

## Do Technology-Based Devices Improve Carious Lesion Detection?

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### Abstract

**Background:** The current concepts of dental caries treatment rely on early carious lesion detection, aiming at a less invasive treatment and better prognosis, both for primary and permanent teeth. This study aimed to compare the visual-tactile examination with the technology-based caries detection examinations in children.

**Methods:** We assessed the teeth next to the cleft area of 95 children aged 6 to 12 years with oral clefts but without the presence of any associated syndrome or craniofacial anomaly, according to the following detection methods: visual-tactile examination (Method I), visual-tactile examination through operating microscope (Method II), visual examination through LED-based fluorescence device (Method III), using ICDAS-II scores. The caries detection methods were compared by Friedman test ( $P < 0.05$ ).

**Results:** The efficacy of carious lesion detection methods were statistically similar ( $P = 0.786$ ).

**Conclusions:** Technology-based devices did not improve caries diagnosis in children because their results were similar to those of visual-tactile clinical examination. From a clinical point of view, we recommended the dentists to be cautious in using these additional diagnostic measures to avoid false positive errors mainly in tooth surfaces difficult to be examined.

**Keywords:** Dental caries; Lenses; Fluorescence; Cleft lip palate

### Introduction

The current concepts of dental caries treatment rely on early carious lesion detection, aiming at a less invasive treatment and better prognosis, both for permanent and primary teeth [1-3]. For this purpose, dentists employ visual-tactile examination and bitewing radiographs to detect the first signs of carious lesion to enable remineralization [4]. While visual-tactile examination is simple to execute, it has low sensitivity and little reproducibility, especially in tooth surfaces of difficult access (e.g. proximal surfaces; malpositioned teeth), sometimes leading to doubt [5]. On the other hand, bitewing radiographs aid in visualizing proximal surfaces, but they do not provide reliable information on the first stages of carious lesions [3].

Accordingly, to achieve earlier detection of carious lesion, technology-based devices are auxiliary tools to visual-tactile examination, mainly in doubtful diagnosis of tooth surfaces. Among them, both the dental operating microscope (DOM) [6-9] and optical fluorescence devices [10-16] are used to improve carious lesion detection. The rationale behind the use of DOM is that it provides a shadow-free field and magnification allowed sharpness and richness of details [6-8]. Fluorescence is a property of natural and artificial materials resulting from the interaction between the wavelength of the light emitted by the device and the material's molecules (e.g. tooth surface) [11,17]. The enamel demineralization assessment is based on the difference between the intrinsic fluorescence of sound enamel and the fluorescence of the demineralized enamel due to the presence of bacterial byproducts [17,18]. In the case of light-emitting diode-based (LED-based) fluorescence devices, a high-energy light of 405-nm wavelength is projected on the tooth surface so that sound enamel fluorescence is green, demineralized enamel is brown, and bacterial plaque is red [11].

In children, the use of non-ionizing auxiliary tools for early carious lesion detection, such as DOM and LED-based fluorescence devices, would be valuable to guide minimally-invasive interventions. Thus, this study aimed to verify whether the technology-based devices would improve carious lesion detection in children.

### Methods

#### Sample selection

This cross-sectional study conducted at a tertiary craniofacial center was submitted and approved by the Institutional Review Board regarding the ethical aspects (protocol number #09727612.2.0000.5441). Informed consent was obtained from all parents/legal guardians of the study participants.

Inclusion criteria comprised 6-to-12 year-old children, both genders, in mixed dentition, with right or left unilateral cleft lip and palate, bilateral cleft lip and palate, right or left unilateral cleft lip and alveolus, and bilateral cleft lip and alveolus, with or without Simonart's band, with the presence of at least one tooth next to the cleft area, who attended routine treatment at the institution. Exclusion criteria were individuals with syndromes or other craniofacial anomalies, the presence of restorations and/or an orthodontic appliance on the surfaces of the eligible teeth, and teeth with shape and size alterations.

Considering the prevalence of dental caries in individuals with oral clefts of the study described by Tannure et al. [19], the sample size was estimated in 345 tooth surfaces for a level of significance of 5% and power of 80%.

All smooth surfaces of the permanent teeth next to the cleft were assessed according to the following methods: Method I - visual-tactile clinical examination; Method II - visual-tactile examination provided

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by operating microscope; Method III - visual examination provided by LED-based fluorescence device.

### Carious lesion detection

The International Caries Detection and Assessment System (ICDAS-II) was used for carious lesion detection [20]. In this study, only the tooth surfaces without restorations were assessed, i.e., those scored as zero regarding to ICDAS-II surface condition. Dental prophylaxis was performed prior to the examinations with a Robinson brush embedded in a mixture of pumice (Maquira Indústria de Produtos Odontológicos Ltd., Maringá, PR, Brazil) and tergentol (Biodinâmica Quím. e Farm, Ltd., Iporã, PR, Brazil) and using dental floss for removing dental plaque from proximal surfaces.

