Scientific Article

In Vitro Evaluation of the Influence of Air Abrasion on Detection of Occlusal Caries Lesions in Primary Teeth

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Abstract: ***Purpose:*** *The purpose of this study was to assess the influence of cleaning pits and fissures with an aluminum oxide air abrasion system on the detection of occlusal caries in primary teeth using laser fluorescence (LF) and visual examination.* ***Methods:*** *The sample comprised 65 pit and fissure sites on extracted primary teeth suspected to be carious. The sites were submitted to 2 visual examinations (examiner JAR) and 2 LF readings (examiner TMV). Next, the occlusal surfaces were air-abraded and re-examined thereafter using both methods. The teeth were sectioned, and the histological analysis of the sites with a stereoscopic magnifying lens at X32 magnification was used as the gold standard.* ***Results:*** *Cohen's kappa statistic for LF and visual examination were, respectively, 0.282/0.884 before and 0.896/0.905 after air abrasion. LF showed a sensitivity of 0.28 increasing to 0.49 and a specificity of 0.50 increasing to 0.92. Visual examination showed sensitivity of 0.78 and specificity of 0.73. Both increased after air abrasion.* ***Conclusion:*** *The findings suggest that cleaning pits and fissures with aluminum oxide air abrasion increased the accuracy of LF and visual examination for detection of occlusal caries in primary teeth.* *(Pediatr Dent 2008;30:15-8) Received November 30, 2006 / Last Revision April 23, 2007 / Revision Accepted April 27, 2007.*

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The detection of occlusal dental caries is difficult.[1] The discoloration of pits and fissures appears to present several effects, and its removal might improve diagnosis.

Caries can be detected using a laser fluorescence (LF) device, particularly on occlusal pits and fissures, and it has been evaluated in many studies.[1-3] This device illuminates the tooth's surface with a red light (λ=655 nm). Inorganic and organic tooth substances and metabolites from oral bacteria emit fluorescence, which is detected by a photodiode. This photodetector estimates the amount of fluorescent light, showing in a digital display a real time value (moment) and a maximum value (peak). As with visual inspection, however, this method, can be influenced by stain,[3] making the diagnosis difficult.

Because the air abrasion of tooth surfaces removes stains and pigments, it is hypothezed that this system may improve the accuracy of LF readings and visual inspection. Several authors have shown that, depending on the parameter settings, air abrasion systems may be indicated either for minimally invasive cavity preparations or for the cleaning of tooth surfaces prior to the use of occlusal caries detection methods.[4-6] Furthermore, the air abrasion system can improve sealant retention rates when followed by acid etching.[7] The combination of pit and fissure cleaning and LF should be investigated as a means of yielding a more reliable detection of caries lesions on occlusal surfaces.

This study's purpose was to evaluate the influence of cleaning pits and fissures with an aluminum oxide air abrasion system on the detection of occlusal caries in primary teeth using LF and visual examination. The reproducibility and accuracy of the methods was also assessed.

Methods

This study was approved by the Ethics Committee of the School of Dentistry, São Paulo State University (UNESP). Twenty-six extracted human primary molars suspected to have initial caries lesions on their occlusal surfaces were selected. After prophylaxis with water/pumice slurry, the teeth were: (1) carefully washed for 15 seconds with a 3-in-1 syringe to remove any debris inside the fissure that could influence the LF readings; and (2) stored in 0.1% thymol solution at 4ºC throughout the study.

The occlusal surfaces were photographed with a digital camera, and the photographs were mounted on cards. An independent senior researcher, who did not take part in the study as an examiner, selected the sites visually exhibiting signs of caries lesions, such as white spots, stained fissures or surfaces,

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and microcavities (small surface defects). The photographs of 65 sites were marked for further examination.

The occlusal surfaces were examined twice with a 1-week interval between the evaluations by 2 calibrated examiners (JAR and TMV). Each used one of the caries detection methods under study (ie, visual examination and LF). The order of methods was not randomized. First, the visual examinations were carried out by examiner JAR. Afterward, the LF measurements were performed by examiner TMV.

