissure walls, where the carious process often begins.(FIG 46)
- ✓ A rising tone, starting with a value of 10, helps the examiner find the maximum fluorescence value of the site under study.
- ✓ The following associations between DIAGNOdent readings and states of caries were found: values 0-13 = no caries; values 14-20 = enamel caries; values > 20 = dentinal caries.

Another promising application of the DIAGNOdent is the detection of residual caries during excavation.

IV. ELECTRICAL RESISTANCE METHODS

- ✓ The low electrical conductance of a tooth is primarily caused by enamel. Enamel demineralistion results in increased porosity, and saliva fills the pores and forms effective pathways for electrical current.
- ✓ As a tooth demineralizes in the caries process, the loss of mineral leads to increased porosity in the tooth structure. This porosity is filled with fluid from the oral environment which contains many ions. Increased ionic content in the pores leads to increased electrical conductivity, or, conversely, increased porosity leads to decreased electrical resistance or impedance.
- ✓ Three types of instruments have been developed for electrical caries measurements.
- ✓ One type incorporates a probe with a coaxial air flow, resistance of the tooth being measured where touched by the probe tip as the surrounding enamel is being dried. Ex.

Electronic Caries Monitor, ECM, Lode Diagnostics, Netherlands.

- ✓ The second type has a solid probe which is placed on the previously air dried surface of a tooth. Ex. Caries Meter L, Onuki Dental Co Ltd., Japan.
- ✓ The Vangaurd Electronic Caries detector Detector (Massachusetts Manufacturing Corp., Cambridge, Mass., USA)
- ✓ Other Devices using the electrical conductance property of human dentition;
- ✓ The modified AC Ohmmeter
- ✓ Modified Electrochemical Impedance Spectroscopy (EIS)
- ✓ Electrical Impedance Tomography (EIT)

V. ELECTRICAL IMPUDENCE SPECTROSCOPY

EIS scans a range of electrical frequencies and provides information on impedence and capacitance among other parameters. The development of an equivalent circuit for the tissue being measured is a way of describing the electrical behaviour of that tissue in terms of resistors, capacitors and constant phase elements. The process provides the potential for a more detailed information to be obtained about the physical structure of the tooth being measured – hence the determination of its caries status than the use of single frequency measurement.

EIS has been applied to proximal sites in vitro and it has the potential for application to occlusal and free smooth surface sites in vitro, with the use of suitable contact probe. One prototype EIS device has been developed – The ACIST (Alternating Current Impedance Spectroscopy Technique) but this is not commercially available. The use of a prototype ACIST device was investigated on a set of subjects in a recent clinical trial, but details are not yet available, since they are still subject to commercial confidentiality. The in vitro performance of electrical impedance spectroscopy in differentiating among sound, non-cavitated carious, and cavitated approximal tooth surfaces is excellent (M.-C.D.N.J.M. Huysmans et al).

VI. MULTI-PHOTON IMAGING

- ✓ Currently, the technique has been performed only on extracted teeth, and the large and complex laser equipment required to produce such an image will require many years to develop into a clinically usable form.
- ✓ Its advantage lies in the noninvasive method of acquisition of a quantifiable measurement of mineral loss, as function of fluorescence loss, from a caries lesion in three dimensions. The low average level of laser power used means that there is low risk of phototoxicity to the pulp, and the longer incident wavelength results in enhanced depth penetration.
- ✓ Although the laser technology could theoretically be made much smaller, and even fit into the oral cavity, the micron accuracy movement required to produce serial tomographic images over a period of 1 min or so is well beyond the capabilities of even the most dextrous dentist.

VII. TERAHERTZ IMAGING

- ✓ Dental caries or tooth decay is the most common human disease, and there is currently no sensitive or accurate means for detecting it using X-rays in its early stages, when tissue damage can be minimized or even reversed.
- ✓ The shortfalls of existing clinical tools are compounded by the fact that some dentists do not regularly assess patients for caries with X-rays owing to fears associated with exposure to ionizing radiation. One needs to go the dentist every six month to reduce exposure to ionizing radiation.These fears are even more serious when it comes to children.[33]
- ✓ Terahertz rays used for tooth imaging have been in the news for more than a decade. Terahertz rays are a viable option for in vivo imaging of dental carries. Interest in biomedical applications has been increasing since the first introduction of THz pulsed imaging (TPI) in 1995 by Hu and Nuss.
- ✓ Their THz images of porcine tissue demonstrated a contrast between muscle and fats. This initial study promoted later research on the application of THz imaging to other biological samples. THz pulsed imaging actually can be viewed as an extension of the THz-Time domain spectroscopy (TDS) method. T-rays have longer wavelength than X-rays resulting in less scattering when passing through tooth samples. Terahertz imaging offers a non-invasive non-ionising alternative to x-rays and additionally provides higher contrast in clinical diagnosis.
- ✓ THz imaging involves in vivo imaging of the tooth to examine surface features and employs reflection geometry THz probe used for THz reflection from the outer layer of enamel.
- ✓ Terahertz Pulsed Imaging system is one such system that distinguishes between the different types of tissue in a human tooth; detect caries at an early stage in the enamel layers of human teeth and monitor early erosion of the enamel at the surface of the tooth .
- ✓ Caries are a result of mineral loss from enamel, and this causes a change in refractive index within the enamel. The change in refractive index means that small lesions, smaller than those detected by the naked eye, can be detected.

