Near-infrared light transillumination for occlusal caries detection in dog teeth: A comparative study

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ARTICLE INFO

Article History
Received : 28.07.2022
Accepted : 28.10.2022
DOI: 10.33988/auvfd.1149921

Keywords
Dental caries
Dogs
Near-infrared light transillumination
Periapical radiography

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How to cite this article: Kolsuz ME, Ekim O, Irmak Ö, Evli C, Bakıcı C, Demirel G (2024): Near-infrared light transillumination for occlusal caries detection in dog teeth: A comparative study. Ankara Univ Vet Fak Derg, 71 (1), 27-30. DOI: 10.33988/auvfd.1149921.

ABSTRACT

The aim of this study is to compare the effectiveness of visual, radiologic, and near-infrared light transillumination caries detection methods on caries of dog teeth in-vitro. A total of 237 dog molar teeth were evaluated with three different methods; visio-tactile examination with a probe, radiographic assessment, and NIR-LT. Each tooth was evaluated with all of the methods; the absence or presence of occlusal caries was scored as either 0, caries not present, or 1, caries present. All caries detection methods yielded the same outcomes for each tooth. Among all caries detection methods positive Spearman's rho value (ϱ=1) indicated that there was a strong positive correlation between the caries detection methods. Since NIR-LT is such a comfortable and easy caries diagnosis method, it can be used without sedation, especially in calm dogs.

Introduction

Dental caries is a term that refers to both the disease and the lesion that occurs as a result of this disease, which is a major healthcare problem as it is the most prevalent disease worldwide for humans. Dental caries is not only seen in human teeth but also develop on the teeth of other animals such as dogs. Dogs have 42 teeth, and these teeth are divided into three main categories with respect to their function and morphology: incisors, premolars and molars, similar to human teeth. Dental hard tissues such as enamel, dentin and cementum; surrounds the pulp tissue consisting of vessels and nerves. Although the prevalence of dental caries in dogs is lower than that of the humans because of the natural resistance of their teeth, it is still a serious oral health problem for dogs. The incidence of dental caries in dogs is between 3.1-5.3% and most commonly occurs on the occlusal surfaces of the molar teeth (3). The maxillary first molar tooth is particularly prone to caries (4).

Early diagnosis and treatment of dental caries are important. If left untreated, caries can finally lead to pulp infections, lodged abscesses, or tooth loss (12). However, the diagnosis of caries lesions on dog teeth could be challenging. The conventional examination method involves checking the pits and fissures of the teeth with a pointed probe. This method is highly subjective and affected by the expertise of the operator, especially for the detection of the initial caries lesions (11). Only after the lesion advances to a certain level, it can be detected easily otherwise could easily be missed. Unfortunately, by that time, caries has usually extended into the pulp dentin complex of the tooth and there is such extensive loss of tooth structure that extraction remains the only viable

option (3). The radiological examination could be a gold standard for the diagnosis of early dental caries in dogs (5), but it is almost impossible to perform without sedating the dogs. Therefore, intra-oral dental radiographs cannot be part of routine oral check-ups for dogs.

A near-infrared light transillumination (NIR-LT) approach which is used for caries diagnosis for human teeth (8) could be an alternative to radiographic and visio-tactile evaluation for caries detection for dogs. Currently, there are two devices available on the market that employ this method (DIAGNOcam, KaVo, Biberach, Germany/CariVu, DEXIS, Hatfield, PA, USA) to visualize enamel and dentin caries lesions in molars and premolars. The intraoral camera of the devices emits near-infrared light with a wavelength of ~780 nm from two light emission windows, each arranged on the buccal and oral branches of the handpiece (Figure 1). The light is transmitted through the alveolar bone and into the dental hard tissue. The image of the transilluminated tooth is captured with a CCD sensor over the occlusal surface (7). It is a radiation-free caries detection method and it can be performed on dogs without the need for sedation or anesthesia. There are many studies that suggest the NILT method is reliable for detecting caries on human teeth (7-11). However, to the author's knowledge, there is no study in the literature comparing the effectiveness of this method with other routine caries detection methods in dogs.

Figure 1. Diagnocam caries detection device.

Therefore, this study aimed to compare the effectiveness of visual, radiologic, and NILT caries detection methods on caries of dog teeth in-vitro. The null hypothesis tested is that the NILT method would not differ from radiological and intraoral examinations regarding the detection of caries on the occlusal surface of dog molar teeth.

Materials and Methods

For this study, 60 canine mandibles and maxillas were randomly selected from the collection of the anatomy department of the Veterinary Faculty of Ankara University. A total of 237 dog molar teeth on the jaws were evaluated with three different methods; visio-tactile examination with a probe, radiographic assessment, and NIR-LT method. Each tooth was evaluated with all of the methods as described below; the absence or presence of occlusal caries was scored as either 0, caries not present or 1, caries present. Radiographs and NIR-LT photographs were taken by single operator and two blinded dentist observers (Restorative dentistry specialist, 15 years of experience and maxillofacial radiologist, 12 years of experience) were involved in the visio-tactile examination, radiographic assessment and NIR-LT photograph evaluation. Before the evaluations, the teeth in question were cleaned with a slurry of pumice and prophy cup using a low-speed rotary handpiece. After rinsing the pumice with water, surfaces were thoroughly dried with compressed air.

