Effectiveness of teaching International Caries Detection and Assessment System II and its e-learning program to freshman dental students on occlusal caries detection

Hatem M. El-Damanhoury[1,2], Kausar Sadia Fakhruddin[1], Manal A. Awad[1]

[1]Department of General and Specialist Dental Practice, College of Dental Medicine, University of Sharjah, Sharjah, UAE,
[2]Department of Operative Dentistry, Faculty of Dentistry, Suez Canal University, Ismalia, Egypt

Correspondence: Dr. Hatem M. El-Damanhoury
Email: hdamanhoury@sharjah.ac.ae

ABSTRACT

Objective: To assess the feasibility of teaching International Caries Detection and Assessment System (ICDAS) II and its e-learning program as tools for occlusal caries detection to freshmen dental students in comparison to dental graduates with 2 years of experience. **Materials and Methods:** Eighty-four freshmen and 32 dental graduates examined occlusal surfaces of molars/premolars ($n = 72$) after a lecture and a hands-on workshop. The same procedure was repeated after 1 month following the training with ICDAS II e-learning program. Validation of ICDAS II codes was done histologically. Intra- and inter-examiner reproducibility of ICDAS II severity scores were assessed before and after e-learning using (Fleiss's kappa). **Results:** The kappa values showed inter-examiner reproducibility ranged from 0.53 (ICDAS II code cut off ≥ 1) to 0.70 (ICDAS II code cut off ≥ 3) by undergraduates and 0.69 (ICDAS II code cut off ≥ 1) to 0.95 (ICDAS II code cut off ≥ 3) by graduates. The inter-examiner reproducibility ranged from 0.64 (ICDAS II code cut off ≥ 1) to 0.89 (ICDAS II code cut off ≥ 3). No statistically significant difference was found between both groups in intra-examiner agreements for assessing ICDAS II codes. A high statistically significant difference ($P \leq 0.01$) in correct identification of codes 1, 2, and 4 from before to after e-learning were observed in both groups. The bias indices for the undergraduate group were higher than those of the graduate group. **Conclusions:** Early exposure of students to ICDAS II is a valuable method of teaching caries detection and its e-learning program significantly improves their caries diagnostic skills.

Key words: Dental caries, e-learning, International Caries Detection and Assessment System II, teaching methods

INTRODUCTION

One of the main challenges that face dental educators is to teach their students a reliable, reproducible, and practical method to detect and assess dental carious lesions.[1] Over a long period of time, teaching caries detection and recording has been done according to World Health Organization (WHO) criteria decayed-missing-filled teeth/surfaces (DMFT/S) index,[2] many drawbacks have been recognized when using this system, namely, unreliable caries diagnosis neglecting enamel caries and the activity of the carious lesions, where both active and arrested lesion are simultaneously counted.[3] Moreover, DMFT gives an equal weight to missing teeth, untreated caries, or restored teeth, and therefore, giving skewed distribution of caries, thus, can overestimate caries experience and would be of a little use for estimating treatment needs.[4]

Schulte et al.,[5] reported that there is a profound need for dental students to receive a systematic education in cariology to be competent enough in the application of this integrated knowledge during making decisions

---

DOI: 10.4103/1305-7456.143631

related to prevention and management of caries in both individual patients and the population.

The International Caries Detection and Assessment System (ICDAS II) has been introduced as a simple, logical, evidence-based system for the detection and classification of caries in dental education.[6] The new system has criteria and codes to record carious lesions present either on coronal and/or root surfaces according to the stage of their progression from early noncavitated enamel lesions to extensive dentinal carious lesions.[7] The validity and reproducibility of ICDAS II has already been tested *in vitro* and in clinical studies,[8,9] as well as some large epidemiological studies.[10,11] In addition, ICDAS II has now become the international recommendation for dental health surveys.[12,13]

In recent times, a 90-min online e-learning program (http://www.icdas.org/icdas-e-learning- course) was introduced through the ICDAS II foundation website, which can support training in the use of ICDAS II for dental education, explaining examination protocol, and reviewing the coding system. This program was found to improve diagnostic skills of senior dental students for the detection of occlusal caries.[14]

There are insufficient data in the literature about the practicality of integrating ICDAS II system in the early preclinical years of dental education, particularly in those dental schools that employ outcome-focused approach in their integrated curriculum. This comparative study was conducted to test the diagnostic skills based on validity and reproducibility of the ICDAS II system between dental graduates who have been trained on WHO criteria versus freshmen dental students at the University of Sharjah – College of Dental Medicine. Moreover, this study aimed to determine if e-learning could improve the participants' diagnostic skills in identifying noncavitated occlusal carious lesions.

