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ORIGINAL ARTICLE

Examiner's experience and the outcome interpretation of ICDAS and Nyvad's system – a prospective *in vitro* study

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ABSTRACT

Objective: To evaluate, prospectively, the influence of examiner's experience in interpreting and applying the caries detection systems ICDAS (IC) and Nyvad (NY).

Material and methods: Twelve second-year undergraduate dental students (UG) and 12 postgraduates (PG) MSc level analysed and codified 77 clinical dental caries photographs at three different moments: initially, without any training; after one week of receiving training through a theoretical class; and after two years. Reproducibility and correlation was evaluated; sensitivity, specificity and area under ROC curve (AUC) were dichotomized according to the presence of cavitation (IC) and in relation to disease activity (NY).

Results: IC presented good kappa values for the first two evaluations. Both criteria resulted in good Spearman's correlation after two years (IC = UG: 0.89; PG: 0.93/NY = UG: 0.81; PG: 0.82). Sensitivity, specificity and AUC were statistically higher in the third evaluation by UG for Nyvad.

Conclusions: ICDAS criteria seem to be instinctively understood by students without clinical experience. Nyvad's concepts performed better after two years where the students deepened their theoretical knowledge and experienced clinical practice, collaborating with the identification of activity signs.

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Introduction

The dynamic development of caries lesions result in detectable signals, such as changes in brightness/opacity, surface texture, pigmentations and progressive structural losses [1], which support the identification and classification of disease development stage. Many authors [2–4] report that the greatest difficulty related to the diagnostic process of these signs refers to the lack of symptoms in the early stages of caries and low sensitivity/reproducibility of visual clinical examination commonly used due to the subjectivity of the method.

In an attempt to reduce the subjectivity of visual clinical examination, many criteria for encoding signs suggestive of the presence of caries lesions were developed [1–7]. Faced with the premise that the diagnostic categories based on visual and tactile criteria should consider the activity condition of the lesion, Nyvad et al. [1] developed a system with predictive and construct validity [8], with relevant application for professionals in the clinical approach [9] which showed good results in studies that evaluated their performance *in vitro* and *in vivo* [6,10,11].

The International Caries Detection and Assessment System – ICDAS [5] classify the lesions according to changes in enamel structure, such as spots, pigmentations and cavitation, with scores ranging from higid surface to large cavitation involving dentin. *In vitro* and *in vivo* studies have shown good validity and reproducibility in the evaluation of caries in primary and permanent teeth [12–16].

Many studies that evaluate the performance of methods by undergraduate students [6,11,17,18] present their results observed in just a moment of their experience at the dentistry course, comparing their classifications before and after offered some kind of training and relating this to the student experience. Different training strategies, such as theoretical classes and online training [19–20,13] have been used to help students in the learning process and good results have been obtained. However, any study really evaluated the examiner's experience obtained during the dentistry course as an understanding factor of the concepts concerning cavitation and activity for dental caries detection.

The aim of this study was prospectively evaluated the individually performance of ICDAS and Nyvad coding criteria by students at different moments of their theoretical learning and clinical deepening.

Material and methods

Study participants

After approval by the Research Ethics Committee (Process Number 701/14) 24 students – 12 undergraduates (UG) in the second year/fourth semester at the Araraquara Dental School-UNESP without clinical and theoretical experience in

