Journal Homepage: -www.journalijar.com
INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)
ISSN NO. 2320-5407
Article DOI:10.21474/IJAR01/6524
DOI URL: http://dx.doi.org/10.21474/IJAR01/6524

RESEARCH ARTICLE

A REVIEW OF DENTAL CARIES DETECTION TECHNOLOGIES.

Liyakath AliKhan R[1], K. Harish S.Shetty[1], S Vidhyadhara shetty[1] and Nishi Jayasheelan[1]

1. Department of Conservative Dentistry and Endodontics.
2. Yenepoya Dental College,Yenepoya deemed to be university Deralakatte, Mangalore-575 018.

Manuscript Info

Manuscript History

Received: 13 December 2017
Final Accepted: 15 January 2018
Published: February 2018

Keywords:-
Dental caries , Caries Detection Dyes , Radiographs.

Abstract

Dental caries, a progressive bacterial damage to teeth, is one of the most common diseases that affects 95% of the population and is still a major cause of tooth loss. Unfortunately, there is currently no highly sensitive and specific clinical means for its detection in its early stages. The accurate detection of early caries in enamel would be of significant clinical value. Since, it is possible to reverse the process of decay therapeutically at this stage, i.e. operative intervention might be avoided. Caries diagnosis continues to be a challenging task for the dental practitioners. Researchers are developing tools that are sensitive and specific enough for the current presentation of caries. These tools are being tested both in vitro and in vivo however, no single method will allow detection of caries on all tooth surfaces. Therefore, the purpose of the present review was to evaluate different caries diagnostic methods.[1]

Many dental schools in the U.S. are adopting a new system for caries diagnosis—the International Caries Detection & Assessment System (ICDAS). We will introduce the ICDAS system and correlate it to the standard ADA recognized U.S. system of caries diagnosis. We will also discuss the importance of caries diagnosis in clinical practice today and also briefly touch on the issue of the ethics of caries diagnosis. In this educational activity, we will review technologies to assist the dentist with the diagnosis of dental caries; however, it is extremely important to realize, especially for the young dental professional, that the diagnosis of a carious lesion is only one aspect of the entire management phase for dental caries. In fact, there are many aspects of managing the caries process besides diagnosis.[2,3]

Caries detection is a basic task that all oral healthcare professionals are taught in school. In principle it is very simple detect mineral loss in teeth visually, radiographically or by some other adjunctive method. There can be many issues that affect this task, including training, experience, and subjectivity of the observer; operating conditions and reliability of the diagnostic equipment. These factors and others can all act in concert and often, the end result is that this ‘simple’ task becomes complex. A critical factor to consider is that most of the research on caries detection has focused on occlusal and smooth surface caries. There are two reasons for this first of all, from a population stand point, more new carious lesions are occlusal lesions

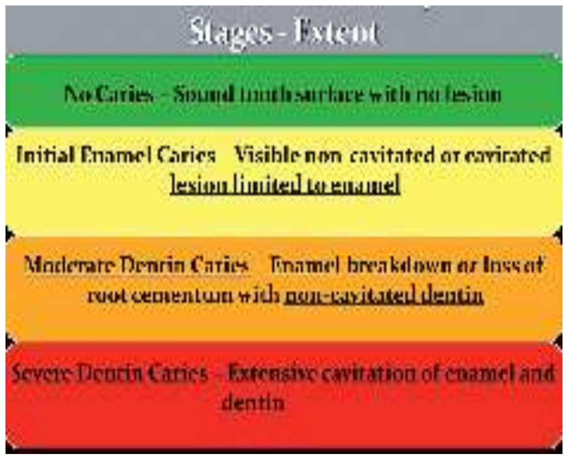
Corresponding Author:-Liyakath AliKhan R.
Address:-Department of conservative dentistry and Endodontics.

today than in the past [4,5] and, secondly, many studies rely on screening examinations without intraoral radiographic capability [6,7]

……………………………………………………………………………………………………....

Introduction:-

The standard American Dental Association (ADA) caries classification system designated dental caries as initial, moderate, and severe.



