

IDENTIFICATION OF THE EARLY STAGES OF CARIES IS CRUCIAL FOR AN ACCURATE DIAGNOSIS AND TREATMENT

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INTRODUCTION

Over the past 30 years, there has been a notable decrease in the occurrence, frequency, and severity of dental caries in developed countries. However, certain segments of these communities, particularly those from lower socioeconomic backgrounds, still face a high risk of developing dental caries. Despite this decline, the accuracy of caries diagnosis is compromised. An early diagnosis is essential because it enables interventions to repair the cavity and tackle the underlying risk elements or to establish whether sealing or restoration procedures are necessary.

Currently, there is significant variation in the diagnostic decisions of clinicians. The development of reliable detection aids could minimize this variation and enhance the decision-making process for dental caries cases. While this variation has been historically accepted as part of the art of dentistry, it is essential to ensure an accurate and consistent diagnosis to avoid

both over- and under-treatment. Appropriate dental care refers to maximizing benefits while minimizing the negative consequences of the intended procedures.

To adequately describe the characteristics of detection methods, it is necessary to provide definitions for certain terms[1,2,3].

The measure of sensitivity is the capacity to identify the presence of a disease, specifically referring to the proportion of individuals with the disease who receive a positive test result[4].

The ability to accurately identify the absence of a disease, known as specificity, is reflected in the proportion of individuals who test negative despite not having a disease.

The positive predictive value refers to the percentage of individuals with a positive test result who are confirmed to have the disease.

The negative predictive value refers to the percentage of individuals who receive a

negative test result and are confirmed to be free of the disease[5,6,7,8].

There are three distinct aspects to consider for dental caries: diagnosis, detection, and measurement. Diagnosis involves identifying the disease based on signs and symptoms, considering various risk factors that contribute to an individual's caries risk. Detection, on the other hand, refers to the use of an objective instrument to determine the presence or absence of the disease, with a simple yes or no outcome. On the other hand, measurement or quantification involves assessing the extent and status of the carious lesion, which can help guide treatment decisions such as sealant placement or restoration. This can be categorized using Pitts' diagnostic threshold model, which ranges from D1 to D4, with D1 representing the initial enamel caries and D4 representing the advanced dentinal caries. The decision to provide restorative care varies among clinicians depending on the stage of the carious lesions[9,10].

To conduct a precise visual evaluation, it is essential that the tooth is free of debris, that moisture is eliminated, and that sufficient lighting is available. The first signs of tooth decay manifest as white spot lesions (WSL), resulting from alterations in the visual properties of the enamel due to reduced mineral content. During the initial stages of demineralization, the WSL may only become apparent to the unaided eye once the tooth has dried[11].

The clinical identification of visual occlusal caries is a complex process due to various factors, such as surface morphology, past fluoride exposure, anatomical fissure topography, and the presence of plaque and stain. Radiography can be employed to

enhance the detection of occlusal lesions that have progressed to the dentine[12]. In the case of interproximal caries in posterior teeth, visualization is challenging because of the tooth structure at the marginal ridge, particularly in the early stages of the carious lesion[13]. However, radiography remains a reliable method for early detection of primary teeth. The use of transillumination in conjunction with radiography can improve the detection of interproximal caries[14,15].

For over a century, tactile detection has been a fundamental aspect of clinical dentistry, with the use of a sharp probe or explorer, which remains prevalent in both clinical practice and dental education. However, for the past 20 years, it has been advised that this technique should be limited or replaced when detecting fissure or smooth surface caries. The reasons behind this recommendation are twofold: first, tactile examination offers limited additional information compared to other detection methods, and second, there is a risk of damaging demineralized enamel during the probing process. It has been suggested that only a ball-ended probe should be used, particularly for assessing the integrity and roughness of the enamel surface.

Various methods have been developed to collect clinical data on dental caries, with the World Health Organization (WHO) method widely used since the late 1970s. This method employs a simple binary system, carious or not, based on the presence or absence of a D3/cavitated lesion, indicating whether the tooth requires clinical intervention. However, as the prevalence of caries has changed in many

communities and no reliable detection device is available, the need for early detection before cavitation has become apparent. Consequently, the International Caries Detection and Assessment System (ICDAS) was developed a decade ago. This system allows for the assessment of carious lesions at early stages, and is particularly useful in epidemiological studies and trials of remineralizing products. The codes in the ICDAS range from the measurement of the first visible carious change in the enamel after drying (code 1) to extensive cavitation (code 6)[16].

Validation is still needed for several other indices, including Nyvad, Pulpal Ulceration Fistula Abscess Index (PUFA), Universal Visual Scoring System (UNIVISS), Caries Assessment and Treatment Instrument (CAST), and FDI caries matrix. One notable advantage of the Nyvad system is its ability to accurately measure lesion activity, which has been utilized alongside the ICDAS and Nyvad activity in clinical trials. The CAST system, on the other hand, documents both non-cavitated and cavitated carious lesions, teeth with pulpal involvement, abscessed teeth, and existing treatments. Finally, the FDI caries matrix combines the elements of ICDAS and PUFA[2,17,18].

RADIOGRAPHY

For almost a century, radiography has played a vital role in dental practice. However, its effectiveness in identifying occlusal carious lesions, particularly in the initial phases, is limited. Studies have shown that radiography has low sensitivity and accuracy, particularly for lesions located within the enamel. Therefore, radiography should be combined with other

detection techniques such as transillumination. The reliability of radiographic results is influenced by the clinician's experience and training. Interestingly, more experienced clinicians tend to exhibit lower sensitivity, but higher specificity, than undergraduate students[17,18,19].

