

# USE OF LASER FLUORESCENCE (DIAGNODENT™) FOR IN VIVO DIAGNOSIS OF OCCLUSAL CARIES: A SYSTEMATIC REVIEW

*O USO DA FLUORESCÊNCIA A LASER (DIAGNODENT™) NO DIAGNÓSTICO DE CÁRIES  
OCCLUSAIS IN VIVO: REVISÃO SISTEMÁTICA*

Isauremi Vieira de Assunção PINHEIRO<sup>1</sup>, Maria Cristina dos Santos MEDEIROS<sup>1</sup>,  
Maria Ângela Fernandes FERREIRA<sup>2</sup>, Kenio Costa de LIMA<sup>2</sup>

1- DDS, MSc, Graduated Student PhD (CCS/UFRN), MsC Professor - UFRN.

2- DDS, MSc, PhD, Assistant Professor - UFRN.

**Corresponding address:** Isauremi Vieira de Assunção PINHEIRO - Av. Senador Salgado Filho, 1787 - Lagoa Nova - Natal - RN  
CEP: 59056-000 - Telefone: 0XX84-2195726 / 8824-0809 - E-mail: isauremi@ig.com.br

**Received: August 12, 2003 - Returned for modification: October 23, 2003 - Accepted: May 20, 2004**

## ABSTRACT

This systematic review was conducted to assess the accuracy of laser fluorescence (DIAGNOdent™) for diagnosis of occlusal caries in permanent teeth, using any sort of gold standard. The MEDLINE, LILACS, BBO and Cochrane library databases accessed by BIREME were searched for English, Spanish and Portuguese-language papers published between 1982 and 2003. Four works in English were selected. DIAGNOdent™ was found to be an accurate method for diagnosis of occlusal caries, mainly if employed simultaneously with visual inspection.

**Uniterms:** Lasers; Fluorescence; Dental caries.

## RESUMO

Esta revisão sistemática foi realizada para avaliar a precisão da fluorescência a laser (DIAGNOdent™) para o diagnóstico da cárie oclusal em dentes permanentes, utilizando qualquer tipo de *gold standard*. As bases de dados MEDLINE, LILACS, BBO e Cochrane Library, acessadas via BIREME, foram utilizadas para a busca de artigos em idioma inglês, espanhol e português, publicados de 1982 a 2003. Foram selecionados quatro trabalhos em inglês. Foi observado que o DIAGNOdent™ é um método preciso para o diagnóstico da cárie oclusal, principalmente se associado à inspeção visual.

**Unitermos:** Lasers; Fluorescência; Cárie dentária.

## INTRODUCTION

Despite its decreasing prevalence in the Brazilian population, dental caries are still an important Public Health problem<sup>2,16</sup>. The diagnosis of dental caries remains a challenge, since its patterns and prevalence have greatly changed in the last few years. The difficulty in diagnosing dental caries lay not only on the morphological changes of lesions and their rate of progression, but on the lack of a precise methodology to correctly diagnose both the disease (accuracy) and the integrity of dental structure (specificity)<sup>10,14,19,20</sup>.

The areas most affected by dental caries are the occlusal surfaces, from which 50 to 60% are damaged by the disease.<sup>6</sup> The early diagnosis of lesions and the establishment of non-invasive treatments consequently have been highly encouraged to preserve the surface integrity. In fact, when compared to the others, occlusal surfaces are known to be the most susceptible surfaces to caries. In addition, they are also the most frequently restored and the most difficult to diagnose<sup>4,12,15,18</sup>.

The methods traditionally employed for diagnosis of caries include clinical (visual) inspection, tactile examination by probing and bitewing radiographs<sup>2,17</sup>. Clinical examination

has been proven to be suitable for smooth surfaces, but inadequate for proximal and occlusal surfaces. Radiographic images, on the other hand, are useful to detect enamel proximal lesions and dentin occlusal lesions, but are usually unsuitable to identify occlusal caries restricted to enamel. Other methods such as fiber optic transillumination (FOTI), videoscopic exam have been under discussion and some have already been developed to help in the diagnosis of caries. The accuracy of FOTI is very similar to that of visual examination<sup>9,20,21</sup>, whereas the videoscopic exam has a lower specificity<sup>7,13</sup>. Laser fluorescence has been also used to aid in diagnosing occlusal caries.

This review compiled all works on the DIAGNODent appliance, the laser fluorescence of which has been employed on *in vivo* occlusal surfaces of permanent teeth. The aim was to evaluate the diagnostic accuracy of such a device for occlusal caries.

