Effect of Cut-Off Points on Performance of Laser Fluorescence for Detecting Occlusal Caries

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This in vitro study aimed to evaluate the influence of cut-off points on the performance of laser fluorescence (LF) in detecting occlusal caries in permanent and primary teeth. The use of different cut-off points influenced the performance of LF device in detection of occlusal caries in both kind of teeth, but the performance in permanent teeth suffered more influence from variation of cut-off points scales than in primary group.
Key-words: *occlusal caries, laser fluorescence, DIAGNOdent, cut-off points, primary teeth, permanent teeth.*
J Clin Pediatr Dent 32(1): 33–36, 2007

INTRODUCTION

Early detection of caries lesions has become essential in evaluating severity of disease and also establishing a treatment.[1,2] Detection of occlusal lesions is a real challenge due to the access and the model of progression of lesions on this surface. New technologies have been extensively studied for this purpose.

The Laser Fluorescence (LF) device is based on emission of a light from a diode laser (λ=655nm), capture of fluorescence emitted by the dental tissues and translation of this fluorescence on a numerical scale from 0-99.[3] The higher the number, the deeper the caries lesion. This equipment has been pointed as an alternative to improve the diagnosis accuracy, especially when adopted as adjunct of visual inspection.[4-8]

Research about performance of laser fluorescence (LF) device has been controversial. Some authors have found high sensitivity for the method,[4-10] while other authors have shown high specificity.[4,7-8,12] A trend of higher sensitivity and lower specificity values for detecting occlusal caries lesions in permanent teeth has been observed with LF, while a similarity between these values has been noted for primary ones.[13] However, few studies have worked with both groups simultaneously.[7,9,14] The use of different cut-off points can be one of the causes for divergence among results about LF performance among different studies.[7,11,15]

Based on these facts, this study aimed to evaluate the performance of laser fluorescence in detecting occlusal caries lesions in permanent and primary teeth using different cut-off points with the same examiners and a standardized protocol.

MATERIALS AND METHODS

The experimental protocol was approved by Local Ethics Committee. Thirty-five permanent and 51 primary extracted or exfoliated teeth, donated by a bank of human teeth, had their occlusal surface photographed. One or two suspected sites were located and dotted on the picture (67 for primary and 56 for permanent group).

The specimens were cleaned with a rotating toothbrush with pumice/water slurry and stored in saline solution. Each tooth was assessed in three different occasions using LF (DIAGNOdent – Kavo – Biberach, Germany). The device was calibrated against a ceramic standard and tooth was dried for 3 s.[16] Tip A was placed firstly on a sound surface for individual calibration and after on the selected site. The tip was placed perpendicular on the site and rotated around its vertical axis. The maximum value was recorded and the mean of three measurements was calculated.

After LF reading, sections around 250μ thick were made and the examination of each section was performed separately by two trained examiners using a stereomicroscope with X16-40 magnification. In case of discrepancies, new examinations were performed until they reached a consensus. The sites were classified in a 5-point scale: D0 – no caries; D1-caries lesion limited to the outer half of the

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enamel; D2 – caries extending into inner half of the enamel but not to amelodentinal junction; D3- caries limited to the outer half of the dentin; D4: caries involving the inner half of the dentin.

Receiver operating characteristics (ROC) analysis was performed for D2 and D3 thresholds considering the results obtained with both permanent and primary teeth. Best cut-off points were determined specifically for this sample by a combination of sum of sensitivity and specificity found with ROC analysis. Moreover, ROC analysis was performed to obtain the best cut-off points for the sample of primary teeth, for the sample of permanent sample and for the entire sample. For the data analysis, we also adopted cut-off points presented by other researches, one performed in primary teeth[4] and other using permanent ones.[12] The cut-off points proposed by the manufacturer were also used.

Using these cut-off points, sensitivity, specificity and accuracy of LF method were calculated at D2 and D3 thresholds. McNemar test was used to assess statistically significant difference among values obtained from different cut-off points with the same kind of teeth, and chi-square test to assess the significance of differences observed between primary and permanent teeth.

Table 1. Cut-off points used for Laser Fluorescence device in the present study

Clinical interpretation	Sound/early enamel caries	Enamel caries	Dentinal caries
Manufacture	0 – 14	15 - 20	> 20
Attrill & Ashley, 1999	0 – 9	10 - 17	> 17
Shi *et al*., 2000	0 - 6.7	6.8 - 22.1	> 22.1
Best cut-off points for permanent teeth	0 – 4	5 – 8	> 8.0
Best cut-off points for primary teeth	0 – 6	7 – 11	> 11
Best cut-off points for all sample	0 – 6	7 - 14	> 14

RESULTS

The best cut-off points for all the sample (permanent and primary teeth), for only primary teeth and for only permanent ones are expressed in Table 1, as well the other points adopted in this study.