Following dental prophylaxis, the teeth surfaces were independently assessed by 2 examiners for allowing interexaminer comparison. Both examiners had more than 10 years of experience in examining tooth surfaces of children with oral clefts and were trained for operating the microscope and LED-based fluorescence devices. Also, the 2 examiners were calibrated regarding the use of ICDAS-II codes for all methods (Kappa=0.85).

Because the results of Methods II and III could influence on the examiners' judgment, we choose visual-tactile examination as the gold standard and performed it first, followed by Method II (operating microscope), and Method III (LED-based fluorescence device).

### Visual-tactile clinical examination

Immediately after dental prophylaxis, visual-tactile examination was performed before and after five seconds of air jet drying under illumination from the dental chair light, with the aid of a WHO probe [21]. Examiners attributed scores for tooth surfaces according to ICDAS-II system.

### Visual-tactile clinical examination by operating microscope

Following Method I, the same tooth was assessed by the complimentary use of the magnification provided by a Dental Operating Microscope (MC-M1232 - DFV Comercial e Industrial Ltd., Valença, RJ, Brazil). The parameters of the microscope are: dichroic light (15V/150W halogen lamp) transmitted through optical fiber; inclined binoculars (160 mm); objective lenses (200 mm); wide-angle ocular lenses (adjustable 12.5-fold magnification); 4-, 6-, 10-, 16-, and 25-fold gradual magnification with macro and micro focus; and photo system composed of beam splitter, adapter, and Sony Cybershot DSC-W610 camera. In this study, 10-fold magnification was used. All surfaces of the permanent tooth next to the cleft area were evaluated *in loco*.

### Visual examination by optical fluorescence device

After the clinical examination by the Dental Operating Microscope, the teeth were assessed by LED-based fluorescence device handpiece (Evince® - MMOptics, São Carlos, SP, and Brazil). LEDs emit a safe intensity of light at 400 nm on the dental tissue, which results in a fluorescence within the visible spectrum, such as green for normal tissue, brown to grey for enamel carious lesions, and red for dental biofilms and dentin carious lesions. The device had a video camera coupled to the handpiece and linked to a computer (Samsung Electronics Co Ltda., Brazil). The images were registered as photographs for storage by Microscope Image Capture and Measurement (MicCam) software version 1.6. All surfaces of the permanent teeth next to the cleft area were assessed *in loco*.

### Statistical Analysis

All statistical analyses were performed with Sigma Plot software for Windows version 12.0 (Systat Software Inc., Germany). After two examiners scored 103 tooth surfaces, the interexaminer reproducibility was analyzed by Kappa test. The comparison among different methods for caries detection was performed by Friedman test. P values <0.05 were considered significant.

### Results

Ninety-five children (37 girls and 58 boys), with a mean age of 10 years (from 6 years and 3 months to 11 years and 10 months), with unilateral cleft lip and alveolus (n=17), bilateral cleft lip and alveolus (n=1), unilateral cleft lip and palate (n=57), and bilateral cleft lip and palate (n=20) were enrolled in the study. A total of 435 tooth surfaces were assessed by visual-tactile clinical examination, while 436 and 406 tooth surfaces were assessed by visual-tactile clinical examination through operating microscope and visual examination through LED-based fluorescence device, respectively. Thus, we had 405 tooth surfaces assessed by the three methods, because 1 surface was assessed by LED-based fluorescence device, but not by visual-tactile examination due to tooth malposition. Consequently, the statistical analysis comprised 405 tooth surfaces evaluated by all three methods for caries detection (Table 1).

The values of Kappa test for the interexaminer agreement were respectively 1.000, 0.848, and 1.000 for visual-tactile examination, visual-tactile examination through operating microscope, and visual examination through LED-based fluorescence device. The Friedman test showed that the comparison among different methods for caries detection at all ICDAS-II scores was similar ( $P=0.786$ ) (Table 2).

### Discussion

This study showed that technology-based devices did not improve carious lesion detection. Also, the complimentary use of operating microscope increase the number of surfaces scored as 1 and decreased those scored as 5, while the exact opposite was noted with the LED-based fluorescence device.

The decrease in the number of surfaces scored as 5 is explained by the richness of details provided by a field illumination free of shadows, when the enamel surface can be verified sharply and accurately compared with the illumination from the light of the dental chair [8,9], allowing that surfaces misclassified as scores 5 could be correctly scored because they were probably developmental (hypoplastic) defects, which have to be classified as score 0 by ICDAS-II system [20]. The increase in the surfaces scored as 1 probably occurred because the high sharpness and details provided by this technology might overestimate dental carious lesion by classifying developmental defects of enamel and extrinsic stains as score 1 [1,9,22].

