

## EVALUATION OF THE CONSISTENCY OF IMAGES OBTAINED WITH THE DIAGNOCAM DEVICE BETWEEN DIFFERENT OBSERVERS IN THE DIAGNOSIS OF INTERFACE CARIES

### Zuhal Özateş DDS, PhD

Research Assistant, Department of Maxillofacial Radiology,  
Faculty of Dentistry, Hacettepe University, Ankara, Turkey  
ORCID: 0000-0002-2419-9793

### Nagihan Koç DDS, PhD

Specialist, Department of Maxillofacial Radiology,  
Faculty of Dentistry, Hacettepe University, Ankara, Turkey  
ORCID: 0000-0002-3339-7783

### Hatice Boyacıoğlu DDS, PhD

Assistant Professor, Department of Maxillofacial Radiology,  
Faculty of Dentistry, Hacettepe University, Ankara, Turkey  
ORCID: 0000-0001-7654-5988

### Yasemin Çamlıbel

Dental Student, Faculty of Dentistry,  
Hacettepe University, Ankara, Turkey  
ORCID: 0000-0001-6819-5877

### Seda Çiçek

Dental Student, Faculty of Dentistry,  
Hacettepe University, Ankara, Turkey  
ORCID: 0000-0001-6320-7613

### Mert Karakaş

Dental Student, Faculty of Dentistry,  
Hacettepe University, Ankara, Turkey  
ORCID: 0000-0001-7385-3213

### Kardelen Berfin Tekin

Dental Student, Faculty of Dentistry, Hacettepe University, Ankara,  
Turkey  
ORCID: 0000-0003-1038-2703

### Erdem Karabulut DDS, PhD

Professor, Department Of Biostatistic,  
Faculty Of Medicine, Hacettepe University, Ankara, Turkey  
ORCID: 0000-0002-7811-8215

### Şevket Murat Özbek DDS, PhD

Professor, Department of Maxillofacial Radiology,  
Faculty of Dentistry, Hacettepe University, Ankara, Turkey  
ORCID: 0000-0002-8490-6429

### Correspondence

### Zuhal Özateş DDS, PhD

Department of Maxillofacial Radiology, Faculty of Dentistry,  
Hacettepe University, 06100, Sıhhiye, Altındag, Ankara.  
ORCID: 0000-0002-2419-9793  
Phone: +90 535 394 19 70  
Fax: +90 312 310 44 40  
E-mail: dtzuhalezates@gmail.com

### ABSTRACT

**Background and Aim:** Near-infrared transillumination system is a novel non-ionizing imaging method which is used in the detection of early caries lesions at interproximal surfaces that are difficult to diagnose clinically and radiographically. The aim of this study was to evaluate the effectiveness of clinical diagnosis of caries diagnosis by determining the consistency between different observers from images obtained with the DIAGNOcam device operating with this system.

**Materials and Methods:** In the present study, patients admitted to the Department of Dentomaxillofacial Radiology of, Faculty of Dentistry, for routine examination in the age range 18–80 years and who had bite-wing radiographs for the detection of approximal caries were included. Images of 274 teeth with or without initial caries were obtained with the DIAGNOcam device. The obtained images were separately evaluated by three experienced radiologists. The data were evaluated using SPSS 20.0 software; weighted kappa and Fleiss kappa tests were used.

**Results:** The Fleiss kappa value was 0.76, showing the inter-observer agreement; the intra-observer agreement values were between 0.670 and 0.749.

**Conclusion:** The high inter-observer consistency level obtained in the evaluation of DIAGNOcam images in this study suggests that the DIAGNOcam device may be useful in dental practice.

