



## NEAR-INFRARED TRANSILLUMINATION COMPARED TO DIGITAL BITEWING RADIOGRAPHY FOR PROXIMAL CARIES DETECTION

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### ABSTRACT

Proximal caries is a diagnostic and therapeutic challenge. Aim: to study the diagnostic accuracy of near-infrared transillumination (DIAGNOcam, KaVo) compared to digital bitewing radiography for initial proximal caries diagnosis. Materials and methods: 1600 proximal surfaces of premolars and molars of 50 patients were examined with DIAGNOcam and digital bitewing radiography, and the level of agreement between them was established. Results: for the diagnosis of proximal caries in dentin, a complete (100%) coincidence of the findings with the type of tooth and type of surface was established. For the diagnosis of proximal caries in enamel, a high level of agreement between the two methods was found, as transillumination with near-infrared light is more sensitive than digital bitewing radiography. Conclusion: DIAGNOcam is a promising screening device in clinical practice for early proximal caries detection.

**Keywords:** early proximal caries detection, transillumination, bitewing

### INTRODUCTION

Proximal caries is a diagnostic and therapeutic challenge. Difficult access to caries lesions prevents their early detection and treatment at the proper moment. Accurate and early caries diagnosis is essential for an optimal treatment plan and assists the clinician in choosing between operative and non-operative medical approaches. Hidden dental caries on the proximal surfaces is detected by bitewing radiography as a gold standard. However, radiographs have a relatively low sensitivity and are unable to identify incipient demineralization [1]. They are also associated with a certain dose of ionizing radiation, and their repeated application leads to an accumulated action in the follow-up of dental caries. These factors pose challenges to early caries diagnosis and necessitate the introduction of new alternatives. Advances in technology have led to the creation of many devices for early caries detection. Near-infrared light transillumination (NILT) is an optical method for caries diagnosis in posterior teeth. It is a further development of the digital imaging fibre optic transillumination method (DiFOTI). While the DiFOTI method uses visible light, the NILT uses invisible long-wave light, which is able to penetrate objects more deeply because of decreased light scattering. As a result, near-infrared light could be transmitted easily through solid dental enamel and could achieve good contrast between a caries lesion and the surrounding sound hard dental tissue. Furthermore, the illuminating light is shone around the alveolar process but not directly into the interproximal space which considerably improves the imaging quality of the proximal surfaces. The near-infrared transillumination does not require any ionizing radiation and is safe to be used repeatedly. The aim of the present clinical trial is to study the diagnostic accuracy of near-infrared transillumination (DIAGNOcam, KaVo) compared to digital bitewing radiography for the diagnosis of initial proximal caries.

### MATERIALS AND METHODS

The study was approved by the Committee of Scientific Ethics at the Medical University - Plovdiv, protocol No. 7/1.10.2020. The procedure and the aim of the research were explained to the patients included in the study and informed consent was obtained. Fifty patients

aged 18-38 years participated in the clinical trial. Sixteen teeth per patient were evaluated, of which 8 premolars and 8 molars. Two surfaces were examined on each tooth, mesial and distal, or a total of 32 surfaces per patient. Visibly intact, non-cavitated proximal surfaces were involved in the study. The examination procedure started with professional dental cleaning, followed by a visual inspection of the entire dentition. Each patient was examined using a dental mirror and a probe with a blunt tip. The results from the visual inspection according to ICDAS criteria were registered in a specially designed clinical card of the patient. The distal teeth were scanned with DIAGNOcam (780 nm wavelength; Kavo, Biberach, Germany). Each tooth was dried with compressed air for 10 seconds before the DIAGNOcam was centered over the examination area parallel to the occlusal surface. The optimal position of the intraoral handpiece with the tooth sensor was confirmed by the image of the tooth on the computer screen. To prevent light interference during image capture, the lighting from the dental unit was turned off. The images were interpreted as per the classification of proximal caries lesions guidelines, based on the criteria put forward by the manufacturer. Each patient was then referred for digital bitewing radiography. Photostimulable phosphor plate (Dûrr Dental) was used. The exposure time was 0.315 s; voltage of 60 kVp; 2mA amperage; the focus-film distance was 20 cm; the X-ray unit was a Planmeca. Radiographs were interpreted on a computer screen (Dûrr Dental computer program) according to the scoring system put

forward by Pitts (1984). In total, all the examined surfaces amounted to 1600, of which 300 were excluded due to the presence of cavitation or obturation. The degree of agreement between the two methods was checked by Cohen's Kappa test.