Tables 2 and 3 show the performance of LF according the cut-off points variation at D2 and D3, respectively. In general, there were no significant differences among primary and permanent when used different scales. However, when we used best cut-off points for permanent sample, sensitivity and accuracy at D2 threshold was better for permanent group, whereas accuracy was better for primary group when adopted manufacturer cut-off points.

Among all scales used, at enamel threshold, higher sensitivity was reached using best cut-off points for permanent sample in both primary and permanent group. The higher specificity, for primary teeth, was found using manufacturer scale but no significant differences were noted about specificity for permanent ones (Table 2).

At dentin threshold, sensitivity was higher for primary teeth in most part of cut-off points scales but no differences in specificity were observed between both group of teeth except for best cut-off points for all sample. At this threshold, sensitivity was higher and specificity lower when used scales with lower cut-off values. Accuracy at D3 was also similar to D2. In permanent group, best cut-off points for permanent sample were superior in accuracy than other ones (Table 3).

DISCUSSION

Despite other studies that have already evaluated the performance of LF device for permanent and for primary teeth, few studies tested both kind of teeth simultaneously.[6,9,14] So that, some variations could have been incorporated in diagnosis process, which causes problems in simply comparing the results from different studies.

Besides, protocols involving LF found in literature have presented divergences about criteria which interfere in LF performance as presence of calculus and dental plaque[3,10,16]

Table 2. Performance of Laser Fluorescence device in detecting occlusal caries lesions in primary and permanent teeth at enamel threshold (D2), expressed in sensitivity, specificity and accuracy.

	Sensitivity			Specificity			Accuracy		
	D T	P T		D T	P T		D T	P T	
Attrill & Ashley	0.54 a	0.53 a	ns	0.79 a	0.90 a	ns	0.66 a	0.60 a	ns
Manufacture	0.37 b	0.42 b	ns	0.90 b	0.90 a	ns	0.62 a	0.51 b	*
Shi *et al*.	0.69 c	0.69 c	ns	0.65 c	0.80 a, b	ns	0.67 a	0.71 c	ns
Best for permanent teeth	0.74 d	0.86 d	*	0.50 d	0.67 b	ns	0.63 a	0.83 d	**
Best for primary teeth	0.69 c	0.69 c	ns	0.65 c	0.80 a, b	ns	0.67 a	0.71 c	ns
Best for all sample	0.69 c	0.69 c	ns	0.65 c	0.80 a, b	ns	0.67 a	0.71 c	Ns

DT: Deciduous teeth / PT: Permanent teeth
Statistically significant difference between DT and PT - * $p < 0.05$; ** $p < 0.01$.
ns = non significant difference between samples ($p \geqslant 0.05$)
Different letters express statistically significant difference within the same column ($p < 0.05$)

time of drying,[10,12,16] professional's experience and training[17-18] and storage of specimens for *in vitro* studies.[19] Our research aimed to compare the performance of LF method to detect occlusal caries in both permanent and primary teeth using the same methodology and to verify the effect of the utilization of different cut-off points on this performance.

An *in vitro* study requires the use of a storage solution, as formaline or chloramine, which could influence LF readings.[19] Among cut-off point scales considered to data analysis, Attrill and Ashley used formaline for storage of specimens[4] and Shi *et al*. (2000) put their samples in sodium hypochlorite for 20 minutes,[12] what could have influenced their cut-off ranges.[19-21] It is a consensus that storage conditions and cleaning of surface can influence the readings done by LF device. Nevertheless, when cut-off points are adjusted for each examination separately, no significant differences have been found.[22]

Post-extraction period could also interfere in LF measurements due to natural decomposition of organic components of carious lesion, which are the most responsible for values obtained from LF device.[20] It probably occurs in this sample and could explain the lower cut-off points of this study compared to other *in vivo* studies.[23] Similar studies should be performed *in vivo* to minimize the problems and the results should be carefully extrapolated for clinical practice.[8,10]

Cut-off points were similar to permanent and primary teeth being 2 to 3 units higher for primary teeth sample. This difference agrees with other authors' *in vitro*[14] and *in vivo* results.[6] Antonnen *et al*. (2003) found lower measures for primary considering sound teeth and, for lesions at D3 threshold, similar measures.[6] In addition, Francescut and Lussi (2003) identified a common range of measures between both kind of teeth.[14]

LF performed similarly in D2 and D3 threshold for primary teeth independent of cut-off points scale adopted whereas for permanent one, the best performance was associated with the scale of best cut-off points for its own sample. Better accuracy for primary teeth when used manufacturer scales arises the hypothesis of shorter period of storage that simulate *in vivo* conditions for what this scale was created.