Clin Dent Res 2020; 44(3): 75-79

**Keywords:** Approximal Caries, Bite-Wing Radiography, DIAGNOcam, Near infrared Transillumination

Submitted for Publication: 04.15.2020

Accepted for Publication: 12.03.2020

## ARA YÜZ ÇÜRÜKLERİNİN TEŞHİSİNDE DIAGNOCAM CİHAZI İLE ELDE EDİLEN GÖRÜNTÜLERİN GÖZLEMCİLER ARASI TUTARLILIĞININ DEĞERLENDİRİLMESİ

### Zuhal Özateş

Araştırma Görevlisi, Hacettepe Üniversitesi, Diş Hekimliği Fakültesi,  
Ağız, Diş ve Çene Radyolojisi Anabilim Dalı, Ankara, Türkiye  
ORCID: 0000-0002-2419-9793

### Nagihan Koç

Dr., Hacettepe Üniversitesi, Diş Hekimliği Fakültesi, Ağız, Diş ve Çene  
Radyolojisi Anabilim Dalı, Ankara, Türkiye  
ORCID: 0000-0002-3339-7783

### Hatice Boyacıoğlu

Dr. Öğr. Üyesi, Hacettepe Üniversitesi, Diş Hekimliği Fakültesi, Ağız,  
Diş ve Çene Radyolojisi Anabilim Dalı, Ankara, Türkiye  
ORCID: 0000-0001-7654-5988

### Yasemin Çamlıbel

Diş Hekimliği Öğrencisi, Hacettepe Üniversitesi, Diş Hekimliği  
Fakültesi, Ankara, Türkiye  
ORCID: 0000-0001-6819-5877

### Seda Çiçek

Diş Hekimliği Öğrencisi, Hacettepe Üniversitesi, Diş Hekimliği  
Fakültesi, Ankara, Türkiye  
ORCID: 0000-0001-6320-7613

### Mert Karakaş

Diş Hekimliği Öğrencisi, Hacettepe Üniversitesi, Diş Hekimliği  
Fakültesi, Ankara, Türkiye  
ORCID: 0000-0001-7385-3213

### Kardelen Berfin Tekin

Diş Hekimliği Öğrencisi, Hacettepe Üniversitesi, Diş Hekimliği  
Fakültesi, Ankara, Türkiye  
ORCID: 0000-0003-1038-2703

### Erdem Karabulut DDS, PhD

Prof. Dr., Hacettepe Üniversitesi, Tıp Fakültesi, Biyoistatistik Anabilim  
Dalı, Ankara, Türkiye  
ORCID: 0000-0002-7811-8215

### Şevket Murat Özbek DDS, PhD

Prof. Dr., Hacettepe Üniversitesi, Diş Hekimliği Fakültesi, Ağız, Diş ve  
Çene Radyolojisi Anabilim Dalı, Ankara, Türkiye  
ORCID: 0000-0002-8490-6429

### Sorumlu Yazar

### Zuhal Özateş

Hacettepe Üniversitesi, Diş Hekimliği Fakültesi,  
Ağız, Diş ve Çene Radyolojisi Anabilim Dalı,  
06100, Ankara, Türkiye  
ORCID: 0000-0002-2419-9793  
Telefon: +90 535 394 19 70  
Faks: +90 312 310 44 40  
E-mail: dtzahalozates@gmail.com

### ÖZ

**Amaç:** Kızılötesine yakın transilluminasyon sistemi, klinik ve radyografik olarak teşhis edilmesi zor olan interproksimal yüzeylerde diş çürüğünün erken tespitinde kullanılan yeni, iyonize olmayan bir görüntüleme yöntemidir. Bu çalışmanın amacı, DIAGNOCAM cihazı ile elde edilen görüntülerde, gözlemciler arası tutarlılığı belirleyerek, klinik çürük tanısının etkinliğini değerlendirmektir.

