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| ORIGINAL

Performance of ICDAS e-learning program in teaching graduate students on the detection of occlusal caries

Desempenho do programa de aprendizagem eletrônico ICDAS no ensino de alunos de pós-graduação na detecção de cáries oclusais

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ABSTRACT

Objective: The aim was evaluate the validity and reproducibility of the International Caries Detection and Assessment System (ICDAS) in detecting occlusal caries among graduate students after training using the e-learning program. **Methods**: A sample of forty-two primary teeth with different ranges of occlusal caries was selected. All teeth were mounted on a wax support and standardized photographs (EOS Rebel XTI, Canon, NY, USA) of the occlusal surfaces were taken. An experienced researcher randomly selected one specific site on the occlusal surface of each tooth to be examined later. Fifteen graduate students with no previous experience in the ICDAS scores completed the ICDAS e-learning program in Portuguese. After the training, visual examination of the occlusal surfaces was taken twice, independently, with a two-week interval. After visual examination, the teeth were longitudinally sectioned 1mm away from the previously selected occlusal site. The teeth were fixed on a wax support and photographed. Histological analysis was performed from these photographs by an experienced researcher to evaluate the depth of demineralization. **Results**: The Intraclass Correlation Coefficient (ICC) inter-examiner values among all participants varied from 0.54 to 0.96 and intra-examiner ICC reproducibility of the examiners ranges from 0.61 to 0.85, showing good to excellent reproducibility. For detection of enamel and dentine lesions (D1), ICDAS obtained sensitivity 0.835 and specificity 0.756. For dentine lesions (D3), the method revealed an increase in sensitivity but specificity was similar to D1. **Conclusion**: ICDAS e-learning training program was efficient for the training of caries lesions detection among graduate students.

Indexing terms: Dental caries. Dental caries activity tests. Health education.

RESUMO

***Objetivo**: O objetivo foi avaliar a validade e a reprodutibilidade do Sistema Internacional de Detecção e Avaliação de Cárie (ICDAS) na detecção de cárie oclusal entre estudantes de pós-graduação após o treinamento usando o programa de e-learning. **Métodos**:*

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Foi selecionada uma amostra de 42 dentes decíduos com diferentes faixas de cárie oclusal. Todos os dentes foram montados em um suporte de cera e foram tiradas fotografias padronizadas (EOS Rebel XTI, Canon, NY, EUA) das superfícies oclusais. Um pesquisador experiente selecionou aleatoriamente um local específico na superfície oclusal de cada dente para ser examinado posteriormente. Quinze estudantes de pós-graduação sem experiência anterior com o ICDAS concluíram o programa de e-learning em português. Após o treinamento, o exame visual das superfícies oclusais foi realizado duas vezes, independentemente, com intervalo de duas semanas. Após o exame visual, os dentes foram seccionados longitudinalmente a 1mm do local oclusal previamente selecionado. Os dentes foram fixados em um suporte de cera e fotografados. A análise histológica foi realizada a partir dessas fotografias por um pesquisador experiente para avaliar a profundidade da desmineralização. ***Resultados****: Os valores interexaminadores do Coeficiente de Correlação Intraclasse (ICC) entre todos os participantes variaram de 0,54 a 0,96 e a reprodutibilidade intra-examinador do ICC dos examinadores variou de 0,61 a 0,85, mostrando reprodutibilidade boa a excelente. Para detecção de lesões de esmalte e dentina (D1), o ICDAS obteve sensibilidade 0,835 e especificidade 0,756. Para lesões de dentina (D3), o método revelou um aumento na sensibilidade, mas a especificidade foi semelhante ao D1.* ***Conclusão****: O programa de treinamento em e-learning do ICDAS foi eficiente no treinamento de detecção de lesões de cárie em estudantes de pós-graduação.*

Termos de indexação: *Cárie dentária. Testes de atividade de cárie dentaria. Educação em saúde.*

INTRODUCTION

Detection of caries lesions in the early stages remains a challenge in the dental practice [1]. The ability to detect the first clinical signs of the dental enamel demineralization is crucial to maintain the dental structures and to make minimally invasive procedures feasible, allowing the reversion of the disease process and a significant reduction of treatment costs [2].

There are several methods for the detection of carious lesions. The most commonly used are the visual and radiographic examination and as alternatives methods, the laser fluorescence induction-based methods and digital images [3-7]. The conventional methods have some advantages, such as easy the application and low costs. However, they are considered subjective methods, depending on the knowledge and experience of the professional [1].

