

Review Article

DIAGNODENT- A Diagnostic Boon for Dental Caries

Anam Siddiqui¹, Sahana S², Anuradha P³, Manu Narayan⁴, Sugandha Agarwal⁵, Shweta Singh⁶

¹PG student, ^{2,4}Reader, ³Professor & HOD, ^{5,6}Senior lecturer,

Department of Public Health Dentistry, Babu Banarasi Das College of Dental Sciences, Lucknow, Uttar Pradesh, India

ABSTRACT

Dental caries are a standout amongst the most widely recognized worldwide health issues. Identifying carious lesions under remedial materials is confused in light of the fact that there can be no immediate perception of dental tissue under the regeneration. The accurate evaluation of the extent or activity of caries is a difficult task dependent on several factors like conditions during the inspection, patients caries risk, morphology and training and experience of the dentist. Although the most frequently used diagnostic methods (conventional methods) offer good diagnostic performance, the main drawbacks of the conventional methods are that they still rely on the clinicians subjective interpretation. For more accurate diagnostic approaches, investigators have used recent, non-invasive techniques for detecting & quantifying demineralization lesions. DIAGNodent may have the capacity to beat this issue and the nonappearance of destructive radiation is another advantage of DIAGNodent. DIAGNodent is a symptomatic instrument dependent on laser fluorescence which estimates the contrast between the fluorescence of typical and carious dental tissue. It gives each tissue an alternate score accordingly, decreasing human blunder.

Key word- Caries, diagnosis, laser fluorescence, diagnostic aids, transillumination.

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Corresponding Author: Dr Anam Siddiqui, PG student, Department of Public Health Dentistry, Babu Banarasi Das College of Dental Sciences, Lucknow, Uttar Pradesh, India

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INTRODUCTION

Dental caries are a standout amongst the most critical health issues in world wellbeing care. With the expanding awareness of individuals toward their oral and dental cleanliness, hopes from the dental practitioner for early caries identification has developed. Likewise examiners have demonstrated that caries identification in pits and fissures is harder.¹⁻⁸

For caries control, it is important to recognize caries lesions in a beginning period of histological changes. The trouble in outwardly investigating the crevices of molars, known as "concealed caries", are regularly missed on visual examination and carious lesions are seen just at a late phase of sickness.⁹

Regular strategies for diagnosing dental caries are frequently incapable in identifying polish imperfections, as they might be too little or out of reach to the indicative tool.¹⁰

Perceptions demonstrate affectability and specificity estimations of 62 and 84 percent with the pioneer and visual examination, individually, showing that clinicians

will probably neglect to treat carious gaps than to re-establish sound gaps⁽¹¹⁾.

The point of present day dentistry must be a preventive approach instead of invasive repair of the infection. This is possible just with early location and separate preventive measures⁽¹²⁾.

There are numerous techniques to distinguish decay like visual and radiographic strategies, gadgets with fluorescence, for example, Quantitative light-incident fluorescence (QLF), Digital Imaging Fiber Optic Transillumination Imaging (DIFOTI), Vista verification, Laser fluorescence (LF or DIAGNodent), Fluorescence Camera (FC) and Digital radiography. DIAGNodent is viewed as a profitable gadget for caries identification⁽¹³⁾.

DIAGNodent has a sensitivity of 0.67 and specificity of 0.94 and helps in detecting caries in its initial stage and can reverse the carious process. Specificity is the extent of cases ordered by a strategy as negative (illness missing) considering the aggregate of cases that did not built up the ailment.

Sensitivity, is the extent of cases named positive (ailment present) considering the aggregate of cases that truly built up the infection ⁽¹⁴⁾.

NEED FOR DIAGNODENT

Dental caries is a perplexing infection, characterized as the procedure of dynamic demineralization of inorganic segment of the tooth joined by breaking down of the natural portion ⁽¹⁵⁾.