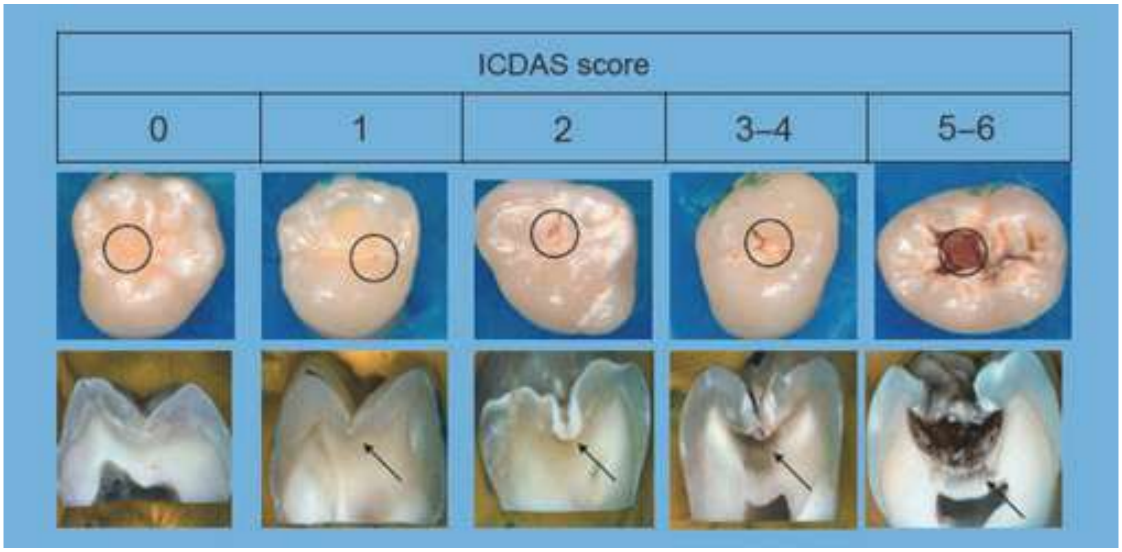
As the result of the International Consensus Workshop on Caries Clinical Trials (ICW-CCT) held in 2002, the work on the International Caries Detection and Assessment System (ICDAS) was begun in earnest; and, today it has emerged as the leading international system for caries diagnosis. [8,9]

A key area of consensus to emerge from the meeting was to separate out specific definitions for three specific terms around caries diagnosis which were confused in the literature.

The consensus (3) was to refer to:

1. Lesion detection (which implies an objective method of determining whether or not disease is present)
2. Lesion assessment (which aims to characterize or monitor a lesion, once it has been detected)
3. Caries diagnosis (which should imply a human professional summation of all available data).

The visual criteria for the full series of sound and six caries codes (from the first visual carious change in enamel seen clinically only when the tooth is dry (code 1) to the histologically more extensive distinct visual change which is visible wet or dry (code 2), through steps to the most severe stage, the extensive distinct cavity with visible dentine)[10]



ICDAS codes, based on the histological extent of lesions, stage the caries continuum

One approach to categorizing the methods that oral healthcare professionals use for caries detection is to place them on a continuum beginning with the most simple, or least invasive, and work up to more sophisticated techniques. With that in mind, the first tool that oral professionals use for caries detection is purely visual—their eyes. The earliest detectable changes within tooth structure affect the microporosity of enamel, which in turn affects the transmission of light through the enamel. Next of course would be color changes within enamel and dentin followed by defects within the enamel. These can all be detected visually with the clinician's eyes using direct vision or vision assisted with a mirror and a standard dental operatory light. In addition, a small, rounded-end dental explorer or probe can assist with the detection of small defects. The use of a sharp explorer for caries detection is now frowned upon by virtually all leading researchers in the field of caries research.[11,12]

