Effect of the Calibration Method of a Laser Fluorescence Device for Detecting Occlusal Caries in Primary Molars

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Abstract

Purpose: The purpose of this study was to verify the influence of individual calibration on sound tooth surfaces and the number of readings on in vitro performance of a laser fluorescence (LF) device to detect occlusal caries in primary teeth.

Methods: After standard calibration (on the porcelain reference object), 72 clinically suspect sites on occlusal surfaces of 54 exfoliated or extracted (for orthodontic purposes) primary molars were assessed using the DIAGNOdent. First, after individual calibration (on a sound surface of each tooth), 3 readings were performed for each site. Subsequently, another 3 readings were taken, but without individual calibration on a sound surface of the tooth. After these assessments, sites were also evaluated with only one reading after individual calibration. Histological validation was performed as the gold standard. LF values, sensitivity, specificity, accuracy (number of correct diagnosis in both sound and diseased teeth) were calculated and compared using the McNemar change test. The area under receiver operating characteristics (ROC) curves was also compared.

Results: Readings with standard calibration only (mean=11.7±10.6 SD) were significantly higher statistically than assessment with 3 readings after individual calibration (10.7±10.7) and with 1 reading (10.2±8.3) after individual calibration. Nevertheless, sensitivity, specificity, accuracy, and area under ROC curve did not change significantly.

Conclusion: Absence of individual calibration does not affect the laser fluorescence device's performance in detecting occlusal caries in primary teeth. (Pediatr Dent 2006; 28:451-454)

KEYWORDS: CALIBRATION, OCCLUSAL SURFACES, DENTAL CARIES, PRIMARY TEETH, LASER FLUORESCENCE

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Occlusal caries detection is an important issue in clinical practice. Visual inspection has shown high specificity and ease of use. It is not a quantitative method, however, and has demonstrated lower sensitivity and reproducibility than other methods.[1,2] The diode laser fluorescence (LF) device (DIAGNOdent, Kavo, Biberach, Germany) is a diagnostic tool that has shown good results in detecting occlusal caries.[3-7]

According to the manufacturer's instructions, the assessment of suspect sites with the LF includes a:

1. standard calibration on a porcelain reference object before the examination (standard calibration); and
2. further calibration on a sound surface of each tooth (individual calibration).[8,9] Calibration on a sound surface, however, has been considered time-consuming.[4] In addition, some authors have performed more than one reading to minimize subjective errors that could be added to LF measurement.[10]

The effect of individual calibration and the number of readings on the LF device's performance requires further study. Earlier research concerning individual calibration was performed with permanent teeth.[8] Primary teeth, however, present differences from permanent teeth.[11-13] For example, the primary enamel is thinner than permanent enamel.[13] In addition, the mineral content of primary enamel is lower, porosity is greater, and caries lesions progress faster than in permanent teeth.[11,12] These differences in physical properties could affect the LF device's performance in primary teeth.[14]

The aim of this in vitro study was to determine whether individual calibration on a sound surface of a primary tooth and number of readings affect the ability of a laser fluorescence device to detect occlusal caries lesions in primary teeth.

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Table 1. Mean±(SD) of Readings and Performance of the Laser Fluorescence (LF) Device in 3 Examinations With or Without Individual Calibration (IC)—Calibration on a Tooth's Sound Surface—and With a Single Reading after Individual Calibration in Each Site Expressed as Sensitivity, Specificity, Accuracy, and Area under the Receiver Operating Characteristics (ROC) Curve (Az) for Diagnosing Occlusal Caries Lesions Affecting Enamel (D2) and Dentin (D3)

	LF values	Sensitivity		Specificity		Accuracy		Az	
		D2	D3	D2	D3	D2	D3	D2	D3
3 readings with IC	10.7±10.7	0.61	0.64	0.79	0.90	0.69	0.86	0.74	0.93
3 readings without IC	11.7±10.6*	0.63	0.73	0.79	0.92	0.71	0.89	0.77	0.95
Single reading with IC	10.2±8.2	0.55	0.82	0.85	0.90	0.69	0.89	0.77	0.93

*Significantly different statistically from other values in same column (P<.05)

Methods

The protocol of this study was approved by the Ethics Committee of the School of Dentistry, University of São Paulo, São Paulo, Brazil. Fifty-four exfoliated or extracted (for orthodontic purposes) primary molars presenting no visible cavities in the occlusal surfaces and intact pulp chambers were selected from Bank of Human Teeth, School of Dentistry, University of São Paulo. The teeth were stored in saline for no longer than 3 months. Excluded were teeth with: (1) occlusal restorations and fissure sealants; (2) hypoplastic pits; (3) stained or brownish occlusal surfaces; (4) frank occlusal cavitation; and (5) large carious lesions on smooth and approximal surfaces. After the sample was selected, the teeth were cleaned with a rotating brush and a pumice/water slurry. They were stored in saline until all examinations were completed.