## METHODOLOGY

### RESEARCH SOURCES

Databases searched were MEDLINE, LILACS (Latin American and Caribbean Literature on the Health Science), BBO (Brazilian Bibliography of Dentistry) and Cochrane Library accessed by BIREME website (Latin American and Caribbean Center on Health Sciences Information - www.bireme.br).

### TYPES OF PARTICIPANTS

All studies on human beings were selected, regardless of age.

### TYPES OF STUDY

All diagnostic clinical trials, on human beings and occlusal surfaces were included. The following languages were chosen: English, Portuguese and Spanish.

### TYPE OF OUTCOME

The outcome of interest was the presence or absence of dental caries as confirmed by the following methods: histological examination, opening of cavities or clinical examination based on scores utilized in studies based on histological corroboration.

### EXCLUSION CRITERIA

*In situ* and *in vitro* studies performed on smooth surfaces and primary teeth.

### SEARCH STRATEGY

#### MEDLINE:

The following strategy was employed for MEDLINE: (Diagnodent or laser fluorescence or laser fluoroscopy) and (occlusal or occlusal) and not vitro [Words] and English or Portuguese or Spanish [Language], from 1982 to 2003.

#### LILACS and BBO:

LILACS and BBO were searched from 1982 to 2003, using the terms:

(Diagnodent or laser fluorescence or laser fluoroscopy) and occlusal and not vitro [Words] and English or Portuguese or Spanish [Language].

All types of studies available on these two databases were searched for (theses, dissertations, monographs and papers).

#### Cochrane Library:

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

## REVIEW METHODS

All reports identified by the search were printed out and independently analyzed by two reviewers on the basis of title, keywords and abstract (when available) to check if the study was likely to be relevant. The full report of all relevant papers was obtained and also when a paper could not be classified. When there was disagreement a third reviewer was consulted to achieve consensus.

The reviewers were not blinded as to authors, journals, date of publication, financial support or results. The inclusion criteria were applied and the data assessed and independently extracted by two reviewers. Consensus was sought in case of discrepancy. This was conducted according to the Users' Guides in the JAMA series on the Rational Clinical Examination<sup>7,8</sup>.

## RESULTS

The searches strategies yielded 11 reports from the MEDLINE database. All had been published in English language between 2001 and 2003. Four of these met the selection criteria after reading the full articles. Of the seven reports excluded, 3 were literature reviews and the remaining 4 were *in vitro* investigations.

One from all selected studies (Anttonen, et al.<sup>3</sup>) examined deciduous and permanent teeth. Nevertheless, only data related to permanent teeth were appraised to this review.

Two reports were found in the LILACS database, both of which were in Portuguese language published in the years 2000 and 2001. These were excluded because the studies were performed on the deciduous dentition.

Three references were found in the BBO database, all in Portuguese language. Two of these were also in the LILACS database; the third was an *in vitro* study.

Four reports in English language were found in the Cochrane Library. All had already been found in the previous databases.

Therefore, four studies were selected for analysis of the methodology and data reliability (Figure 1).