Visio-tactile examination: A ball-ended explorer was then manually used under light pressure for assessment of the occlusal surfaces of the teeth under dental operating light. The tooth had score 1 (caries present). When the probe was stuck in the fissures, the surface had a cavity or demineralized surface. Otherwise, the tooth was scored 0 (caries not present).

NIR-LT examination: The NIR-LT device (DIAGNOcam, KaVo) was used in a room with ambient lighting and without dental operating light. The device was positioned on the occlusal surface of the tooth and images were obtained with the integrated software (KaVo Integrated Desktop/version 2.4.1.6374, KaVo, Biberach, Germany) of the NIR-LT device. Changes are displayed as dark shades in contrast to the healthy tooth substances and were scored. If the image had no change in light transmission throughout the surface, a tooth was scored 0 (caries not present); but if the visible shadow was observed on the occlusal surface, a tooth was scored 1 (caries present).

Radiographic examination: Digital periapical radiographs were taken with the paralleling technique. A Size 2 (31x41 mm) photostimulable phosphor plate attached to a sensor holder (XPP-DS Digital Sensor Holders for Sirona, Dentsply, IL, USA) was exposed with a digital dental x-ray unit (Expert DC, Gendex Dental Systems, Des Plaines, IL, USA) operated at 70 kVp and 7 mA with a 0.05 s exposure time. The focal spot distance was 30 cm and 1.5 mm Al equivalent at 20 kV, with a constant working distance, and images with magnification ranging from x5000 to 30000 were taken. Images were

DOI: 10.33988/auvfd.1149921

then evaluated by the observers, and each tooth was scored 0 (caries not present) or 1 (caries present).

Statistical analysis: Kappa values were calculated for the assessment of inter-observer agreement. The Spearman's rank-order correlation test was used to measure the association between the caries detection methods. A computer software (Jamovi 1.6, The Jamovi project, jamovi.org) was used for statistical analysis (α=0.05).

Results

There was a perfect agreement between the two observers for visio-tactile, radiographic and NIR-LT caries detection methods (Cohen's kappa=1) All caries detection methods yielded the exact same outcomes for each tooth. Between all the caries detection methods, positive Spearman's rho value (ϱ=1) indicated that there was a strong positive correlation between the caries detection methods (P<0.001) (Table 1). In other words, if one test scored 0 (caries not present) in a particular tooth, other two tests also scored 0 in the same tooth; similarly, if one test scored 1 (caries present) in a particular tooth, other two tests also scored 1 in the same tooth. This was true for all teeth evaluated.

Discussion and Conclusion

This study compared the outcomes of visual, radiographic, and NIR-LT approaches for the detection of occlusal caries in dog molar teeth. The null hypothesis was accepted, as there was no difference between the tested caries detection methods; all methods yielded the exact same outcomes for each tooth examined.

Although dental caries in dogs is a rare disease compared to the prevalence of dental calculus and periodontal disease (2), without early detection and appropriate treatment, caries almost always results in tooth loss (3, 4). However, early diagnosis of dental caries in dogs is quite challenging. In the early diagnosis of caries lesions, diagnostic methods are as important as the clinician's experience. Although the visio-tactile examination with a probe is the most commonly used diagnostic method, its reliability is debatable. Diagnosing early caries lesions by inspection may not always be accurate, and small lesions can be easily missed. Although the radiological examination is reliable, it is almost impossible to include it in a routine dental check-up due to the necessity of sedation.

Table 1. Correlation Matrix of caries diagnosis methods.

		Visio-tactile	Radiography	NIR-LT
Visio-tactile	Spearman's rho	—		
	P-value	—		
Radiography	Spearman's rho	1.000	—	
	P-value	< .001	—	
NIR-LT	Spearman's rho	1.000	1.000	—
	P-value	< .001	< .001	—