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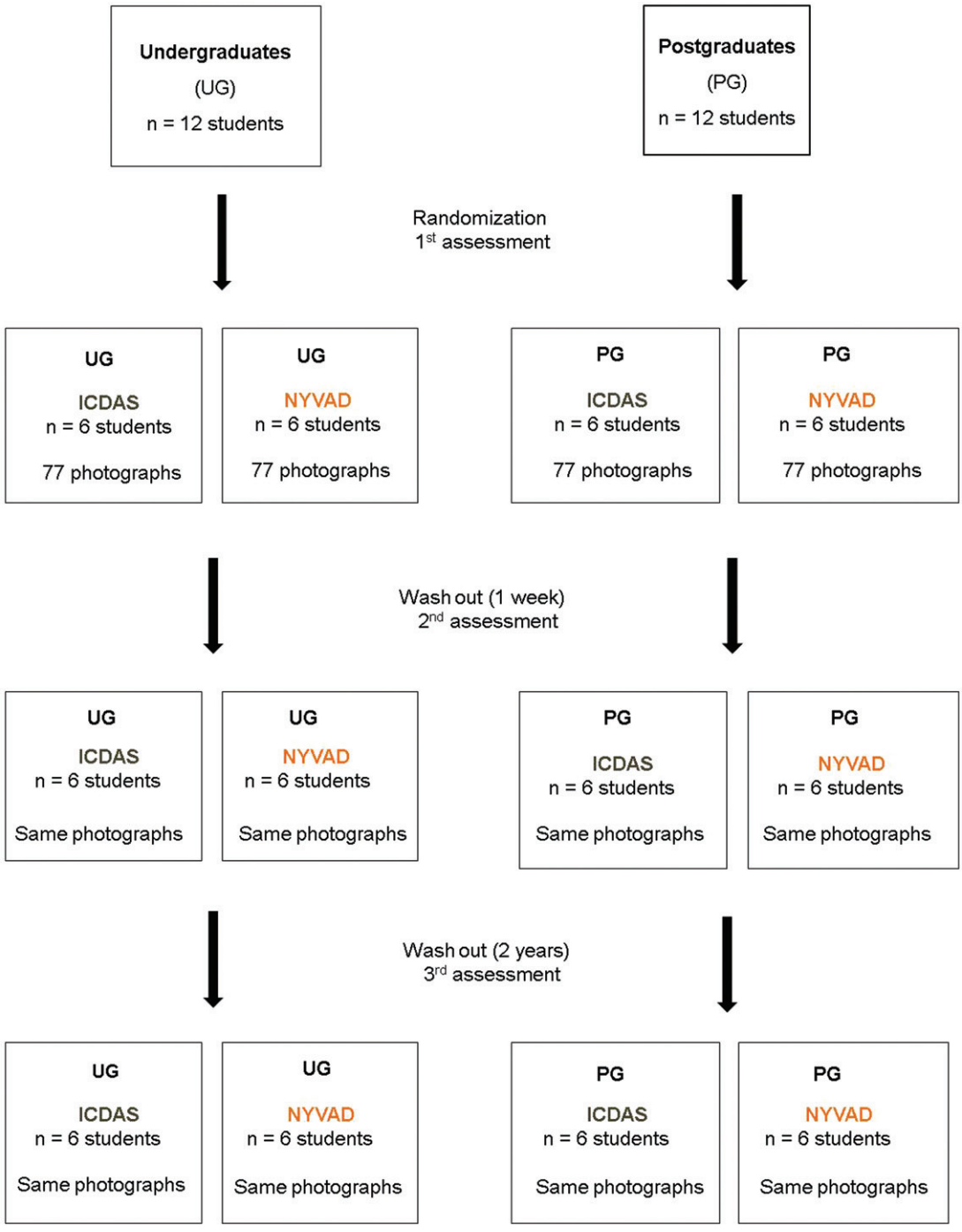

Figure 1. Flow diagram showing the study design.

cardiology; and 12 postgraduate (PG) students, doing courses in the programme of Dental Sciences at the same institution – participated in the study. The participants had no previous experience whatever with both – ICDAS (IC) or Nyvad (NY) – criteria. The students were divided into different levels of experience (UG or PG) and distributed to apply the coding criteria (IC = 6UG and 6PG; or NY = 6UG and 6PG), resulting in four groups (Figure 1).

Photographs

A total of 77 photographs in digital format were used, presenting clinical situations of different stages of caries lesion development in primary and permanent teeth. Only surfaces that allow direct visualization were selected, which may be proximal, occlusal or free faces. For each of the 77 photographs, it was developed a schematic template with the delineation of the exact sites to be analysed.

