

Caries Detection with DIAGNOCam: A Review

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Abstract

This article describes the diagnostic capabilities of DIAGNOCam, which uses infrared radiation for dental transillumination. The principle of operation and construction of the device has been described, as well as the application of this method in the detection of caries. Also, cases in which it should not be applied were described. Based on the literature analysis, it can be considered that this is an effective method especially in the diagnosis of Approximal cavities.

Keywords: Caries diagnostics methods; DIFOTI; DIAGNOCam

Introduction

Detecting caries at its earliest stages constitutes one of the biggest challenges in contemporary Dentistry. A variety of methods have been described for caries diagnostics, such as e.g. visual, radiographic examination, or other methods which utilise other physical phenomena. However, none of the methods available nowadays is perfect and that is why several methods should be used in the decision-making process. Accurate diagnosis, and – caries treatment in early stages is possible if appropriate diagnostic tools are available. The features of a perfect tool include non-invasiveness, ease of use, high sensitivity and specificity. Visual examination is the basic diagnostic method used on a daily basis in clinical practice. It is most useful when applied for detecting cavities within the surfaces that are readily accessible, such as occlusal or buccal walls of the teeth. Nevertheless, in many cases it is not effective at detecting caries cavities located on proximal surfaces, particularly in posterior teeth [1-3]. In some of the studies almost 50% of proximal caries cavities remained unnoticed in visual examination. Usually, the cavity that can be diagnosed visually is at such stage in which enamel and dentine are involved, and cavity preparation procedures are related with high amounts of hard tissue being removed [4].

Radiography encompasses another group of methods used for caries diagnosis. Several types of diagnostic methods may be used, however, one has to bear in mind that caries cavities are visible in x-rays only after approximately 30-40% of mineral substances are lost [5]. Also, superimposition of structures, both anatomical (adjacent teeth, anatomical phenomena), and iatrogenic (orthodontic appliances, crowns) may cause a decrease in its effectiveness. Even though cone-beam computed tomography may solve some of the problems, research studies seem to indicate that its sensitivity is relatively low at early stages of caries in which the cavity involves enamel. Such outcome does not meet the needs of modern cariology, as it may be seen as a failure of oral prophylaxis both by the patient, and the dental team. An important thing that needs to be kept in mind is that all these methods utilise ionising radiation, and, therefore, their use may be severely limited for an important group of patients including children and pregnant women.

In order to overcome those difficulties attempts have been made to transilluminate the teeth using a different kind of electromagnetic waves, including visible Light, ultraviolet Light, or laser Light [6,7]. Devices that utilized visible light are not used nowadays, as they did not prove effective at diagnosing caries particularly in posterior teeth. Ultraviolet light is still sometimes used, mainly due to easy availability (e.g. curing lamps). Modern devices, however, utilize near-infrared laser light which is safe both for the patient and the operator, and can be used easily in all segments of dentition. DIAGNOCam (KaVo, Germany) is an example of such device. It utilises infrared Light of 780 nm wavelength, therefore, it may be referred to as near-infrared digital imaging transillumination (NIDIT).

Physical Principles

The basic principle for the use of DIAGNOCam is based on the fact that Light, as it is transferred through tooth tissue, undergoes such processes as absorption and scattering of infrared light [8].

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Wavelength values for this kind of light are higher than these of visible light and enables better penetration of tooth structures. That is why images acquired in such way may be clearer than in other methods of digital transillumination [9]. In a healthy tooth, there picture will include lighter enamel on the outside of the tooth, and darker dentine in the centre Dentin appears darker as it absorbs and scatters higher amounts of the Light due to lower content of mineral compounds and higher content of water [10,11]. Enamel, on the other hand, is highly mineralised and Light can pass through it without being scattered to such a high extends that much. If demineralisation in enamel occurs, affected areas will be visible as a darker spot, that is distinctly different than healthy tissue. The cavity will disperse and absorb higher amounts of light than healthy enamel [12].

The device itself is easy to use. The set includes a hand piece with camera and a specially designed stand. Also, a computer is needed to view and interpret images. The hand piece included CCD sensors and two plastic sheaths through which optic fibres pass. Two types of sheaths are available – smaller ones for deciduous teeth, and larger ones for permanent teeth. The hand piece is placed in the mouth so that rubber holders encompass the teeth. Then, it can be moved along the arch to inspect all teeth. Infrared light passes through the teeth, and photons that reach CCD sensors induce electric current in the sensor. The picture is then visualized in the computer screen. It can be assessed directly or stored and exported for future reference. KaVo provides specially designed software for image assessment, and the features of the software include depth analysis, greyscale evaluation, pseudocolor, or magnification [13,14]. The images acquired in such way can later on be shown to the patients in order to educate him/her.