Photographs of each occlusal surface were taken to identify and select the sites to be examined. One examiner evaluated the dried teeth by visual inspection, with no magnification or probing. Then, 72 sites were chosen on the basis of visual suspicion of a caries lesion.

For the LF examination, DIAGNOdent was used. For all measurements, the device was calibrated against a ceramic standard (standard calibration) prior to the first readings and again after every 10th tooth. Teeth were air-dried for 3 seconds, the tip A was placed on previously selected sites and rotated around a vertical axis.

The assessments were made by 3 different methods:

1. Three readings with individual calibration. The individual calibration comprised the calibration of the device against a sound surface of the evaluated tooth. The center of each tooth's buccal surface was chosen to standardize this procedure. The sound surface was previously checked to avoid doing the calibration in sites with staining or mineral alterations. After the individual calibration, 3 assessments were made on each selected site and the mean response was calculated.

2. Three readings without individual calibration. In this group, the individual calibration on a sound surface was eliminated and the examination was performed under the same conditions as described in the first assessment. Therefore, 3 assessments were made of each selected site using only the standard calibration on the ceramic reference object.

3. One reading with individual calibration. In the third evaluation, the individual calibration was made as described previously for the first group, but only one measurement was performed in each site instead of 3 measurements.

After the LF assessments were completed, the teeth were sectioned faciolingually through the fissures using a 0.3-mm thick diamond saw mounted in a microtome (Labcut 1010, Extec Co, Enfield, Conn), creating sections approximately 250-μm thick. The sections were manually polished with silicon carbide paper (400-, 600-, 1,000-, and 1,200-grit in sequence) under running water. Examination of each section was performed separately by 2 examiners using a stereomicroscope at X16 to X40 magnification and reflected light (SZPT Olympus, Tokyo, Japan). In cases of examiner disagreement, examinations were repeated until they reached a consensus.

The sites were classified in a 5-point scale[15]:

1. D1=caries lesion limited to the outer half of the enamel;
2. D2=caries extending into the inner half of the enamel, but not to the dentinoenamel junction;
3. D3=caries limited to the outer half of the dentin;
4. D4=caries involving the inner half of the dentin; and
5. D0=no caries.

For the data analysis, cutoff points previously described in a study in primary teeth were used to represent the limit between the sound and diseased teeth/site: 0-9=sound/early enamel caries; 10-17=enamel caries; and 18-99=dentinal caries.[16] Using these cutoff points, the sensitivity (true positive), specificity (true negative), and accuracy (number of correct diagnoses in both sound and diseased teeth) of the LF method was calculated at the D2 and D3 thresholds. The McNemar test was used to assess the statistically significant difference among the values. Receiver operating characteristics (ROC) analysis was performed, and the areas under the ROC curves for each condition were compared. The LF values in each assessment were compared using the Friedman 1-way ANOVA test. The MedCalc statistical software was used (MedCalc, Mariarke, Belgium). The level of significance for all the tests was chosen as $P<.05$.

Results

The mean LF readings from assessments performed without individual calibration (on a sound surface) were statistically significantly higher than readings for which individual calibration was performed ($P<.001$). Furthermore, there was no statistically significant difference in the mean LF values obtained from 3 readings with individual calibration compared to the single reading after individual calibration (Table 1).

At both D2 and D3 thresholds, there were no significant differences among sensitivity, specificity, and accuracy values. There were also no significant differences among areas under ROC curves in the assessments performed with 3 readings after individual calibration compared to 1 reading after individual calibration or with 3 readings without individual calibration (Table 1). In all groups, the specificity values were higher than the sensitivity values at both enamel and dentin caries thresholds. The proportion of correct results was higher in the sound teeth than in carious teeth.