Examination design

Initially, the participants received the original article that described the criteria used [1,8] according to the group belonged. After reading these, the participants analysed the images on computers located in the Didactic Informatics

Laboratory. All the appliances had a 21.5-inch LED screen with 1920 × 1080 pixel resolution. To the selected sites, scores were attributed in accordance with the ICDAS (0) sound; (1) first visual change in enamel; (2) distinct visual change in enamel; (3) localized enamel breakdown, without visible dentin or shadows; (4) underlying dentin shadow; (5) distinct cavity with visible dentin; and (6) extensive cavity within visible dentin; and Nyvad criteria (0) sound; (1) active caries: intact surface; (2) active caries: discontinuous surface; (3) active caries: cavitated; (4) inactive caries: intact surface; (5) inactive caries: discontinuous surface; and (6) inactive caries: cavitated.

Students noted the codes on individual template containing the schematic design described before. The caries lesion coding criteria were offered in the form of printed guide for assistance during evaluation.

Seven days after the first evaluation, the responsible researches for the study ministered an expositive class, separately for each group, about the aetiology and pathogenesis of dental caries, characteristics, diagnostic process and lesion detection. The class was presented in the routinely mould offered to undergraduates, simulating the daily student learning. Each group also received information about the criteria and discussed photographs of clinical cases that were not part of the sample together with the researchers responsible. The following week, students performed the second evaluation of the photographs similarly to that previously reported.

The third evaluation was applied using the same 77 photographs two years after the first analyses. This way, the graduate students were enrolled in the fourth year/eighth semester of the course and the postgraduate students were in their final semester of the master program. The original articles were once again delivered and new analysis carried one week after the reading.

Reference standard

The reference standard used for encoding criteria was established by two experienced researchers. Initially, these evaluated all photographs and reached a consensus on the most appropriate classification for each assessment site. After a week, each examiner independently performed a new analysis. The result (kappa =0.84) represented effective calibration, allowing the consensus among researchers was adopted as the reference standard.

Statistical analysis

For statistical analysis MedCalc software (Mariakerke – Be. Version 9.3 for Windows) was used. Kappa statistics [21] were used to determine inter- (Fleiss's Kappa) and intraexaminer (Cohen's Kappa) reliability. The reproducibility values were classified according to Fleiss [21], at: <0.20 = poor; 0.21–0.40 = weak; 0.41–0.60 = moderate; 0.61–0.80 = good; and 0.81–1.00 = very good. The correlation between the methods and the reference standard was determined using Spearman correlation and a Wilcoxon test compared the values at the different analyses. Sensitivity, specificity and area under ROC curve (AUC) determine different cut-off points: ICDAS dichotomization established cut between sound teeth and enamel lesions of dentin lesions at D4 (considering ICDAS scores from 4 to 6 as disease); for Nyvad, the dichotomization has established cut between sound teeth and inactive lesions of lesions considered active at A3 (considering Nyvad score from 1 to 3 as disease). The groups were compared by means of a McNemar test and the significance level was set at $p < 0.05$.

Results

In a total of 77 photographs, the reference standard scored 18 (23%) as sound, 26 (34%) had lesions in enamel, and 33 (43%) involved dentine. As to activity, 47 (62%) were active and 12 (15%) inactive lesions.

Considering the first two analysis, the intra-examiner reliability kappa scores (Table 1) for ICDAS criteria were classified as 'good' for undergraduate students and 'good' to 'very good' among postgraduates. For Nyvad criteria, the reliability values observed were classified as 'poor' to 'good' among undergraduate students and as 'moderate' to 'good' among postgraduates. Interexaminer reliability and Spearman correlation (r_s) presented better results in the third assessment, both to ICDAS as to Nyvad, and being all classified as 'very good'. Only r_s obtained by undergraduates of ICDAS group showed no statistically significant difference with previous assessments.

Sensitivity, specificity and area under the ROC curve (AUC) are presented in Table 2. Sensitivity values showed significant differences to UG as to PG at the third assessment. The specificity values were those who suggested the greatest difficulties of classification, in the first and second evaluation, among UG both to ICDAS and to Nyvad. Better results are

Table 1. Unweighted kappa coefficient for intra- and interexaminer, and spearman correlation (r_s) for ICDAS and Nyvad by undergraduates and postgraduates in three assessments: (1st) before class; (2nd) after class; and (3rd) after two years.