The precision of diagnosing "covered up" occlusal caries is perceived to be a test. These sores are practically difficult to identify utilizing traditional strategies. DIAGNOdent is a to a great degree exact and dependable subordinate for the identification of sub-surface caries. It expands the dental specialist's vision into those difficult to-reach and difficult to-see destinations where caries can grow, duplicate and flourish ⁽¹⁶⁾.

When left undetected, sub-surface caries can make significant harm a tooth's structure, bringing about broad helpful work or even tooth misfortune. This new innovation is totally sheltered and torment free. This exceptional instrument gives moment input on the soundness of the tooth. A number scale and a caution flag the administrator when there are indications of concealed decay. DIAGNOdent enables dental specialists to identify caries as right on time as could be expected under the circumstances and enhancing treatment choices ⁽¹⁷⁾.

Methods for detection of dental caries

There are a few strategies which are utilized to analyze dental caries which incorporate conventional methods and advance methods

Conventional methods consists of visual examination, tactile examination and radiographic methods where as advance methods consists of Digital Imaging Fiber Optic Transillumination Imaging (DIFOTI), quantitative light-induced fluorescence (QLF), Laser-induced fluorescence (Diagnodent) and Fiber Optic Transillumination (FOTI) ⁽¹⁸⁾.

Conventional Methods

- **Visual-Tactile Examination:-** Visual and visual-tactile examinations have been the most ordinarily utilized analytic guides in caries examination.
- **Visual examination** in view of the measure of hardness and shade of the rotted territory is the best apparatus to analyze little size caries, but because of its low sensitivity and high specificity, it can't well recognize decayed area ⁽¹⁹⁾.
- **Tactile examination** of dental caries has been scrutinized due to the likelihood of exchanging cariogenic microorganisms starting with one site then onto the next, prompting the dread of additionally spread of the sickness in a similar oral depression ⁽²⁰⁾.
- The use of explorer during the visual examination can further harm the crevices and result in advance of the caries procedure ⁽²¹⁾.
- **Conventional radiography-** Radiography is the most widely recognized caries identification method. Bitewing radiography has been utilized for the

discovery and assessment of caries sores profoundly, which are undetectable or ineffectively noticeable for examination ⁽²²⁾.

- Bitewing radiography demonstrates the histology of the decayed procedure which achieved the dentin other than the enamel. In addition, radiography can't recognize dynamic and captured lesions and between non-cavitated and cavitated lesions. Radiograph also increment the danger of x-beam overexposure ⁽²³⁾.
- Conventional techniques for the recognition of caries have neglected to recognize early beginning of caries successfully. The advanced strategies give promising outcomes in identification both early caries and furthermore caries happening on all surfaces of the tooth, which prepares for a more preventive way to deal with caries administration ⁽²⁴⁾.

ADVANCE METHODS

Digital Imaging Fiber Optic Transillumination Imaging (DIFOTI) - DIFOTI replaces the human eye with a CCD(charged couple device) sensor. It uses fiber-optic transillumination of safe visible white light to image the tooth, which can be digitally captured using a digital CCD and sent to a computer for analysis. When the teeth are transilluminated, areas of demineralised enamel or dentin scatter light and incipient caries appear darker in the resultant image. It can also be used to detect other changes in coronal tooth anatomy, such as tooth fractures and fluorosis. DIFOTI presents higher sensitivity in detection of early lesions when compared to the radiographic examination ⁽²⁵⁾.

Quantitative light-induced fluorescence (QLF)- QLF is based on the principle of fluorescence. QLF is a diagnostic aid for detection, quantification and monitoring of early enamel demineralisation. It provides a fluorescent image of a tooth surface within yellow-green spectrum of visible light that quantifies mineral loss and size of the lesion. When a lesion is present, an increase of light scattering makes appear the lesion as dark spots on a bright green background. The loss of fluorescence images can be quantified with respect to adjacent healthy tissue ⁽²⁶⁾.