#### Statistical methods.

The statistical analysis was performed using Statistical Package for Social Sciences (SPSS) Version 26. The results included the number and percentage of detected proximal caries in enamel and dentin for all 1300 surfaces. The two methods for diagnosis of proximal caries were then compared according to the type of tooth (molars/ premolars) and the type of surface (mesial/distal) separately for the findings in enamel and dentin. The value of the Kappa coefficient was interpreted against the reference ranges by Cohen, 1960.

#### RESULTS

The NILT method detected 126 enamel caries lesions, constituting 9.7% of all the 1300 surfaces, while digital radiography detected 106 caries lesions, amounting to 8.15% of all surfaces. All 20 positive enamel caries lesions detected by NILT were negatively diagnosed for caries by digital radiography. The findings of caries in dentin revealed complete (100%) agreement between the two methods, with a total of 50 caries lesions. According to Cohen's reference ranges, the value of the Kappa coefficient showed a very high degree of agreement between the two methods ( $\kappa = 0.933$ ,  $p < 0.001$ ). (Table 1)

**Table 1.** Level of agreement between NIRT and digital bitewing radiography for proximal caries diagnosis.

Depth	Transillumination	Radiography	Cohen's Kappa (95% CI)	P
<b>1300 surfaces</b>				
In enamel	126 (9.7%)	106 (8.15%)	0.933	0.000**
In dentin	50 (3.8%)	50 (3.8%)	(0.903 – 0963)	

\* - Statistical significance at  $p < 0.05$ ; \*\* - Statistical significance at  $p \leq 0.01$

Table 2 presents the results from the comparison of the two diagnostic methods in more details. According to the type of tooth, 38 out of a total of 126 caries were detected by the NILT method (30%) and 31 out of 106 caries by the radiography method (29%). The Kappa coefficient showed a high degree of agreement on the diagnosis of proximal enamel caries in molars ( $\kappa = 0.893$ ,  $p < 0.001$ ). A very high level of coincidences between the two methods was observed in the premolars ( $\kappa = 0.903$ ,  $p < 0.001$ ). Eighty-eight caries findings (70%) were detected by transillumination and 75 caries lesions (71%) by digital radiography.

According to the type of surface, a very high level of agreement was found in the mesial surfaces ( $\kappa = 0.930$ ,  $p < 0.001$ ). The transillumination method revealed 68 sur-

faces with proximal caries in the enamel (54%) and 60 by the method of digital bitewing radiography (47%). In the distal surfaces, 58 proximal caries (46%) were detected by transillumination and 46 lesions (43%) by digital radiography. The Kappa coefficient showed a high level of agreement between the two methods in the diagnosis of proximal caries in the enamel of the distal surfaces ( $\kappa = 0.874$ ,  $p < 0.001$ ).

Regarding the diagnosis of caries in dentin, all indicators showed a complete coincidence between the findings recorded by the two methods. The Kappa coefficient had a value of 1.00 in all 4 comparisons (teeth, surfaces), which corresponds to a 100% coincidence, without any discrepancy in the diagnosis of proximal caries in the dentin.

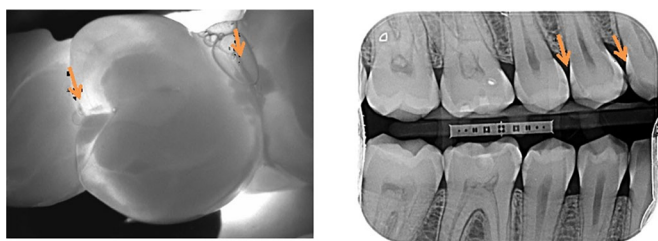
**Table 2.** Level of agreement between transillumination with near-infrared light and digital bitewing radiography regarding the diagnosis of proximal caries according to the type of tooth and the surface