| Author/Year                                   | Subjects  | Methodology  | Results   | Conclusion   |
|---|---|--|---|--|
| Sheehy, et al. <sup>18</sup> (2001)           | 170 permanent molars of children with mean age of 6.85±0,58.  | Gold standard: Visual examination, DIAGNOdent™ manufacturer's criteria and Lussi et al. <sup>11</sup> (1999) criteria. | -Kappa = 0.94<br><br>-DIAGNOdent™ (according to the manufacturer) Sensitivity = 70% Specificity = 87%<br><br>- DIAGNOdent™: according to Lussi, et al. <sup>11</sup> (1999) Sensitivity = 100% Specificity = 33%  | - DIAGNOdent™ can be useful as an aid to visual inspection.<br>- Alone, DIAGNOdent™ is unable to distinguish between hypomineralized caries and stainings<br>- DIAGNOdent™ values were found to be more similar to those provided by the manufacturer than those reported by Lussi, et al. <sup>11</sup> (1999).   |
| Lussi, et al. <sup>12</sup> (2001)            | 332 occlusal surfaces of molars and premolars from 240 patients   | Gold standard: opening of cavities   | - Kappa = 0.93<br>- Spearman coefficient = 0.98<br>- Visual examination: Sensitivity = 31% (in dentine) and 63% (in enamel).<br>- DIAGNOdent™ Sensitivity = above or equal to 92% (when the cut point was <i>in vivo</i> occlusal carious dentin) and 96% for enamel caries.<br>- Bitewing radiography Sensitivity = 63%  | - DIAGNOdent™ > sensitivity than visual inspection.<br>- Combination of visual examination and the DIAGNOdent™ is recommended.   |
| Heinrich-Weltzien, et al. <sup>5</sup> (2002) | n = 97 In the 97 patients, (281 untreated first and second molars with sound occlusal surfaces or enamel and dentinal lesions) were selected. The mean age of the patients was 19.2 years (SD±1.4). | Gold standard: opening of cavities   | Visual examination: Sensitivity = 25% Specificity = 100%<br>DIAGNOdent™ Sensitivity = 93% Specificity = 63%<br><br>Kappa = 85% for examiner 1 and 91% for examiner 2.<br><br>Radiographic examination: Sensitivity = 70% Specificity = 96%  | DIAGNOdent™ is an important supplement for this purpose, since the recommended DIAGNOdent™ value above 20 as a cut-off for detection of occlusal dentinal caries could be confirmed as a sensitive marker for use in daily practice.<br>The combination of visual examination, which is highly specific, and the DIAGNOdent™ laser, which is highly sensitive, is recommended. |
| Anttonen, et al. <sup>3</sup> (2003)          | 613 occlusal surfaces on permanent molars in children aged 7-8 (n=55) and 13-14 years (n=54) and 436 surfaces of primary molars.  | Gold standard: opening of cavities   | Kappa of visual examination = 0.85.<br><br>The mean values for the first DIAGNOdent™ measures was 33.3 and for the second DIAGNOdent™ measures that were accomplished four weeks later was 31.3<br>The Pearson's correlation coefficient = 0.74<br>Intraclass correlation coefficient (ICC) = 0.78.<br>DIAGNOdent™ For permanent teeth (according to cut-off 30) Youden's index = 60%<br>DIAGNOdent™ For permanent teeth (according to cut-off 30) Sensitivity = 92% Specificity 69%<br>with visual examination for validation. Sensitivity = 92% Specificity 82% with validation by fissure opening. | In routine dental check-ups of children, DIAGNOdent™ appears to be useful as an adjunct to visual examination.   |

FIGURE 1- Selected studies about DIAGNOdent™ employed on *in vivo* occlusal surfaces of permanent teeth

## DISCUSSION

The occlusal surface is the area most susceptible to dental caries. It is also the most difficult surface to reliably detect caries. For this reason, several investigators have attempted to discover a method capable to assist the clinical examination in diagnosing occlusal caries. Such method would be highly useful for incipient lesions that otherwise could not be detected by visual examination alone. In fact, this would definitely allow earlier and more conservative treatments, thus ensuring maximum preservation of dental structure.

Among the reviewed methods, laser fluorescence of the DIAGNOdent™ appliance (KAVO, Biberach, Germany) has shown to be promising. However, most published articles have been *in vitro* investigations, the data of which are not easily applied to the clinical setting. For this reason, only clinical studies that tested the accuracy of the DIAGNOdent™ laser for diagnosis of occlusal caries were considered in the present literature review. These studies were also expected to use a diagnostic gold standard for comparison.

In the present literature review, Lussi, et al.<sup>12</sup> (2001), Heinrich-Weltzien, et al.<sup>5</sup> (2002) and Anttonen, et al.<sup>3</sup> (2003) regarded cavity opening as a gold standard, whereas Sheehy, et al.<sup>18</sup> relied on clinical examination. The clinical characteristics achieved were compared to the histological criteria of an *in vitro* study performed by Lussi, et al.<sup>11</sup> in 1999, as well as to DIAGNOdent™ (Kavo) manufacturer's criteria. Cavity opening or tooth extraction (for histological analysis) can be considered gold standards for the evaluation of diagnostic methods. However, the opening of cavities should always be avoided in borderline cases, clinical examination is satisfactory, although quite limited<sup>19</sup>. As tooth extraction would only be considered on permanent teeth extracted for orthodontic or prosthetic reasons, the reliability of any investigation is limited.

Another aspect to consider is whether the test results and gold standard were assessed independently of each other. The interpretation of a new test is likely to be influenced by the knowledge of the results of the reference standard (or vice versa), therefore the independent interpretation of both is highly important. Assessment was accomplished with measurement of the DIAGNOdent™ completed independently. As a result, the exams were not influenced by laser fluorescence values.

