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Evaluation of Various Caries Diagnostic Devices in Occlusal Caries Detection in Conjunction with Visual Inspection: An In vivo/ In vitro Study

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Abstract

This study aimed to investigate in vivo and in vitro conditions for the effectiveness of the devices DIAGNOdent Pen, Caries ID, and CarieScan Pro in conjunction with ICDAS II in diagnosing occlusal decay.

88 permanent molar teeth chosen for extraction were used. The teeth were assessed with the ICDAS II system and evaluated using the DIAGNOdent Pen, Caries ID, and CarieScan Pro in vivo and in vitro. Scoring with visual inspection and scoring with each caries diagnostic device were analyzed together and a single score was obtained. After these examinations, sections were obtained from the specimens for histological examination.

Evaluation with the ICDAS II system resulted in the findings of Caries ID in vivo and the findings of the DIAGNOdent Pen in vitro being different from those of histological examination. Only the findings of the DIAGNOdent Pen in vitro with ICDAS II were found to be similar to the histological evaluation findings. At the D3 level, in vivo, ICDAS II showed the highest values (0.67–0.85). In vitro, Caries ID showed the highest values (0.78–0.84). Under in vivo conditions where the devices were used with the ICDAS II system, the DIAGNOdent Pen showed the highest values (0.73–0.85). Findings under in vitro conditions were similar to those in vivo, with the DIAGNOdent Pen showing the highest values (0.82–0.80).

Thus, none of the methods were found to be effecetive for initial diagnosis of occlusal decay. The methods were found to be more relatively successful in diagnosing dentin level.

Keywords: Occlusal caries, ICDAS II, Caries diagnostic devices, DIAGNOdent Pen, Caries ID, CarieScan Pro

Introduction

Early diagnosis of caries is very important to create an appropriate treatment plan and reduce loss of tooth structure. In clinical practice, the most commonly used diagnostic methods of occlusal caries are visual and radiologic examination. Several caries classification systems have been developed to make visual examination more efficient, correct and standardized [1-3]. ICDAS II criteria are the the latest development in such classification [4]. In addition to these methods, several diagnostic devices with practical utility using which objective data can be obtained and standardization can be

achieved are available for use by dentists such as DIAGNOdent Pen, CarieScan Pro, Caries ID.

The objective of this study was to evaluate the effectiveness of the devices DIAGNOdent Pen, Caries ID and CarieScan Pro in conjunction with the ICDAS II system in diagnosing occlusal decay under in vivo and in vitro conditions.

Materials and Methods

This study was prospectively designed and ethical approval was obtained (Document No: 2016/009). In our study, the occlusal surfaces of 88 permanent mandibular molar teeth which had indications for extraction were evaluated in vivo and in vitro. All evaluations were done by a single investigator. Inclusion criteria were patients with no medical condition and age range of 18–50 year. Teeth with cavitated caries lesions, restoration or fissure sealant, caries at their interfaces, hypoplasia, use of tetracycline, fluorosis, or occasionally, discoloration on the tooth surface were excluded from the study. The informed consent was obtained from all participants.

In vivo study

Evaluation of occlusal surfaces of the teeth in the oral environment were done using the caries diagnostic devices DIAGNOdent Pen, CarieScan Pro, or Caries ID in combination with the ICDAS II (Table 1). Prior to evaluation, plaque on the teeth was removed.

ICDAS II

Visual inspection was performed by examining occlusal surfaces of the teeth under the light of the reflector. Based on the criteria of Ekstrand 's ICDAS II, each tooth was given a score and these scores were recorded.[4]

DIAGNOdent Pen

Before the measurements were made, the device was calibrated. The DIAGNOdent Pen was used in the fissure areas, especially at the points deemed to contain the deepest decay. Measurements for each tooth were repeated three times and the highest values were recorded [5].

Caries ID

The Caries ID diagnostic device was calibrated. In the presence of decalcification or bruising on the tooth surface, the instrument gave an audible signal with a red light. The device gave three types of audible signals and scoring was done according to signal status.

CarieScan Pro

Unlike other devices, this device's lip hook is placed in the patient's cheek cavity. The measurements were repeated five times for each tooth. The average of these five scores was recorded as the CarieScan Pro score for that tooth.

In vitro study

Teeth were placed in 4 ºC saline solution for two weeks. Evaluations with the ICDAS II system, DIAGNOdent Pen, and Caries ID were repeated in the same manner as in the in vivo process. When using the CarieScan Pro, the tooth surfaces were moistened for electrical stream.

Combined Assessment using Each Caries Diagnostic Device with Visual Inspection

When the caries diagnostic devices were used along with visual examination for evaluating occlusal surfaces, the scoring via visual inspection was analyzed along with the scoring with each caries diagnostic device, and a single score was obtained (Table 2). Thus, the effectiveness of the diagnostic devices in a practical clinical routine was asssessed.