Visual inspection was performed on dry, clean tooth surfaces, with direct visualization and excellent illumination, without probing. The teeth were never allowed to become dehydrated.

The LF measurements were also performed on dry, clean tooth surfaces, using DIAGNOdent, a battery-powered quantitative diode LF device (KaVo, Biberach, Germany), according to the manufacturer's specifications. For each tooth, the device was calibrated prior to the operator's evaluation by holding the selected probe tip (cone-shaped Tip A, indicated for fissure areas) against a ceramic reference (standard calibration) and then against an anatomic reference point of the tooth that was apparently healthy. Afterwards, the probe tip was placed perpendicularly on the suspicious site with light contact. The tip was slowly rocked in a pendulum motion to carefully scan the periphery of the site at various angles, and the maximum (peak) value was recorded. This peak value was then correlated with the definitions of a scale supplied by the manufacturer, which corresponds to the absence or presence of carious lesions, and to its degree of progression (0-13=sound; 14-20=enamel caries lesions; 21-29=deep caries lesions in enamel; 30-99=dentin caries lesions).

One week after the first exams, the occlusal pits and fissures of all teeth were air-abraded and the sites were re-examined. Air abrasion procedures were carried out by the independent senior researcher, who did not participate as an examiner. This researcher used an aluminum oxide air abrasion system (Prep Star, Danville Engineering, San Ramon, Calif), with a 0.38-mm diameter active point, which was positioned at a distance of 2 mm from the enamel surface at an 80° angle, and using a 50-mm aluminum oxide particle stream at 80 psi for 2 seconds. In a previous study from our group, the air abrasion system was used for 15 seconds for cavity preparation on the enamel of primary teeth. We hypothesized that a 2-seconds use would not remove significant dental tissue.[5]

The air-abraded surfaces were thoroughly rinsed, dried, and examined twice by the same calibrated examiners using the caries detection methods under study (ie, visual examination and LF), according to the same parameters, with the interval and ranking scores previously described.

For validation of the results, the teeth were bisected buccolingually through the center of the carious lesion using a water-cooled diamond disc at low-speed. The deepest areas of the caries lesions were examined with the aid of a stereoscopic magnifying lens at X32 magnification. These analyses were carried out by the senior researcher who was not involved as an examiner, according to the same scores used for visual examination (Table 1). For histological criteria, the cut-off between 1 and 2 was determined when the caries lesion reached the enamel-dentin junction. To evaluate the influence of air abrasion on caries detection with LF and visual examination, the reproducibility and accuracy of both methods were assessed. Reproducibility of the methods was calculated using Cohen's kappa statistic (intra-examiner variability) before and after use of the air abrasion system. Differences in reproducibility were evaluated using t tests. The accuracy of the methods was determined by calculation of the sensitivity and specificity. Statistical differences were assessed using *t* test.

Table 1. RANKED SCORING SCALES CORRESPONDING TO VISUAL EXAMINATION AND HISTOLOGICAL CRITERIA

Scores	Visual examination	Histological criteria
0	Sound (no change in enamel translucency)	No caries present
1	Enamel caries lesion (visible opacity)	Demineralization involving enamel
2	Superficial caries lesion in dentin (localized enamel breakdown and discoloration from the dentin)	Demineralization involving outer half of dentin
3	Deep dentin caries lesion (cavitation in enamel exposing the dentin beneath)	Demineralization involving inner half of dentin

Results

From the 65 occlusal sites analyzed in this study, the histological examination (gold standard) carried out by the independent senior researcher showed that: (a) 42 (65%) were sound; (b) 11 (17%)had enamel caries lesions; (c) 7 (11%) had superficial caries lesions in the dentin; and (d) 5 (8%) had deep caries lesions in dentin.

The reproducibility values (Cohen's kappa statistic) for LF and visual examination were, respectively, 0.282/0.884 before air abrasion of the occlusal surfaces and 0.896/0.905 after air abrasion.