Comparison between the results of DIAGNOdent™ and a gold standard is represented by values of methodological sensitivity and specificity. In the study reported by Lussi, et al.<sup>12</sup>, in which carious dentin was the cut point, the sensitivity and specificity of the experimental method (DIAGNOdent™) was 92% and 86%, respectively. When carious enamel was the threshold, sensitivity was about 96%. Similar outcomes were found for the dentinal caries. Anttonen, et al.<sup>3</sup> observed a sensitivity of 92% and specificity of 82% with employment of a cut-off point of 30. Similarly, the study conducted by Heinrich-Weltzien, et al.<sup>5</sup> revealed sensitivity values of 93%, however the specificity

was lower (63%) when compared to the others. The study of Heinrich-Weltzien, et al.<sup>5</sup>, on the other hand, observed a specificity 20% lower than the other investigations. This was probably due to the exclusion of caries-free molars, which were assessed but not operatively validated. On the other hand, this procedure avoided the problem of false negative findings, which are common in clinical studies in respect to ethical aspects.

It appears from this data that DIAGNOdent™ may provide an accurate diagnosis of occlusal caries. The work published by Sheehy, et al.<sup>18</sup> was an epidemiological survey and did not rely on suitable gold standards (cavity opening or histological examination). Consequently, it failed to show very clear sensitivity and specificity data, although they could be estimated from table results. When comparing the clinical results for DIAGNOdent™ stated on the manufacturer's table, the outcomes were 87% specificity and 70% sensitivity. Different values were achieved when clinical characteristics were compared to values of an *in vitro* study reported by Lussi, et al.<sup>11</sup>. In this case, specificity was 33%, whereas sensitivity was 100%. Such divergence in the results were likely due to the *in vitro* design of the Lussi, et al.<sup>11</sup> study, compared to the *in vivo* survey by the manufacturer. A noticeable finding is that the manufacturer's results were very similar to those revealed by Lussi, et al.<sup>12</sup> in 2001, who also elected to conduct an *in vivo* investigation (86% and 92%, respectively). However, sensitivity of Sheehy, et al.<sup>18</sup> study was lower.

With regard to the subjects selected, the inclusion of a spectrum of patients very similar to those of clinical practice was observed in all studies. In fact, the samples contained all occlusal surfaces of any tooth (molar or premolar) from the maxillary or mandibular arches.

Another essential feature to be discussed is the test reproducibility and interpretation, which are directly important for clinical practice. Comparison of the final results to those of other studies requires them to be reproducible. Reproducibility is nothing other than the precision of diagnostic instruments. In other words, it represents the agreement of results when an examination is repeated under identical or very similar conditions. Reproducibility is a fundamental characteristic when the goal is to assess the accuracy of a diagnostic method. The kappa coefficient has been employed to measure the agreement of categorical data and seems to be very important to assess the reproducibility of a method<sup>1</sup>. When considering non-categorical quantitative data, correlation coefficients seem to be a much better choice<sup>1</sup>.

Lussi, et al.<sup>12</sup> and Sheehy, et al.<sup>18</sup> calculated the kappa value for DIAGNOdent™ of 0.98 and 0.89, respectively. Lussi, et al.<sup>12</sup> achieved a value of 0.93 in the study for categorical data. Similarly, Anttonen, et al.<sup>3</sup> achieved a kappa value of 0.85, whereas Heinrich-Weltzien, et al.<sup>5</sup> found a kappa value of 0.75. These figures represent good to excellent agreement. However, being reproducible is not always as, because a test may be reproducible, but inaccurate.

It should also be mentioned that the test description

should be clear enough to permit replication of the study. The DIAGNOdent™ method was clearly described in all studies selected.

The results of the studies evaluated allow us to conclude that DIAGNOdent™ is a reproducible and accurate diagnostic tool that may be greatly helpful for clinical diagnosis.

Considering the present literature review, the results of which were shown to be acceptable, DIAGNOdent™ may be regarded as an auxiliary diagnostic method to aid in disclosure of dental caries in surfaces where they tend to be extremely hidden to the eyes. In turn, this may considerably decrease the risk of false-positive or false-negative diagnosis that could otherwise lead to equivocal and harmful treatments. With the improvement in diagnosis precision, less dental structures shall be damaged and the patients will be granted with further clinical profits.

