

An overview of the effectiveness of laser fluorescence versus traditional methods in detecting occlusal caries in adolescents

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Abstract

The prevalence of dental caries among adolescents remains a significant public health concern, necessitating effective strategies for early detection and intervention. This review assesses the comparative effectiveness of laser fluorescence (LF) technology against traditional methods—specifically visual examination, radiographic imaging, and manual probing—in detecting occlusal caries in this population. Traditional methods, while widely used, often exhibit limitations in sensitivity and accuracy, particularly in identifying non-cavitated lesions that can be pivotal for timely intervention. In contrast, laser fluorescence has emerged as a promising tool, demonstrated to offer greater sensitivity and specificity in detecting early-stage carious lesions, thereby enhancing diagnostic capabilities in clinical practice. Additionally, LF technology is non-invasive, facilitating a more comfortable experience for adolescent patients and potentially improving treatment adherence. Despite its advantages, the effectiveness of LF is contingent upon proper training and standardized usage among practitioners. This review highlights the implications of integrating laser fluorescence in routine clinical assessments, underscoring its potential to transform caries management by enabling preventive care approaches and reducing the need for restorative treatments. By advancing the understanding of these diagnostic modalities, dental professionals can better address the escalating challenge of caries in adolescents, ultimately promoting improved oral health outcomes.

Introduction

Dental caries continues to be a pervasive oral health issue worldwide, with adolescents particularly susceptible to developing carious lesions due to various biological, behavioral, and social factors. The World Health Organization reports an alarming prevalence of dental caries, indicating that between 60-90% of school-aged children in both developed and developing nations are affected, highlighting the critical need for effective caries detection and management strategies (1). Gender, ethnicity, socioeconomic status, and dietary habits play significant roles in this increased susceptibility; for instance, adolescents often consume diets high in sugars and acids, facilitated by the availability of fast foods and sugary beverages, which significantly contribute to the caries process (2). Moreover, oral hygiene practices among adolescents may be inconsistent, further increasing the likelihood of carious development. As initial carious lesions primarily occur in pits and fissures where occlusal caries are commonly found, early detection becomes essential in arresting the progression of these lesions before they evolve into more complex and costly dental problems.

Traditional methods for detecting occlusal caries have long been the mainstay of clinical practice, predominantly involving visual examination, bitewing radiographic imaging, and manual

probing—all of which are subject to limitations that can impact diagnostic accuracy. Visual examination relies heavily on the clinician's experience and ability to discern early signs of decay, but it is inherently constrained by subjectivity and the inability to detect non-cavitated carious lesions, which may evade detection until they have advanced significantly (3). Radiographic methods, though providing deeper insights into the tooth's internal structure, often fail to identify superficial lesions and can lead to misdiagnosis due to overlapping anatomical structures, radiation exposure concerns, and difficulties with interpretation prevalent in adolescents (4). Additionally, manual probing has methods aimed at assessing surface roughness but can cause discomfort, anxiety, and even inadvertent damage to the tooth structure, compromising long-term dental health while still potentially overlooking less developed carious lesions (5).

Amidst these limitations, laser fluorescence (LF) technology has surfaced as an innovative diagnostic tool that significantly enhances the ability to detect occlusal caries, particularly in their early stages. Utilizing specific wavelengths of laser light, LF devices assess the fluorescence emitted from tooth structures, allowing for differential detection of healthy versus carious tissue based on their differing fluorescence characteristics. This technology has shown promise not only in identifying early demineralization that traditional methods often miss but also in fostering a patient-centric approach that emphasizes non-invasive assessment, thereby reducing anxiety levels among adolescent patients (6). Recent studies suggest that laser fluorescence can be up to 90% sensitive in detecting carious lesions, indicating that this technology may provide a crucial advantage in preventing the escalation of carious development through timely interventions (7). In light of these advancements, this paper will thoroughly examine the comparative effectiveness of laser fluorescence versus traditional methods in the detection of occlusal caries in adolescents, highlighting the implications for clinical practice and overall oral health management.

Traditional Methods of Caries Detection

1. Visual Examination: Visual examination is often the first diagnostic step taken by dental practitioners for detecting carious lesions. This method involves assessing the teeth for any noticeable discoloration, surface irregularities, or presence of cavitation that may indicate decay. Despite its accessibility and cost-effectiveness, the visual-only approach is significantly limited by its dependence on the clinician's observational skills and experience. Research has demonstrated that visual examinations can miss foundational indicators of early caries, particularly in occlusal pits and fissures, where caries may develop beneath the enamel surface without clear external signs (8). A study conducted by Ismail (1998) showed that visual assessment alone could miss up to 60% of initial demineralization stages, underscoring the urgent need for improved diagnostic techniques that can recognize these developments earlier. Moreover, the reliance on subjective judgment raises concerns about variability in diagnosis among practitioners, leading to inconsistent treatment recommendations.