Histological examination

Sections were obtained using the Exact (Exakt 300 CL, Exakt Apparatbau, Norderstad, Germany) hard tissue section device. These sections were thinned to a thickness of 100 µm with abrasives attached to a micro-abrasive system (Exakt 400 CS, Exakt Apparatbau, Norderstad, Germany). Histological evaluations of all sections were performed with light microscopy (Olympus® CX41,

Tokyo, Japan). Evaluation of the sections examined under the microscope was made in accordance with Downer's histological scoring criteria (Figure 1) [6].

Data processing and statistical analysis

Statistical analyses of the data were performed using SPSS 19.0 (IBM Inc., Chicago, IL, USA). McNemar - Bowker test was used to evaluate the consistency of the methods with histological evaluation. Scores obtained from the methods were combined to fit D1 (sound-decay separation), D2 (enamel decay), and D3 (dentin decay) threshold values.

Based on the threshold value of D1, a score of 0 represented healthy teeth and scores of 1, 2, or 3 represented decayed teeth. For the D2 threshold, scores of 0 or 1 represented healthy teeth and scores of 2 or 3 represented decayed teeth. For the D3 threshhold, scores of 0, 1, or 2 represented healthy teeth and a score of 3 represented decayed teeth. Sensitivity, specificity, and accuracy values and areas under the ROC (Receiver-Operating Characteristics) curves were calculated to allow comparative evaluation of the methods of caries diagnosis.

Results

Caries distribution based on the histological evaluation results are D0: 16% (n=14), D1: 29% (n=26), D2: 23% (n=20), D3: 32% (n=28). Caries prevalence was determined to be 84 %. Results of evaluation of similarity between caries diagnosis methods and histological examination in vivo and in vitro are shown in Table 3. There was a significant similarity between the findings obtained using the DIAGNOdent Pen combined with the ICDAS II system in vivo, and histological evaluation findings (p=0.338).

In vivo validity of each system

Sensitivity and selectivity based on the threshold values of D1, D2, and D3, and AUC for each method are given in Table 4. No method was found to be successful at the D1 and D2 thresholds. Associations between the areas under the curve obtained as a result of evaluation with ICDAS II, DIAGNOdent Pen, and Caries ID at the D3 threshold value were statistically significant. Caries ID showed the highest selectivity and ICDAS II system showed the highest sensitivity value. The difference between the ICDAS II system and other methods was statistically significant.

In vitro validity of each system

The results of analysis based on the discrimination factors of AUC, sensitivity, selectivity, and accuracy of each method at the threshold values of D1, D2, and D3 are shown in Table 4. At the D1 and D2 thresholds, no method could show success. A statistically significant correlation was found between all methods at the D3 threshold value. While Caries ID showed the highest sensitivity, CarieScan Pro showed the lowest sensitivity. While CarieScan Pro showed the highest selectivity, the DIAGNOdent Pen showed the lowest selectivity.

In vivo validity of each system evaluated with the ICDAS II

In vivo evaluations using the devices with ICDAS II did not show success at the D1 and D2 thresholds. However, it was determined that the sensitivity, selectivity, and AUC values were increased in comparison with the findings of the devices used alone. A statistically significant correlation was found between combined evaluations using each device with the ICDAS II at the D3 threshold value. While the DIAGNOdent Pen showed the highest sensitivity, Caries ID showed the highest selectivity value.

In vitro validity of each system evaluated with the ICDAS II

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statistically significant correlation was found between combined evaluations using each device with the ICDAS II at the D3 threshold value. While the DIAGNOdent Pen showed the highest sensitivity, Caries ID showed the highest selectivity.

Discussion

In this study, the ICDAS II system and caries diagnostic devices were evaluated both in vivo and in vitro. Studies on caries diagnosis methods and activities can be carried out under in vitro or in vivo conditions [7,8]. The gold-standard histological examinations can accurately determine widths and depths of caries lesions [9,10].

In this study, only third molar teeth containing intact or initial lesions were included. Thus, the histological depths of selected specimens were evenly distributed. This is an important factor in determining sensitivity and selectivity values obtained via ROC analysis of the methods. In studies where the effectiveness of diagnostic methods is assessed using ROC analysis, calculations are usually made based on the threshold values of D1 and D3 [11-13]. It is technically risky to evaluate an ordinal evaluation method such as ICDAS II which evaluates using a scoring system of six levels, in the context of a two-level gold standard method. Such studies do not add useful information to the parameters that the method is evaluating; ICDAS not only calculates the width of the decay, but also evaluates the state of cavitation clinically [11].