Considering the limitation of the conventional methods, visual criteria for caries detection can decrease the subjectivity of the visual examination, allowing the follow up of the first signs of the demineralization. The International Caries Detection and Assessment System (ICDAS) is a visual score system that classifies the stages of caries lesions according to the severity of dental demineralization [8,9]. This system was developed from other validated systems [10] and it aims standardization between studies and a proper diagnosis in clinical practice [8,9,11].

The ICDAS offers a ninety-minutes e-learning program (www.icdas.org) available in four languages. This e-learning program was developed to be a general introduction to the criteria and scores [12]. It explains ICDAS clinical examination protocols and describes the coding system for various surface conditions. In the end, the participant completes exercises about carious lesions classification [8,12].

The use of such criteria in academia could be a good method to capacitate professionals in training for the detection of early carious lesions, minimizing diagnosis errors and providing a higher quality of the clinical treatment provided to the patients, under the concepts of minimum intervention. However, there are few studies evaluating the effectiveness of the ICDAS e-learning program with graduate students [7,11,13]. Thus, this study aimed evaluate the validity and reproducibility of the ICDAS in detecting occlusal caries among graduate students after training using the e-learning program.

METHODS

Ethics

The extracted human teeth sample was obtained from the Biobank and Biorepository of Human Teeth of the Federal University of Paraná. Prior to extraction of the teeth, patients were informed about its use for research purposes

and their consent was obtained. The identity of the donors will not be revealed. The study was approved by the Ethics Committee in Research (report 1.137.966).

Sample preparation

A sample of forty-two teeth with different ranges of occlusal caries was selected. Teeth with occlusal surfaces with sealants, restorations, hypoplasia or hypomineralization were excluded from the sample.

Previously, the teeth were thoroughly cleaned for 10 seconds using tap water and a toothbrush. All teeth were mounted on a wax support and standardized photographs (EOS Rebel XTI, Canon, NY, USA) of the occlusal surfaces were taken. An experienced researcher randomly selected one specific site on the occlusal surface of each tooth to be examined later. This site was hidden by a dot on the photographs to avoid bias during examinations [1]. Teeth were randomly identified and kept individually in containers with saline solution and a wet cotton roll was placed at the bottom of each container to guarantee 100% humidity.

Training of the examiners

Fifteen graduate students who was attending the pediatric dentistry specialty course, of both genders, with different clinical experience and no previous experience in the ICDAS scores completed the ICDAS e-learning program in Portuguese (ICDAS e-learning, available on www.icdas.org), under the supervision of an experienced researcher. The 90 minutes program is divided into: (1) Introduction – 5 minutes of instructions about the uses of the program and the aims of the ICDAS training; (2) Clinical examination protocols – 5 minutes about the recommended sequence for clinical assessment of carious lesions; (3) Caries codes – 50 minutes describing ICDAS codes for various surface conditions (chart 1); (4) Decision tree – 10 minutes presenting characteristics that must be observed in the tooth for the correct use of ICDAS codes; (5) Special consideration – 5 minutes of instructions about coding teeth in special situations such as banded or bracket teeth and primary and permanent teeth in the same space; (6) Recording – 5 minutes about how to record the scores for permanent and primary teeth; and (7) Quiz – 5 minutes of exercises in which the participant can classify carious lesions.

Chart 1 – ICDAS criteria.

ICDAS Score	Criterion
0	Sound tooth surfaces, no evidence of caries after prolonged air drying (5 s)
1	First visual change in enamel, opacity or discoloration (white or brown) is visible at the entrance to the pit or fissure after prolonged air drying, which is not or hardly seen on a wet surface
2	Distinct visual change in enamel, opacity, or discoloration distinctly visible at the entrance to the pit and fissure when wet, and lesion is still visible when dry
3	Localized enamel breakdown due to caries with no visible dentin or underlying shadow, opacity, or discoloration wider than the natural fissure/ fossa, when wet and after prolonged air drying
4	Underlying dark shadow from dentin with or without localized enamel breakdown
5	Distinct cavity with visible dentin, visual evidence of demineralization and dentin exposed
6	Extensive distinct cavity with visible dentin and more than half of the surface involved

Visual examination

After the training, a visual examination of the occlusal surfaces was taken twice, independently, with a two-week interval, in order to check the intra and inter examiner agreements. All teeth were evaluated under artificial light, direct visualization, an air syringe, without probing and without magnifier.