MATERIALS AND METHODS

All freshmen undergraduate dental student and graduates with 2 years of clinical experience at the University of Sharjah were invited to participate in this study. Only participants who had no previous training on ICDAS or ICDAS II were included in this study. One hundred and sixteen participants volunteered to participate in the study and met the inclusion criteria (84 freshmen undergraduate dental student and 32 graduates with 2 years of clinical experience).

Seventy two permanent, un-restored posterior teeth were selected from a pool of extracted teeth representing ICDAS II scores between 0 and 6 on their occlusal surfaces.[15] These teeth were recently extracted, collected after patients' informed consents were obtained under a protocol approved by the University's research ethics committee, and in conformity with the University's guidelines for handling biological tissues and stored in 0.1% thymol solution at 4°C. The teeth were cleaned and polished with pumice, using a low-speed prophylaxis brush, then roots were embedded in a self-cure acrylic resin blocks. The blocks were coded at the base and occlusal surfaces were photographed. Following this, only one occlusal test site was selected and marked on the photograph with an arrow.

The study was conducted in two phases, that is, before and after e-learning training sessions. The freshmen were divided equally into six groups, and the graduates were divided equally into two groups. For the hands-on training, a 60-min lecture on the ICDAS II score criteria followed by 120-min hands-on training by visual examination conducted by three calibrated instructors who are experienced in using ICDAS II. The participants were then allowed to discuss codes.

In order to avoid bias of memorizing teeth and specific codes, phase 1 of the study was conducted 2 weeks after the lecture, and hands-on training following the protocol described by Jablonski-Momeni *et al*.[8] The participants visually examined the marked site on the photographs of the occlusal surfaces of the prepared teeth under light illumination and using air-water syringe while moist and after drying. A 0.5 mm ball ended the explorer (CP-11.5B, Hu-Friedy, Chicago, IL) was used with negligible pressure to confirm for roughness or cavitations. The visual examinations were repeated twice, to assess intra-examiner repeatability and teeth were kept hydrated with wet gauze between the examinations.

Phase 2 were conducted 4 weeks after phase 1, all groups simultaneously had been through the 90-min online ICDAS II e-learning program. After e-learning session, there was an additional discussion session and overview given by the supervisors. Both groups examined the same set of teeth twice with a 1 month interval.

Following phase 2, the roots of all teeth were removed using a slow-speed, water-cooled diamond precision

saw (Isomet 1000, Buehler, Lake Bluff, IL) and teeth were hemi-sectioned through the center of each predetermined test site. The most severe section from each tooth was analyzed for demineralization either in enamel or both enamel and dentin. The deepest demineralization area was examined by two examiners according to the histological classification system proposed by Ekstrand *et al*.[16] to determine and record caries extension at the tested sites.

Results were analyzed with statistical software (SPSS version 20.0, SPSS Inc., Chicago, IL) using Chi-square test to compare frequencies of correct responses of caries detection before and after e-learning by groups of freshmen and graduates. Intra- and inter-examiner reproducibility both before and after e-learning program of the ICDAS II were assessed using weighted kappa values (κ) and According to the classification by Landis and Koch.[17] Bias index was calculated as the absolute value of the difference between frequencies in the disagreement cells divided by the total number of ratings.

RESULTS

A total of 7 teeth (9.7%) had no enamel demineralization, whilst 22% (*n* = 16) of the teeth had enamel demineralization only confined to the outer 50% of the enamel. Almost 21% (*n* = 15) of the sampled teeth showed demineralization involving half of enamel and outer third of the dentin. Another 26% (*n* = 19) had demineralization involving the middle third of the dentin layer, while demineralization involving the inner third of the dentin was only observed in 8% (*n* = 6) of the sample teeth. In addition, 12% (*n* = 9) of the sample had a frank cavitation with exposed dentin.

The weighted kappa values (Fleiss's kappa) for intra and inter-examiner reproducibility are shown in Table 1. The results demonstrated an improvement by both freshmen and graduates after e-learning. Intra and

inter-examiner reproducibility of the graduates were better than those of the freshmen, but no statistically significant difference was found between graduates and freshmen ($P > 0.05$) as measured by kappa.

The distribution of correct ICDAS II code identification by the freshmen group before and after e-learning program is illustrated in Figure 1. There was a statistically significant difference ($P \leq 0.01$) in correct identification of codes 1, 2, and 4 from before to after e-learning. Figure 2 shows the distribution of correct code identification by the graduates group. After training using the e-learning tool for ICDAS II, statistically significant differences ($P \leq 0.05$) were observed for code 1 and code 2.