In this study, the D2 threshold value was also evaluated, as Mortensen et al. and Souza et al.[12,14]. In addition to the D1 and D3 thresholds, analyses of the D2 threshold were also performed to investigate the effectiveness of the methods in diagnosing decay at the enamel level. While the methods were not successful at the D1 and D2 threshold values, they were successful at the D3 threshold. This demonstrates that these methods can identify caries lesions at the level of dentin, but not those at an initial stage or enamel level.

Successful results could not be obtained at the D1 and D2 threshold values using the Diagnostic Pen. A possible reason for this, which may be a significant limitation of this device, is excessive scoring in areas that are colored or not cleaned. Although successful in the identification of caries at the D3 level under in vitro and in vivo conditions, it was less successful than the other methods.

There are insufficient studies reporting the use of Caries ID. Known studies have typically been performed in vitro. However, it has been reported that Caries ID should also be used in patients in order to determine its performance in clinical conditions [15]. The performance of the device has been found to be similar to that of the DIAGNOdent Pen. Similar results were obtained in our study. Even in at the D3 level, Caries ID was found to be more successful than the DIAGNOdent Pen.

CarieScan Pro, designed for the detection of cavity-free caries lesions, did not achieve success at the D1 and D2 levels, similar to the other methods. At the D3 level, its success was lowest among all the methods. We are of the opinion that the technical precision and environmental factors required in the use of this device make it difficult to use for ideal measurements. Based on the results of other studies, this device could not meet expectations and its performance was found to be inadequate [11,14].

When in vivo and in vitro findings were compared, it was found that sensitivity and selectivity values of all devices were increased during in vitro measurements. This may be a reason for better standardization under in vitro conditions than under in vivo conditions.

In the majority of studies carried out to date, it has been reported that diagnostic devices can be used alone as adjuncts to the conventional methods to obtain more successful results [11,16,17]. Although it is reported that the

devices offer similar or better performances than the conventional methods, it would be incorrect to make an operational decision based only on performance of the devices in the routine clinical setting. Our study found that the diagnostic performance of the devices was better under both in vivo and in vitro conditions when evaluated along with the findings of the ICDAS II system.

Conclusion

Within the limitations of this study, the combined in vivo use of the ICDAS II system and the DIAGNOdent Pen showed the results closest to those of the histological examination. This combination can be considered the most appropriate method for detection of occlusal caries in the clinical environment.

Conflict of Interest

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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. 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: 170–178.
3. Kühnisch J, Goddon I, Berger S, Senkel H, Bücher K, Oehme T, et al. Development, methodology and potential of the new Universal Visual Scoring System (UniViSS) for caries detection and diagnosis. Int J Environ Res Public Health. 2009;6: 2500–2509.
4. Ekstrand KR, Martignon S, Ricketts DJN, Qvist V. Detection and activity assessment of primary coronal caries lesions: a methodologic study. Oper Dent. 2007;32: 225–235.
5. Fung L, Smales R, Ngo H, Moun G. Diagnostic comparison of three groups of examiners using visual and laser fluorescence methods to detect occlusal caries in vitro. Aust Dent J. 2004;49: 67–71; quiz 101.
6. Downer MC. Concurrent validity of an epidemiological diagnostic system for caries with the histological appearance of extracted teeth as validating criterion. Caries Res. 1975;9: 231–246.
7. Ricketts DN, Kidd EA, Wilson RF. A re-evaluation of electrical resistance measurements for the diagnosis of occlusal caries. Br Dent J. 1995;178: 11–17.
8. Nyvad B. Diagnosis versus Detection of Caries. Caries Res. 2004;38: 192–198.
9. 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: 224–231.
10. 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.
11. Teo TK-Y, Ashley PF, Louca C. An in vivo and in vitro investigation of the use of ICDAS, DIAGNOdent pen and CarieScan PRO for the detection and assessment of occlusal caries in primary molar teeth. Clin Oral Investig. 2013;18: 737–744.
12. Souza JF, Boldieri T, Diniz MB, Rodrigues JA, Lussi A, Cordeiro RCL. Traditional and novel methods for occlusal caries detection: performance on primary teeth. Lasers Med Sci. 2013;28: 287–295.
13. Achilleos E-E, Rahiotis C, Kakaboura A,

Vougiouklakis G. Evaluation of a new fluorescence-based device in the detection of incipient occlusal caries lesions. Lasers Med Sci. 2013;28: 193–201.