In order to be examined, the occlusal surfaces were moisted and then dried with an air syringe after five seconds. Examiners evaluated all the occlusal sites previously selected and recorded their scores according to the ICDAS criteria and Decision Tree (available on www.icdas.org).

Histological validation

After visual examination, the teeth were longitudinally sectioned 1 mm away from the previously selected occlusal site. The cuts were performed with a diamond disc in a sectioning machine (Isomet 1000, Buehler, IL, USA). Then, to reach the outskirts of the chosen site with maximum precision and without any losses, a progressive grinding was taken manually, using a grain sandpaper (grain size paper 600 and 1200). This process progression was constantly checked under x6.25 magnification (EOS Rebel XTI, Canon, NY, USA). The teeth were then fixed on a wax support and photographed under suitable approximation and distinctness. Histological analysis was performed from these photographs by an experienced researcher to evaluate the depth of demineralization, giving each tooth a score, as shown in chart 2.

Chart 2 – Criteria for the scores of the histological caries lesion depth.

Score	Visual criteria	Histological criteria
0	No or slight change in enamel after prolonged air drying	Sound
1	Opacity or discoloration hardly visible on wet surface but distinct after air drying	Caries extending to the outer half of the enamel
2	Opacity distinctly visible without air drying	Caries extending to the inner half of the enamel or the outer third of dentine
3	Localized enamel break-down in opaque or discolored enamel and/or grayish discoloration from the under lying dentine	Caries extending to the middle third of the dentine
4	Cavitation in opaque or discolored enamel exposing the dentine	

Statistical analyses

Intra and interexaminer reproducibility were calculated with intra-class correlation coefficient (ICC, 95% CI). For the determination of interexaminer reproducibility, all the examiners scores were compared.

To calculate sensitivity, specificity and area under the ROC curve (AUC) of the ICDAS, the ICDAS scores were recoded for comparison with the histological scores. As ICDAS comprises seven scores and four histological analyses, the scores were recorded into five categories [7]: from 0 to 0; from 1 to 1; from 2 to 2; from 3 and 4 to 3; and from 5 and 6 to 4. Then, sensitivity, specificity and area under the ROC curve of ICDAS were calculated at D1, D2 and D3 thresholds. At D1 (enamel and dentine lesions), D2 (inner enamel and dentine lesions), D3 (dentine lesions).

Data were analyzed using SPSS (version 20.0, SPSS, Inc., Chicago, Il, USA) and MedCalc for Windows (version 9.3.0.0, Mariakerke, Belgium). The significance level was set at 0.05.

RESULTS

Histological examination showed that 6 out of 42 teeth analyzed were caries free, 9 had caries extending histologically into the outer half of the enamel, 18 into the inner half of the enamel, 6 in the outer half of the dentine and 3 into the inner half of the dentine (table 1).

Considering the reproducibility, the ICC interexaminer values among all participants varied from 0.54 to 0.96, as shown on table 2. The intra-examiner ICC reproducibility of the examiners ranges from 0.61 to 0.85, as shown on table

3. Inter and intra-examiner values showed good reproducibility values, but the inter examiner showed values of low and good reproducibility.

For detection of enamel and dentine lesions (D1), ICDAS obtained sensitivity 0.835 and specificity 0.756. At D2, the sensitivity values were reduced while the specificity values were increased, as shows on table 4. For dentine lesions (D3), the method revealed an increase in sensitivity but specificity was similar to D1.

Table 1 – Histological examination results for the extension of caries lesions.

Extension of carie lesion	Number of teeth
Caries free	6
Caries into the outer half of the enamel	9
Caries inner half of the enamel	18
Caries in the outer half of the dentine	6
Caries into the inner half of the dentine	3

