

## Do technology-based devices improve carious lesion detection in children with oral cleft?

Os aparelhos baseados em tecnologia melhoram a detecção de lesões de cárie em crianças com fissura labiopalatina?

Luciana Lourenço Ribeiro VITOR<sup>1</sup>, Tatiana YuriKO KOBAYASHI<sup>2</sup>, Cleide Felício Carvalho CARRARA<sup>3</sup>, Daniela RIOS<sup>1</sup>, Thiago Cruvinel SILVA<sup>1</sup>, Maria Aparecida Andrade Moreira MACHADO<sup>1</sup>, Thais Marchini OLIVEIRA<sup>1,2</sup>

1 – University of São Paulo – Bauru School of Dentistry – Bauru – SP – Brazil.

2 – University of São Paulo – Hospital for the Rehabilitation of Craniofacial Anomalies – Bauru – SP – Brazil.

3 – University of São Paulo – Pediatric Dentist of Hospital for Rehabilitation of Craniofacial Anomalies – Bauru – SP – Brazil.

### ABSTRACT

**Objective:** To compare the visual-tactile examination with the technology-based caries detection examinations in children. **Material and Methods:** Two previously calibrated examiners assessed 405 mesial, distal, labial, and palatal surfaces of the upper anterior permanent teeth next to the cleft area of 95 children aged 6 to 12 years (mean age of 10 years  $\pm$  2 years and 9 months) with oral clefts but without the presence of any associated syndrome or craniofacial anomaly. The following detection methods were used: visual-tactile examination (Method 1), visual-tactile examination through operating microscope (Method 2), visual examination through LED-based fluorescence device (Method 3). ICDAS was the system used to score all caries lesions for all methods. WHO probe was used during the examination with visual-tactile examination. Operating microscope was used at x10 magnification. LED-based fluorescence (Evince™) had a video camera coupled to the handpiece and linked to a computer. The adjunct caries detection methods were compared to visual-tactile examination by Friedman test ( $P < 0.05$ ). **Results:** The efficacy of carious lesion detection methods were statistically similar ( $P = 0.786$ ). **Conclusion:** Both the operating microscope and the LED-based fluorescence device did not improve caries lesion detection in the permanent anterior teeth next to the cleft area.

### KEYWORDS

Dental caries; Lenses; Fluorescence; Cleft lip; Cleft palate.

### RESUMO

**Objetivo:** Comparar o exame visual-tátil com os exames baseados em tecnologia na detecção de lesões de cárie em crianças com fissuras labiopalatina. **Material e Métodos:** 405 faces mesial, distal, vestibular e palatina dos dentes permanentes anteriores superiores próximos a área da fissura de 95 crianças com idade entre 6-12 anos (média 10 anos  $\pm$  2 anos e 9 meses) foram avaliadas por dois examinadores previamente calibrados. Os seguintes métodos de detecção de lesão de cárie foram usados: exame visual-tátil (Método 1), exame visual-tátil com o auxílio do microscópio operatório (Método 2), exame visual por meio de um aparelho de fluorescência por LED (Método 3). ICDAS foi o sistema usado para classificar todas as lesões de cárie nos três métodos. A sonda OMS foi usada durante o exame visual-tátil. O microscópio operatório foi usado em magnificação de 10x. O aparelho de fluorescência por LED (Evince®) tinha uma câmera ligada à peça de mão e conectada ao computador. Os métodos auxiliares de detecção de cárie foram comparados ao exame visual-tátil pelo teste de Friedman ( $P < 0,05$ ). **Resultados:** Não houve diferença estatisticamente significativa na eficácia dos métodos de detecção de lesão de cárie ( $P = 0,786$ ). **Conclusão:** O microscópio operatório e o aparelho de fluorescência por LED não mostraram diferença na a detecção de lesão de cárie para avaliar dentes próximos à área da fissura labiopalatina.

### PALAVRAS-CHAVE

Cárie dentária; Lentes; Fluorescência; Fenda labial; Fissura palatina.

## 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]. Visual-tactile examination is simple to execute, but 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 tooth surfaces. Among them, both the dental operating microscope (DOM) [6-8] and optical fluorescence devices [9-14] 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 [6,7]. 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) [11,15]. 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 either the presence of water on subsurface for early lesions or the presence of bacterial byproducts, especially the stimulus of porphyrins, for advanced lesions [15,16]. 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].