Usage

In the majority of research studies, DIAGNOCam was used to diagnose proximal caries cavities [14-20]. Occlusal caries was assessed in a few studies. *Maia* AMA et al. compared radiography and NIDIT in *in vitro* environment and concluded that NIDIT showed higher sensitivity and specificity in diagnosing enamel caries [15]. Infrared Light provides better contrast between healthy and demineralised tissue. *Malina-Novak* et al. performed comparative analysis of DIAGNOCam and panoramic radiographs for detecting primary caries [21]. In their study, higher number of teeth with caries was diagnosed correctly with NIDIT than with panoramic radiographs, and the difference was significant statistically. Infrared-light transillumination can also be used in patients who wear orthodontic appliances. [14]. In such cases, radiography does not enable a precise analysis of images due to the presence of the elements of an orthodontic appliance. *Marinova-Takorova* et al. performer research studies in *in vitro* conditions and compared five methods of occlusal caries diagnosis [22]. DIAGNOCam correlated well with the clinical examination, better than Diagnodent. Another study, including clinical conditions by *Söchtig* bitewing radiographs were used as the "golden standard" to which NIDIT was compared [12]. Also, in this study, high agreement between those methods was shown. *Söchtig* et al. proposed an own classification of cavities located in proximal areas on the bases of images acquired with the use of DIAGNOCam. They classified the cavities into five stages according to the extent of the lesion and the involvement of dentinoenamel junction. They provided guidelines on proper management of each stadium. *Kühnisch* i wsp. evaluated the accuracy of NIDIT in the diagnostics of prepared cavities [18]. The accuracy of NIDIT was shown to be high and comparable with radiography – however, only in cases in which the

cavity reached the dentino-enamel junction *Simon* et al. used infrared light to diagnose the so-called "occult" caries on occlusal surfaces. They used light of higher wavelength, i.e. 1500-1700 nm, which made it possible to detect cavities in radiography [23]. Moreover, some authors claim that infrared Light can be used to evaluate the severity and extent of enamel defects in fluorosis [24,25].

Limitations

Evaluation with the use of infrared Light may, however, be related to some limitations. It is not effective at detecting secondary caries lesions located under restorations or prosthodontic restorations [26]. The only kind of information possible to assess is the seal of restorations or fissure sealants [27,28]. Also, evaluation of subgingivally located caries lesions and root caries is limited with the use of this Imaging modality [19,29]. *Söchtig* i wsp. also showed that it is not fully effective for disclosing the extent of the lesion in dentine and its proximity to dental pulp. Early caries in the outer layer of dentine in proximal surfaces in not always visible, as optic characteristics of such lesion do not differ significantly from those of healthy dentine. Therefore, early dentine caries can be assessed indirectly. In such cases, the involvement of dentinoenamel junction by the demineralization process is the main indicator of pathology, which is usually related to rectangular shape of the cavity in enamel. Only after dentine has reached deeper layers of dentine, the permeability of tissues is going to reach such extent enough that it will be possible to disclose the lesion in the picture [12].

The operatory field should also be prepared in an appropriate manner before diagnostic process begins. The teeth should be cleaned and dried, particularly the occlusal surfaces. Discolorations and calculus also scatter light and cause a Shade to appear in the picture, which may be mistaken later on for caries [30]. *Simon* et al., however, concluded that discolorations may be easily differentiated from destruction due to demineralisation by infrared Light as opposed to visible Light. Longer wavelength, however, would be needed for it to be more reliable [23].

Conclusions

The analysed literature seems to indicate that DIAGNOCam can be seen as an effective diagnostic tool for the purposes of modern cariology. First of all, it is effective at evaluating proximal surfaces of posterior teeth particularly in cases in which enamel caries is expected. It enables to detect caries a tan earl stage at which remineralisation due to prophylaxis can be introduced instead of surgical treatment that involved tooth structure removal. Due to the fact that the images can be saved electronically, the device may serve as a valuable tool in patient education and motivation. Because no ionising radiation is used, this modality is safe, and the examination can be performer multiple times, also in pregnant patient. Even though radiography, particularly bitewing radiographs, remain widely used in caries diagnosis, examination with the use of infrared Light may constitute a supplement of other diagnostic modalities, which may make the diagnostic process more accurate and reliable.

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