Table 2 – ICC values for interexaminer reproducibility.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
A	1.000	0.774	0.781	0.765	0.829	0.972	0.821	0.784	0.828	0.815	0.823	0.826	0.796	0.858	0.727
B	0.774	1.000	0.746	0.761	0.801	0.733	0.855	0.637	0.743	0.670	0.753	0.756	0.682	0.772	0.769
C	0.781	0.746	1.000	0.966	0.817	0.784	0.719	0.745	0.752	0.777	0.769	0.838	0.812	0.739	0.681
D	0.765	0.761	0.966	1.000	0.812	0.769	0.739	0.698	0.744	0.774	0.762	0.834	0.802	0.742	0.672
E	0.797	0.815	0.724	0.744	1.000	0.771	0.853	0.665	0.778	0.819	0.804	0.770	0.760	0.783	0.781
F	0.972	0.817	0.784	0.769	0.839	1.000	0.825	0.785	0.836	0.795	0.794	0.800	0.814	0.854	0.677
G	0.821	0.821	0.719	0.739	0.870	0.825	1.000	0.719	0.813	0.747	0.785	0.727	0.742	0.821	0.669
H	0.784	0.708	0.746	0.698	0.804	0.786	0.719	0.670	0.840	0.764	0.779	0.728	0.765	0.750	0.542
I	0.828	0.743	0.752	0.744	0.897	0.836	0.813	1.000	1.000	0.816	0.865	0.740	0.726	0.836	0.678
J	0.815	0.670	0.777	0.744	0.836	0.795	0.747	0.840	0.816	1.000	0.877	0.798	0.819	0.786	0.715
K	0.823	0.753	0.769	0.762	0.858	0.794	0.785	0.764	0.865	0.877	1.000	0.772	0.752	0.761	0.683
L	0.826	0.756	0.838	0.834	0.735	0.800	0.727	0.745	0.740	0.798	0.772	1.000	0.813	0.718	0.682
M	0.796	0.682	0.812	0.802	0.806	0.814	0.742	0.765	0.726	0.819	0.752	0.813	1.000	0.703	0.666
N	0.858	0.772	0.739	0.742	0.836	0.854	021	0.750	0.8.36	0.786	0.761	0.718	0.703	1.000	0.668
O	0.727	0.752	0.681	0.672	0.688	0.677	0.669	0.542	0.678	0.715	0.683	0.682	0.666	0.668	1.000

Table 3 – ICC values for intra-examiner reproducibility.

Examiner	ICC
A	0.81
E	0.85
F	0.81
G	0.76
H	0.72
I	0.77
J	0.75
K	0.83
L	0.61
M	0.65

Table 4 – Sensitivity, specificity, accuracy and the area under the ROC curve (AUC) mean values for ICDAS at D1, D2 and D3 thresholds.

Method	Sensitivity	Specificity	AUC
D1	0.835	0.755	0.795
D2	0.792	0.861	0.827
D3	0.858	0.759	0.809

Note: For D1 threshold: Histology: 0=sound; 1-4=decayed. ICDAS: 0=sound; 1-6=decayed. For D2 threshold: Histology: 0-1=sound; 2-4=decayed. ICDAS: 0-1=sound; 2-6=decayed. For D3 threshold: Histology: 0-2=sound; 3-4=decayed. ICDAS: 0-2=sound; 3-6=decayed.

DISCUSSION

Currently, the evidence based on cariology and dentistry has been teaching and developing a more conservative approach, which aims to maintain dental tissues with minimally invasive clinical procedures. Thus, early detection of carious lesions is essential to paralyze them non-invasively. However, the conventional methods for detecting incipient lesions (non cavitated enamel carious lesions) have low sensitivity and are subjective [5,6,14]. Thus, visual criteria have been used to improve the detection of dental caries lesion [1].

Likewise, in the academy, the training for the detection of caries lesions should be based on the early detection of lesions. Basically, this training is based on tactile, visual and radiographic examinations [15], which are based on subjective methods of detecting carious lesions. Consequently, students presented difficulties in applying these methods, once these methods were based on the clinical experience.

The effectiveness of ICDAS in detecting caries lesions is already established on the literature, both for deciduous [1,3-6] and permanent [2,11,14] dentitions. Its applicability has been demonstrated by in vitro studies [1,12] and in vivo studies [7,16,17]. Thus, in the present study, graduated students with different clinical experience have been training for ICDAS only for 90 minutes of e-learning program, showing good to excellent results of reproducibility inter and intra-examiner. Similar results have been observed in previous studies evaluating the ICDAS e-learning program as a teaching methodology. Diniz et al. [11] evaluated the effectiveness of ICDAS e-learning program in detecting occlusal lesion caries among graduated students. The authors observed that ICDAS e-learning program improved the reproducibility and validity only in terms of specificity of the diagnostic skills. Based on the good to excellent values of reproducibility, we could affirm that the ICDAS training by e-learning program may be an applicable method to improve the subjectivity of the visual examination among the students.