Many practitioners now commonly use digital radiography, which offers similar detection capabilities to film-based methods, but with the added benefits of reduced radiation exposure and easy image transfer. Subtraction radiographic methods have been found to improve accuracy and reproducibility compared with visual assessment. With regard to bitewing radiography, computer-assisted detection can enhance the accuracy, particularly for lesions that extend beyond the enamel's halfway point. When tactile detection was combined with radiography, the sensitivity of detecting cavitated and non-cavitated lesions in the posterior teeth significantly increased from 0.34 to 0.63, although the specificity slightly decreased from 0.99 to 0.93 with the addition of tactile detection[20,21].

TRANSILLUMINATION

Transillumination involves placing a light source on the side of a tooth, typically on the buccal or lingual side. Fiber-optic transillumination (FOTI) is commonly used because it provides a reliable source of light. FOTI works on the principle that a healthy tooth structure allows for better transmission of light than a tooth affected by decay. Essentially, when a tooth is demineralized, photons scatter. FOTI is primarily used to detect carious lesions between teeth and complements visual

inspection and radiographic methods. Some studies have shown that it can enhance the visual detection of occlusal lesions. Enamel-only carious lesions appear as grey shadows, whereas those in the dentine present as orange-brown or bluish shadows[22].

Despite being promoted for over three decades and being reported as having similar validity to visual inspection and greater sensitivity than radiography for detecting occlusal lesions, the use of transillumination has remained limited. One drawback of FOTI is the absence of a visual record, which has been addressed by the development of digital imaging FOTI (DIFOTI). However, commercially available systems are yet to provide software for quantifying lesion changes, even with the recent release of a new DIFOTI system (DIAGNOcam™, KaVo Dental GmbH, Biberach, Germany)[3,17,18,22].

The DIAGNOdent™ laser fluorescence tool developed by KaVo Dental GmbH can detect both occlusal and interproximal issues. This technology uses laser light to excite porphyrins, which then emit fluorescence. However, it is important to note that the accuracy of laser fluorescence in identifying intradentinal lesions can vary significantly, with false positives being the main drawback. To achieve optimal outcomes, it is crucial to maintain consistent angulation of the tool and to combine the results with other detection methods. Laser fluorescence should not solely be relied on as the ultimate standard, as the sensitivity and specificity of the findings can differ[16,23,24].

Quantitative Light-induced Fluorescence (QLF™) systems, such as Inspektor BV, Vistaproof™, and Sopralife™, utilize the disparities in autofluorescence between healthy and demineralized enamel and dentin. The demineralized enamel appears noticeably darker than the surrounding intact tooth structure, while the carious dentin emits red fluorescence, the intensity of which depends on the specific filters employed. With the QLF™ and Vistaproof™ systems, specialized software enables precise measurement of fluorescent changes, facilitating the longitudinal capture of images and analytical data[24].

By utilizing QLF, it is viable to identify enamel demineralization at an early stage. Furthermore, there is potential for QLF to differentiate between affected and infected dentin. Similar to DIAGNOdent™, the effectiveness of the QLF technology depends on employing a standardized technique, particularly in terms of controlling ambient light. It is important to interpret these results alongside other detection methods, taking into consideration an individual's risk of caries.

Changes in the mineral content of dental structures result in alterations in their electrical characteristics. To assess these changes, a current is passed through a tooth using an instrument such as Cariescan™ (Cariescan Ltd, Dundee, UK) to measure the impedance of the tissue, offering a potential means of quantifying the mineral content. However, several factors can affect the accuracy and reliability of these measurements, including the hydration level of the tooth surface, tissue thickness, and temperature.

A recently launched system, known as photothermal radiometry/modulated luminescence (PTR-LUM), utilizes laser technology to detect changes in luminescence and temperature, allowing the measurement of mineralization changes. The system captures and stores images in its software, generating a unique "Canary" number that is believed to represent the characteristics of the lesion[25].

Further research is necessary to fully explore the potential of these new technologies. Comprehensive information is available in the subsequent publication by Tassery et al.[14].

The evaluation of lesion activity involves assessing caries activity at the surface level. This information can be combined with other risk measures to determine the current caries risk and establish a baseline for future assessment. The visual and tactile index developed by Nyvad et al.[6,7] is the most commonly used system for this purpose. This index distinguishes between active and inactive caries based on surface appearance and integrity. For example, a score of 1 indicates active caries with an intact surface that appears white/yellow opaque and lacks a lustre. When probed gently, the surface became rough.

REPRODUCIBILITY

Achieving reproducibility among examiners is a challenging task because practitioners tend to form their own unique concepts based on their experience with caries detection and subsequent preventive or restorative treatment options. The length of experience also plays a role, as more experienced examiners tend to exhibit

higher sensitivity, specificity, and reproducibility than their less experienced counterparts do.

To ensure accurate detection, it is advisable to employ multiple methods, rather than relying on a single detection method that may lack either high sensitivity or high specificity. For instance, one can enhance the accuracy of detection by combining DIAGNOdent's findings with visual and radiographic images or FOTI. However, it is important to note that certain factors, such as fluorescent lighting, can interfere with the results obtained using fluorescent-based detection methods. Therefore, it is crucial to exercise caution when controlling ambient lighting and standardizing the methodology when utilizing these innovative detection methods[16,23,26,27,28,29].

Raman spectroscopy, optical coherence tomography (OCT), and ultrasound are among the various detection methods available[30,31]. However, it is important to note that none of these technologies has been commercially released with scientific validation.

CONCLUSIONS

An early and precise identification and assessment of dental caries play a crucial role in the comprehensive care of dental patients. Clinicians have a variety of disposal methods for this purpose. Nevertheless, it is vital to employ methods that offer adequate levels of sensitivity and specificity in combination to ensure an accurate diagnosis that guides the appropriate and effective treatment for each patient.

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