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A COMPARISON OF DIFFERENT METHODS FOR FISSURE CARIES DETECTION

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Summary. The aim of the study is to compare the diagnostic capabilities of three different diagnostic methods: Quantitative Laser Fluorescence (QLF) – DIAGNOdent Classic (DD), Light-Induced Fluorescence (LIF) – SoproLife daylight and blue fluorescence, and their relevance to ICDAS II system in detection of fissure caries lesions in permanent molars. Permanent molars (n = 45) are divided in two groups: 1) third molars, n = 35; 2) first and second molars, n = 10. They are examined by 2 examiners with and without magnification x5 using ICDAS II, SoproLife "day light" and "blue light" (405nm), LIF, DIAGNOdent Classic – emitting laser light on 655nm, QLF. The results are proven with histological bucco-lingual or mesio-distal sections through the body of the lesion with diamond blade rinsed with water. Photos of all occlusal surfaces of the molars are taken before and after the sections. The lowest overdiagnosis rate is found with SoproLife camera. When visual examination is applied overdiagnoses are fewer than with DD. DD is not capable to differentiate white and brown spots from a caries lesion. Soprolife is not capable to differentiate brown spots from a caries lesion. The most accurate method in this in vitro study for diagnosis of fissure caries is LIF (SoproLife) – 75.6% of the teeth are correctly diagnosed, followed by ICDAS (57.8%) and QLF (DIAGNOdent) (40%).

Key words: *ICDAS II, Light Induced Fluorescence, Quantitative Laser Fluorescence*

INTRODUCTION

Currently, the most common used caries detection methods are visual inspection, radiographs, Quantitative laser fluorescence (QLF). Fiber-optic trans-illumination (FOTI) is a technique that uses light transmission through the tooth and has been available for more than 40 years [3, 4, 12]. A

method based on the same principles as FOTI is the digitized DIFOTI method [18]. An in vitro study of A. Lussi shows that explorers are correct in less than 50% and there is no difference in diagnostic accuracy between explorer and visual technique only [11]. Radiographs are more ineffective in detection of occlusal caries before the lesion reaches 1-2 mm in dentine due to the amount of sound tissues after mineral loss of 15-20% [7]. By the time a fissure caries lesion is detectable radiographically, it is too large to be treated with non-operative techniques.

The International Caries Detection and Assessment System (ICDAS II) provides a standardized method of lesion detection and assessment leading to caries diagnosis [9].

Fluorescence is an ability of some materials and tissues to absorb energy at certain wavelengths and emit light at longer wavelengths. Fluorescence is used for diagnostics and several caries detection methods are based on it. DIAGNOdent emits laser light (655 nm). The system is well performed with reproducibility for detection and quantification of occlusal caries lesions in in vitro studies [10, 20, 21]. Contradictory results can occur in vivo, both in the primary and permanent dentitions [1, 15, 16].

The phenomenon of tooth autofluorescence for detection of dental caries is introduced back in 1928 [Benedict C. H., 1928]. An increased porosity due to a subsurface enamel lesion, occupied by water, scatters the light and teeth emit fluorescence to a lesser extent than the one of sound tissues. SoproLife system is invented to combine the advantages of a visual inspection method (high specificity) with a high magnification of intra-oral camera and Light-induced fluorescence (LIF). The possibility of adapting the LIF method for fissure caries diagnosis is under investigation since 1992 [8].

LIF tools that provide high-resolution fluorescence pictures are likely to provide more reliable scores than QLF devices. A better visibility of the high-resolution fluorescence imaging can prevent unnecessary operative interventions [Peter Rechmann et al. 2011] [14].

The aim of the study is to compare the diagnostic capabilities of the three more or less successful diagnostic methods – Quantitative laser fluorescence, DIAGNOdent Classic, and Light-induced fluorescence – SoproLife daylight and blue fluorescence, and their relevance to ICDAS II system in detection of fissure caries lesions in permanent molars.

MATERIAL AND METHODS

Teeth

The occlusal surfaces of 89 extracted matured human molars are visually examined by 2 dentists using the ICDAS-II graded scores 0-6. **Exclusion criteria:** large root caries lesions and approximal caries, teeth with restorations, abrasio, fluorotic teeth, any presence of dental hypoplasia. **The included teeth** (n = 45) are placed in two groups: the 1st – third molars, n = 35, and the 2nd – the first and second molars, n = 10.

Cleaning and storage

After extraction the teeth are placed for 1 week in formalin, 1 week in hydrogen peroxide 3% and stored in saline. Before evaluating the occlusal surfaces, teeth were cleaned with sodium cleaning tool Air flow – 7.5 l/min, with bicarbonate powder for 5 to 10 s, rinsed and dried with 3-in-1 syringe [Ricketts D. N. J, 1997].

