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# Evaluation of different methods for monitoring incipient carious lesions in smooth surfaces under fluoride varnish therapy

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**Background.** There are only a few studies relating visual inspection methods and laser fluorescence when monitoring regression of incipient carious lesions.
**Aim.** The purpose of this study was to monitor incipient carious lesions in smooth surfaces under varnish fluoride therapy using visual inspection methods and laser fluorescence (LF).
**Design.** Active white spot lesions ($n = 111$) in upper front teeth of 36 children were selected. The children were subjected to four or eight applications of fluoride varnish in weekly intervals. The visual systems were activity (A) and maximum dimension in millimetres (D). They were applied together with LF readings (L) in the beginning of the study (W1), in the 5th week (W5), and in the 9th (W9) week.
**Results.** The mean (SD) of L values in W5 and W9 were 5.6 (3.8) and 4.5 (3.3), respectively; both were significantly different from the initial score of 7.4 (5.1) in W1. There was a positive correlation between D and L in W5 ($r = 0.25$) and W9 ($r = 0.36$; $P < 0.05$). The mean (SD) values of L were lower following the activity criteria.
**Conclusions.** Our findings support the finding that incipient carious lesions in smooth surfaces under fluoride therapy can be monitored by laser fluorescence and visual inspection methods.

## Introduction

White spot lesions represent the first clinical observation of demineralization in the enamel and can be regarded as a sign of dental caries[1,2]. Several studies point out that fluoridated dental products, such as fluoride varnishes, are able to promote remineralization and to control the development of the carious process[3–6], to reduce demineralization adjacent to orthodontic brackets[7,8], and to reduce incidence of early childhood caries[9].

Despite the simplicity of the method, the recommended frequency of varnish applications is still under debate. Half-yearly applications have been proven to be efficient in preventing dental caries[3,10]. In high caries-active patients is recommended four consecutive weekly applications[11]. It has been found in a school preventive programme that monthly application of this product is more effective than trimonthly and half-yearly applications[12].

The current caries pattern of slow progression raises the chances to reverse a demineralization process of an incipient carious lesion[5]. Accurate caries diagnostic or inspection methods are, however, needed for monitoring active incipient carious lesions in children enrolled in a preventive programme and to help professionals during a restorative clinical decision[13]. Among these methods used for initial caries lesions in occlusal and smooth surfaces, the visual examination and laser fluorescence have been extensively investigated[14–16].

Basically, the visual inspection consists of cleaning and drying the tooth or surface to be examined under a good light source. The observation of changes in colour and anatomical configuration will indicate the presence of a carious lesion[17]. In order to improve accuracy

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of this method for determining the progression of a carious lesion, different clinical classification systems have been proposed[18–20].

The use of the 655-nm laser diode fluorescence is regarded as a promising option for caries diagnosis despite the risk of false positives for sealed surfaces and stained fissures[21]. The sensitivity, specificity, and reproducibility of this device have been investigated *in vitro* in occlusal surfaces[14,16] and in smooth surfaces[22–24]. There are, however, only few *in vivo* clinical studies evaluating the laser fluorescence for monitoring changes in incipient caries lesions under preventive procedures[25,26].

The aim of this work was to monitor incipient carious lesions in smooth surfaces under varnish fluoride therapy using visual inspection methods and a laser fluorescence device.

## Materials and methods

### *Experimental design*

This study was approved by the Ethics Committee of the Federal University of Paraiba (Joao Pessoa, Brazil).

Three hundred and twenty-seven schoolchildren (7–12 years old) from two public schools of the city of João Pessoa were invited to participate in this study. Apart from the fluoride varnish and fluoridated toothpaste, no other fluoride source was available for the subjects. The city does not have water fluoridation[27] and has not received any preventive programme that could provide a high fluoride exposure before and during the study. All children with visible dental biofilm received professional cleaning and were examined for active and intact incipient carious lesions in the upper canines and incisors. One hundred and eleven active incipient carious lesions, from 36 children, were selected due to the evident visual presence of active incipient carious lesions (roughness and opaque). A pilot study was carried out to calibrate one examiner for selecting the active incipient carious lesions (kappa = 0.78). The criteria for exclusion were the following: children with caries as small cavities or restorations in the target teeth, development of alterations in the teeth's enamel (hypoplasia, fluorosis), use of orthodontic devices, being under medical treatment or taking any kind of medicine, and children whose parents did not sign the informed consent.