Laser-induced fluorescence (Diagnodent)- Laser fluorescence device is a non-invasive and quantitative method based on the laser induced fluorescence. In 1998 Laser fluorescence (DIAGNOdent) was presented to the market for detection of occlusal caries. DIAGNOdent decay detection is based on the principle that when Diode laser with 655nm wavelength is irradiated on dental surface, it is absorbed by metabolites of intraoral bacteria and these metabolites emit a red fluorescence. This fluorescence reflected by the dental surface is indicated as a number between 0 and 99 on the screen of the device. Greater numbers are an indication of a greater decay area ⁽²⁷⁾.

Fiber Optic Transillumination (FOTI)- Fiber-optic transillumination(FOTI) is based on the phenomenon of light scattering to increase contrast between normal and carious enamel. Sound enamel is comprised of modified hydroxyapatite crystals that are densely packed, 'producing an almost transparent structure. Dentine appears orange, brown, or grey underneath enamel and this can help in the discrimination between enamel or dentine lesions⁽²⁸⁾.

Diagnodent is a better diagnostic procedure than the rest of the techniques (both conventional and advanced) as it can detect the caries at a very early stage i.e. the first sign of demineralization, from which the caries process can be reversed.

INSTRUMENT DESCRIPTION

Diagnodent is a little seat side battery controlled laser fluorescence based caries discovery gadget that uses a quantitative optical technique to distinguish mineral leaching⁽²⁹⁾.

It has a 655nm diode laser, takes into account recognition of non-cavitated, occlusal, pit-and-crevice tooth decay, notwithstanding smooth surface caries at a prior stage than visual review⁽³⁰⁾.

As the incident laser light is dispersed into the site, two-way handpiece optics enables the unit to at the same time evaluate the reflected laser light vitality⁽³¹⁾.

The dispatched fluorescence indicates different scales in the vicinity of 0 and 99. The estimation of 20 or 25 and higher shows caries sore, higher the scale further the caries attack⁽³²⁾.

A sound flag enables the administrator to hear changes in the scale esteems, empowering centre around the patient and not exclusively on the gadget⁽³³⁾.

WORKING PROCEDURE

The exact mechanism of DIAGNOdent based on two theories-

First, when the red light meets an adjustment in tooth tissue, for example, porosity because of demineralization or hypomineralization, it animates bright light of an alternate wavelength. Second, some bacterial metabolites, for example, porphyrines (proto-porphyrine, meso-porphyrine, or proporphyrin), result in the red fluorescence of carious teeth⁽³⁴⁻³⁵⁾.

MECHANISM OF ACTION

Diagnodent innovation utilizes a straightforward laser diode to look at the reflection wavelength against an outstanding solid standard to reveal caries.

At particular wavelength that the gadget works, solid tooth structure shows almost no fluorescence, bringing about low scale readings on the show.

Carious tooth structure shows fluorescence proportionate to the level of caries, bringing about raised scale readings on the show⁽³⁶⁾.

The unit has a fiber-optic link that transmits light source to a handpiece that contains a fiber-optic eye in the tip. To start with, the laser diode is gone for the sound finish tooth structure to get a benchmark readings. After

adjustment, it is moved to review every one of the surfaces of the teeth, sparkling the laser at 2.5 mm into every single speculated zone.

As the laser beats into notches, crevices and splits, it reflects bright light with specific wavelength. This is on the grounds that light is consumed by the natural and inorganic segments of the tooth which initiate infrared fluorescence.

This fluorescence is gathered at the highest point of handpiece and transmitted back to the diagnodent unit. Light is estimated by receptors, changed over into an acoustic flag and assessed electronically to uncover esteems in the vicinity of 0 and 99⁽³⁷⁾.