In general, the bias indices for the undergraduate group were higher than those of the graduate group. Although an improvement was observed in the bias indices after e-learning program for both groups, high bias index for ICDAS II codes cut off ≥1 was noticed for undergraduate group, both before and after e-learning.

DISCUSSION

The way cariology is taught varies widely on a global scale and the differences in didactic and organizational approach are substantial.[18] At the University of Sharjah, students are introduced to cariology in year one of the dental curriculum, where caries recognition exercises are taught regularly. Examination of caries according to the WHO criteria have long been taught to our dental students, but using these criteria for identification of pit and fissure caries is a diagnostic challenge for students and clinicians alike. Dentists' diagnostic behavior based on these criteria have shown wide individual variation in their accuracy of caries diagnosis.[19] Alternatively, the ICDAS presents a new criteria for visual-tactile detection

Table 1: Inter- and intra-examiner reproducibility (Fleiss's kappa), before and after the e-learning program, by groups of undergraduates (*n*=84; freshmen) and graduates (*n*=32)

Training	ICDAS code cut-off	Undergraduates (freshmen)		Graduates	
		Intra-examiner	Inter-examiner	Intra-examiner	Inter-examiner
Before e-learning	≥1	0.58 (0.31-0.71)	0.53 (0.22-0.72)	0.69 (0.63-0.79)	0.64 (0.41-0.87)
	Bias index	0.29	0.35	0.21	0.23
	≥3	0.61 (0.42-0.88)	0.58 (0.42-0.69)	0.76 (0.72-0.87)	0.71 (0.35-0.83)
	Bias index	0.22	0.24	0.09	0.16
After e-learning	≥1	0.73 (0.49-0.81)	0.68 (0.61-0.75)	0.86 (0.48-0.78)	0.81 (0.72-0.84)
	Bias index	0.21	0.25	0.13	0.15
	≥3	0.75 (0.45-0.85)	0.70 (0.58-0.77)	0.95 (0.82-1.00)	0.89 (0.79-1.00)
	Bias index	0.16	0.19	0.04	0.06

ICDAS: International Caries Detection and Assessment System
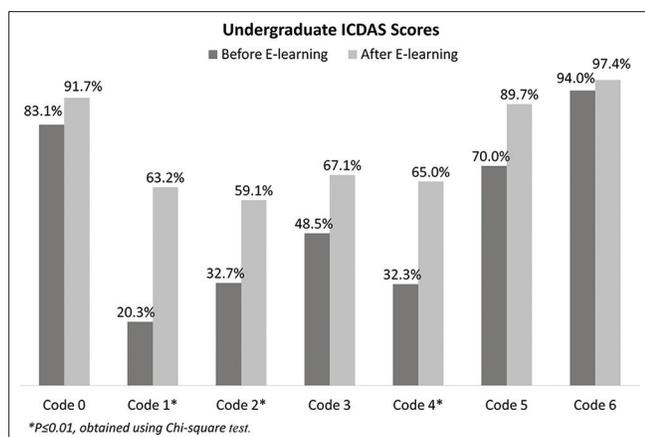
Figure 1: Frequency distribution (%) of correct responses of caries detection according to International Caries Detection and Assessment System codes before and after e-learning by group of undergraduates (freshmen)
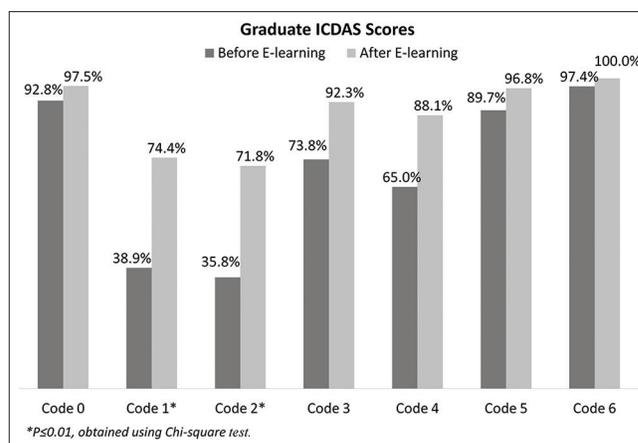

Figure 2: Frequency distribution (%) of correct responses of caries detection according to International Caries Detection and Assessment System codes before and after e-learning by group of graduates

and classification of dental caries, that demonstrate good reproducibility and correlation with histological examination of extracted teeth.[20]

The present study compared the use of ICDAS II to detect occlusal caries in permanent teeth, between a group of year-1 dental students and dental graduates with 2 years of clinical training both before and after receiving training with online e-learning program. Fleiss's kappa revealed an overall improvement from moderate to substantial inter and the intra-examiner reproducibility for undergraduates and from substantial to almost perfect for graduates with 2 years of clinical training after they have been trained using the e-learning program.

