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EARLY DETECTION OF DENTAL CARIES

Abstract: Early detection of dental caries is a critical component of modern preventive dentistry. Identifying carious lesions at an initial stage allows for non-invasive or minimally invasive treatment, preventing disease progression and preserving natural tooth structure. Recent advancements in diagnostic technologies, including digital radiography, laser fluorescence devices, fiber-optic transillumination, and artificial intelligence-based systems, have improved the accuracy and reliability of early caries diagnosis. This article discusses the importance of early detection, contemporary diagnostic methods, and their clinical significance in improving long-term oral health outcomes.

Keywords: Early caries detection, preventive dentistry, digital radiography, laser fluorescence, transillumination, minimally invasive treatment

Introduction

Dental caries remains one of the most prevalent chronic diseases worldwide. It is a multifactorial condition caused by the interaction of bacteria, dietary sugars, and host factors, leading to demineralization of enamel and dentin. Traditionally, caries was often diagnosed only after visible cavitation occurred, requiring restorative treatment. However, modern dentistry emphasizes early detection to prevent irreversible damage.

The early stage of caries is characterized by enamel demineralization without cavity formation. At this stage, the process is reversible through remineralization therapies and improved oral hygiene practices. Therefore, accurate and timely diagnosis is essential for effective prevention and conservative management.

Main part

Early caries detection focuses on identifying non-cavitated lesions before structural damage occurs. At the initial stage, enamel demineralization appears clinically as a white spot lesion, indicating mineral loss without cavitation. Visual-tactile examination remains the primary diagnostic method in daily practice; however, its sensitivity is limited when lesions are located interproximally or beneath the enamel surface. According to Pitts et al., early recognition of non-cavitated lesions allows for preventive and non-operative management, reducing the need for restorative intervention [2].

Digital radiography has significantly improved diagnostic accuracy. Compared to conventional film radiographs, digital systems provide enhanced image contrast, magnification options, and reduced radiation exposure. Bitewing radiographs are especially useful for detecting proximal caries that are not visible during clinical inspection.

Laser fluorescence technology enables quantitative assessment of early enamel demineralization. These devices detect fluorescence changes associated with bacterial metabolites in carious tissue. Fiber-optic transillumination (FOTI) and digital imaging fiber-optic

transillumination (DIFOTI) allow clinicians to visualize structural changes through light transmission without ionizing radiation.

Artificial intelligence (AI) has recently been integrated into radiographic diagnostic systems. AI algorithms analyze radiographic data to detect early carious lesions with improved consistency and reduced observer variability. Schwendicke et al. report that AI-supported diagnostics demonstrate promising sensitivity and specificity in identifying early-stage caries [4].

Salivary diagnostics also play a preventive role by assessing bacterial levels, salivary pH, and buffering capacity. These tests help determine individual caries risk and guide personalized preventive strategies. Early detection enables the use of remineralization therapies, fluoride varnishes, calcium-phosphate agents, and sealants to arrest or reverse enamel lesions before cavitation develops.

Table: Modern methods for early caries detection

Diagnostic method	Mechanism of action	Clinical application	Advantages
Visual-tactile examination	Direct inspection of tooth surfaces	Initial screening of enamel lesions	Simple, inexpensive, immediate results
Digital radiography	X-ray imaging with digital sensors	Detection of interproximal and dentinal caries	High image quality, lower radiation dose
Laser fluorescence	Measurement of fluorescence from demineralized tissue	Early enamel caries assessment	Quantitative, non-invasive
Fiber-optic transillumination (FOTI/DIFOTI)	Light transmission through tooth structure	Identification of proximal and occlusal lesions	Radiation-free, useful for early detection
Artificial intelligence systems	Automated radiographic image analysis	Early lesion detection and risk assessment	Increased diagnostic consistency
Salivary testing	Evaluation of biological risk indicators	Caries risk assessment and prevention planning	Personalized preventive approach

Conclusion

Early detection of dental caries represents a fundamental principle of modern preventive dentistry. Identifying carious lesions at the initial stage, before cavitation occurs, allows for non-invasive and conservative management strategies. Technological advancements such as digital radiography, laser fluorescence devices, fiber-optic transillumination, artificial intelligence-based diagnostic systems, and salivary risk assessment have significantly enhanced the accuracy and reliability of early diagnosis.

Timely identification of enamel demineralization makes it possible to apply remineralization therapies, fluoride treatments, and sealants, thereby preventing disease progression and preserving natural tooth structure. As emphasized in recent research [2,4], early diagnostic approaches not only reduce the need for invasive restorative procedures but also improve long-term oral health outcomes and decrease treatment costs.

In conclusion, integrating modern diagnostic technologies with preventive strategies ensures more effective, patient-centered dental care. Continued research and technological development will further strengthen early caries detection systems, contributing to improved global oral health standards.

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