	Transillumination	Radiography	Cohen's Kappa (95% CI)	P
<b>In the enamel</b>				
Molars	38 (30%)	31 (29%)	0,893 (0.823 – 0.971)	0.000**
Premolars	88 (70%)	75 (71%)	0.908 (0.903 – 0.963)	0.000**
Mesial	68 (54%)	60 (57%)	0.93 (0.880 – 0.977)	0.000**
Distal	58 (46%)	46 (43%)	0.874 (0.824 – 0.944)	0.000**
<b>In the dentin</b>				
Molars	21 (21%)	21 (21%)	1	0.000**
Premolars	29 (58%)	29 (58%)	1	0.000**
Mesial	26 (52%)	26 (52%)	1	0.000**
Distal	24 (48%)	24 (48%)	1	0.000**

\* - Statistical significance at  $p < 0.05$ ; \*\* - Statistical significance at  $p \leq 0.01$

Figure 1 shows the images of proximal caries detection with both methods and their agreement.

**Fig. 1.** Agreement in proximal caries detection with NILT and bitewing radiography.



## DISCUSSION

Accurate and early detection of caries is essential for an appropriate treatment plan. Radiography is relatively low in sensitivity and unable to identify initial demineralization until it reaches at least 40-60% [1, 2]. Furthermore, radiographs are associated with a certain dose of ionizing radiation. These factors call for the necessity for new methods for early caries diagnosis. Transillumination is one of the oldest alternative means for caries detection [2]. The optical properties of enamel change with a slight increase in enamel porosity. Methods using wavelengths in the visible region of the electromagnetic spectrum are limited by strong light scattering in the solid enamel, while longer waves (near infra-red spectrum 780 - 1550 nm) can enter the tissues deeper [3]. The DIAGNOcam (KaVo), which uses 780 nm of infrared light,

was recently launched (2012). The present study aims to establish the level of agreement in NILT caries detection and bitewing radiography. The first such studies show that NILT was at least as effective a diagnostic tool as bitewing radiography. The method has been found to be more sensitive than radiographs in detecting early changes in enamel [3, 4, 5, 6]. In lesions reaching the dentin, both methods register the same number of caries lesions, but DIAGNOcam detects more proximal lesions in the enamel. According to Kühnisch et al., 99% (126 of 127 cases) of dentin caries lesions diagnosed with DIAGNOcam were clinically confirmed by operative detection and validation [6]. The same study found 96% agreement between DIAGNOcam and bitewing radiography in caries lesions reaching the dentino-enamel junction. Another similar study by Söchtig et al. [2] found 95.3% agreement in the diagnosis of dentin caries. A clinical trial by Marinova-Takorova et al., validating dentin lesions by in vivo excavation, confirms the high degree of consistency between transillumination and radiography in the diagnosis of dentin caries [7]. The results of our study are also compatible with the results of a research conducted by Shaya et al., demonstrating a 97.3% agreement between near-infrared transillumination and bitewing radiography in the diagnosis of dentin caries [8]. A systematic review and meta-analysis concluded that near-infrared transillumination presents a reasonably comparable accuracy to that of bitewing radiography for detecting proximal caries lesions in the permanent dentition [9].

A disadvantage of NILT is the difficulty in determining the depth of the lesion in the dentin relative to the pulp because of a strong light scattering [10]. In the present study, dentin lesions were diagnosed with DIAGNOcam when the caries process reached the dentin, and there was no translucent healthy enamel between the lesion and the dentin.

An advantage of NILT is that the proximal and occlusal surfaces can be examined simultaneously and repeatedly [11]. DIAGNOcam can reduce or even eliminate the need for x-ray monitoring. Recent studies suggest that near-infrared imaging has a great potential as a screening tool for the detection of proximal lesions without the use of ionizing radiation [12, 13]. It can be advantageous in screening pregnant and adolescent patients and in cases where multiple follow-ups are needed [9, 14].

## CONCLUSION

Based on the results of this study, the following conclusions can be drawn: A high level of agreement in the diagnosis of enamel proximal caries and complete agreement in the diagnosis of dentin proximal caries was established by the method of near-infrared light transillumination and digital bitewing radiography, transillumination being a more sensitive tool for initial proximal caries detection. The DIAGNOcam could be reliable for detecting initial proximal caries in permanent teeth and could yield reproducible results. The introduction of near-infrared light transillumination using the DIAGNOcam allows the integration of this imaging procedure into everyday dental practice, which may result in a reduced usage of radiographs for the diagnostics of proximal caries. Near-infrared light transillumination might be an alternative to bitewing radiography in early proximal caries detection.

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