TYPES OF DIAGNODENT

The first main laser fluorescence gadget, DIAGNOdent 2095 (KaVo, Biberach, Germany), was produced in 1998. It depends on the evaluation of radiated fluorescence from natural segments of dental tissues when energized by a 655nm laser diode (aluminum, gallium, indium and phosphorus - AlGaInP) situated on the red range from the obvious range

Two optical tips are accessible: tip A for occlusal surfaces, and tip B for smooth surfaces. This gadget has demonstrated great outcomes in the discovery of occlusal caries⁽³⁸⁾

As of late, another and conservative gadget - DIAGNOdent 2190 or DIAGNOdent pen - (KaVo, Biberach, Germany) has been presented. This gadget capacities on an indistinguishable guideline from the most punctual yet the tips were altered.

The tips utilized as a part of this gadget are produced using sapphire fiber and a similar strong single sapphire fiber tip is utilized for spread of the excitation and for gathering of the fluorescence light, however in inverse headings and distinctive wavelengths

There are two tips which can be coupled on this gadget: an occlusal and an approximal tip. The gadget weights 140g and just a single battery (1,5V) is required⁽³⁹⁾.

LITERATURE EVIDENCE

- Hanieh Nokhbatolfoghahaie, Marzieh Alikhasi et al had done a systematic review on Evaluation of accuracy of diagnodent in diagnosis of primary and secondary caries in comparison to conventional methods. They concluded that the sensitivity and specificity reported in the different studies showed that diagnodent is an appropriate modality for caries detection as a complementary method beside other methods⁽⁴⁰⁾.
- Zahra Bahrololoomi, Seyed Ahmad Musavi and Mona Kabudan conducted in vitro study to evaluate the efficacy of laser fluorescence (diagnodent) to detect demineralization and remineralization of smooth enamel lesions. The authors concluded that the results showed that LF is an appropriate method for detection of demineralization in an in vitro condition in smooth enamel lesions, but it was not so efficient in the detection of remineralization⁽⁴¹⁾.