**Gereç ve Yöntem:** Hacettepe Üniversitesi Diş Hekimliği Fakültesi Ağız, Diş ve Çene Radyolojisi Anabilim Dalı'na rutin muayene için başvurmuş, ara yüz çürüğünün değerlendirilmesi amacıyla bite-wing radyografisi alınan 18-80 yaş arası bireyler çalışmaya dahil edildi. Başlangıç çürüğü olan veya olmayan 274 adet dişin görüntüleri DIAGNOCAM cihazı ile elde edildi. Görüntüler, üç deneyimli radyolog tarafından ayrı ayrı değerlendirildi. Veriler SPSS 20.0 yazılımı ile değerlendirilerek ağırlıklandırılmış kappa ve Fleiss kappa testleri kullanıldı.

**Bulgular:** Gözlemciler arası uyumu gösteren Fleiss kappa değeri 0.76; gözlemci içi uyum değerleri ise 0.670 ile 0.749 arasında bulundu.

**Sonuç:** DIAGNOCAM görüntülerinin değerlendirilmesinde gözlemciler arası yüksek uyumun gözlemlendiği çalışmanın sonuçları, DIAGNOCAM cihazının diş hekimi kliniklerinde yararlı olabileceğini düşündürmektedir.

Clin Dent Res 2020; 44(3): 75-79

**Anahtar Kelimeler:** Aproximal Çürük, Bite-Wing Radyografi, DIAGNOCAM, Kızılötesine Yakın Transilluminasyon

Yayın Başvuru Tarihi : 15.04.2020

Yayına Kabul Tarihi : 03.12.2020

## INTRODUCTION

Dental caries constitute a common oral disease that affects billions of people around the world. It is known that demineralisation–remineralisation of tooth structure occurs overtime. An imbalance in this cycle can cause mineral loss or gain, resulting in the carious lesion destroying the tooth structure and causing cavitation, which can be arrested and even remineralised. The rate of caries lesion progression depends on the balance between the pathologic and protective factors.<sup>1</sup>

Detecting caries at the earliest stage plays a vital role in preventive dentistry. A variety of methods have been described for caries diagnosis, such as visual inspection, radiographic examination, fibre-optic transillumination (FOTI) and its digital imaging version (DIFOTI), laser fluorescence (DIAGNOdent), quantitative light-induced fluorescence (QLF) and electrical caries monitoring (ECM).<sup>2</sup> Recently, an X-ray-free, near-infrared light (780 nm) transillumination (NILT) caries detection system called DIAGNOCam was introduced to enhance the accuracy of detecting non-cavitated caries lesions.<sup>3</sup> The system is based on DIFOTI, which uses long-wave light for the transillumination of the tooth from cervical to occlusal, making it possible to visualise changes within the enamel and the dentin.<sup>4</sup> In this system, a camera digitally acquires the light transpiring from the opposite surface, and images of teeth are captured with an integrated sensor.<sup>5</sup> Recent studies show that DIAGNOCam provides accurate results and is suitable for the detection of early caries lesions.<sup>3,4,6</sup>

Thus, the aim of this study was to evaluate the usefulness of images obtained by DIAGNOCam and determine the consistency in caries detection across observers.

## MATERIALS AND METHODS

The present study was approved by the Clinical Research Ethics Board of the University of Hacettepe [No. 2019/03-49 (KA-19017)]. A written informed consent was obtained from each participant. A total of 90 patients of 18–80 years who were admitted to the Department of Dentomaxillofacial Radiology, Hacettepe University, for dental examination were included in the study. The

presence of premolar and molar teeth and indication of bite-wing radiography for the detection of insidious approximal caries were used as the inclusion criteria. Patients who had teeth with visible caries lesions or restorations were excluded from the study. The images of 274 teeth with or without initial caries were obtained with the DIAGNOCam device (KaVo Z170, wavelength 780 nm) by one radiologist (ZÖ). Patient identities were anonymised by the dental students interning in the clinic (YÇ, SÇ, MK and KBT). The images were separately evaluated by three experienced radiologists (HB, NK and ZÖ). The observers independently determined the presence or absence of approximal caries. Images were evaluated by observers for the presence or absence of caries and were scored as 1 or 0, respectively. For the intra-observer agreement, 223 images were re-evaluated three weeks later. The data were evaluated using SPSS 20.0 software and weighted and Fleiss kappa tests. The kappa values were assessed using the Koch's criteria as follows:

Poor:  $\leq 0.20$

Fair: 0.21–0.40

Moderate: 0.41–0.60

Good: 0.61–0.80

Very good: 0.81–1.00

## RESULTS

A total of 90 patients (23 males with a mean age of 32.4 years and 67 females with a mean age of 28.7 years) with early interproximal caries lesions were included in this study. Kappa coefficients were used for inter-observer and intra-observer agreements for the NILT examination method. The weighted and Fleiss kappa coefficients were used to determine intra-observer and inter-observer agreements, respectively. The observers scored 274 teeth caries and sound teeth as 1 and 0, respectively.

Intra-observer kappa coefficients calculated for each observer, as shown in Table 1, were found to be in the "good" range. The intra-observer kappa coefficients of the observers 1 and 2 were similar and higher than observer 3. The inter-observer kappa coefficients are shown in Table 2. The Fleiss multi-rater kappa statistic shows good inter-observer reliability among three observers (Table 3).

**Table 1.** Intra-observer kappa coefficients

Intra-observer Agreement	1. observer	2. observer	3. observer
Kappa value	0.746	0.749	0.670

**DISCUSSION**

DIAGNOcam is effective and accurate at evaluating proximal surfaces of posterior teeth, particularly in cases wherein enamel caries are expected.<sup>7</sup> It enables the detection of caries at preliminary stages such as demineralisation.<sup>8</sup> Studies have used the bite-wing radiograph as the gold standard for detecting proximal caries. However, it has been reported that enamel proximal caries lesions are poorly detected by radiography, since at least 40% demineralisation must already be present for radiographic detection to be possible. Non-invasive treatment of early caries lesions by remineralisation has become of major importance in daily clinical practice.<sup>9</sup>

In our study, the efficacy of interpretation of the NILT images in clinical caries diagnosis was evaluated. The highest result was 0.749 and the lowest was 0.670 for intra-observer agreement, indicating the repeatability of DIAGNOcam image evaluation and that the observers classified the same patients similarly. The inter-observer results were between 0.783 and 0.815, showing the reproducibility of the interpretation of the DIAGNOcam images. The inter-observer agreement found in the present study (kappa = 0.795) was higher than that reported by Ozkan et al.<sup>10</sup> (kappa = 0.44). Intra-observer agreements (kappa values=0.746, 0.749 and 0.670) in this study were also higher than those reported in their study (kappa values=0.65 and 0.66). Evaluation with the use of NILT has some limitations. It is not effective at detecting secondary caries lesions located under restorations or prosthodontic restorations.<sup>11</sup> Also, the evaluation of subgingival caries lesions and root caries is limited with the use of NILT.<sup>12</sup> The teeth to be screened should be cleaned and dried, particularly the

occlusal surfaces, because even a small amount of saliva prevents proper evaluation and interpretation of the tooth surface. Discolorations and calculus also scatter light and cause a shade to appear in the image, which may then be mistaken for caries.<sup>13</sup> Simon et al.,<sup>14</sup> however, concluded that discolorations can be easily differentiated from destruction due to demineralisation by infrared light as opposed to visible light. Longer wavelength, on the other hand, would be needed for the results to be more reliable. NILT is cleaned with a disinfectant because it is not produced from material resistant to sterilisation methods.

**CONCLUSION**

The study results reveal that the performance of NILT in the detection of early carious lesions is accurate and applicable across different observers. The NILT method can be a reliable alternative for the diagnosis of early caries lesions based on the observers' performance.

**ACKNOWLEDGEMENT**

The authors declare that they have no conflict of interest. This study was presented at the 1st International Congress of Hacettepe University Faculty of Dentistry, 2019, Ankara.