Children with oral clefts tend to have higher caries prevalence both for permanent and deciduous dentition [17-19]. This is related to neglected oral hygiene by indulgent parents [18,20], malposition of the teeth next to the cleft area, and presence of the lip scar that impair oral hygiene [17,18,20-22]. Notwithstanding, to the best of our knowledge, the literature lacks studies on the use of adjunct technology-enhanced methods for caries lesion detection in these individuals. In children with oral clefts, 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 adjunct technology-based devices would improve carious lesion detection in the mesial, distal, labial, and palatal surfaces of the upper permanent anterior teeth of children with oral clefts.

## 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. [23], the sample size was estimated in a minimum of 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 1 – visual-tactile clinical examination; Method 2 - visual-tactile examination provided by operating microscope; Method 3 - visual examination provided by LED-based fluorescence device.

### ***Carious lesion detection***

The International Caries Detection and Assessment System (ICDAS) was used for carious lesion detection [24]. The examiners were trained regarding this criteria using the training material available at ICDAS website until calibration was reached. 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.

ICDAS score refers to the histological changes on the tooth surface, accordingly: score 0 – sound surface; score 1 – first visual change in enamel; score 2 – distinct visual change in enamel; score 3 – localized enamel breakdown; score 4 – underlying dentine shadow; score 5 – distinct cavity with visible dentine; score 6 – extensive cavity with visible dentine[24]. Only the teeth meeting the inclusion/exclusion criteria were assessed.

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., Ibitiporã, 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 inter-examiner comparison. Because the results of Methods 2 and 3 could influence on the examiners' judgment, we choose visual-tactile examination as the gold standard and performed it first, followed by Method 2 (operating microscope), and Method 3 (LED-based fluorescence device), always at the same appointment. This examination flow attempted to mimic a clinical situation where the dentist first assesses the tooth surface by visual-tactile examination, and in case of doubt, he/she would use the adjunct method to help in the caries detection. All examinations took about 30 min.

### ***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 [24]. Examiners attributed scores for tooth surfaces according to ICDAS visual criteria (scores 0-6).

### ***Visual-tactile clinical examination by operating microscope***

Following Method 1, 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**

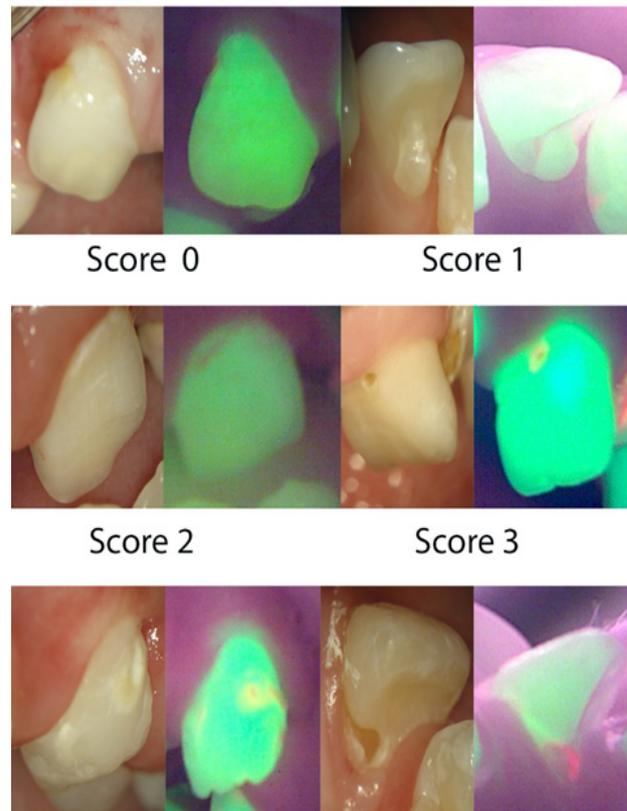
After the clinical examination by the Dental Operating Microscope, the teeth were assessed by LED-based fluorescence device handpiece (Evince® – MMOptics, São Carlos, SP, Brazil). LEDs emit a safe intensity of light at 400 nm on the dental tissue, which results in a fluorescence within the visible spectrum, 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). With the aid of a software (Image Capture and Measurement (MicCam) software version 1.6), the device provided the caries lesion detection based on color change: green is sound (ICDAS score 0), demineralized enamel is brown (ICDAS scores 1, 2, or 3), and dentin involvement is red (ICDAS scores 4, 5, 6) (Figure 1). Thus, the same guidelines of the ICDAS criteria were applied. All surfaces of the permanent teeth next to the cleft area were assessed *in loco*. The images were registered as photographs for storage.