	Intra-examiner[a]		Inter-examiner			r_s[b]		
	Minimum/	Maximum	1st	2nd	3rd	1st	2nd	3rd
Undergraduates								
ICDAS	0.61	0.77	0.67 (0.56–0.77)	0.65 (0.57–0.74)	0.81 (0.78–0.92)	0.81	0.86	0.89
NYVAD	0.35	0.62	0.30 (0.20–0.46)	0.31 (0.24–0.37)	0.81 (0.77–0.86)	0.42	0.42	0.81[c]
Postgraduates								
ICDAS	0.70	0.90	0.65 (0.57–0.77)	0.70 (0.62–0.81)	0.87 (0.84–0.89)	0.80	0.84	0.93[c]
NYVAD	0.58	0.70	0.43 (0.37–0.67)	0.53 (0.41–0.74)	0.80 (0.76–0.85)	0.50	0.51	0.82[c]

[a]Intra-examiner: extreme values between (1st) before class and (2nd) after class assessment for all examiners.
[b]Spearman (r_s): Correlation values between assessments and the reference standard.
[c]Statisticaly significant difference for the same group (Wilcoxon test, $P < 0.05$).

Table 2. Sensitivity, specificity and area under the ROC curve (AUC) for ICDAS at D4 and Nyvad at A3 threshold by undergraduates and postgraduates in three assessments: (1st) before class; (2nd) after class; and (3rd) after two years.

		Sensitivity			Specificity			AUC		
Threshold[a]		1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
ICDAS										
D4[a]	UG	0.85	0.82	0.94[b]	0.66[c]	0.79[c]	0.93[b]	0.76[c]	0.80[c]	0.85[b,c]
	PG	0.85	0.85	0.97[b]	0.85[c]	0.89[c]	0.93	0.85[c]	0.87[c]	0.95[b,c]
NYVAD										
A3[a]	UG	0.57	0.50[c]	0.85[b]	0.61[c]	0.65[c]	0.97[b]	0.59[c]	0.58[c]	0.91[b]
	PG	0.60	0.65[c]	0.89[b]	0.89[c]	0.97[c]	0.97	0.75[c]	0.81[c]	0.93[b]

[a]ICDAS: D4: Sound and enamel lesions = 0–3, Dentin lesion = 4–6.
NYVAD: A3: Sound and inactive lesions = 0, 4, 5 and 6, Active lesions =1–3.
[b]Difference for the same group.
[c]Between groups for the same criteria (McNemar test, $p < 0.05$).

observed at the third assessment after two years which presented a significant statistical difference in relation to previous assessments.

Discussion

We prospectively evaluated the performance of undergraduate (UG) and postgraduate (PG) students in the interpretation of signs that suggest the presence/absence of carious lesion using ICDAS and Nyvad's criteria before/after a theoretical class and after two years of the course, representing different moments of theoretical learning and clinical deepening inside the dentistry course. The results will be discussed individually for each criterion since this is not a comparative study. We emphasize that UG did not have any clinical/theoretical knowledge of cardiology prior to first assessment and that the PG had distinct educational background since these were originally from different universities of different teaching philosophies.

Extracted teeth are commonly used for the evaluation of criteria that classify the extension of lesions, such as ICDAS, enabling the study of the reproducibility and avoiding patient exposure to multiple examinations. Parviainen et al. [11] consider that the manipulation of the extracted tooth coupled with assessment through probing study site may lead to changes in surface discontinuity of lesion, such as the evolution of a surface spot into a micro cavity after repeated examinations, resulting in misclassification. Braga et al. [3] suggest that the findings in extracted teeth should not be compared with clinical findings especially when evaluating the lesion activity. In this context, the use of clinical photographs enable visualization of indicators as plaque area of stagnation, quality of the marginal gingiva and the presence of brightness and opacity, which are fundamental to the distinction of active from inactive lesions, as well as prevent dehydration process of the tooth outside the oral cavity. Thus, the photographs become more representative of real clinical situations when compared to extracted teeth. The photographic assessment is common as a way of training in studies of this nature [10,11,13,14,17,22] enabling the exemplification of all encoded signals justifying the methodology applied by us.