The Figure shows the intraexaminer variability for LF. The mean difference in the 2 readings was 1.40 for LF before and -0.38 for LF after. The limits of agreement were ±21.56 and ±6.61, respectively (Figure). A statistically significant difference (P=.002) was observed for reproducibility between before and after use of the system.

Sensitivities, specificities, and kappa values observed for LF and visual examination before and after aluminum oxide air abrasion are shown in Table 2.

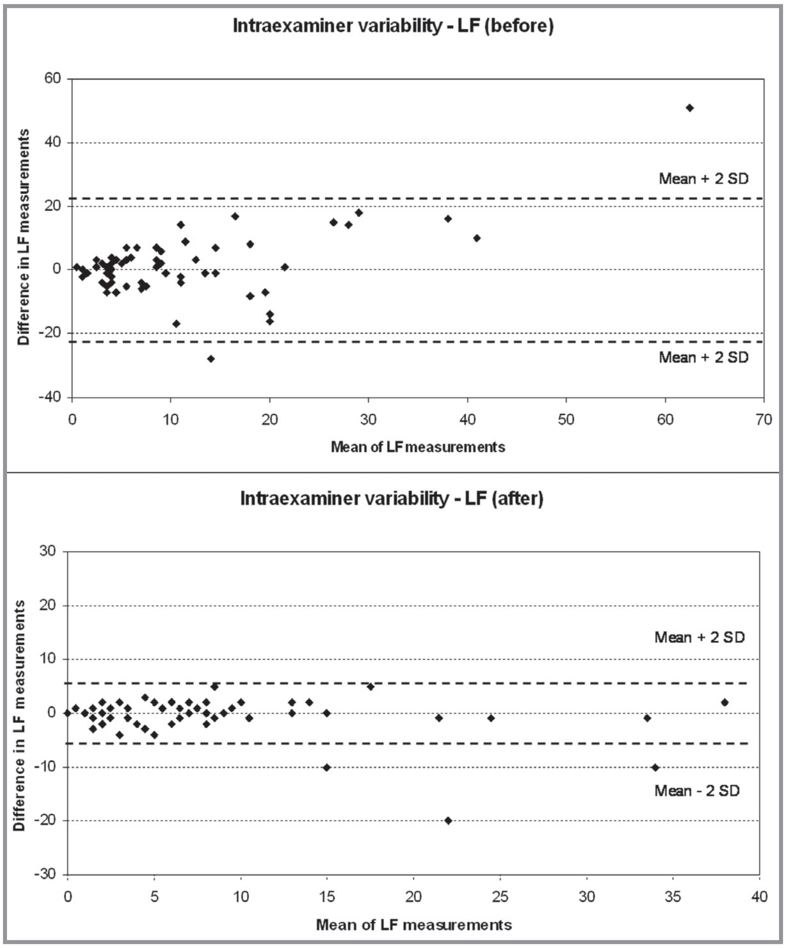

Figure. Intraexaminer variability for laser fluorescence (examiner B) before and after use of the air abrasion system. Dashed lines=mean difference ±2 SD.

Table 2. SENSITIVITY, SPECIFICITY, AND REPRODUCIBILITY (KAPPA) FOR LASER FLUORESCENCE AND VISUAL EXAMINATION

	Visual examination (examiner JAR)		LF (examiner TMV)	
	Before	After	Before	After
Sensitivity	0.95	0.78	0.28	0.49
Specificity	0.28	0.73	0.50	0.92
Reproducibility (kappa)	0.884	0.905	0.282	0.896

Discussion

One of the most important characteristics of air abrasion systems is their ability to remove only minimal tooth structure. The cutting efficacy of the air abrasion devices depends on a series of factors, such as the: (1) type and diameter of the handpiece tip; (2) size of the aluminum oxide particles; (3) air pressure; and (4) distance from the handpiece tip to tooth surface. Because of its minimally invasive nature, air abrasion has been suggested for removal of stains and pigments from occlusal surfaces prior to the use of caries detection methods.[3-5]