## CONCLUSIONS

The literature review demonstrated that laser fluorescence (DIAGNOdent™) is an accurate method for diagnosis of occlusal caries, particularly when associated to visual inspection. Further investigation should however be conducted in populations with caries whose patterns differ from those observed in the evaluated studies. This would certainly broaden the spectrum of teeth with a clinically doubtful diagnosis.

## REFERENCES

- 1- Altman D G. Practical statistics for medical research. New York: CRC Press; 1990. 616 p.
- 2- Angmar-Mansson B, Ten Bosch JJ. Advances in methods for diagnosing coronal caries - a review. *Adv Dent Res* 1993 Aug; 7(2):70-9.
- 3- Anttonen A, Seppä L, Hausen H. Clinical study of the use of the laser fluorescence device DIAGNOdent for detection of occlusal caries children. *Caries Res* 2003 Jan/Feb; 37(1):17-23.
- 4- Garcia AFG, Araújo FB, Tovo MF. Estudo dos métodos visual, radiográfico interproximal e a laser no diagnóstico de cárie. *Rev Assoc Paul Cir Dent* 2000 Set/Out; 54(5):384-9.
- 5- Heinrich-Weltzien R, Weerheijm K L , Kühnisch J, Oehme T, Stösser L. Clinical evaluation of visual, radiographic, and laser fluorescence methods for detection of occlusal caries. *ASDC J. Dent Child* 2002 May/Aug; 69(2):127-32.
- 6- Horowitz HS. Pit and fissure sealants in private practice and public health programmes: analysis of cost effectiveness. *Int Dent J* 1980 Jun; 30(2):117-26.
- 7- Jaeschke R, Guyatt GH, Sackett DL. User's guides to the medical literature III. How to use an article about a diagnostic test. A. Are the results of the study valid? *JAMA* 1994 Feb; 271(5):389-91.
- 8- Jaeschke R, Guyatt GH, Sackett DL. User's guides to the medical literature III. How to use an article about a diagnostic test. B. What are results and will they help me in caring for my patients? *JAMA* 1994 Mar; 271(9):703-7.

- 9- Longbottom C, Pitts NB. Initial comparison between endoscopic and conventional methods of caries diagnosis. *Quintessence Int* 1990 Jul; 21(7): 531-40.

- 10- Lussi A. Comparison of different methods for the diagnosis of fissure caries without cavitation. *Caries Res* 1993 Sep/Oct; 27(5): 409-16.

- 11- 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 Jul/Aug; 33(4):261-6.

- 12- 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 Feb; 109(1):14-9.

- 13- Mialhe FL, Pardi V, Pereira AC, Meneghim MC, Flório FM, Ambrosano GMB. Comparação in vitro de quatro métodos de diagnóstico para cárie oclusal: visual, videoscópico, FOTI e laser fluorescente. *RPG Rev Pós Grad* 2000 Abr/Jun; 7(2):125-32.

- 14- Nyvad B, Machiulskiene V, Baelum V. Construct and predictive validity of clinical caries diagnostic criteria assessing lesion activity. *J Dent Res* 2003; 82(2):117-22.

- 15- Pardi V, Mialhe FL, Pereira AC, Meneghim MC. Avaliação in vitro do aparelho DIAGNOdent para diagnóstico oclusal. *Pesqui Odontol Bras* 2000 Out/Dez; 14(4):372-77.

- 16- Pegoraro CN, Franco EB. Cárie dentária: métodos de diagnóstico e filosofia atual de tratamento. *CECADE News* 1994 Jan/Abr; 2(1):1-14.

- 17- Pitts NB. Diagnostic methods for caries: what is appropriate when? *J Dent* 1991 Dec; 19 (6):377-82.

- 18- Sheehy EC, Brailsford SR, Kidd EA, Beighton D, Zoitopoulos L. Comparison between visual examination and a laser fluorescence system for in vivo diagnosis of occlusal caries. *Caries Res* 2001 Nov/Dec; 35(6):421-6.

- 19- Thylstrup A, Fejerskov O. Características clínicas e patológicas da cárie dentária. In: Thylstrup A, Fejerskov O. *Cariologia clínica*. 2 ed. São Paulo: Ed. Santos;1995. p.111-57.

- 20- Wenzel A. New caries diagnostic methods. *J Dent Educ* 1993 Jun; 57(6):428-32.

- 21- Wenzel A, Pitts N, Verdonschot EH, Kalsbeek H. Developments in radiographic caries diagnosis. *J Dent* 1993 Jun; 21(3):131-40.