14. Mortensen D, Dannemand K, Twetman S, Keller MK. Detection of Non-Cavitated Occlusal Caries with Impedance Spectroscopy and Laser Fluorescence: an In Vitro Study. Open Dent J. 2014;8: 28–32.
15. Aktan AM, Cebe MA, Ciftçi ME, Sirin Karaarslan E. A novel LED-based device for occlusal caries detection. Lasers Med Sci. 2012;27: 1157–1163.
16. Patel SA, Shepard WD, Barros JA, Streckfus CF, Quock RL. In Vitro Evaluation of Midwest Caries ID: A Novel Light-emitting Diode for Caries Detection. Oper Dent. 2014;39: 644–651.
17. Iranzo-Cortés JE, Terzic S, Montiel-Company JM, Almerich-Silla JM. Diagnostic validity of ICDAS and DIAGNOdent combined: an in vitro study in pre-cavitated lesions. Lasers Med Sci. 2017;32: 543–548.

Table and Figure

Table 1 Diagnostic criteria used in this study for the ICDAS II, Diagnodent Pen, Caries ID and the CarieScan Pro

Score	ICDAS	Diagnodent	Caries ID	CarieScan
0	II 0	Pen 0-13	No signal/ green light	Pro 0/ green light
1	1	14-20	Low level signal/ red light	1-30/ green- yellow light
2	2,3	21-30	Middle level signal/ red light	31-90/ yellow light
3	4,5,6	>30	Fast or uninterrupted signal/ red light	91-100/ red light

Table 2 Regulation of scoring with ICDAS II with each caries diagnostic device

	Visual Examination				
		0	**1**	**2**	**3**
Caries Diagnostic Devices	**0**	0	0	1	2
	1	0	1	2	2
	2	1	2	2	3
	3	2	2	3	3

Visual examination score= VES / Caries diagnostic devise score= CDDS

VES/ CDDS: 0-0 → 0 0-1 → 0 1-1 → 1

1-2 → 2 2-2 → 2 2-3 → 3 3-3 → 3

Table 3 Evaluation of similarity between caries diagnosis methods and histological examination

	in vivo		*in vitro*	
	Chi square	**p**	**Chi square**	**P**
ICDAS II	*	*	*	*
Diagnodent Pen	21.773	<0,001	37.554	<0,001
Caries ID	28.462	<0,001	*	*
CarieScan Pro	*	*	*	*
ICDAS II+ Diagnodent Pen	6.819	**0,338**	15.788	0,0149
ICDAS II+ Caries ID	23.0428	<0,001	*	*
ICDAS II+ CarieScan Pro	*	*	*	*

***** Histological examination results were compared; but it was observed that the data set did not provide the necessary assumptions for cross-analysis.

Table 4 ROC analysis values calculated for each method according to the threshold values D1, D2 and D3 in the *in vivo* and *in vitro* environment.

System	**Downer's histology**	**Cut-of**	**Sensitivity** ***in vivo/in vitro***	**Specificity** ***in vivo/in vitro***	**AUC** ***in vivo/in vitro***
	D1	**1**	-	-	0,332
ICDAS II	**D2**	**2,3**	-	-	0,485
	D3	**4,5,6**	**67,9**	**85**	**0,817**
	D1	**14-20**	-	-	0,444 / 0,634
Diagnodent Pen	**D2**	**21-30**	**87,5 / -**	**73,8 / -**	**0,802 / 0,662**
	D3	**>30**	**63,6 / 71,4**	**78,8 / 75,7**	**0,775 / 0791**
	D1	**1**	6,3 / -	62,5 / -	0,226 / 0,328
Caries ID	**D2**	**2**	-	-	0,335 / 0,419
	D3	**3**	**53,3 / 78,3**	**90,7 / 84,6**	**0,810 / 0,866**
	D1	**1-30**	-	-	*
CarieScan Pro	**D2**	**31-90**	**- / 11,4**	**- / 47,7**	0,345 / 0,218

	D3	**91-100**	**- / 52,3**	**- / 88,6**	0,485 / 0,782
ICDASII+	**D1**	**1**	-	-	0,338 / 0,428
Diagnodent	**D2**	**2**	-	-	0,535 / 0,616
pen	**D3**	**3**	**73,1 / 82,4**	**85,5 / 80,3**	**0,851 / 0,863**
	D1	**1**	7,1 / 22,2	63,5 / 37,1	0,244 / 0,273
ICDAS	**D2**	**2**	-	-	0,390 / 0,426
II+Caries ID					
	D3	**3**	**54,5 / 68,8**	**90,9 / 99,3**	**0,806 / 0,850**
ICDAS	**D1**	**1**	16,7 / 25	42,7 / 41,2	0,136 / 0,136
II+CarieScan	**D2**	**2**	10,8 / 12,8	52,9 / 53,1	0,314 / 0,322
Pro	**D3**	**3**	**53,3 / 56,1**	**90,7 / 89,4**	**0,774 / 0798**

Figures

Figure 1 : Evaluation of images obtained during histological examination

(A) - Sample for "0" score, (B) - Sample for "1" score

(C) - Sample for "2" score, (D) - Sample for "3" score