- N Sridhar, S Tandon and Nirmala Rao had done in vitro study to compare evaluation of diagnodent with visual examination and radiography for detection of occlusal caries. The authors concluded that the laser fluorescence device diagnodent has shown more superior results in diagnosing the caries which is almost comparable to histological gold standard. It has shown very good sensitivity and specificity in diagnosing the caries⁽⁴²⁾.
- Ava Vali Sichani, Shahrzad Javadinejad, and Roshanak Ghafari conducted a study on diagnostic value of diagnodent in detecting caries under composite restorations of primary molars. The authors concluded that diagnodent showed a greater accuracy in detecting secondary caries under primary molar restorations, compared to radiographs. It is also an effective method for detecting caries under composite restorations⁽⁴³⁾.
- Lussi A, Imwinkelried S et al conducted a study on Performance and reproducibility of a laser fluorescence system for detection of occlusal caries in vitro. The authors concluded that for occlusal caries the new laser device has a higher diagnostic validity than the ECM, and in vitro, measurements using the device are highly reproducible. Thus, the laser device could be a valuable tool for the longitudinal monitoring of caries and for assessing the outcome of preventive interventions⁽⁴⁴⁾.
- Lussi A, Megert B et al conducted a study on Clinical performance of a laser fluorescence device for detection of occlusal caries lesions. The authors found that the Clinical inspection and analysis of bitewing radiographs exhibited statistically significant lower sensitivities (31-63%) than did the DIAGNODent device (sensitivity > or = 92%). So it is recommended that the laser device is used in the decision-making process in relation to the diagnosis of occlusal caries as a second opinion in cases of doubt after visual inspection⁽²⁹⁾.
- Lussi A, Hack A et al conducted a study on detection of approximal caries with a new laser fluorescence device. The authors concluded that the new LF system might be a useful additional tool in detecting approximal caries because of its good reproducibility and it could be used to monitor caries regression or progression on approximal surfaces⁽⁴⁵⁾.
- Anttonen V., Seppä L and Hausen H. conducted a clinical study of the use of the Laser Fluorescence Device Diagnodent for detection of occlusal caries in children. The authors concluded that the radiographic examination was the least accurate as compared to diagnodent. In routine dental check-ups of children, diagnodent appears to be useful as an adjunct to visual examination⁽⁴⁶⁾.
- Attrill DC¹ and Ashley PF. conducted a study to compare the accuracy and repeatability of three diagnostic systems (Diagnodent, visual and radiographic) for occlusal caries diagnosis in primary molars. The authors found that the Diagnodent was the most accurate system tested for the detection of occlusal dentine caries in primary molars⁽¹⁴⁾.
- Pinelli C¹, Campos Serra M et al conducted a study to determine the reproducibility and validity of diagnodent in detecting active and arrested caries lesions on free smooth surfaces. The authors found that the sensitivity was 0.72 and the specificity was 0.73, which indicates that the diagnodent was a good auxiliary method for detecting incipient caries lesions on free smooth surfaces⁽⁴⁷⁾.
- Shi XQ¹, Welander U and Angmar-Månsson B. conducted a study on an in vitro comparison of occlusal caries detection with diagnodent and radiography. The authors concluded that the diagnostic accuracy of diagnodent was significantly better than that of radiography (p<=0.001). In this, in vitro study of detection of occlusal caries, the diagnostic performance of the diagnodent method was superior to that of radiography⁽⁴⁸⁾.
- Takamori K¹, Hokari N et al conducted a study on detection of occlusal caries under sealants by use of a laser fluorescence system. The authors found that the laser diagnosis system makes it easy to detect the existence of caries under a pit and fissure sealant during a routine check-up⁽⁴⁹⁾.
- Bader JD¹ and Shugars DA. conducted a systematic review of the performance of a laser fluorescence device for detecting caries. The authors concluded that diagnodent is more sensitive than traditional diagnostic methods; however, the increased likelihood of false-positive diagnoses compared with that with visual methods limits its usefulness as a principal diagnostic tool⁽⁵⁰⁾.
- Al-Khateeb S¹, Forsberg CM et al conducted a longitudinal laser fluorescence study of white spot lesions in orthodontic patients. The authors found that during a 1-year follow-up period, the areas of the lesions decreased and the enamel fluorescence lost was partly regained indicating that a remineralization process had occurred. It was concluded that quantitative laser fluorescence seems suitable for in vivo monitoring of mineral changes in incipient enamel lesions, and useful for the evaluation of preventive measures in caries prone persons, such as orthodontic patients⁽⁵¹⁾.
- N. M. Başeren and S. Gokalp conducted an in vitro study on Validity of a laser fluorescence system (diagnodent) for detection of occlusal caries in third molars. The authors indicates that the diagnodent provides not only almost perfect agreement but also sufficient repeatability at D1(sound and fissure lesion in the half of the outer enamel), D2(enamel decay), D3 (dentin decay) levels and better specificity at D1 level as well as lower sensitivity at D2 level and excellent sensitivity at D3 level⁽⁵²⁾.

CONCLUSION

Present day dentistry stresses more on counteractive action, and thus the first saying of "expansion for

avoidance" has been shunned for a negligible mediation approach.

The move in treatment reasoning from "expansion for avoidance" to "insignificantly obtrusive dentistry" has managed the dental specialist the chance to determination and to oversee caries at a beginning period.

Regular or customary devices are subjective in nature. They demonstrate a poor validity with low affectability and direct specificity.

Progressed demonstrative strategies are altogether quantitative in nature. They identify injuries at a prior stage and are more dependable than the regular techniques.⁽⁵³⁾

DIAGNOdent has a higher affectability and specificity when contrasted with regular strategies. It has indicated more prevalent outcomes in diagnosing dental caries.

Dental caries is a reversible illness that can be ended at any given point, as long as the biofilm can be expelled. False positive analyses are more hazardous as far as pointless obtrusive treatments⁽⁵⁴⁾.