Discussion

LF is based on excitation of tooth structure by light from a diode laser (655 nm) and quantitative detection of the resulting fluorescence emitted from the dental tissues. The device must be calibrated using a standard made of a material whose fluorescence is known and stable, because the system is subject to variation.[9] In fact, most LF studies have applied this calibration before the assessment of teeth with LF.[3,4,6,15,16] A previous study, however, conducted measurements using an earlier device made by the same manufacturer that did not include the reference standard as well as a new model and reference standard similar to the one used in this study.[5] Despite the absence of standard calibration with the older device, minimal differences were observed when compared to those obtained by the newer device using standard calibration.[5] Nevertheless, calibration of the current LF device using the ceramic standard is considered essential since LF works with a relative numerical scale.

DIAGNOdent's manufacturer has also recommended individual calibration using the tooth prior to the examination of a suspect site to provide a baseline value for each tooth.[9] A recent study with extracted permanent teeth has shown that fluorescence readings were dependent on the calibration mode.[8] That study demonstrated variation between the readings with and without individual calibration of about 6 units. A systematic difference of that magnitude could lead to erroneous restorative treatment for lesions that presented LF values near 30.[8] In this study, a significant difference between measurements with and without individual calibration was observed. Nevertheless, the overall diagnostic performance of the methods did not differ. Additionally, another in vivo study without individual calibration found variations of 1 to 2 units in LF readings, similar to this study's results, but the authors did not mention whether there was any reduction in the accuracy of caries detection.[6]

The differences between the findings of this study and those of a previous one could be related to the kind of teeth used.[8] Primary teeth present structural differences, and caries lesions progress more rapidly than in permanent teeth.[11,13] Moreover, studies using the LF device have found some differences related to its performance in detecting occlusal caries lesions in permanent and primary teeth.[7] Studies to evaluate the influence of individual calibration on the performance of the LF device in permanent teeth should be performed.

Treatment decisions must not be based solely on LF readings. Rather, LF should be used as an adjunct to visual inspection to minimize the effect on treatment decisions caused by minor differences in LF readings created by an absence of individual calibration. Based on these assertions and the results of this study, individual calibration of an LF device on a sound primary tooth surface may not substantially improve the caries diagnosis process.

Calibration is an additional and time-consuming step in clinical practice.[4] This is particularly important, since any diagnostic test may become more difficult when applied to children.[2,16] Clinical procedures in children, including caries lesions detection, should be simplified as much as possible.

Another means of simplifying the LF examination investigated in this study is the number of readings taken of each suspect site. DIAGNOdent's manufacturer has not recommended a specific number of measurements that should be made in each site or surface to achieve a reliable value. Some authors have recorded the mean of 2 or more readings to minimize subjective errors.[3,10,15] In the present study, values obtained from one reading were similar to the mean of 3 readings. The high reproducibility of LF readings found in previous studies could explain these findings.[3,4,8-10,16] Thus, the individual calibration exerted an influence on LF values, while the number of readings did not.

This study found that LF performance was not affected when the individual calibration was omitted, or when only one reading with the device was made. Further in vivo studies with primary and permanent teeth should be conducted to confirm these findings. For monitoring the progression of caries lesions, however, it is important to perform more than one measurement, and the mode of calibration must be standardized. Earlier studies have shown that LF was useful for monitoring caries lesions in permanent and primary teeth, even though individual calibration was not performed.[6,17]

Conclusions

Based on this study's results, the following conclusions can be made:

1. The absence of individual calibration of the laser fluorescence (LF) device does not adversely affect its performance in detecting occlusal caries lesions in primary teeth in vitro.
2. The protocol for utilization of the LF device in primary teeth may be simplified in clinical practice.

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Abstract of the Scientific Literature

Child Behavior After Anesthesia

The objective of this study was to evaluate the validity of a post-hospitalization behavior questionnaire (PHBQ) given to children in Sweden. The relationship between the psychometric properties of the PHBQ and age and gender were also tested. Two- to 13-year-old children who were scheduled for an elective procedure—including anesthesia—were consecutively recruited. Parents of 340 children provided the final sample population. The 5 most consistent factors were: (1) general anxiety-withdrawal; (2) eating disturbances; (3) separation anxiety; (4) regression-aggression; and (5) sleep anxiety. In addition, age was associated with higher PHBQ scores. Children who were 5 years old or younger had significantly higher mean scores than older children. Gender, however, was not significantly related to total PHBQ scores, even when controlling for age. The authors also conclude that the PHBQ is adequately reliable and should be used for further research. A 5-factor model for the PHBQ, however, would be more appropriate for data from Swedish children.

Comments: Anesthesia has been found to be associated with changes in children's behavior. The PHBQ is a reliable and valid tool used to help assess children's post-hospital behavior. More research should be conducted to further validate the instrument and to determine its relationship with different factors. **THB**

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