The intra-examiner reproducibility allows evaluating the agreement between two assessments of the same examiner. Statistical Cohen's Kappa was applied considering the first two evaluation of each student for both criteria before and after a theoretical class. To suppose that the theoretical concepts discussed could facilitate the understanding of the criteria by the students, a low agreement between assessments could reflect a difference in the classifications suggesting some positive influence of class. This premise could be discussed in the results presented by Nyvad's criteria, which were classified as 'weak', 'moderate' to 'good'. The lower intra-examiner agreement observed was 0.35 among UG indicating weak reproducibility, but the s_r with the reference standard observed showed that UG had the same performance (0.42 at both), discarding the possible influence. Better results in terms of reproducibility were observed between PG (intra =0.58–0.70), but the r_s values in both assessment ($r_s = 0.50$ and 0.51) also did not indicate influence by the offered class. When evaluating a criterion that considers the activity of caries lesions, Parviainen et al. [11] and Gimenez et al. [6] showed that UG were able to estimate and classify the signs of activity when these had limited clinical/theoretical experience on cardiology. In these studies, it was offered prior training to assessment, which generally is based on reading about the criteria and discuss concepts of cardiology, followed by hand-on lab with extracted teeth. The results presented by UG and PG in our investigation showed considerable values obtained without any prior training resembling the correlation values of 0.48 [11] and 0.65 and 0.69 [6] of these studies.

The ICDAS criteria showed good values of intra-examiner reproducibility between UG (intra = 0.61–0.77) and PG (intra = 0.70–0.90). The strong r_s with the reference standard in the first and second analysis (UG: $r_s = 0.81$ and 0.86; PG: $r_s = 0.80$ and 0.84, respectively) suggests ease understanding of the method and correct classification of lesions without influence of offered class between assessments. The values we found are similar to those obtained in other studies [10–14] in which some kind of training was also offered prior to the application of the criteria.

Between the UG, sensitivity and specificity values (Table 2) for Nyvad's criteria represent the difficulty of determining the lesions in the first two evaluations. For example, the A3 sensitivity of 0.50 and specificity of 0.65 together with the r_s of 0.42 in the second evaluation allows us to state that the activity signal proposed by Nyvad's criteria were not instinctively deducted among students without experience. Best performance in the third assessment with sensitivity of 0.85, specificity of 0.97 and r_s of 0.91 represents the influence of absorbed clinical/theoretical experience after two years.

An exponential leap from the ICDAS specificity of the first assessments (0.66 and 0.79) for the third (0.93) in D4 when dichotomization data established difference between initial lesions in enamel of dentin lesions shows us a better understanding of concepts regarding the identification of linear progression of cavities. Nevertheless, good sensitivity values had already been obtained in the first two assessments, and similar to those observed in the postgraduate group. Good results had been found in previous studies of our team, as Diniz et al. [14] found good sensitivity (0.83) and specificity (0.79) of the undergraduate students from ICDAS criteria and

Bussaneli et al. [18] who reported values of 0.54 to sensitivity and 0.93 to specificity for students attending the second year of graduation.

When proposing the coding system, Nyvad et al. [1] required of evaluators detailed observation of gengiviais and structural conditions besides characteristics such as brightness and opacity. We understand that the visualization of activity signs can be difficult in photographs and that the lack of tactile perception by probing the classified sites limits our study. These characteristics are essential in differentiating an active lesion that can present in the form of white/yellow opaque spots, porous, or rough cavities of disorganized appearance contrasting with the inactive spots of white, brown or black surface but bright and organized cavities. This identification is different than the linear differentiation used by ICDAS criteria where the classification of the disease is determined by their evolution in spot, microcavity without dentin exposure, cavity with dentin exposure affecting less than half of surface or cavity with dentin exposure affecting more than half of the surface.

Faced with the diverse and complex signals involved with dental caries, we evaluated two criteria which embody different concepts used as guides to determine the presence/absence of caries lesions. Not count initially with any training in the application of these criteria and the evaluations at different moments of the experience in the dentistry course only reflected the students' perception and understanding of the signals.

Conclusions

Our results suggest that ICDAS criteria seem to be instinctively understood by students without clinical experience. Nyvad's concepts performed better after two years where the students deepened their theoretical knowledge and experienced clinical practice, collaborating with the identification of activity signs.

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Disclosure statement

The authors report no conflicts of interest. The authors alone are responsible for the content.