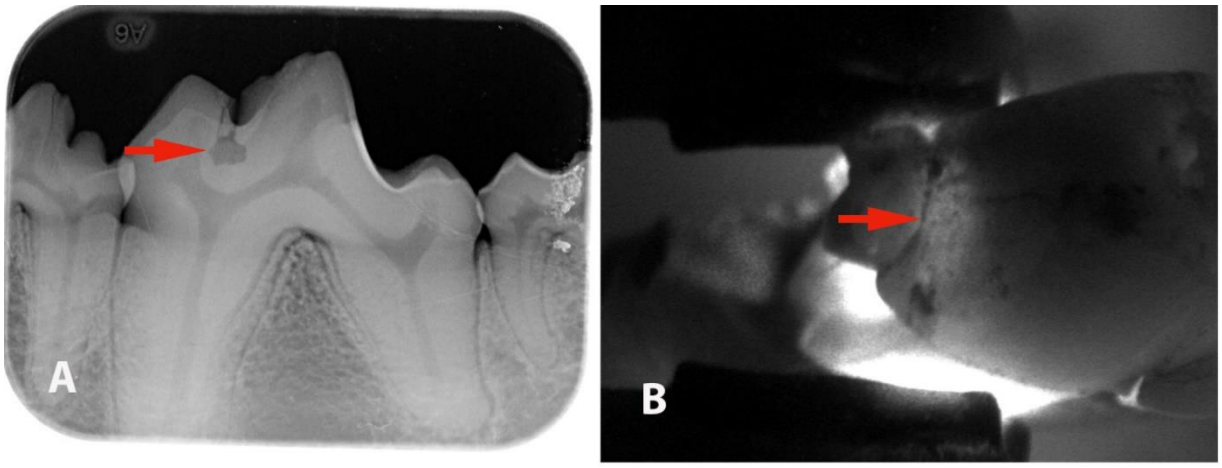

Figure 2. A: Representative radiographic image of caries dog tooth. Red arrow indicates caries. B: Diagnocam image of the same tooth. Red arrow indicates the caries.

The other technique for caries detection is using light. NIR-LT method uses invisible long-wavelength light. The camera of DIAGNOcam based on photo-optical principles, uses an illuminating wavelength of 780 nm (6). This device consists of a USB connection to a computer and specific software is used for the detection of dental caries (1). The use of this device allows capturing different stages of caries lesions and could be used effectively for the detection of occlusal caries without cavitation (6, 9). Nevertheless, the diagnostic accuracy of DIAGNOcam exhibited similarity with bitewing in human teeth (6-9, 11).

In this study, three different diagnostic methods were compared, and the result of this study showed that the NIR-LT method could be used reliably for the detection of dental caries in dogs. The NIR-LT device is portable and very easy to use. It does not cause pain during its use, and therefore it is widely used in pediatric dentistry as well as in adult human patients. Another advantage of the NIR-LT method is that there is no exposure to ionizing radiation. Furthermore, NIR-LT can be repeated as often as necessary, and occlusal and proximal surfaces can be evaluated simultaneously with this method.

This study has some limitations. Experiments were performed in vitro conditions. Especially in vivo NIR-LT and radiography may yield different outcomes, therefore results of this study should be verified with further in vivo setup. Investigating the use of the NIR-LT method for the detection of caries in dogs in vivo will be an important step towards introducing this method in routine dental check-ups in dogs.

Financial Support

This research received no grant from any funding agency/sector.

Conflict of Interest

The authors declared that there is no conflict of interest.

Author Contributions

MEK, GD and ÖI conceived and planned the experiments. GD and CE arried out the experiments. MEK, OE and CB contributed to sample preparation. MEK, OE, ÖI and GD contributed to the interpretation of the results. MEK and GD took the lead in writing the manuscript. All authors provided critical feedback and helped shape the research, analysis and manuscript.

Data Availability Statement

The data supporting this study's findings are available from the corresponding author upon reasonable request.

Ethical Statement

No examination, research, manipulation or experimentation was performed on any animal species during this study.

References

1. **Abdelaziz M, Krejci I, Perneger T, et al** (2018): *Near infrared transillumination compared with radiography to detect and monitor proximal caries: A clinical retrospective study.* J Dent, **70**, 40-45.
2. **Bell A** (1965): *Dental disease in the dog.* JSAP, **6**, 421-428.
3. **Hale FA** (1998): *Dental caries in the dog.* JOVD, **15**, 79-83.
4. **Hale FA** (2009): *Dental caries in the dog.* Can Vet J, **50**, 1301-1304.
5. **Hamp SE, Olsson SE, Farsø-Madsen K, et al** (1984): *A macroscopic and radiologic investigation of dental diseases of the dog.* Vet Radiol Ultrasound, **25**, 86-92.
6. **Kühnisch J, Söchtig F, Pitchika V, et al** (2016): *In vivo validation of near-infrared light transillumination for interproximal dentin caries detection.* Clin Oral Investig, **20**, 821-829.
7. **Schwendicke F, Elhennawy K, Paris S, et al** (2020): *Deep learning for caries lesion detection in near-infrared light transillumination images: A pilot study.* J Dent, **92**, 103260.
8. **Söchtig F, Hickel R, Kühnisch J** (2014): *Caries detection and diagnostics with near-infrared light transillumination: clinical experiences.* Quintessence Int, **45**, 531-538.
9. **Tassoker M, Ozcan S, Karabekiroglu S** (2020): *Occlusal Caries Detection and Diagnosis Using Visual ICDAS Criteria, Laser Fluorescence Measurements, and Near-Infrared Light Transillumination Images.* Med Princ and Pract, **29**, 25-31.
10. **Zakian CM, Pretty IA, Ellwood R** (2009): *Near-infared hyperspectral imaging of teeth for dental caries detection.* J Biomed Opt, **14**, 064047.
11. **Zandoná AF, Zero DT** (2006): *Diagnostic tools for early caries detection.* J Am Dent Assoc, **137**, 1675-1684.
12. **Zero DT** (1999): *Dental caries process.* Dent Clin N Am, **43**, 635-664.