QLF measurements:-

A portable QLF device (QLF\clin) was used, equipped with a xenon microdischarge arc lamp as the light source and an optical filter system producing blue light with a maximum wavelength of 370 nm, conducted by a liquid filled guide . To avoid interference to the fluorescence images by bubbles of saliva or blood from gingival bleeding, drying of the teeth was prolonged (> 5 s) before the images were captured in the darkened dental office. The QLF image capturing was performed on buccal and lingual surfaces of all permanent maxillary and mandibular teeth by a trained examiner (R.H.-W.) 2 week after the clinical examination. No information about the visual scoring of presence/absence of an initial caries lesion was noted on the fluorescence image. QLF 2.0f software (Inspektor Research Systems) was used to display, store and analyse the images.[13,14,15]

Initially, the QLF images were visually viewed for signs of decalcification, which appear as dark areas surrounded by bright green fluorescent sound tooth tissue. If a lesion was detected, the fluorescence loss (DF; %), lesion area (A; mm2) and the fluorescence loss integrated over the lesion area (DQ; % · mm2) were analysed using the systems analysis software to determine lesion severity. The image analysis was considered to be optimal when the grey-level image showed a homogeneous status.

The reproducibility of the QLF image analysis was assessed by calculation of the intra- and interexaminer reliability. After an intensive calibration training of 1 week for the analysts (J.K., S.I), 60 smooth surfaces with various appearance of initial caries lesions were randomly selected; a second image analysis was performed 3 days later by both analysts.[13,14,15,16]

Laser fluorescence:-

Laser fluorescence detection techniques such as the DIAGNOdent®, (KaVo USA) rely on the differential refraction of light as it passes through sound tooth structure versus carious tooth structure. The values giving from 0(no fluorescence) to 99(maximum fluorescence)[17]

Light is transmitted through a descendent optical fiber to a hand-held probe, having an oblique tip that is applied on the dental surface. The device comes with two optical fiber active heads, one angular for occlusal surfaces and one straight for smooth surfaces. Calibration of DIAGNOdent rods are made on healthy enamel. Both organic and inorganic molecules in the tooth substance absorb the light and the fluorescence appears in infrared spectrum. The emitted fluorescence, as well as the scattered light, are captured and passed through the ascending fibers to a photodiode detector. Backscattered excitation and short wavelength ambient light are absorbed through a filter in front of the photo-diode detector. In order to discriminate the fluorescence form the ambient light, the laser diode is modulated. By amplifying only the modulated fraction of the signal, ambient light is suppressed. The signal is finally processed and presented on a screen as an integer between 0 and 99, depending on maximum value and time; an audio signal is emitted. In order to collect fluorescence form the maximum extension of carious lesions on occlusal surfaces, the instrument has to be tilted on the inspected surfaces. Variations in the output power of the laser should be regularly compensated by calibrating the instrument against the standard fluorescence, according to manufacturer's instructions. Fluorescence increases in the presence of carious tooth substance. The origin of fluorescence is still on debate, but proto- and mesoporphyrins, bacterial metabolites in the mitochondrial respiratory chain, play a major role. Increased fluorescence in the carious lesions is most probably due to porphyrin, especially protoporphyrin IX, which is synthesized by oral microorganisms[18]

Electrical Conductance:-
The basic concept behind electrical conductance technology is that there is a differential conductivity between sound versus demineralized tooth enamel due to changes in porosity. Saliva soaks into the pores of the demineralized enamel and increases the electrical conductivity of the tooth.[19]

Alternating current impedance spectroscopy

CarieScan PRO™ (**Dun dee, Scotland**) is one of the recent examples of these technologies .A proactive device using technology know as AC impedence spectroscopy technique (ACIST) identifies decay much earlier than other methods, allowing for timely preventive and restorative treatment while being minimally invasive. This is innovative hand held dental device that enables the early detection and monitoring of hidden tooth decay developed at the **Universities of Dundee and St Andrews**, the device is safer and more accurate alternative to dental x-rays with no radiation risks to patient. Passing a tiny electric current through the site, a measurement of the tooth's density is taken.