International Caries Detection and Assessment System II codes 1 and 2 can be considered the most difficult scores to be diagnosed, as it could easily be overlooked or misdiagnosed with scores 0, 3 or 4 on the ICDAS II criteria, therefore, ICDAS cut offs ≥1 and ≥3 were used to monitor the improvement in detecting more difficult scores. A higher bias index for ICDAS code cutoff ≥1 was noticed for undergraduate group both before and after e-learning in comparison to graduates. These findings demonstrate that freshmen participants experienced some difficulties in comparison to graduates in identifying caries specially lesions with initial pathological changes in the tooth leading to incorrect scoring due to their limited clinical exposure.

However, it was noted in the present study that the two groups did not differ significantly in intra-examiner agreement for assessing ICDAS II codes as evaluated by kappa, which are similar findings those reported by Zandona *et al.*[21] Thus, previous dental clinical

exposure may have some effect on accuracy of caries detection but this effect is of no significant value when ICDAS II codes and criteria are applied. These findings were in agreement with those reported by Diniz *et al.*,[14] who reported an increase in the intra- and inter-examiner repeatability after the e-learning, but were not significantly different ($P > 0.05$) additionally the specificity of the ICDAS scores was significantly improved after the e-learning program.

The improvement in diagnostic skills after e-learning as demonstrated in the current study could be attributed to the fact that employing ICDAS interactive online training package engaged participants through elaborating a "decision tree" providing for standardized recording of ICDAS II codes with explicit information of how to apply codes under special circumstances made e-learning quite a comprehensive tool for teaching caries detection using ICDAS II. One limitation of this study is the higher bias index values for the undergraduate group compared to the graduate group, which could have contributed to higher kappa values in the undergraduate group.

On the contrary, Rodrigues *et al.*,[22] showed no statistically significant difference between before and after the e-learning program. These results were attributed to the participants' long experience in detecting occlusal caries, which was indicated by high values of sensitivity and specificity both before and after the program.

For the last few decades, it has been generally accepted by the dental profession that application of caries preventive measures in patients and populations represent an important part of dental activities, but one major challenge for applying these measures is detection and diagnosis of initial carious changes on

the tooth surface, which is the most important phase towards preventive therapies.[23] It was observed in the present study that after the interactive online training in both groups, the number of sites which were classified as codes 1, 2 and 4 have increased significantly after e-learning. The capability to detect initial changes on the tooth surface has a significant impact on treatment decisions, as well as on improving the possibility of a successful preventive intervention.[24]

Using ICDAS II e-learning program in the preclinical years can direct students to preventive care strategy based on the assessed needs, caries risk status and compliance possibility of the patient.[25] This can also help them learn systematic evaluation of all preventive treatment outcomes at recall visits and be able to formulate alternative treatment plans for the individual cases when needed.[26]

CONCLUSION

Introducing ICDAS in the early stages of teaching cariology can be a useful tool in improving caries diagnostic skills (the validity and reproducibility) of freshman students. As it was observed in this study, previous clinical exposure does not influence learning and application of caries diagnostic criteria and coding system of ICDAS II. Using ICDAS II e-learning program in combination with conventional teaching of ICDAS II significantly improves diagnostic skills of the dental students, especially in detecting caries in its early stages and might be a step toward standardization of caries detection.