**REFERENCES**

1. Abogazalah N, Eckert GJ, Ando M. In vitro performance of near infrared light transillumination at 780-nm and digital radiography for detection of non-cavitated approximal caries. *J Dent* 2017; 63: 44-50.
2. Schaefer G, Pitchika V, Litzemberger F, Hickel R, Kuhnisch J. Evaluation of occlusal caries detection and assessment by visual inspection, digital bitewing radiography and near-infrared light

Table 2. Inter-observer kappa coefficients.

	Kappa value	Asymptotic Standard Error	Approximate T	p-value
1. and 2. observers	0.815	0.035	13.503	0.000
2. and 3. observers	0.783	0.038	13.127	0.000
1. and 3. observers	0.789	0.038	13.152	0.000

Table 3. Fleiss' multi-rater kappa values of three observers

Kappa value	Asymptotic Standard Error	Z	p-value	Lower limit 95% CI	Upper limit 95% CI
0.795	0.035	22.804	0.000	0.727	0.864

CI: confidence interval

transillumination. *Clin Oral Investig* 2018; 22: 2431-2438.

3. Kuhnisch J, Sochtig F, Pitchika V, Laubender R, Neuhaus KW, Lussi A et al. In vivo validation of near-infrared light transillumination for interproximal dentin caries detection. *Clin Oral Investig* 2016; 20: 821-829.

4. Błażejewska A, Dacyna N, Niesiobędzki P, Trzaska M, Gozdowski D, Turska-Szybka A et al. Comparison of the Detection of Proximal Caries in Children and Youth Using DIAGNOcam and Bitewing Radiovisography. *Dent Med Probl* 2016; 53: 468-475.

5. Marinova-Takorova M, Anastasova R, Panov VE. Comparative evaluation of the effectiveness of five methods for early diagnosis of occlusal caries lesions-in vitro study. *J of IMAB* 2014; 20: 533-536.

6. Litzemberger F, Heck K, Pitchika V, Neuhaus KW, Jost FN, Hickel R et al. Inter- and intraexaminer reliability of bitewing radiography and near-infrared light transillumination for proximal caries detection and assessment. *Dentomaxillofac Radiol* 2018; 47: 20170292.

7. Abdelaziz M, Krejci IJJED. DIAGNOcam--a near infrared digital imaging Transillumination (NIDIT) technology. *Int J Esthet Dent* 2015; 10: 158-165.

8. Al Shaya SA, Saeed MH, Kheder WMJJoID, Research M. Proximal Caries Detection in Permanent Teeth by Using DIAGNOcam: An in Vivo Study. *J. Int Dent Medical Res* 2018; 11: 45-50.

9. Önem E, Baksi B, Şen B, Söğüt Ö, Mert A. Diagnostic accuracy of proximal enamel subsurface demineralization and its relationship with calcium loss and lesion depth. *Dentomaxillofac Radiol* 2012; 41: 285-293.

10. Ozkan G, Guzel KGU. Clinical evaluation of near-infrared light transillumination in approximal dentin caries detection. *Lasers Med Sci* 2017; 32: 1417-1422.

11. Eliaz W, Raczkowski M, Surdacka AJJDF. Caries Detection with DIAGNOCam: A Review. *J DentForecast* 2018; 1: 1009.

12. Lee RC, Darling CL, Staninec M, Ragadio A, Fried D. Activity assessment of root caries lesions with thermal and near-IR imaging methods. *J Biophotonics* 2017; 10: 433-445.

13. Almaz EC, Simon JC, Fried D, Darling CL. Influence of stains on lesion contrast in the pits and fissures of tooth occlusal surfaces from 800-1600-nm. *Proc SPIE Int Soc Opt Eng* 2016; 9692.

14. Simon JC, Kang H, Staninec M, Jang AT, Chan KH, Darling CL et al. Near-IR and CP-OCT imaging of suspected occlusal caries lesions. *Lasers Surg Med* 2017; 49: 215-224.