This technique is used in CarieScan PRO™ allows determining the mineral density of the dental substrate meaning repeated measurements create an accurate and reliable picture of the remineralisation/demineralization of the tooth. It looks nice for the patient by design; it causes no pain, sensation, or ionising radiation – with each measurement taken in a very short time per site. The sensor tip (a small component) comprised of wire bristles allowing for multiple site readings per tooth, is simply touched on each suspected site giving the numerical reading supplemented by a colour. The CarieScan PRO™ remains accurate with placement sensor being used for each patient – an in-built system test for automatic calibration and accuracy as well as eliminating potential cross infection issues thanks to using of disposable sleeves that wraps the unit, leaving the single- use sensor tip exposed. The full set contains sensors, sleeves, accessories; including lip hook cables, cable test adaptors, power supply units, and collars. To detect caries it re quires the placement of a lip clips to complete circuit. When a lip hook is placed, the tooth should be dried by blowing dry air over the surface for five seconds to re move visible moisture. Then the CarieScan PRO™ sensing brush is moved over the pits and fissures of the tooth scanning for dental caries. The sensor tip easily bends after each application and this affects both the angulations and the pressure on tooth surface. From a clinical stand point, care [20].

X Ray- Based Imaging:-

Intra Oral Radiography (INR):-

Most oral healthcare professionals that have been in practice a few years have developed routines that have resulted in distinctive practice personalities. These are generally good, but sometimes these routines may need to be evaluated to see if they still meet good scientific principles that are accepted by the profession. One of these routines may be the radiographic selection criteria that were recently updated by the ADA and FDA[21].

Radiography is useful for the detection of dental caries because the caries processcauses tooth demineralization. The lesion is darker than the unaffected portion and maybe detected in radiographs. An early carious lesion may not have yet caused sufficientdemineralization to be detected in radiographs. It is often useful to mount successive sets of bitewing radiographs in one film holder to facilitate comparison and evaluation of evidence of progression. Intra oral radiography can reveal carious lesions that otherwise might go under detection during a thorough clinical examination. On the other hand, early carious lesions are difficult to detect with radiographs, particularly, when they are small and limited to the enamel. Therefore, clinical and x-ray examinations are necessary in the detection of dental caries. Posterior bitewing radiographs are the most useful x-ray projections for detecting caries in the distal third of a canine and the interproximal and occlusal surfaces of premolar and molars[1,22]

Extra Oral Radiography (EOR):-

Extraoral radiographic techniques for proximal caries detection have been studied and proven to be inferior to intraoral techniques. However, the main focus was on conventional panoramic radiography. Clifton et al. used multidirectional tomography and panoramic radiography as well as intra-oral D-speed film for combined assessment of proximal and occlusal caries. It was concluded that when proximal surfaces were evaluated alone, D-speed film was significantly better. For occlusal caries, there was no statistically significant difference between multi directional tomography and D-speed film.[23]

One study has demonstrated that scanogram images have the potential to be the first practical extraoral imaging modality for proximal caries detection. Influencing factors to be discussed are the sample, exposure techniques, resolution and contrast enhancement. In this study, the performance of screen-film and enhanced digital scanograms were not statistically different from Insight film for proximal caries detection. Unenhanced digital scanograms exhibited a statistically significant lower diagnostic accuracy than Insight film.[24]

Including image manipulation and a reduction in radiation required to obtain a diagnostic image.In addition, Alkurt MT showed that the diagnostic performance of Eand F- speed films and direct digital radiography are similar for proximal caries detection.[25]

Digital radiography:-

The use of digital radiography addresses two primary disadvantages of dental film,periapical diseases as it was previously thought.Increasing the diagnostic yield for caries may be possible with three-dimensional (3D) imaging methods. However, general dentists currently use two-dimensional (2D) images, and although CT/MRI modalities exist for hospitals, there are no systems for general practitioner caries diagnosis. The choices for 3D imaging of dentoalveolar diagnostic tasks are currently limited to different forms of local CT including x-ray microtomography (XMT), tuned aperture computed tomography (TACT) and super-ortho-cubic CT.[26]