REFERENCES

1. Braga MM, Mendes FM, Ekstrand KR. Detection activity assessment and diagnosis of dental caries lesions. Dent Clin North Am 2010;54:479-93.
2. Oral Health Surveys-Basic Methods. 4th ed. Geneva, Switzerland: World Health Organization; 1997. p. 39-44.
3. Featherstone JD. The caries balance: Contributing factors and early detection. J Calif Dent Assoc 2003;31:129-33.
4. Kühnisch J, Berger S, Goddon I, Senkel H, Pitts N, Heinrich-Weltzien R. Occlusal caries detection in permanent molars according to WHO basic methods, ICDAS II and laser fluorescence measurements. Community Dent Oral Epidemiol 2008;36:475-84.
5. Schulte AG, Pitts NB, Huysmans MC, Splieth C, Buchalla W. European Core Curriculum in Cariology for undergraduate dental students. Eur J Dent Educ 2011;15 Suppl 1:9-17.
6. Pitts N. "ICDAS": An international system for caries detection and assessment being developed to facilitate caries epidemiology, research and appropriate clinical management. Community Dent Health 2004;21:193-8.
7. Braga MM, Oliveira LB, Bonini GA, Bönecker M, Mendes FM. Feasibility of the International Caries Detection and Assessment System (ICDAS-II) in epidemiological surveys and comparability with standard World Health Organization criteria. Caries Res 2009;43:245-9.
8. Jablonski-Momeni A, Stachniss V, Ricketts DN, Heinzel-Gutenbrunner M, Pieper K. Reproducibility and accuracy of the ICDAS-II for detection of occlusal caries *in vitro*. Caries Res 2008;42:79-87.
9. Shoaib L, Deery C, Ricketts DN, Nugent ZJ. Validity and reproducibility of ICDAS II in primary teeth. Caries Res 2009;43:442-8.
10. Agustsdottir H, Gudmundsdottir H, Eggertsson H, Jonsson SH, Gudlaugsson JO, Saemundsson SR, *et al*. Caries prevalence of permanent teeth: A national survey of children in Iceland using ICDAS. Community Dent Oral Epidemiol 2010;38:299-309.
11. Arruda AO, Senthamarai Kannan R, Inglehart MR, Rezende CT, Sohn W. Effect of 5% fluoride varnish application on caries among school children in rural Brazil: A randomized controlled trial. Community Dent Oral Epidemiol 2012;40:267-76.
12. Bourgeois DM, Llodra JC, Christensen LB, Pitts NB, Ottolenghi L, Senekola E. Health Surveillance in Europe, Oral Health Interviews and Clinical Surveys: Guidelines, European Global Oral Health Indicators Development Program (Egohid II). Lyon, France: Lyon University Press; 2008.
13. Aidara AW, Pitts N, Markowska N, Bourgeois D. Quality of data gathered with International Caries Detection and Assessment System (ICDAS) assessment and dentists' perceptions of completion of dental records. Int Dent J 2011;61:314-20.
14. Diniz MB, Lima LM, Santos-Pinto L, Eckert GJ, Zandoná AG, De Cássia Loiola Cordeiro R. Influence of the ICDAS e-learning program for occlusal caries detection on dental students. J Dent Educ 2010;74:862-8.
15. Ismail AI, Sohn W, Tellez M, Amaya A, Sen A, Hasson H, *et al*. The International Caries Detection and Assessment System (ICDAS): An integrated system for measuring dental caries. Community Dent Oral Epidemiol 2007;35:170-8.
16. Ekstrand KR, Kuzmina I, Bjørndal L, Thylstrup A. Relationship between external and histologic features of progressive stages of caries in the occlusal fossa. Caries Res 1995;29:243-50.
17. Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics 1977;33:159-74.
18. Yorty JS, Walls AT, Wearden S. Caries risk assessment/treatment programs in U.S. dental schools: An eleven-year follow-up. J Dent Educ 2011;75:62-7.
19. Chong MJ, Seow WK, Purdie DM, Cheng E, Wan V. Visual-tactile examination compared with conventional radiography, digital radiography, and diagnodent in the diagnosis of occlusal occult caries in extracted premolars. Pediatr Dent 2003;25:341-9.
20. Ekstrand KR, Ricketts DN, Kidd EA. Reproducibility and accuracy of three methods for assessment of demineralization depth of the occlusal surface: An *in vitro* examination. Caries Res 1997;31:224-31.
21. Zandona AG, Al-Shiha S, Eggertsson H, Eckert G. 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.
22. Rodrigues JA, de Oliveira RS, Hug I, Neuhaus K, Lussi A. Performance of experienced dentists in Switzerland after an e-learning program on ICDAS occlusal caries detection. J Dent Educ 2013;77:1086-91.
23. Bottenberg P, Ricketts DN, Van Loveren C, Rahiotis C, Schulte AG. Decision-making and preventive non-surgical therapy in the context of a European Core Curriculum in Cariology. Eur J Dent Educ 2011;15 Suppl 1:32-9.
24. Pitts NB. How the detection, assessment, diagnosis and monitoring of caries integrate with personalized caries management. Monogr Oral Sci 2009;21:1-14.
25. Frencken JE, Peters MC, Manton DJ, Leal SC, Gordan VV, Eden E. Minimal intervention dentistry for managing dental caries: A review: Report of a FDI task group. Int Dent J 2012;62:223-43.
26. Budenz AW, Subar P. Community-based prevention and early intervention strategies. J Calif Dent Assoc 2012;40:597-603.

Access this article online	
Quick Response Code:	**Website:** www.eurjdent.com
	Source of Support: Nil. **Conflict of Interest:** None declared