All children received toothpaste (1500 p.p.m.) and a toothbrush to be used twice a day during the study. No oral hygiene instructions were given to the subjects. The children were subjected to four or eight applications of fluoride varnish (Duraphat®, Colgate-Palmolive, Brazil) in weekly intervals and according to the manufacturer's recommendations. Four fluoride applications were previously planned to avoid fluoride overtreatment in children with inactive lesions before finishing the study period. Prior to the varnish applications, supervised brushing was carried out. The incipient carious lesions that remained active after the fourth application were submitted to four more weekly applications.

### *Visual examinations*

The incipient carious lesions were evaluated using two visual criteria systems and a laser fluorescence device (DIAGNOdent® 2095, KaVo, Biberach, Germany) in the beginning of the study (W1), in the 5th week (W5), and in the 9th (W9) week. Before each evaluation, a professional cleaning was performed. For each diagnostic method, the tooth surface was examined just after a 15-s air-drying period with at least 2 min of saliva moisture period in between to have a standard time for the laser fluorescence readings. Evaluations were carried out by only one calibrated examiner who selected patients randomly and performed examinations in a blinded way.

Two visual features of the lesion were observed: activity (A) and dimension (D). Activity was observed using three scores of Nyvad scale[20]: 0 (healthy), 1 (activity, with intact surface), and 4 (inactivity). Maximum lesion dimension was measured based on the guidelines of Maia and Valença[28]. The lesion was measured with the aid of a periodontal probe. The values of D were obtained by the average of the largest mesial–distal (horizontal) and incisal–gingival (vertical) diameters in millimetres. The final dimension mean value (D) was also categorized (D′) in four levels:

A (0.1–2 mm), B (2.1–4 mm), C (4.1–6 mm), and D (larger than 6 mm).

### *Laser fluorescence measurements*

Laser fluorescence (LF) readings were carried out using the point B specific for smooth surface. The maximum reading (peak) of the examined area was recorded and a drawing of the lesion was used for locating the site in future evaluations. Calibration of the LF device was done according to the manufacturer's recommendation every 10 readings using the ceramic pattern as well as the sound tooth surface of the dental element. The peak values of the readings were noted as real values (L) and also classified in agreement with Lussi scale (L′)[14], which are 0–4, 4.01–10, 10.01–18, 18.01, and above.

### *Data analysis*

After sample selection, 18 carious lesions (in five patients) were randomly selected for assessing intra-examiner agreement (kappa) for D′ and L′. The kappa values were calculated before starting fluoride applications to avoid influence of the enamel changes during the study. The intra-examiner agreement (kappa) for D′ and L′ was 0.6 and 1.0, respectively.

The mean (SD) values of LF readings (L) and lesion dimension (D) were calculated for each evaluation week (W1, W5, and W9). Since lesion activity (A) is a categorical variable, the mean values of D and L were also calculated according to activity category. Longitudinal differences of visual caries scores within groups were evaluated by paired *t*-test. Normal distribution of the values was checked by normal plots and also using one-sample Kolmogorov–Smirnov test. For correlation between lesion dimension (D) and LF readings (L) Pearson's correlation was applied. Level of significance was set to 5%.

## Results

The mean (SD) of L values in W5 and W9 were 5.6 (3.8) and 4.5 (3.3), and both were significant different from the initial score of 7.4 (5.1) in W1 ($P < 0.05$). Figure 1 shows the number of incipient carious lesions according to the scores of L′ readings. A reduction in the number of incipient carious lesions with high values of laser fluorescence readings (group from 10.01 to 18) can be observed. For W1 and W9, the figures were $n = 22$ (19.8%) and $n = 3$ (2.7%), respectively. The number of incipient carious lesions allocated in the group with L′ readings from 0 to 4 (close to the sound surface scores) increased. In W1, there were 38 white spot lesions (34.2%), whereas in W9, 72 (64.7%) lesions were scored as sound surfaces (below 4). Three white spot lesions increased the value of L′ during the study.

Figure 2 shows the mean (SD) of D during the study. In W1, W5, and W9, the mean (SD) values were 3.4 (1.2), 2.7 (1.2), and 2.0 (1.3), respectively. These values are significantly different from each other in all tested pairs

