

Diagnodent in Diagnosis of Early Dental Caries – A Systematic Review

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ABSTRACT

Background

Dental caries is a chronic disease which requires early diagnosis. Numerous advanced diagnostic methods have been reported better than the conventional methods. In this systematic review, an attempt was made to evaluate the accuracy of the diagnodent in diagnosis of early dental caries compared to other diagnostic methods.

Methods: A literature review was carried out by searching for all articles on the use of diagnodent in detection of early dental caries on the occlusal and interproximal surfaces of premolar and molars from year 2007 to 2024 in PubMed and Cochrane databases. Seven (7) articles that met the inclusion criteria were selected for the systematic review.

Results: Results showed that the sensitivity of diagnodent ranged from 61-92.24% while that of specificity was within the range of 51-96.8%. Hence diagnodent was found to be more accurate in early dental caries detection.

Conclusion: The review showed that laser fluorescence (diagnodent) is an accurate method in detecting early dental caries on the occlusal and interproximal surfaces of premolars and molars. However, to arrive at an adequate diagnosis, the diagnodent should be used as an adjunct to visual method and bitewing radiography.

Keywords: diagnodent, early dental caries, diagnosis

INTRODUCTION: Dental caries, a microbial disease of the teeth characterized by irreversible loss of tooth structure due to demineralization of the inorganic component along with dissolution of the organic matrix of the tooth, is one of the most common oral diseases in the world;¹ Yet, the diagnosis remains a challenge because there is no precise method to diagnose, especially in the early stages.

The areas commonly affected by dental caries are the occlusal and interproximal surfaces of premolars and molars which are the commonly

restored surfaces.² To facilitate adequate preventive/restorative clinical management rather than the need for substantial drillings and restorations; arriving at a good diagnosis is essential.¹

The conventional means of diagnosing dental caries are: visual, visuo-tactile examination (using mouth mirrors and probes) and conventional radiography.^{3,4} These techniques have been the cornerstone of caries diagnosis but exhibit numerous disadvantages. Visual diagnosis for cavitated lesions is usually accurate but cannot be used alone for the diagnosis of incipient, hidden or non-cavitated carious lesions.⁵ Visuo-Tactile diagnosis is rapid, minimally invasive and cost effective while the use of sharp probes has been confirmed to transfer microorganisms from one site to another, and may lead to further spread of the carious lesions that may have adverse and

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damaging effect on the teeth.⁵ Some other studies,^{5,6} indicate that the use of probes have limited value in caries detection and is known to disrupt remineralization. Radiographs, though usually advocated for diagnosis of interproximal carious lesions are of limited use in the diagnosis of incipient occlusal caries and early onset caries (white spot lesions). Furthermore, radiographs are associated with health hazards of radiation and underestimation of the lesion size.⁷ In summary, conventional caries detection methods (visual/ visuo-tactile/ radiographic) depend on subjective judgment and are prone to misinterpretation.⁷ However, modern dentistry emphasizes early detection, which may facilitate preventive treatment and minimal intervention approach rather than the usual traditional surgical approach.¹ To improve accuracy, numerous adjunctive diagnostic instruments are available such as digital radiography, subtraction radiography, X-ray micro-tomography, transverse microradiography (TMR), cone beam computed tomography (CBCT) and tuned aperture CT), fibre-optic transillumination (FOTI), digital imaging FOTI (DIFOTI), endoscopically viewed filtered fluorescence, intra-oral television camera (IOTV), electrical conductance measurement (ECM), the Canary System, CarieScan and use of LASERS (light amplification by stimulated emission of radiation e.g. quantitative light-induced fluorescence and diagnodent).⁹ Of these, laser fluorescence (e.g. diagnodent) has received the most interest.^{7,8}

The diagnodent is a diagnostic tool, which operates based on the principle of fluorescence and detects the difference between the fluorescence of normal and carious teeth. It scores each tissue and thus reduces human error.⁷ This device has two types; the chairside device (diagnodent 2095 Kavo Biberach Germany) and the battery-powered diagnodent pen (diagnodent 2190 Kavo Biberach Germany) which both function with the same principle.^{9,10} The diagnodent comes with 2 fibre-optic probes, one with the tapered tip "A", intended for occlusal surfaces, and the other with the flat tip "B", intended for smooth surfaces.¹¹ The diagnodent pen however, has a portable digital screen which displays the values read by the device.¹² The underlying mechanism of action of the diagnodent is that carious tissue emits

stronger fluorescence than sound tissue within the red and infrared part of the spectrum (L = 655 nm). Thus, the fluorescence from a carious region is greater than that from sound tissue and is expressed as a higher numerical read-out by the device with a loud audible signal to alert the clinician. The diagnosis by this method has a high sensitivity and specificity.¹³⁻¹⁵ The review compiles all articles on the diagnodent device which has been employed in in vivo occlusal and interproximal surfaces of permanent teeth. The aim was to evaluate the diagnostic accuracy of the diagnodent in diagnosing early dental caries on occlusal and interproximal surfaces.