The cut-off points will determine a numeric limit between health and disease and consequently a range that will correspond to any one. Low cut-off points have been related to high sensitivity values.[10-17] In spite of the cut-off points are low, the reading of LF device can vary between 0 and 99. Therefore, a straight range will represent health (0 to 4-6, for enamel lesions and 0 to 8-14, for dentin lesions); while another, extremely high, will comprehend the disease (5-7 to 99, for enamel and 9-15 to 99, for dentin).

An increase of sensitivity is commonly associated with a specificity decrease[13] what explains why specificities values of this study were lower than those found by Attrill and Ashley[4] and manufacturer scale. As accuracy is a balance of detection of health and disease, no differences were observed among different cut-off points for primary teeth.

At dentin threshold, LF seemed to perform better in primary than in permanent teeth, which agrees with previous authors.[14] Better performance in primary teeth could not be considered an anatomical difference due to their similarity to permanent ones[29] but could be associated to reduced thickness of enamel.[25] Alwas-Danowska *et al*. (2002) suggested better performance of LF at D2 threshold because of difficulty of photons penetration in D3 threshold.[5] For permanent teeth, the present study emphasizes this statement exactly as other previous studies.[10,14] However, for primary teeth, LF sensitivity was better for dentin threshold.[7,14,16]

In contrast, specificity was also higher in dentine for primary teeth.[7,14,16] Considering permanent group, depending on cut-off points, specificity was higher at D3 in some research[10,12] or for D2 threshold in others.[8]

It is essential to consider the choice for one or another cut-off point depends on what you expect from the diagnosis method. A method to associate it with another with high specificity, such as visual inspection, one should consider cut-off scales which emphasizes the sensitivity of the method. On the other hand, if the aim is use a method by

Table 3. Performance of LF device in detecting occlusal caries lesions in primary and permanent teeth at dentin threshold, expressed in sensitivity, specificity and accuracy.

	Sensitivity			Specificity			Accuracy		
	D T	P T		D T	P T		D T	P T	
Attrill & Ashley	0.69 a	0.40 a	**	0.90 a	0.82 a, c	ns	0.86 a	0.61 a	**
Manufacture	0.47 b	0.35 a	Ns	0.91 a	0.85 a	ns	0.83 a, b	0.60 a	**
Shi et al.	0.31 c	0.27 b	Ns	0.93 b	0.88 a	Ns	0.82 a, b	0.57 a	**
Best for permanent teeth	0.97 d	0.68 c	**	0.72 c	0.70 b	Ns	0.76 b	0.69 b	ns
Best for primary teeth	0.94 d, e	0.56 d	**	0.81 c	0.75 b, c	Ns	0.83 a, b	0.65 b, c	**
Best for all sample	0.81 a, e	0.49 d	**	0.88 a	0.77 b, c	*	0.87 a	0.63 a, c	**

DT: Deciduous teeth / PT: Permanent teeth

Statistically significant difference between DT and PT - * $p < 0.05$; ** $p < 0.01$.

ns = non significant difference between samples ($p \geqslant 0.05$)

Different letters express statistically significant difference within the same column ($p < 0.05$)

itself, it could be desirable to select points that permit well balanced values for specificity and sensitivity, resulting in a satisfactory accuracy. For populations with low incidence of caries lesions, methods with high specificity are preferable. Therefore, the selection of the cut-off points should be based on what you expect from the device.

CONCLUSION

Depending on the cut-off points chosen, the performance of LF device to detect occlusal caries can be influenced both in permanent and in primary teeth. Cut-off points at enamel and dentin threshold were similar for primary and permanent teeth but performance in permanent teeth suffered more influence from variation of cut-off points scales than in primary group.

ACKNOWLEDGEMENTS

The authors wish to thank the Department of Restorative Dentistry of Faculty of Dentistry of University of São Paulo for its technical support.

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