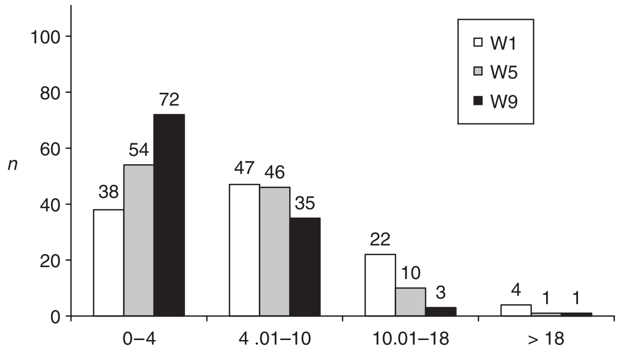


**Fig. 1.** Frequency of incipient carious lesions according to laser fluorescence readings scores (L′).

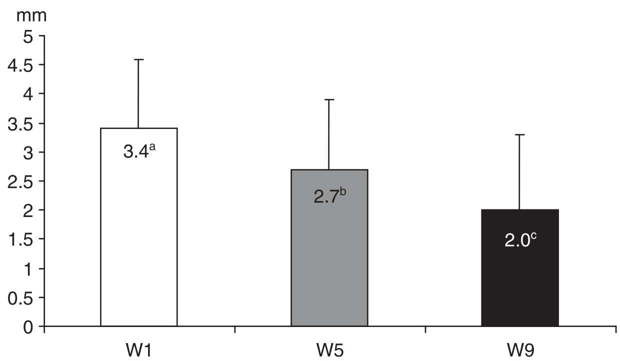


**Fig. 2.** Mean values of dimension (in millimetres) of carious lesions during the study in João Pessoa, Brazil, in 2006. Means followed by different letters denote statistically significant differences ($P < 0.05$).

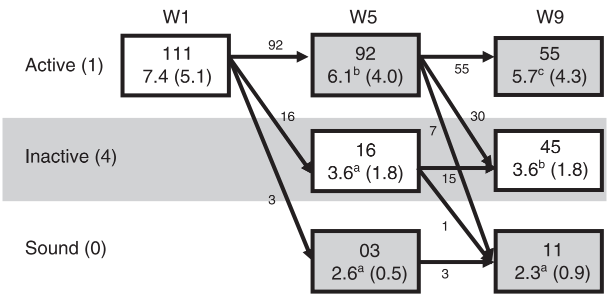


**Fig. 3.** Mean (SD) values for L (laser fluorescence) according to three scores of A (activity) in W1, W5, and W9. Means followed by different letters denote statistically significant differences ($P < 0.05$).

(W1–W5, W5–W9, and W1–W9) ($P < 0.05$). Regarding the mean (SD) of D in relation to A in W9, the results were 0.0 (0.0) for sound surfaces ($n = 3$), 1.7 (0.9) for inactive lesions ($n = 16$), and 2.7 (1.1) for the remaining active lesions ($n = 92$). These values were statistically significantly different ($P < 0.05$).

Figure 3 expresses the mean (SD) of L according to activity (A). In W1, the 111 active lesions showed an L mean (SD) score of 7.4 (5.1). In W5, the means (SD) of L categorized by A as sound surfaces ($n = 3$), inactive ($n = 16$), and active lesions ($n = 92$) were 2.6 (0.5), 3.6 (1.8), and 6.1 (4.0), respectively; with significant difference between the last values and the former ones ($P < 0.05$). In W9, these values were 2.3 (0.9), 3.6 (1.8), and 5.7 (4.3) for sound surfaces ($n = 11$), inactive lesions ($n = 45$), and active lesions ($n = 55$), respectively; with statistically significantly differences between the groups ($P < 0.05$).

There was a positive correlation between D and L in W5 ($r = 0.25$) and W9 ($r = 0.36$) ($P < 0.05$). In W1, no correlation was observed ($r = 0.04$).

## Discussion

In the present study, the white spot lesions in the upper front teeth of the children were related to poor oral hygiene since all children had visible dental biofilm covering these incipient carious lesions during selection. Thus, the indication of remineralization of white spot lesions in W5 and W9 cannot be attributed to the fluoride varnish only, since biofilm removal with delivery of fluoride from toothpaste had also played a role. Professional cleaning as well as good illumination and drying of the dental element are important procedures for accurate visual examination[17,20]. Professional cleaning is also important for laser fluorescence since nonremoval of organic matter on the tooth surface can influence laser fluorescence readings[15]. Hence, for an adequate caries inspection, prophylaxes prior the examinations were necessary.

A control group without fluoride exposure would be interesting. In this situation, it would have been possible to minimize the effect of fluoride and follow up the evolution of these white spot lesions affected by biofilm removal only. This situation was, however, regarded unethical due to the risk of progression of active lesions and no beneficial effect of fluoride in one of the groups. In addition, no oral hygiene instructions were given to the children and the twice-daily brushing at home was not supervised during the study. On the other hand, supervised brushing was carried out once per week prior to fluoride varnish applications except for W1, W5, and W9 when professional cleaning was performed. Therefore, possible differences in oral hygiene practices at home had a minimal effect on the progression of remineralization of these lesions.