X-ray microtomography:-

X-ray microtomography is a miniaturized version of computerized axial tomography with a resolution of the order of micrometres. In the biomedical field, it is particularly useful in the study of hard tissue because of its ability to accurately measure the linear attenuation coefficient. From this, the mineral concentration can be computed, which is one measure of bone quality. Using microtomography we can form threedimensional images of bone from which structural parameters can be derived which could not be measured using conventional histomorphometry.[27]

Daatselaar et al. described the development of a bench top local CT device which is able of producing spatial and contrast resolutions necessary for improved detection of interproximal caries as well as other dentoalveolar conditions. The authors concluded that 'local CT reconstruction are feasible' and 'the resolution of the local CT images produced from basis projections that were acquired using standard dental CCD sensor was diagnostically suitable. This makes local CT a potential technique for the diagnosis of interproximal caries[26]

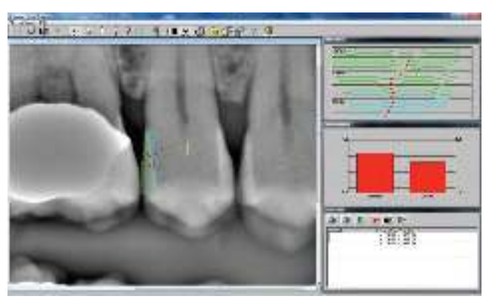
Computer-Aided Diagnosis:-

The use of Computer-aided diagnosis (CAD) of disease is well-established in medical radiology, having been utilized since the 1980's at the University of Chicago and other medical centers for assistance with the diagnosis of lung nodules, breast cancer, osteoporosis and other complex radiographic tasks.[28]

A major distinction has been made in the medical community between automated computer diagnosis versus computer-aided diagnosis. The main difference is that in automated computer diagnosis, the computer does the evaluation of the diagnostic material, i.e., radiographs, and reaches the final diagnosis with no human input. In computer-aided diagnosis; both a medical practitioner and a computer evaluate the radiograph and reach a diagnosis separately. Depending on the practitioner's confidence level, he or she will then either make the final diagnosis or use the computer's diagnosis, if it is different from the practitioner's.[29]

The Logicon® system (Carestream Dental LLC, Atlanta, GA) is an example of CAD caries detection technology[30]

The software contains within its database, teeth with matching clinical images, radiographs and histologically known patterns of caries. As a tooth is radiographed and an interproximal region of interest is selected for evaluation, this database is accessed for comparison purposes. The software will then, in graphic format, give the dental professional a tooth density chart and calculate a probability displayed on a scale of 0 to 1.0 that the area in question is a sound tooth, decalcified or carious and if a restoration is required. In addition, the level of false positives can be adjusted, or specificity, that the clinician is willing to accept.[29,31,32]



Caries Indicator Dyes:-

In 1972, it was suggested that cariesdetector dyes could help differentiate infected dentin from affected dentin. However, more recent studies have shown that these dyes are non specific protein dyes that stain collagen in the organic matrix of less mineralized dentin, whether it is infected or not, rather than being specific for the pathogenic bacteria.[33]

Al-Sehaibany et al. evaluated the use of caries detector dye in the diagnosis of occlusal carious lesions. 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 examined by two methods: the caries detector dye versus traditional tactile examination using a dental explorer. Histological cross sections confirmed a ratio of 1:1 (100%) accuracy by caries detection dye in diagnosing decay underlying the occlusal surface. Concurrent examination of the same occlusal surface by traditional explorer examination was only reliable in a 1:4 ratio (25%)[34].

Terahertz Pulse Imaging (TPI):-

Terahertz pulse imaging (TPI) is s relatively new imaging technique that has been demonstrated in both non-biological applications. Although, the TPI system is a new technique for imaging caries using non ionizing impulses of terahertz radiation, (an electromagnetic radiation) and its ability to detect early stages of caries lesions in various sections of teeth and a hope in future when this technique could indicate caries in all areas of teeth. Terahertz systems are relatively expensive and do not offer the resolving power of radiographic examination. This system also needs more researches to make it possible to be inserted into the mouth for in vivo studies, while it is expected that technological developments will improve the systems to bring them within easy reach of dentists. The coherent detection scheme of the TPI system uses only micro-watts of radiation of a type that is non-ionizing. Because the exposure levels from this system are orders of magnitude smaller than exposure levels that occur naturally, this system will be safer than those employing Xrays. Unlike radiography TPI also delivers a spectrum of different frequencies for each pixel measured. This offers the possibility of using that spectrum for diagnosis that goes beyond simply measuring mineralization levels.[35].