Diagnodent identifies precisely uncovered regions of tooth decay without scratching, examining or "opening up the tooth". This gives a more prominent possibility of recognizing, treating and holding a characteristic tooth without the requirement for costly and tedious rebuilding efforts.⁽⁵⁵⁾

REFERENCES

- Matteson SR, Phillips C, Kantor ML, Leinedecker T. The effect of lesion size, restorative material, and film speed on the detection of recurrent caries. *Oral Surg Oral Med Oral Pathol* 1989;68:232-7.
- Pretty IA. Caries detection and diagnosis: Novel technologies. *J Dent* 2006;34(10):727-39.
- Huysmans MC, Longbottom C. The challenges of validating diagnostic methods and selecting appropriate gold standards. *J Dent Res* 2004;83:48-52.
- Craounanidy U, Sathyanarayanan R. Dental caries: A complete changeover (Part II)-Changeover in the diagnosis and prognosis. *J Conserv Dent* 2009;12:87-100.
- Pontual AA, de Melo DP, de Almeida SM, Bóscolo FN, Haiter Neto F. Comparison of digital systems and conventional dental film for the detection of approximal enamel caries. *Dentomaxillofac Radiol*. 2010;39:431-6.
- Bamzahim M, Aljehani A, Shi XQ. Clinical performance of DIAGNOdent in the detection of secondary carious lesions. *Acta Odontol Scand* 2005;63:26-30.
- Lussi A. Validity of diagnostic and treatment decisions of fissure caries. *Caries Res* 1991; 25:296-303.
- Sanchez-Figueras A. Laser Fluorescence Detection of Occlusal Caries. Clinical utilization of the KaVoDIAGNOdent
- Astvaldsdottir A., W.P. Holbrook and S. Tranaeus. Consistency of DIAGNOdent instruments for clinical assessment of fissure caries. *Acta Odontologica Scandinavica* 2004; 62(4):193-198. [Google Scholar]
- Hibst R, Paulus R, Lussi A (2001). Detection of occlusal caries by laser fluorescence. *Basic and clinical investigations. Med Laser Appl* 16:205-213
- Petersson GH, Bratthall D. The caries decline: a review of reviews. *Eur J Oral Sci* 1996;104(4):436-43.
- Ando M, Gonzalez-Cabezas C, Isaacs RL, Eckert GJ, Stookey GK. Evaluation of several techniques for the detection of secondary caries adjacent to amalgam restorations. *Caries Res* 2004;38(4):350-6.
- Lussi A, Hellwig E. Performance of a new fluorescence device for the detection of occlusal caries in vitro. *J Dent* 2006;34(7):467-71.
- Atrill DC, Ashley PF. Occlusal caries detection in primary teeth: a comparison of DIAGNOdent with conventional methods. *Br Dent J* 2001;190:440-443.
- Shafer WG. *Textbook of Oral Pathology*. 6th ed. Bangalore: Prism Book Pvt. Ltd.; 1997. p. 409-45.