LF identifies color alterations on tooth surfaces. These alterations may be caused either by demineralization resulting from the carious process, or by plaque accumulation and pigment incorporation on the examined sites. In this study, prophylaxis was done to remove surface-adherent debris that could interfere with the direct action of the aluminum oxide stream on the hard dental tissue, as well as affect the LF readings, and lead to false-positive results.[2,6,8-10] Although a recent study's findings showed no differences in the LF readings of dry and moist tooth surfaces, in the present study the teeth were dried before visual examination and LF measurements.[8] This procedure is in accordance with a study by Lussi et al that demonstrated that occlusal surfaces should be clean and dry for precise longitudinal monitoring of caries with LF as well as for visual examination.[1]

The establishment of the parameter settings was important to settle the use of the air abrasion system for cleaning purposes (ie, for removal stains and pigments from the occlusal surface only).

The reproducibility was assessed using kappa statistics: (a) <0.4=poor agreement; (b) 0.41-0.75= good agreement; (c) >0.75=excellent agreement; and (d) 1=perfect agreement.[11] The results showed poor (0.282) and excellent (0.884) intraexaminer agreement for both LF and visual examination, respectively, before air abrasion (Table 2). Intraexaminer agreement for LF increased after air abrasion (0.896), suggesting that cleaning tooth surfaces with this system was advantageous for detection of occlusal caries lesions. The agreement for visual examination was excellent before air abrasion and nearly perfect afterwards (0.905). This can be observed in the Figure, in which the dispersion points in the second moment (after air abrasion - graph B) are closer to the mean ±2 SD lines than in the first moment (before air abrasion; graph A). The LF values showed good agreement after the use of the air abrasion device. The good intraexaminer reliability (ranging from 0.72-0.86) was also described in a systematic review, confirming the authors' results.[12]

It is important to highlight that improving the intraexaminer agreement does not mean that the method can detect the lesion better than before air abrasion treatment. It means simply that the air abrasion system made the agreement between the exams easier, thus assisting the caries detection process. The exam's validity can be determined by sensitivity, specificity, and reproducibility values, associated with the gold standard.

Kappa value for visual examination did not show a statistically significant difference between before and after use of the air abrasion system (P=1.00), which may possibly be attributed to the fact that visual inspection is a qualitative and subjective caries detection method.

The sensitivities and specificities recorded for LF improved significantly after use of the air abrasion system. These results reflect the accuracy of LF for caries detection after cleaning pits and fissures, approaching the values obtained for the gold standard. This may be explained by the ability of the laser device to identify any color alteration or presence of bacterial metabolites on the tooth surface. Cleaning with a rotating instrument and water spray before taking LF measurements is recommended and advisable in cases in which LF readings approach the threshold level for operative intervention.[9] LF has shown lower specificity and higher sensitivity (0.52-1.0) when compared with visual methods that disagree with this study (sensitivity=0.28 before air abrasion).[12]

Sensitivity for visual examination remained high after air abrasion, indicating that only conventional prophylaxis of tooth surfaces is required when this is the method of choice for caries detection. On the other hand, the specificity increased considerably (0.28-0.73). This may be attributed to the fact that the high-speed aluminum oxide air stream was able to remove the pigments incorporated to the occlusal surface, even when it was not decayed, thus increasing the accuracy for detection of caries disease and minimizing the occurrence of false-positive results.

We suggest that air abrasion devices are important adjunctive tools for detecting occlusal caries because of their ability to: (1) clean pits and fissures deeply; and (2) eliminate stains and pigments without substantial removal of tooth structure.

Nevertheless, there are no studies in the literature addressing the association of air abrasion and caries detection methods. This study's results confirm that this combination may be advantageous and suggest that the removal of dental tissues by the aluminum oxide stream was not significant, considering the total enamel thickness on the analyzed areas. These results indicate the advantages of combining different methods for accurate detection of caries lesions.

Conclusions

Based on the results of this in vitro study, we conclude that cleaning pits and fissures with an aluminum oxide air abrasion system increased the effectiveness of visual examination and LF for detection of occlusal caries in primary teeth.

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