Diagnostic Criteria

Table 1. The Applied Diagnostic Criteria

ICDAS II criteria	SoproLife daylight codes for occlusal caries	SoproLife blue fluorescence codes for occlusal caries	DIAGNOdent codes	Histological scale Ekstrand et al., 1997
0 Sound 1 First Visual Change in Enamel (seen only after prolonged air drying or restricted to within the confines of a pit or fissure) 2 Distinct Visual Change in Enamel 3 Localized Enamel Breakdown (without clinical visual signs of dentinal involvement) 4 Underlying Dark Shadow from Dentin 5 Distinct Cavity with Visible Dentin 6 Extensive Distinct Cavity with Visible Dentine	0 Sound, no visible change in the fissure 1 Center of the fissure showing whitish, slightly yellowish change in enamel, limited to part or all of the pit and fissure system 2 Whitish change comes up the slopes (walls) toward the cusps; the change is wider than the confines of the fissure, seen in part or all the pit and fissure system, no enamel break down is visible 3 Fissure enamel is rough and slightly open with beginning slight enamel breakdown; no visual signs of dentinal involvement 4 Caries process is not confined to the fissure width; presents itself much wider than the fissure; 5 Enamel breakdown with visible open dentin	0 Sound, no visible change in enamel (rarely a graphite-pencil colored thin shine/line can be observed) shiny green fissure 1 Tiny, thin red shimmer in the pits and fissure system, can come up the slopes, no red dots visible 2 In addition to tiny, thin red shimmer in pits and fissures possibly coming up the slopes darker red or black spots confined to the fissure 3 Dark red or black extended areas confined to the fissures; slight beginning roughness 4 Dark red or black or orange areas wider than fissures; surface roughness occurs, possibly grey/black or rough grey/black zone visible 5 Obvious wide openings with visible dentin	0-10 Healthy zone 11-20 Caries in the outer part of the enamel 21-30 Caries in the inner part of the enamel +30 Caries in dentin	0 No enamel demineralization or a narrow surface zone of opacity (edge phenomenon) 1 Enamel demineralization limited to the outer 50% of the enamel layer 2 Demineralization involving the inner 50% of the enamel, up to the enamel-dentine junction 3 Demineralization involving between 50% of the enamel and outer third of the dentine 4 Demineralization involving the outer 50% of the dentine Demineralization involving the middle third of the dentine 5 Demineralization involving the inner 50% of the dentine Demineralization involving the inner third of the dentine

Examination

The visual examination is performed from 2 examiners using ICDAS II.

DIAGNOdent Classic (KaVo, Biberach, Germany) is calibrated on sound smooth enamel surface, after drying time of 5 sec. Probe A for occlusal caries is used.

SoproLife (ACTEON Group, France) Light-induced fluorescence evaluator in daylight and blue light florescence mode is used. In the daylight mode, the system uses four white LEDs; in the fluorescence mode it uses four blue LEDs emitting a wavelength of 450 nm. The tool takes pictures at different distance to a tooth resulting in different magnification: intra-oral from x 30 times to more than 100 times (macro position). The images are recorded with the SOPRO imaging software (Fig. 1).

Fig. 1. Images of SoproLife diagnostic lamp

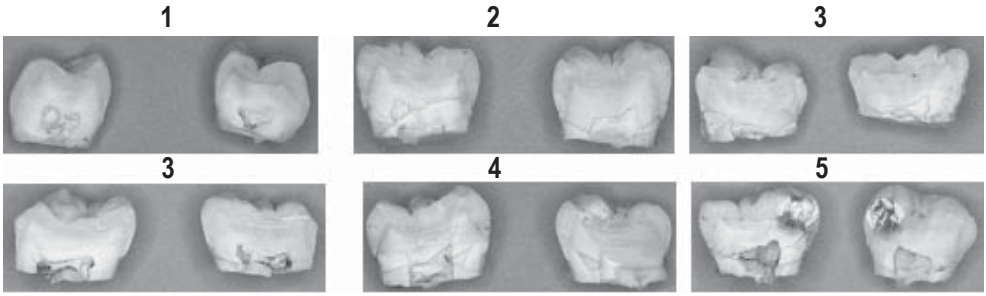

Fig. 2. Histological sections of teeth diagnosed with ICDAS II scores from 0 to 5

Bitewing X-rays

Four of the tested teeth diagnosed with fissure dentine caries ICDAS 3,3,4,4 are fixed in a model and bitewing x-rays are taken for validation of the absence of radiolucency (Fig. 2).