Recently, Aljehani *et al.*[26] used a laser fluorescence device to follow up incipient carious lesions in a study design similar to ours. The major differences were that white spot lesions were formed around fixed orthodontic appliances; the treatments did not include topical fluoride application but oral hygiene instructions or professional cleaning and the duration of the study was 12 months.

Most of the incipient carious lesions related to orthodontic treatment can be controlled with the removal of the brackets, which reduces the cariogenic challenge[7,8]. In our study, the incipient carious lesions were related to poor oral hygiene in children at risk for dental caries. Therefore, in our study the incipient carious lesions were probably more severe than those reported by Aljehani *et al.*[26]. In our study, the white spot lesions were rather large in dimension (D) with 3.4 mm and the first mean DIAGNOdent reading in our study was higher, 7.4, than the values, 5.4 reported in their study.

After 1 year of treatment with oral hygiene, Aljehani *et al.*[26] observed that the mean laser fluorescence readings in incipient carious lesions had a significant decrease of 1.5 units, from 5.4 in the first measurement to 3.9 in the end. In our study, in a shorter period with fluoride varnish applications, the reduction observed was of 1.9 units. Despite the differences in design and treatments, both studies support the idea that laser fluorescence can be an alternative method for monitoring incipient carious lesions in smooth surfaces under caries preventive-control programmes.

For incipient carious lesions in fissures, the laser fluorescence may not have the same performance as for smooth surfaces. More clinical studies are necessary to evaluate this issue. One possible explanation is that when using a laser fluorescence device for longitudinal caries monitoring, the same mode of calibration should always be used[29]. Since the probe position on the target sites has to be recorded carefully, in longitudinal studies it is recommended to have a drawing of the tooth with the lesion and the target sites.

The values of D and L were correlated in W5 and W9. This suggests that the LF readings followed the reduction in dimension of the white spot lesions. These were, however, weak correlations. In addition, even after intense fluoride therapy, the white spot lesions classified as active by A remained with mean L′ in the group 4.01–10 in W9. Our findings are in contrast with *in vitro* studies that supports a low precision of LF in smooth surfaces[21,22]. In our study, all three methods were able to follow clinical improvement over time and this is a support to clinical activity assessment (A) that in most situations is used for assessing carious lesions development but not carious lesions regression[20].

Our findings suggest that eight consecutive applications of fluoride varnish in patients with regular oral hygiene with fluoridated toothpaste can produce at least a short-term 50% reduction in white spot lesions. This information is relevant since a recent study showed that an increment of caries is expected to be high among children who present white spot lesions in the beginning of a 1-year follow-up period[30]. Although our data do not include a 1-year follow-up, a recent study concluded that within a period of 6 months of fluoridated toothpaste use white spot lesions are stable concerning fluorescence loss[6].

## Conclusions

Our findings support that regression of incipient carious lesions in smooth surfaces under topical fluoride applications can be monitored by laser fluorescence and visual inspection methods as maximum dimension (D) and activity (A).

**What this paper adds**

- This paper adds knowledge about methods that can be used to monitor white spot lesion under fluoride therapy.
- The results indicate that laser fluorescence and visual inspection methods such as activity criteria (A) and lesion dimension in mm (D) were able to follow the regression of incipient carious lesions after fluoride varnish applications.

**Why this paper is important to paediatric dentists**

- This paper is important for paediatric dentists because it shows to the clinician that 8 weekly applications of fluoride varnish is an effective way to control the progression of white spot lesions.
- This paper is also important because the paediatric dentist can monitor by visual and laser fluorescence methods the outcome of incipient carious lesions under fluoride therapy.

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## References

1 von der Fehr FR, Loe H, Theilade E. Experimental caries in man. *Caries Res* 1970; **4**: 131–148.
2 Ferreira MAF, Mendes NS. Factors associated with active enamel lesions. *Int J Paediatr Dent* 2005; **15**: 327–334.
3 Seppä L, Tuuitti H, Luoma H. Three-year report on caries prevention using fluoride varnish application for risk children in a community with fluoridated water. *Scand J Dent Res* 1982; **90**: 89–94.
4 Seppä L. Studies of fluoride varnishes in Finland. *Proc Finn Dent Soc* 1991; **87**: 541–547.