MATERIAL AND METHOD

RESEARCH SOURCES

Databases searched were MEDLINE (PubMed) and Cochrane Library using MESH words diagnodent OR laser fluorescent AND caries AND occlusal AND interproximal. 65 articles were found through this search and only 7 articles that met the inclusion criteria were selected.

TYPE OF PARTICIPANTS

All clinical (in vivo) studies were selected from 2007-2024

TYPE OF STUDY

All diagnostic studies on human beings on occlusal and interproximal surfaces of premolars and molars.

TYPE OF OUTCOME

The outcome of interest was presence of dental caries as confirmed by visual examination.

OBJECTIVES OF THE STUDY

1. To evaluate the diagnostic accuracy of the diagnodent with the sensitivity and specificity values in diagnosing early dental caries on occlusal and interproximal surfaces of premolars and molars.
2. To assess the accuracy of diagnodent in diagnosing early dental caries compared to other diagnostic methods

INCLUSION CRITERIA

In vivo studies on diagnodent studies with sensitivity and specificity outcome

EXCLUSION CRITERIA

Case Reports and Case Series
In vitro studies
Studies on primary teeth

SEARCH STRATEGY

Cochrane Library. The text word 'diagnodent' was used to search the library

MEDLINE (PubMed)

The search words were; diagnodent OR laser fluorescent AND caries AND occlusal AND interproximal.

METHODS

All articles identified by the search were analyzed on the basis of the search words and checked for relevancy. The articles that did not

meet the inclusion criteria were excluded from the study while the 7 articles selected were printed out and reviewed.

RESULTS

The search strategy yielded 65 articles which were published between 2007 and 2024. A total of 58 articles were excluded from the study. 20 articles were excluded because they were conducted on primary teeth, 18 were in vitro studies, 10 were on secondary caries, 6 were on root caries and 4 on both primary and permanent teeth. 7 articles that met the inclusion criteria were selected for the study.

Table 1: Selected in vivo studies on diagnodent in permanent teeth.

Author/Year	Subjects	Methodology	Results	Conclusion
Krause et al ¹⁶ (2007)	94 occlusal surfaces of Premolars and Molars of 82 Patients	Laser fluorescence values were measured with conventional Laser Fluorescence Device and a New pen Diagnodent	Sensitivity values conventional=92.6% Pen diagnodent=88.9% Specificity values conventional=53.7% Pen diagnodent=63.7%	The new pen diagnodent was suitable for occlusal caries diagnosis
Bozdemir et al ¹⁷ (2013)	156 occlusal surfaces	standard was visual Inspection	Inter-examiner agreement (k= 0.61, 0.76, 0.87 For light Emitting diode (LED), laser Fluorescence (LP) Device and Visual Inspection (VI) Respectively Specificity values= 0.80 for LF based 0.62 for LED and 0.93 For VI	Caries lesion can be detected more accurately by LF based devices and LED
Melo et al ¹⁸ (2017)	302 teeth from 152 patients (occlusal) Patient's older than 18years With mean age 39.1 ± 14.3 years old	True extent of lesion was determined by Fissurotomy	Diagnodent and vistaproof showed greater internal and External validity Sensitivity= 79% 53% and 92.4% 92.9% for visual tactile, diagnodent and vistaproof respectively. Specificity =72% 92.7% and 98% respectively95.8%	Vistaproof was the best method in diagnosing early caries
Mortensen et al ¹⁹ (2018)	62 adults with 62 occlusal surfaces were examined	Visual (ICDAS), CarieScan PRO, Diagnodent pen	LF pen has moderate sensitivity but high specificity	All the methods were useful for detecting occlusal caries

		and bitewing Radiographs were used to examine the teeth.	Accuracy was highest for bitewing radiographs. Kappa values Cariescan k= 0.88 to visual LF pen = 0.94, scoring. ICDAS =0.91 and bitewing=0.92	but bitewing exhibited the best performance when compared
Alammar et al ²⁰ (2020)	30 females over 16 years 120 proximal Surfaces with No cavitation On posterior teeth	Diagnodent and digital bitewing radiographs values were obtained	Sensitivity values diagnodent= 95% bitewing radiograph =64% Specificity diagnodent= 89% bitewing radiograph = 77%	The diagnostic accuracy of diagnodent in detecting enamel caries is significantly higher than that of digital bitewing radiography
Achilleos et al ²¹ (2021)	44 adult patients with 230 occlusal Surfaces were Examined	They were assessed with DP= 0.61 ICDAS clinical criteria, diagnodent pen (DP) and vista proof (VP) fluorescence devices. ICDAS served as gold standard	Sensitivity values VP= 0.64 Specificity values DP= 0.51 VP= 0.54	Diagnodent pen and the vista proof showed no differences in their diagnostic ability compared to the visual examination
Shaan et al ²² (2023)	60 patients with 161 non cavitated white spot carious lesions and 32 sound teeth (smooth surfaces) 18-30 years Old. 40 males and 20 females	All teeth were examined by 2 calibrated examiners with ICDAS II and Diagnodent	Diagnodent's values for overall accuracy, sensitivity and specificity were visual 84.5%, 87.58% and 96.87% respectively which were higher compared to ICDAS II K= 0.83 for Diagnodent and 0.94 for ICDAS II	Overall performance of diagnodent was equivalent to inspection using ICDAS II. Diagnodent can be a useful adjunct in diagnosis and monitoring of non cavitated carious lesion