Pickwell et al. compared terahertz pulse imaging (TPI) with transmission microradiography (TMR) for depth measurement of enamel demineralizations. It was concluded that TPI measured demineralization in the range of 47% of that the TPI system uses only micro-watts of radiation of a type that is non-ionizing.

Summary:-

Many oral healthcare professionals are quite surprised to learn that, as a group, they do not excel at diagnosing caries, especially interproximal caries using bitewing radiography. If dentists were able to diagnose teeth with 95+% accuracy with the basic tools of their eyes, probes and bitewing radiographs, there would be no market demand for any other caries detection technologies. Currently available technology and improvements in the future will enhance accuracy in detection of caries improving the oral health of the public.

References:-

1. Zangooei booshehry M, Fasihinia, H, Khalesi, M, Gholami L Dental Caries Diagnostic Methods. DJH 2010; Vol.2, No.1.
2. Kidd E. Essentials of Dental Caries: The Disease and Its Management: The disease and its management: OUP Oxford; 2005.
3. Whitaker EJ. Primary, secondary and tertiary treatment of dental caries A 20-year case report. The Journal of the American Dental Association. 2006;137(3):348-52.
4. NIH. Diagnosis and Management of Dental Caries Throughout Life. 2001 NIH Conference on Diagnosis and Management of Dental Caries Throughout Life; Washington, DC2001.
5. Pitts N. Detection, assessment, diagnosis and monitoring of caries: Karger Basle, Switzerland; 2009
6. Bader JD, Shugars DA, Bonito AJ. Systematic reviews of selected dental caries diagnostic and management methods. Journal of Dental Education. 2001;65(10):960 8.
7. Bader JD, Shugars DA, Bonito AJ. A systematic review of the performance of methods for identifying carious lesions. Journal of public health dentistry. 2002;62(4):201-13.
8. Ismail AI, Sohn W, Tellez M, Amaya A, Sen A, Hasson H, et al. The International Caries Detection and Assessment System (ICDAS): an integrated system for measuring dental caries. Community Dentistry and Oral Epidemiology. 2007;35(3):170-8.
9. ICDAS. International Caries Detection and Assessment System; [updated 2013; cited 2013 April 1, 2013]. Available from: http://www. icdas.org/home.
10. NB Pitts, KR Ekstrand. International Caries Detection and Assessment System (ICDAS) and its International Caries Classification and Management System (ICCMS) – methods for staging of the caries process and enabling dentists to manage caries. Community Dent Oral Epidemiol 2013; 41: e41–e52.
11. Braga MM, Mendes FM, Ekstrand KR. Detection activity assessment and diagnosis of dental caries lesions.Dental Clinics of North America. 2010;54(3):479
12. Ekstrand K, Qvist V, Thylstrup A. Light microscope study of the effect of probing in occlusal surfaces. Caries research. 2009;21(4):368-74.
13. Heinrich-Weltzien R, Kuhnisch J, Ifland S, Tranæus S, Angmar-Mansson B, Stoßer L. Detection of initial caries lesions on smooth surfaces by quantitative light-induced fluorescence and visual examination: an in vivo comparison. Eur J Oral Sci 2005; 113: 494–498. _ Eur J Oral Sci, 2005