VIII. CROWN SURFACE TEMPERATURE

- ✓ Thermography or temperature measurement has been previously used for variety of facial conditions, but it has not gained widespread acceptance. Temperature measurement, as a diagnostic procedure for human teeth, has been described with the use of thermistors, infrared thermography, and liquid crystals. Cholesteric liquid crystals, which exhibit different colours when heated, have been previously employed to determine pulp vitality.
- ✓ The underlying principle was that teeth with an intact pulp blood supply (vital/ healthy pulp tissue) had a warmer tooth surface temperature compared with teeth that had no blood supply. Surface temperature of teeth has also been measured over a period of time at 15 s intervals

using an electric thermometer attached to a surface probe, placed in contact with the tooth. These studies showed that, following cooling, only vital teeth showed a subsequent rise in surface temperature.

- ✓ Thermographic imaging is a non-invasive and highly accurate method of measuring the body's surface temperature. It has been used to demonstrate that, following cooling, nonvital teeth were slower to rewarm than vital teeth113. The disadvantage of using this technique is that the teeth must be isolated with rubber dam, after which a period of acclimatization is necessary prior to imaging. The technique is complex and requires the subjects to be at rest for 1 h prior to testing.

IX. CHOLESTERIC LIQUID CRYSTALS

- ✓ Cholesteric crystals are a type of 'liquid' crystal, i.e. ordered fluids, with a helical structure ordered along the long axis known as chiral‑ nematic liquid crystals. Due to their fluidity these are easily influenced by temperature or pressure.
- ✓ The pitch of the very structure of the crystal varies when the pressure or temperature are altered thus changing their color heated i.e. they are thermochromic. These were used in a study by Howell et al.[52] in Lexington 1970. They found that nonvital teeth have lower temperature than vital teeth
- ✓ They experimented various liquid crystals until they arrived at a combination that would indicate temperatures in 30° to 40°C range. They used cholesteric compounds that were in a 10% solution in a chlorinated hydrocarbon solvent. When applied to the tooth surface, the crystals went through color changes that were compared with adjacent or contralateral‑teeth.
- ✓ Their usage in detecting pulp vitality is based on the principle that the teeth in intact pulp blood supply have a higher tooth‑surface temperature compared with teeth that had no blood supply.

X. THERMOGRAPHIC IMAGING

- ✓ Here a color image is produced which indicates a relative difference in temperature in both superficial and deep areas. Computer‑controlled infrared thermographic imaging is another noninvasive method of recording the surface temperature of the body.
- ✓ It is highly sensitive and has been used extensively in nonmedical military applications.
- ✓ The use of Huges Probeye 4300 Thermal Video System (Hughes Aircraft Co., Carlsbad, CA) was reported in 1989 by Pogrel et al. and was found to be sensitive enough to measure temperature differences as low as 0.1°C. Newer, less cumbersome, and easier to use models is now available.
- ✓ Some other experimental techniques have also been considered for endodontic diagnostics. Work on developing Optical Reflection Vitalometry started in late 1990s and a preliminary report was published in 1997 by Oikarinen et al.
- ✓ This method is another noninvasive method to detect pulp vitality. One can 'see' the pulse of the pulp or the oral mucosa. This device, too, is yet to be clinically accepted and commercially available.

XI. CONCLUSION

Diagnosis forms the basis of treatment. The vistas of endodontic diagnosis are ever evolving. Correct usage of appropriate imaging technology, cost effectiveness, novel radiographic strategies can aid in the reduction of morbidity, mortality, and in improving the life expectancy of patients.

REFERENCES

[1] Ingle J I etal,Endodontic Diagnostic Procedures Ingle J I,Bahland J K,Endodontics 6th Edition Hamilton ON BC Decker,2008 pp520.
[2] Dhingra A,Nagar N.Recent Advances In Endodontic Visualization-a review.IOSRJDMS.2014;13(1):15-20.
[3] Vander veen ,MH etal.Comparative study to quantify demineralized enamel in deciduous and permanent teeth using laser- and light-induced fluorescence techniques. Caries Res. 2001 Nov-Dec;35(6):464-70.
[4] Stabholz A et al Lasers in endodontics.Dent Clin N Am 48 (2004) 809–832
[5] Ribeiro A et al. A preliminary investigation of a spectroscopic technique for the diagnosis of natural caries lesions. Journal of Dentistry (2005) 33, 73–78
[6] Schneiderman A1, Elbaum M, Shultz T, Keem S, Greenebaum M, Driller J. Assessment of dental caries with Digital Imaging Fiber-Optic TransIllumination (DIFOTI): in vitro study. Caries Res. 1997;31(2):103-10
[7] Meller C1, Heyduck C, Tranaeus S, Splieth C. A new in vivo method for measuring caries activity using quantitative light-induced fluorescence. Caries Res. 2006;40(2):90-6.
[8] Grande N M etal. Review study of electrochemical impedance spectroscopy and equivalent electrical circuits of conducting polymers on carbon surfaces.2008;71(1):1-10
[9] Gopikrishna V etal. Assessment of pulp vitality: a review. International Journal of Paediatric Dentistry 2009; 19: 3–15
[10] Tyagi et al.New Vistas In Endodontic Diagnosis. Saudi Endodontic Journal .May-Aug 2012 ;2 (2):85-89