### **Statistical Analysis**

All statistical analyses were performed with Sigma Plot software for Windows version 12.0 (Systat Software Inc., Germany). To test the inter-examiner reproducibility Kappa test was applied in 25% of the sample to verify the inter-examiner consistency level [25]. The comparison among different methods for caries detection was performed by Friedman test. P values < 0.05 were considered significant.

### **ICDAS System**



**Figure 1** - Examples of ICDAS score found in this study for visual examination by optical fluorescence device.

## **RESULTS**

Ninety-five children (37 girls and 58 boys), with a mean age of 10 years ( $\pm 2$  years and 9 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 was 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, due to tooth malposition. Consequently, the statistical analysis comprised 405 tooth surfaces evaluated by all three methods for caries detection (Table I).

**Table I** - Distribution of the total of tooth surfaces

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%)

The values of Kappa test for the inter-examiner 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. Because the

consistency level of the examiners was between 85-95%, the data could be pooled [25]. The Friedman test showed that the comparison among different methods for caries detection at all ICDAS scores was similar ( $P = 0.786$ ) (Table II).

**Table II** - Comparison among methods for caries lesion detection.

ICDAS	Methods	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 ( $P = 0.78$ ).

## DISCUSSION

This study showed that technology-based devices did not improve carious lesion detection. Although the complimentary use of operating

microscope increased 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 differences were not statistically significant.

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 [7,8], 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 system [24]. 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 [1,8,26]. If this misdetection already occurred with the x10 magnification, we hypothesized that greater magnification would provide even more detection errors, not justifying the use.

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 [27,28]. 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 [10,16,28-30].

Most of the studies on fluorescence [9,10,12,27,29] and magnification [8,26] were performed on the occlusal and interproximal surfaces of posterior teeth, unlike this study. 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 [17]. 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 [19,22,31].

The ICDAS system was chosen because it has a histologic validation between the carious lesions and the respective system scores [24], enabling the comparison of the carious lesion prevalence and the effectiveness of the three methods studied [32]. Some studies report that ICDAS 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 [33]. Such fact was not confirmed by this present study, in which most of the surfaces were scored as sound. However, this present study was conducted in a practice setting with the aid of adjunct methods to detect caries lesion. Probably, 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 [23], the children with syndromes would not cooperate with the examinations and the ICDAS system has different surface conditions for teeth with and without orthodontic appliance [24]. Moreover, a recent study using ICDAS for caries lesion detection and risk assessment affirms that children with oral clefts had higher caries risk due to impaired oral hygiene even without the use of orthodontic

appliances [34]. The factors that accounted for this result were impaired hygiene and increased salivary lactobacilli counts [19]. Teeth showing shape and size alterations were excluded, although highly prevalent in cleft area [35], because the fluorescence readings can be altered by the enamel hypomineralization not coming from carious lesion [2].

In this study, we were unable to determine the specificity and sensibility of the adjunct methods tested because of the high number of surfaces scored as sound. This low detection of caries lesion had probably occurred because of the experience of the examiners with this population. Other important point to be considered is that ICDAS system classifies the developmental defects of enamel as sound surfaces [24]. A meta-analysis of the prevalence of caries lesions in patients with oral clefts only found statistically significant differences for the component “filled” of the DMFT index between patients with and without clefts [18]. One should take into consideration that the restorations could have been performed to cover hypoplastic enamel defects instead of treating caries lesions on the teeth close to the cleft, known to present high number of developmental defects of enamel [21]. Thus, further studies are necessary to assess the sensitivity and specificity of these novel technologies on tooth surfaces difficult to be examined, as well as to understand how the developmental defects of enamel could influence on the accuracy of caries lesion detection in children with clefts.

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 adjunct methods 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 with oral clefts.

## CONCLUSION

1 - Technology-based devices did not improve caries lesion detection 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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**Luciana Lourenço Ribeiro Vitor  
(Corresponding address)**

Faculdade de Odontologia de Bauru, Universidade de São Paulo  
Alameda Dr. Octávio Pinheiro Brisolla, 9-75  
Bauru, São Paulo, Brasil - CEP: 17012-901  
E-mail: luvitor@usp.br

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