5 Featherstone JD. Prevention and reversal of dental caries: role of low level fluoride. *Community Dent Oral Epidemiol* 1999; **27** (1): 31–40.
6 Zantner C, Martus P, Kielbassa AM. Clinical monitoring of the effect of fluorides on long-existing white spot lesions. *Acta Odontol Scand* 2006; **64** (2): 115–122.
7 Todd MA, Staley RN, Kanellis MJ, Donly KJ, Wefel JS. Effect of a fluoride varnish on demineralization adjacent to orthodontic brackets. *Am J Orthod Dentofacial Orthop* 1999; **116**: 159–167.
8 Schmit JL, Staley RN, Wefel JS, Kanellis M, Jakobsen JR, Keenan PJ. Effect of fluoride varnish on demineralization adjacent to brackets bonded with RMGI cement. *Am J Orthod Dentofacial Orthop* 2002; **122**: 125–134.
9 Weintraub JA *et al*. Fluoride varnish efficacy in preventing early childhood caries. *Evid Based Dent* 2006; **7**: 65–66.
10 Bruyn H, Arends J. Fluoride varnishes – a review. *J Biol Buccale* 1987; **15**: 71–82.
11 Cury JA. *Fluorterapia*. São Paulo, Brazil: Biblioteca Científica, 1991: 6.
12 Marinho V. Substantial caries-inhibiting effect of fluoride varnish suggested. *Evid Based Dent* 2006; **7**: 9–10.
13 Baelum V, Heidmann J, Nyvad B. Dental caries paradigms in diagnosis and diagnostic research. *Eur J Oral Sci* 2006; **114**: 263–277.
14 Lussi A *et al*. Performance and reproducibility of detection of occlusal caries *in vitro*. *Caries Res* 1999; **33**: 261–266.
15 Lussi A, Reich E. The influence of toothpastes and prophylaxis pastes on florescence measurements for caries detection *in vitro*. *Eur J Oral Sci* 2005; **113**: 141–144.
16 Lussi A, Hellwig E. Performance of a new laser fluorescence device for the detection of occlusal caries *in vitro*. *J Dent* 2006; **34**: 467–471.
17 Marthaler TM. A standardized system of recording dental conditions. *Helv Odontol Acta* 1966; **10**: 1–18.
18 Ekstrand KR, Ricketts DNI, Kidd EAM. Reproducibility and accuracy of three methods for assessment of demineralization depth on the occlusal surface: an *in vitro* examination. *Caries Res* 1997; **31**: 224–231.
19 Bjorndal L, Thylstrup A. A structural analysis of approximal enamel caries lesions and subjacent dentin reactions. *Eur J Oral Sci* 1995; **103**: 25–31.
20 Nyvad B, Machiulskiene V, Baelum V. Reliability of a new caries diagnostic system differentiating between active and inactive caries lesions. *Caries Res* 1999; **33**: 254–260.
21 Shi X, Traneus S, Angmar-Manson B. Validation of DIAGNOdent for quantification of smooth-surfaces caries: an *in vitro* study. *Acta Odontol Scand* 2001; **59**: 74–78.
22 Shi X, Traneus S, Angmar-Manson B. Comparison of QLF and DIAGNOdent for quantification of smooth surface caries. *Caries Res* 2001; **35**: 21–26.
23 Aljehani A, Yang L, Shi XQ. In vitro quantification of smooth surface caries with DIAGNOdent and the DIAGNOdent pen. *Acta Odontol Scand* 2007; **65**: 60–63.
24 Mendes FM, Siqueira WL, Mazitelli 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.
25 Anttonen V, Seppä L, Hausen H. A follow-up study of the use of DIAGNOdent for monitoring fissure caries in children. *Community Dent Oral Epidemiol* 2004; **32**: 312–318.
26 Aljehani A, Yousif MA, Angmar-Mansson B, Shi X-Q. Longitudinal quantification of incipient carious lesions in postorthodontic patients using a fluorescence method. *Eur J Oral Sci* 2006; **114**: 430–434.
27 Sampaio FC, Hossain AN, von der Fehr FR, Arneberg P. Dental caries and sugar intake of children from rural areas with different water fluoride levels in Paraiba, Brazil. *Community Dent Oral Epidemiol* 2000; **28**: Special Issue: 307–313.
28 Maia LC, Valença AMG. A influência da profilaxia prévia à aplicação tópica de flúor no comportamento das lesões de mancha branca em dentes permanentes – um estudo *in vivo*. Cadernos da ABROPEV 1993. *Vencedores do Prêmio Nacional de Odontologia Preventiva* 1993; 91–100.
29 Braun A, Krause F, Jepsen S. The influence of the calibration mode of a laser fluorescence device on caries detection. *Caries Res* 2005; **39**: 144–149.
30 Scavuzzi AI, De Franca Caldas Junior A, Couto GB, De Vasconcelos MM, De Freitas Soares RP, Valenca PA. Longitudinal study of dental caries in Brazilian children aged from 12 to 30 months. *Int J Paediatr Dent* 2007; **17**: 123–128.