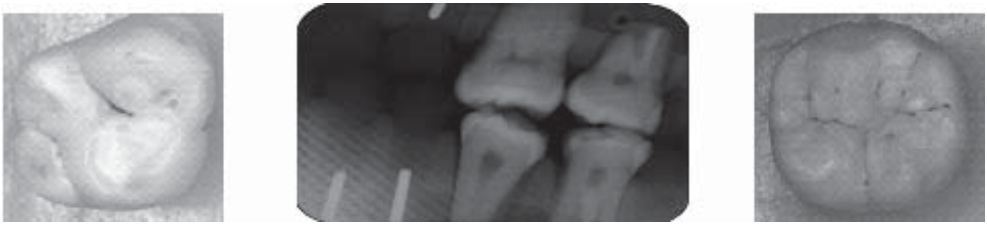

Fig. 3. Bitewing x-rays

Bitewings x-ray approving that the suspected deepest occlusal enamel and outer dentine lesions are not detectable radiographically. The X-ray machine is Siemens, Dental x-ray film is CEA DI – size 2 (31 x 41 mm), exposure time is 0.25 s, 60 kV.

Histological validation

Bucco-lingual or mesio-distal sections are obtained using a low-speed diamond blade, rinsed with water. 1 blade is used for up to 10 sections. The assessment scale of the histological images is the one used from Ekstrand et al., 1997 (6) (Fig. 3).

Statistics

Statistical methods included are the graphic and table analyses, the Chi-square, Student-Fisher's and Tukey's tests.

RESULTS

A comparison from the scores assessed with all methods is shown in the tables 2 and 3.

Table 2. Histological data and number of teeth with different diagnostic methods

Histological scale	Histology results	ICDAS II	SoproLife (daylight and blue light)	DIAGNOdent
0 No changes in enamel	31	20	24	15
1 Enamel demineralization outer 1/2	1	3	12	0
2 Enamel demineralization inner 1/2	1	1	-	3
3 Inner 1/2 of the enamel and 1/3 of the dentine	7	9	7	8
4 Demineralization outer 1/2 dentine	2	10	2	19
5 Inner 1/2 of the dentine	3	2	–	–

The biggest differences between histological scales were found for the results with DIAGNOdent.

Friedman Repeated Measures Analysis of Variance on Ranks showed statistically significant differences between all of the used methods for diagnosis of occlusal caries according to the histological scale – Chi-square = 54.391; d.f. = 3; $p < 0.001$. Tukey's test for comparison of the methods in pairs showed differences between QLF and the other two scales ($p < 0.05$). There is a significant differences in correspondence of diagnosis to histological scale (Cochran Q = 39.35; d.f. = 3; $p < 0.05$) and between the LIF, QLF and ICDAS methods (Cochran Q = 19.2; d.f. = 2; $p < 0.05$).

Table 3. Total number and proportion of diagnosed teeth with different methods – correspondence, non-correspondence, hyperdiagnosis, underestimated diagnosis

		Correspondence	Non-correspondence	Hyperdiagnosis	Underestimated diagnosis
SoproLife	number	34	11	7	4
	%	75.6	24.4	15.6	8.9
DIAGNOdent	number	18	27	24	3
	%	40.0	60.0	53.3	6.7
ICDAS	number	26	19	18	1
	%	57.8	42.2	40.0	2.2

CORRESPONDENCE IN THE DIAGNOSIS

For all of the three methods the number of correspondence to the diagnosis was 17, and to non-correspondence – 2. One case was diagnosed correctly according to the histological scale by both DIAGNOdent and ICDAS, but SoproLife made a mistake. There were 2 cases that ICDAS diagnosed correctly, but the other two methods were wrong.

McNemar's test showed significant differences for correspondence in diagnosis when using the QLF and LIF methods – Chi-square = 12.5, d.f. = 1, $p < 0.001$. McNemar's test showed significant differences for correspondence in diagnosis when using QLF and ICDAS – Chi-square = 6.125, d.f. = 1, $p = 0.013$.

The highest proportion of non-correspondence of the diagnosis was found with QLF (DIAGNOdent) – 60%, followed by ICDAS – 42.2% and LIF (SoproLife) – 24.4%.

In relation to overdiagnosing the highest proportion was found for QLF (DIAGNOdent) – 53.3%, followed by ICDAS – 40%, and LIF (SoproLife) – 15.6%.

In relation to underestimated diagnosis the highest proportion was found for LIF (SoproLife) – 8.9%, followed by QLF (DIAGNOdent) – 6.7%, and ICDAS – 2.2%.