Considering the validity of ICDAS in this study, the area under the ROC curve (AUC) showed good accuracy of the ICDAS method e-learning program (0.79 to 0.82). The results are similar to another study [7], which evaluated the performance of four Switzerland dentists with an average of eight years of clinical practice, in detecting occlusal caries before and after training with the ICDAS e-learning program. The authors obtained an increasing in the number of sites identified as early stages of desmineralization, confirming the important role of this method to the enhancement of the minimally invasive dentistry. When comparing the studies, it could be observed that, even though the method was used for examiners with different clinical experience, it presented effectiveness on the caries lesion detection in both groups of examiners. This validity of the ICDAS on the caries lesion detection could be attributed to the detailed description of the clinical characteristics of the caries lesion different stages, which are adequately related to the histological one.

At D1 threshold, ICDAS presented more sensitivity than specificity. This could be justified because this threshold considered as caries lesion the enamel to dentin stages. This result is in accordance with Souza et al. [1], which also obtained higher values of sensitivity than specificity in this threshold. At D2 threshold, the values of specificity were higher than sensitivity value (0.86 and 0.79 respectively). In this threshold, the examiners considered as caries lesions, those in the inner half of enamel and dentine. It is known the difficult to detect enamel caries lesion. In the study of Rodrigues et al. [7], 170 teeth were evaluated by 4 experienced dentists before and after the e-learning training for ICDAS and the specificity values were higher than the sensitivity values in the D2 threshold (0.81 and 0.63 respectively). In this same

study, comparing the sensitivity and specificity values before and after the e-learning training, higher sensitivity values were observed before the e-learning training than after, which was contrary to the results of our study. This may be due to the fact that the participants already have much more time of clinical experience than the students who participated in our study. However, specificity values were higher after the e-learning training, which is in concordance with our results. At D2 threshold, AUC value of our study was higher than D1. Souza et al. [1] observed the similar results. Thus, it could be inferred that the detection of carious lesions in the inner half of the enamel and dentin presented higher validity when compared to the diagnose of the lesions at outer of enamel.

Finally, differences among studies can be explained in part by variations in the methodology, such as inclusion and exclusion criteria used for sample selection, number of sound teeth or enamel and dentine demineralization, resources available for evaluation (use of ballpoint probe, artificial or natural light), criteria for histological validation, examiner´s experience and the type of study – in vitro or in vivo. In vitro studies have an advantage for comparing methods, because the examiners evaluation can be compared to a true gold standard, the histological validation [18], although in vivo training is also important, since the methods are developed to guide the clinical practice.

Previous researches have shown good reproducibility among graduated students [19,20], in addition to an adequate validity in the detection of caries lesion [8,14,21]. We could consider that the reproducibility and the validity were high, even though in some studies the sensitivity was higher than the specificity at certain cut-off points, and in others the result was the inverse. We believe that one of the factors that contributed to the good results of the study was the 90-minute e-learning training, available in Portuguese, the native language of the examiners, as also observed by Diniz et al. [11].

One of the limitations of the study was the fact that the sample was not evaluated before and after the ICDAS e-learning program. Another limitation is that the examinations were performed on extracted teeth, turning it easier to examine than the in clinical conditions. Further in vivo studies are suggested to evaluate the applicability of the ICDAS as a teaching method for clinical caries detection after ICDAS e-learning program.

CONCLUSION

ICDAS e-learning training program proved to be efficient for the training of detection of early caries lesions among graduated students, since it obtained good to excellent reproducibility and validity, allowing visual examination to be more objective. Moreover, the results showed the applicability of the method to the clinical practice, reducing the subjectivity of the diagnosis and aiding in the decision making of clinical treatment.

Collaborators

TZC ROLIM wrote the manuscript and performed the critical review of the manuscript. G MARCHETTI collected the data, interpreted data, wrote the manuscript. PK FELIPAK collected the data, interpreted data and wrote the manuscript. MT REYES collected the data, interpreted data and wrote the manuscript. JVNB MENEZES contributed to the study design, statistical analysis, interpretation of data and performed the critical review of the manuscript. JF SOUZA was the research adviser, was responsible for the study design, performed the statistical analysis and interpretation of data and performed the critical review of the manuscript.

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