DISCUSSION

Out of all the articles recruited into this study, those on detection of dental caries on occlusal surfaces were observed to be more than interproximal.²³ This was attributed to the complex morphology of the occlusal surface and in-effective brushing of narrow hard breach pits and fissures making them more susceptible to caries.²⁴ Ramamurthy et al²⁵ corroborated that this might be due to deep narrow pits and fissures which favour the retention of food debris leading to caries. For the proximal surfaces however, dental caries has been associated with stagnation regions which are non-self-cleansing leading to plaque accumulation making premolars and molars more susceptible to caries.

It has been observed that most of the studies on the diagnostic accuracy of diagnodent compared to other methods are in vitro studies. The in vivo studies appeared to be limited. The data of this in vitro studies cannot be easily transferred to clinical settings, hence, only in vivo studies were considered in this review.

Till date, histological examination serves as the most widely used gold standard for the validation of dental caries diagnostic methods²⁶ even though, various methods such as visuo-tactile, visual and radiography have been considered gold standard for clinical studies.

Comparison between results of diagnodent and other diagnostic methods showed varying values for sensitivity and specificity.

In a study by Melo et al¹⁸ in which the true extent of lesion was determined by fissurotomy, diagnodent demonstrated a high sensitivity value of 92.4% and specificity value of 92.7%. Similarly in a study by Alammar et al²⁰ sensitivity was 95% and specificity was 89% compared to the bitewing radiography which had sensitivity 64% of and specificity of 77%. Furthermore, a study by Bozdemir et al¹⁷ reported 80% sensitivity for diagnodent compared to 93% for visual inspection.

Conversely, a study by Achilleos et al²¹ reported a low sensitivity value of 61% and specificity value of 51%. Still, the diagnostic accuracy documented in the reviewed literature shows great variation; sensitivity ranged from 61% to 95% and specificity from 51% to 96.87%.

A variety of factors influence the differences in

the diagnostic accuracy of diagnodent across various studies. These factors include disparities in research populations, the level of operator expertise, the specific models of devices used, and the types of carious lesions that are being investigated. For instance, it has been suggested that these elements contribute to considerable variation in the sensitivity and specificity ranges of diagnodent.^{17,21} The observed differences highlight the necessity for standardized procedures to enhance reliability and uniformity across various contexts.

Another important aspect is reproducibility. Bozdemir et al¹⁷ reported a kappa score of 0.76 for diagnodent and 0.87 for visual. Similarly, a study by Mortensen recorded 0.94 for diagnodent, 0.92 for bitewing radiography and 0.91 for visual method. These values indicate substantial to almost perfect agreement confirming the reliability of diagnodent as a diagnostic tool, although this does not necessarily equate to diagnostic accuracy.

Based on the results of the evaluated studies, it can be concluded that diagnodent is a reliable and accurate diagnostic tool and may be beneficial in clinical diagnosis. Also, diagnodent, visual examination, bitewing radiography are effective in diagnosing early dental caries.

Additionally, its cost-effectiveness and diagnostic usefulness across various patient populations and settings still need to be completely assessed by more studies. The cost-effectiveness of diagnodent compared to traditional methods is a critical factor for its adoption, especially in resource-limited settings. While it offers high sensitivity and specificity as noted in most studies,^{16,17,20} its high cost can be a barrier to use²⁷. Although the Mortensen et al's¹⁹ study lent credence to the consensus that diagnodent is a useful adjunct tool for identifying early dental caries, especially on occlusal surfaces, with great sensitivity and specificity when used in conjunction with visual and radiographic techniques, its effectiveness as a standalone instrument is not guaranteed.

In this review, diagnodent can be regarded as an adjunctive diagnostic tool to aid in detection of early dental caries.¹⁶⁻²² Though it should not replace conventional methods like visual-tactile examination and bitewing radiography, diagnodent can work as a major supplementary

tool for the early identification of caries, helping to avoid overtreatment, prevent unnecessary drillings of the teeth and conserve tooth structure.²⁸ Diagnodent is non-invasive and provides quick results, making it suitable for chair-side use.⁵ However, its integration with existing methods and the learning curve for operators are important considerations. Further rigorous in vivo investigations are needed to completely evaluate its cost-effectiveness, and relevance across various patient groups and environments.

CONCLUSION

The review showed that laser fluorescence (diagnodent) is an accurate method in the detection of early dental caries on the occlusal and interproximal surfaces of premolars and molars when associated with other diagnostic methods.

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