- Lussi A. Comparison of different methods for the diagnosis of fissure caries without cavitation. *Caries Res* 1993;27:409-16.
- Lennon AM, Buchalla W, Switalski L, Stookey GK. Residual caries detection using visible fluorescence. *Caries Res* 2002; 36:315-9.
- Pinheiro I MM, Ferreira M, Lima K. Use of laser fluorescence (DIAGNOdent) for in vivo diagnosis of occlusal caries: A systematic review. *J Appl Oral Sci*. 2004;12:177-81.
- Kishen A, Shrestha A, Rafeig A. Fiber optic backscatter spectroscopic sensor to monitor enamel demineralization and remineralization in vitro. *J Conserv Dent* 2008;11:63-70
- Ekstrand K, Qvist V & Thylstrup A. (1987). Light microscope study of the effect of probing in occlusal surfaces. *Caries Research* 1987;21(4):368-374. ISSN 0008-6568.
- Angnes G, Angnes V, Grande RH, Battistella M, Loguercio AD, Reis A. Occlusal caries diagnosis in permanent teeth: an in vitro study. *Braz Oral Res* 2005;19(4):243-8.
- Ricketts D.N., Kidd E.A., Smith B.G. & Wilson R.F. Clinical and radio graphic diagnosis of occlusal caries: a study in vitro. *Journal of Oral Rehabilitation* 1995;22(1):15-20. ISSN 0305-182X.
- Wenzle A FE, Hintze H. Patient discomfort and cross infection control in bitewing examination with a storage phosphor plate and a CCD-based sensor. *J Dent* 1999;27(3):243-6.
- Madhumitha Mohanraj, V. Ratna Prabhu1, R. Senthil. Diagnostic Methods for Early Detection of Dental Caries – A Review. *International Journal of Pedodontic Rehabilitation* 2016;1(1):29-36.
- Yang J, Dutra V. Utility of radiology, laser fluorescence, and transillumination. *Dent Clin North Am* 2005;49:739-52.
- Gomez. Detection and diagnosis of the early caries lesion. *BMC Oral Health* 2015;15(1):1-7.
- De Paula AB, Campos JA, Diniz MB, Hebling J, Rodrigues JA. In situ and in vitro comparison of laser fluorescence with visual inspection in detecting occlusal caries lesions. *Lasers Med Sci* 2011;26(1):1-5.
- Cortes DF, Ellwood RP, Ekstrand KR: An in vitro comparison of a combined FOTI/visual examination of occlusal caries with other caries diagnostic methods and the effect of stain on their diagnostic performance. *Caries research* 2003;37(1):8-16.
- Lussi A, Megert B, Longbottom C, Reich E, Francescut P. Clinical performance of a laser fluorescence device for detection of occlusal caries lesions. *Eur J Oral Sci* 2001;109:14-19. doi:10.1034/j.16000722.2001.109001014.x
- Lussi A. Clinical performance of the laser fluorescence system DIAGNOdent for detection of occlusal caries (in German). *Acta Med Dent Helv* 2000;5:15-19.
- Mendes FM, Siqueira WL, Mazzitelli JF, Pinheiro SL, Bengtson AL. Performance of DIAGNOdent for detection