Table 4. Sensitivity and Specificity (threshold 1+ threshold 2)

Method	Threshold NC (0+1+2); Sound		Threshold D3 (3+4+5); Caries	
	Sensitivity	Specificity	Sensitivity	Specificity
VE	0.91	0.63	0.84	0.96
SL	1	0.53	0.56	1
DD	1	0.80	0.92	0.69

Abbreviations: D3 – dentine caries, DD – DIAGNOdent Classic, QLF method, NC – non-cavitated caries lesion, SL – SoproLife, LIF method; VE- visual examination

Overall analysis of the data on sensitivity and specificity of each detection method was performed at 2 different thresholds: non-cavitated caries lesion (NC) and dentine caries (D3) as shown in table 4.

DISCUSSION

ICDAS II criteria are based on enamel properties of translucency, micro- and macroporosity. There is an association between ICDAS II scores in the precavitated and first cavitated stages and the lesions histological depth [Ekstrand K. et al., 1997] (6). In the present study ICDAS code gives different results depending on the clinical experience. Fewer differences between histological results and other methods are found using SoproLife camera as a diagnostic tool. LIF day light and blue fluorescence codes serve as a distinct classification for sound enamel, precavitated and cavitated caries lesions. The method can allow for the prediction of the histological depth of caries lesions more accurately compared to DIAGNOdent [Rechmann P. et al., 2012]. Discussions about the differences in DD cutoff point to determine an operative intervention are ongoing. The manufacturers recommend a cutoff point between 15 and 30 depending on the individual caries risk. Eakle et al. (2005) recommend a cutoff point value of 25 to 30 [5]. As the ICDAS code 3 is considered a reason for operative treatment, according to our study the DIAGNOdent value is 25±2 which is close to results of P. Rechmann around 22 [14]).

For DIAGNOdent a wide range of reports are available, but the sensitivity values range widely from 19% to 100%. The specificity values exhibit a similar pattern, ranging from 0.52 to 1 [2]. According to P. Rechmann DIAGNOdent shows a sensitivity of 0.87 and specificity of 0.66, followed by SoproLife camera – sensitivity of 0.95 and specificity of 0.63. Rodrigues et al. describe sensitivity of 0.86 and specificity of 0.63 for LIF, and QLF sensitivity of 0.51 and specificity of 0.89 [17]. Results of the present study show the threshold NC sensitivity 1 for both SoproLife and DIAGNOdent, which is a higher value than the sensitivity of ICDAS – 0.91. The highest specificity is found for DIAGNOdent – 0.80, followed by ICDAS – 0.63 and SoproLife – 0.53. For the threshold D3 the highest sensitivity is found for DIAGNOdent 0.92, followed by ICDAS – 0.84, and SoproLife – 0.56. The highest specificity is found for SoproLife-1, followed by ICDAS-0.96 and DIAGNOdent – 0.69. Combination of ICDAS II and Light Induced Fluorescence looks quite appropriate and can combine the benefits of the two methods: the high sensitivity of LIF and the high specificity of ICDAS. ICDAS sensitivity of 0.73 and specificity of 0.66, the LIF sensitivity of 0.93 and specificity of 0.38 can obtain a relatively high significance of the final diagnosis.

In the study, the highest differences are found between DIAGNOdent and histology. DIAGNOdent cannot differentiate macula cariosa alba and fusca from a caries lesion. Brown spots are diagnosed as caries media (scores 30-40) and white spots are diagnosed as caries superficialis (scores 10-30). These findings are similar to the observations of Sheehy E. C. et al. (2001) [19] that high scores of QLF can occur due to other sources such as stains, hypomineralization, enamel hypoplasia, etc. Light Induced Fluorescence appears better because white spots can be diagnosed by both regimes daylight and blue light. However, SoproLife is also unable to differentiate macula cariosa fusca from a caries lesion like QLF.

In the study no differences are found between visual examination with or without magnification x5 using ICDAS II. The SoproLife lamp with magnification x30–x100 is helpful in diagnosis of fissure caries and leads to rare cases of overdiagnosis. P. Mitropoulus et al. found that magnification does not improve detective performance of the ICDAS system [12, 13].

CONCLUSIONS

1. The most accurate method in that in vitro study for diagnosis of fissure caries is LIF (SoproLife). 75.6% of the teeth are correctly diagnosed, followed by ICDAS (57.8%) and QLF (DIAGNOdent) (40%).

2. QLF (DIAGNOdent) shows the highest proportion of overdiagnosis – 53.3%, followed by ICDAS – 40%, and LIF (SoproLife) – 15.6%. The highest proportion of underestimated diagnosis is found for LIF (SoproLife) – 8.9%, followed by QLF (DIAGNOdent) – 6.7%, and ICDAS – 2.2%.

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