References

[1] Nyvad B, Machiulskiene V, Baelum V. Reliability of a new caries diagnostic system differentiating between active and inactive caries lesions. Caries Res. 1999;33:252–260.

[2] Bader JD, Shugars DA, Bonito AJ. A systematic review of the performance of methods for identifying carious lesions. J Public Health Dent. 2002;62:201–213.

[3] Braga MM, Mendes FM, Ekstrand KR. Detection activity assessment and diagnosis of dental caries lesions. Dent Clin North Am. 2010;54:479–493.

[4] Baelum V, Hintze H, Wenzel A, et al. Implications of caries diagnostic strategies for clinical management decisions. Community Dent Oral Epidemiol. 2012;40:257–266.

[5] Ismail AI, Sohn W, Tellez M, et al. The International Caries Detection and Assessment System (ICDAS): an integrated system for measuring dental caries. Commun Dent Oral Epidemiol. 2007;35:170–178.

[6] Gimenez T, Bittar DG, Piovesan C, et al. Influence of examiner experience on clinical performance of visual inspection in detecting and assessing the activity status of caries lesions. Oper Dent. 2013;38:583–590.

[7] Ekstrand KR, Zero DT, Martignon S, et al. Lesion activity assessment. Monogr Oral Sci. 2009;21:63–90.

[8] Nyvad B, Machiulskiene V, Baelum V. Construct and predictive validity of clinical caries diagnostic criteria assessing lesion activity. J Dent Res. 2003;82:17–22.

[9] Baelum V. What is an appropriate caries diagnosis?. Acta Odontol Scand. 2010;68:65–79.

[10] Braga MM, Mendes FM, Martingnon S, et al. In vitro comparison of Nyvad's system and ICDAS-II with lesion activity assessment for evaluation of severity and activity of occlusal caries lesions in primary teeth. Caries Res. 2009;43:405–412.

[11] Parviainen H, Vähänikkilä H, Laitala ML, et al. Evaluating performance of dental caries detection methods among third-year dental students. BMC Oral Health. 2013;13:6–70.

[12] Shoaib L, Deery C, Ricketts DN, et al. Validity and reproducibility of ICDAS II in primary teeth. Caries Res. 2009;43:442–448.

[13] Diniz MB, Lima LM, Santos-Pinto L, et al. Influence of the ICDAS e-learning program for occlusal caries detection on dental students. J Dent Educ. 2010;74:862–868.

[14] Diniz MB, Lima LM, Eckert G, et al. In vitro evaluation of ICDAS and radiographic examination of occlusal surfaces and their association with treatment decisions. Oper Dent. 2011;36:133–142.

[15] Mendes FM, Novaes TF, Matos R, et al. Radiographic and laser fluorescence methods have no benefits for detecting caries in primary teeth. Caries Res. 2012;46:536–543.

[16] Jablonski-Momeni A, Stucke J, Steinberg T, et al. Use of ICDAS-II, fluorescence-based methods, and radiography in detection and treatment decision of occlusal caries lesions: an in vitro study. Int J Dent. 2012;2012:371595.

[17] Zandona AG, Al-Shiha S, Eggertsson H, et al. Student versus faculty performance using a new visual criteria for the detection of caries on occlusal surfaces: an in vitro examination with histological validation. Oper Dent. 2009;34:598–604.

[18] Bussaneli DG, Boldieri T, Diniz MB, et al. Cordeiro RD, Influence of professional experience on detection and treatment decision of occlusal caries lesions in primary teeth. Int J Paediatr Dent. 2015;25:418–427.

[19] Luz PB, Stringhini CH, Otto BR, et al. Performance of undergraduate dental students on ICDAS clinical caries detection after different learning strategies. Eur J Dent Educ. 2015;19:235–241.

[20] Rodrigues JA, de Oliveira R, Hug I, et al. Performance of experienced dentists in Switzerland after an e-learning program on ICDAS occlusal caries detection. J Dent Educ. 2013;77:1086–1091.

[21] Fleiss IL, Statistical methods for rates and proportions. New York: Wiley. 1981; 212–225.

[22] Foley JI. Dental students consistency in applying the ICDAS system within paediatric dentistry. Eur Arch Paediatr Dent. 2012;13:319–322.