- and quantification of smooth surface caries in primary teeth. *J Dent* 2005;33:79-84.
32. Kuhnisch J, Ziehe A, Bradstadt A, Heinrich-Weltzein R. An in vitro study of the reliability of DIAGNOdent measurements. *J Oral Rehabil* 2004;31:895-9.
 33. Burin C, Loguercio AD, Grande RH, Reis A. Occlusal caries detection: A comparison of laser fluorescence and conventional methods. *Pediatr Dent* 2005;27:307-12.
 34. Buchalla W, Attin T, Niedmann Y, Niedmann PD, Lennon AM. Porphyrins are the cause of red fluorescence of carious dentin: Verified by gradient reversed-phase HPLC. *Caries Res* 2008;42:223.
 35. Amaechi BT. Emerging technologies for diagnosis of dental caries: The road so far. *J Appl Phys* 2009;105:1020-47.
 36. Alwas-Danowska HM, Plasschaert AJM, Suliborski S, Verdonshot EH: Reliability and validity issues of laser fluorescence measurements in occlusal caries diagnosis. *J Dent* 2002; 30:129–134.
 37. Ie YL, Verdonshot EH. Performance of diagnostic systems in occlusal caries detection compared. *Community Dent Oral Epidemiol* 1994;22(3):187-91.
 38. Diniz MB, Paes Leme AF, Cardoso KS, Rodrigues JA, Cordeiro RCL: The efficacy of laser fluorescence to detect in vitro demineralization and remineralization of smooth enamel surfaces. *Photomed Laser Surg* 2009;27(1):57-61.
 39. Zandona AF, Zero DT. Diagnostic tools for early caries detection. *J Am Dent Assoc* 2006;137(12):1675–1684.
 40. Hanieh Nokhbatolfoghahaie1, Marzieh Alikhasi, Nasim Chiniforush, Farzaneh Khoei, Nassimeh Safavi, Behnoush Yaghoub Zadeh. Evaluation of Accuracy of DIAGNOdent in Diagnosis of Primary and Secondary Caries in Comparison to Conventional Methods. *Journal of Lasers in Medical Sciences* 2013;4(4):159-67.
 41. Zahra Bahrololoomi, Seyed Ahmad Musavi, Mona Kabudan. In vitro evaluation of the efficacy of laser fluorescence (DIAGNOdent) to detect demineralization and remineralization of smooth enamel lesions. *Journal of Conservative Dentistry* 2013;16(4):362-366.
 42. Sridhar N, Tandon S, Rao N. A comparative evaluation of DIAGNOdent with visual and radiography for detection of occlusal caries: An in vitro study. *Indian J Dent Res* 2009;20(3):326-31.
 43. Ava Vali Sichani, Shahrzad Javadinejad, and Roshanak Ghafari. Diagnostic value of DIAGNOdent in detecting caries under composite restorations of primary molars. *Dent Res J (Isfahan)* 2016;13(4):327–332.
 44. Lussi A, Imwinkelried S, Pitts N, Longbottom C, Reich E. Performance and reproducibility of a laser fluorescence system for detection of occlusal caries in vitro. *Caries Res* 1999;33(4):261-6.
 45. Lussi A, Hack A, Hug I, Heckenberger H, Megert B, Stich H. Detection of approximal caries with a new laser fluorescence device. *Caries Res* 2006;40(2):97-103.
 46. Anttonen V, Seppä L, Hausen H. Clinical study of the use of the laser fluorescence device DIAGNOdent for detection of occlusal caries in children. *Caries Res* 2003;37(1):17-23.
 47. Pinelli C, Campos Serra M, de Castro Monteiro Loffredo L. Validity and reproducibility of a laser fluorescence system for detecting the activity of white-spot lesions on free smooth surfaces in vivo. *Caries Res* 2002;36(1):19-24.
 48. Shi XQ, Welander U, Angmar-Månsson B. Occlusal caries detection with KaVo DIAGNOdent and radiography: an in vitro comparison. *Caries Res* 2000;34(2):151-8.
 49. Takamori K, Hokari N, Okumura Y, Watanabe S. Detection of occlusal caries under sealants by use of a laser fluorescence system. *J Clin Laser Med Surg* 2001;19(5):267-71.
 50. Bader JD, Shugars DA. A systematic review of the performance of a laser fluorescence device for detecting caries. *J Am Dent Assoc* 2004;135(10):1413-26.
 51. Al-Khateeb S, Forsberg CM, de Josselin de Jong E, Angmar-Månsson B. A longitudinal laser fluorescence study of white spot lesions in orthodontic patients. *Am J Orthod Dentofacial Orthop* 1998;113(6):595-602.
 52. Başeren NM, Gokalp S. Validity of a laser fluorescence system (DIAGNOdent) for detection of occlusal caries in third molars: an in vitro study. *J Oral Rehabil* 2003;30(12):1190-4.
 53. Choo-Smith LP, Dong CC, Cleghorn B, Hewko M. Shedding new light on early caries detection. *J Can Dent Assoc* 2008;74:913-8.
 54. Baelum V, Hintze H, Wenzel A, Danielsen B, Nyvad B: Implications of caries diagnostic strategies for clinical management decisions. *Community Dentistry and Oral Epidemiology* 2012;40(3):257-266.
 55. Costa AM, Bezzerra AC, Fuks AB. Assessment of the accuracy of visual examination, bite-wing radiographs and DIAGNOdent on the diagnosis of occlusal caries. *Eur Arch Paediatr Dent* 2007;8(2):118–122.

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