14. Angmar-Mansson B, Ten Bosch JJ. Quantitative light-induced fluorescence (QLF): a method for assessment of incipientcaries lesions. Dento-Maxillo-Facial Radiol 2001; 30: 298–307.
15. De Josselin de Jong E, Sundstro¨m F, Westerling H, TranÆus S, Ten Bosch JJ, Angmar-Mansson B. A new method for in vivo quantification of changes in initial enamel caries with laser fluorescence. Caries Res 1995; 29: 2–7.
16. Van Der Veen MH, de Josselin de Jong E. Application of quantitative light-induced fluorescence for assessing early caries lesions. Monogr Oral Sci 2000; 17: 144–162.
17. Akbari M, Ahrari F, Jafari MA Comparative Evaluation of DIAGNOdent and Caries Detector Dye in Detection of Residual Caries in Prepared Cavities. July-August 2012;13(4):515-20.
18. Oancea R, Podariu A C, vasile L ,roşianu R S, folescu R In vitro evaluation of laser fluorescence devices for caries detection through stereomicroscopic imaging, Rom J Morphol Embryol 2013, 54(2):333–341
19. Amaechi BT. Emerging technologies for diagnosis of dental caries: The road so far. Journal of Applied Physics. 2009;105(10):102047--9..
20. Renata chałas , Ilona wójcik-chęcińska, Dominika piątek, Joanna zubrzycka-wróbel,Teresa bachanek, Usefulness of AC-impedance spectroscopy technique in occlusal caries determination – own investigations, Curr. Issues Pharm. Med. Sci. Vol. 26, No. 4, Pages 440–442.
21. ADA, FDA. Dental Radiographic Examinations: Recommendations for Patient Selection and Limiting Radiation Exposure. 2012.
22. Bahrami G, Hagstrom C, wenzel A. Bitewing examination with four digital receptors. Dentomaxillo facial Radiol 2003; 32: 317-321.
23. Clifton TL, Tyndall DA, Ludlow JB. Extraoral radiographic imaging of primary caries. Dentomaxillofac Radiol 1998; 27(4):193-8.
24. Khan EA, Tyndall DA, Caplan D. Extraoral imaging for proximal caries detection: Bitewing vs scanogram. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2004; 98(6): 730-7.
25. Alkurt MT, Peker I, Bala O, Altunkaynak B. In vitro comparison of four different dental X-ray films and direct digital radiography for proximal caries detection. Oper Dent 2007; 32(5):504-9. Dentomaxillofacial Radiol 2003; 32: 235-241.
26. Daataselaar AN, Tyndall DA, Stelt PF. Detection of caries with local CT.Dentomaxillofacial Radiol 2003; 32: 235-241.
27. Daatselaar AN, Dunn SM Spoelder HJW, Germans DM, Renambot L, Bal HE et al. Feasibility of local CT of dental tissues. Dentomaxillofacial radiol 2003; 32:173-180.
28. Doi K. Computer-aided diagnosis in medical imaging: historical review, current status and future potential. Computerized medical imaging and graphics: the official journal of the Computerized Medical Imaging Society. 2007;31(4-5):198.
29. Gakenheimer DC. The efficacy of a computerized caries detector in intraoral digital radiography. The Journal of the American Dental Association. 2002;133(7):883-90.
30. Yoon DC, Wilensky GD, Neuhaus JA, Manukian N, Gakenheimer DC. Quantitative dental caries detection system and method. Google Patents; 1998.
31. Tracy KD, Dykstra BA, Gakenheimer DC, Scheetz JP, Lacina S, Scarfe WC, et al. Utility and effectiveness of computer-aided diagnosis of dental caries. General dentistry. 2011;59(2):136.
32. Gakenheimer D, Farman T, Farman A, Benjamin S, Huysing P, Chang H, et al., editors. Advancements in automated dental caries detection using DICOM image files. International Congress Series; 2005:
33. Young DA. New caries detection technologies and modern caries management: Merging the strategies. Gen Dent 2002; 50(4):320-31.
34. Al-Sehaibany F, White G, Rainey JT. The use of caries detector dye in diagnosis of occlusal carious lesions. J Clin Pediatr Dent 1996; 20(4):293-8.
35. Crawley David A, Longbottom C, Cole Bryan E, Ciesla Craig M, Arnone D, Wallace V, et al. Terahertz pulse imaging: A pilot study of potential applications in dentistry. Caries Res 2003; 37:352-359.