In the visual examination through LED-based fluorescence device, the decreasing in the detection of enamel carious lesions occurred probably due to malposition of the teeth next to the cleft area. Studies performed on occlusal surfaces found that the farther the carious lesion from the fluorescence device's tip, e.g. in the bottom of the pit and fissure system, the smaller is the detection ability of the device [23,24]. A similar phenomenon may have occurred in the malpositioned teeth next to the cleft area. The increase of score 5 probably occurred due to the presence of enamel hypoplasia with dentin exposure, which resulted in the red reading of fluorescence, because of the stimulus of the porphyrin from the bacterial byproducts inside the dentinal tubules with mature biofilm [12,18,23,25,26].

Surfaces Tooth	Labial (n)	Palatal (n)	Mesial (n)	Distal (n)	Total (n)
11	41	29	40	40	150 (37.0%)
12	6	5	5	6	22 (5.4%)
21	57	46	52	53	208 (51.4%)
22	6	3	6	6	21 (5.2%)
23	1	1	1	1	4 (1%)
Total	111 (27.5%)	84 (20.7%)	104 (25.6%)	106 (26.2%)	405 (100%)

**Table 1:** Distribution of the total of tooth surfaces.

Methods ICDAS-II	Visual-tactile examination		Visual-tactile examination through operating microscope		Visual examination through LED-fluorescence device	
	n	(%)	n	(%)	n	(%)
0	377	93.1	378	93.34	376	92.84
1	12	2.96	15	3.70	10	2.47
2	2	0.49	2	0.49	3	0.74
3	2	0.49	0	0	0	0
4	0	0	0	0	0	0
5	8	1.97	6	1.48	12	2.96
6	4	0.99	4	0.99	4	0.99
Total	405	100	405	100	405	100

Friedman test showed no statistically significant differences for the comparison of different caries detection methods (P=0.78).

**Table 2:** Comparison among methods for caries lesion detection.

Most of the studies on fluorescence and magnification were performed on the occlusal and interproximal surfaces of posterior teeth, unlike this study [9,10,12,13,22,24,25,27]. This makes difficult to compare our results with those from the literature. The rationale behind assessing the anterior teeth of children with oral clefts is that these individuals may be at higher risk of developing dental caries because of indulgent parents regarding dietary habits and potential neglected oral hygiene [28,29]. Additionally, the prevalence of dental caries in teeth next to the cleft is higher because the fear of handling the surgery area; tooth malposition that makes oral hygiene difficult; longer oral clearance time due to the damage caused by lip scar; food impaction by the presence of oronasal fistulae; and a probable genetic susceptibility for dental caries [28-33].

The ICDAS-II system was chosen because it has a histologic validation between the carious lesions and the respective system scores [20], enabling the comparison of the carious lesion prevalence and the effectiveness of the three methods studied [34]. Some studies report that ICDAS-II system would not help in epidemiologic studies and would lead to an over estimation of carious lesion prevalence because the health-disease threshold is the enamel carious lesion (score 1), which is capable of remineralizing [35,36]. Such fact was not confirmed by this present study, in which most of the surfaces were scored as sound. Notwithstanding, the assessment of the prevalence of carious lesion in teeth without restorations (score 0 of surface condition), the exclusion of patients with associated syndromes and with orthodontic appliances, and the evaluation of only the teeth next to the cleft area could have influenced on these outcomes. We excluded children with associated syndromes and orthodontic appliances attempting to decrease the study bias. Although both conditions impair oral hygiene [19], the children with syndromes would not cooperate with the examinations and the ICDAS-II system has different surface conditions for teeth with and without orthodontic appliance [20]. Moreover, a recent study affirms that children with oral clefts had higher caries risk due to impaired oral hygiene even without the use of orthodontic appliances [14]. Teeth showing shape and size alterations were excluded, although highly prevalent in cleft area [37], because the fluorescence readings can be

altered by the enamel hypomineralization not coming from carious lesion [2].

Technology-based caries detection without ionizing radiation (e.g. those provided by the operating microscope and optical fluorescence associated with a system for recording the lesion stages) might be important auxiliary tools for diagnosing and monitoring the carious lesion over time, decreasing the invasive restorative treatment in children. However, we emphasized that these devices should be used with caution to avoid over estimation of carious lesion, and consequently, overtreatment. For now, we recommended the use of visual-tactile examination because it is a safe, reliable, and cost-effective method for detecting carious lesion in children. Further studies are necessary to assess the sensitivity and specificity of these novel technologies on tooth surfaces difficult to be examined, such as those employed in this study.

## Conclusion

1. Technology-based devices did not improve caries diagnosis because their results were similar to those of visual-tactile clinical examination on clean smooth surfaces of teeth next to the cleft area.
2. From a clinical point of view, we recommended the dentists to be cautious in using these additional diagnostic measures to avoid false positive errors mainly in tooth surfaces difficult to be examined.

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