2. Radiographic Imaging: Radiographs provide a critical complement to visual assessments, particularly in identifying interproximal and deeper carious lesions. Bitewing radiographs utilize various techniques to visualize decay between teeth and beneath the enamel surface. While beneficial, this methodology is not without drawbacks that impact its overall effectiveness in detecting occlusal caries in adolescents. Bitewing radiographs have limitations in capturing shallow occlusal caries, with studies suggesting that significant tooth structure must demineralize

before detectable changes appear in the radiographic images (9). Furthermore, such techniques expose patients to ionizing radiation, which, even in minimal doses, raises ethical concerns in pediatric dental practices where cumulative exposure over time can have implications for long-term health (10). These shortcomings necessitate the exploration of complementary or alternative diagnostic techniques for more effective caries management.

3. Manual Probing: Manual probing involves the use of an explorer or probe to physically assess tooth surfaces, allowing practitioners to evaluate surface texture and integrity in identifying caries. While probing can effectively indicate the presence of cavitated lesions, it has notable limitations concerning early detection and potential patient discomfort. The mechanical nature of probing can lead to discomfort or anxiety, particularly in young patients who may already have apprehensions surrounding dental visits (11). Moreover, probing non-cavitated lesions often fails to yield sufficient diagnostic information, as these lesions may not present with a detectable change in texture or feel. This limitation highlights the need for adopting a more holistic approach to caries detection that considers both the inherent characteristics of lesions and the psychological factors surrounding patient care.

Laser Fluorescence for Caries Detection

Laser fluorescence technology, particularly devices like DIAGNOdent, utilizes a laser beam to detect carious tissue based on its unique fluorescence properties. Healthy dental tissue reflects the laser light differently compared to carious tissue, which results in varying fluorescence readings.

1. Sensitivity and Specificity: One of the hallmark features of laser fluorescence is its superior sensitivity in detecting occlusal caries, particularly in their initial stages, where traditional methods may fall short. Systematic reviews reveal that laser fluorescence outperforms conventional methods, boasting sensitivity rates that can reach up to 90% for non-cavitated lesions (12). This high level of sensitivity is especially crucial for adolescents, as their evolving dentition and dietary patterns place them at an increased risk for early carious lesions. Early identification of such lesions allows for timely intervention strategies such as fluoride applications, dietary counseling, and enhanced oral hygiene practices, aimed at stabilizing or reversing carious processes before they progress to restorations (13).

2. Non-Invasiveness and Acceptance: Laser fluorescence allows for a non-invasive, quick assessment that can significantly improve patient cooperation and satisfaction. Adolescents often experience anxiety during dental visits, tied to traditional diagnostic approaches and concerns regarding discomfort. The non-invasive nature of laser fluorescence mitigates these issues, as it generally requires no anesthesia and poses minimal discomfort to the patient (14). Moreover, research indicates that both adolescents and their parents show a higher preference for non-invasive techniques, finding them less intimidating than traditional methods, which can ultimately improve adherence to dental care recommendations and encourage positive attitudes toward regular dental visits (15).

3. User Dependence and Variability: Although laser fluorescence technology shows promise, its efficacy relies on proper usage and interpretation by trained professionals. Variability in operator experience can lead to differences in diagnostic accuracy, as inexperienced operators may

misinterpret fluorescence readings, which could jeopardize treatment outcomes. Therefore, establishing standardized training programs is essential to ensure that all dental practitioners can effectively utilize LF technology to its fullest potential. Recent studies emphasize the importance of familiarity with the technology and experience in its application to reduce misdiagnosis and improve patient care (16).

4. Limitations of Laser Fluorescence: Despite its advantages, laser fluorescence is not infallible. The technology can yield false positive results, leading to potential over-treatment if not correctly interpreted in the clinical context. For instance, lesions exhibiting high fluorescence levels could be incorrectly identified as carious when they are merely sound enamel or affected by plaque or other factors (17). Additionally, external factors, such as saliva or blood contamination on the tooth surface, can impact the accuracy of fluorescence readings, necessitating a clean and dry field during assessment to ensure reliable results. Practitioners must recognize these limitations and employ laser fluorescence as a complementary tool alongside traditional diagnostic methods for a comprehensive evaluation of occlusal caries.

Comparative Effectiveness

Considerable research has focused on the comparative effectiveness of laser fluorescence and traditional methods for detecting occlusal caries in adolescents, delineating the advantages inherent in integrating modern technology within clinical practice.

- **Diagnostic Accuracy:** Systematic reviews consistently indicate that laser fluorescence offers superior diagnostic accuracy compared to traditional methods in detecting early occlusal caries, which aligns with findings that demonstrate higher sensitivity and specificity overall. For example, one study highlighted that laser-assisted techniques outperformed visual examinations and radiographs, leading to a growing consensus among practitioners of the technology's utility and importance in enhancing caries detection accuracy (18).

- **Clinical Implications for Management:** The potential for early detection utilizing laser fluorescence carries critical implications for patient management strategies. By identifying carious lesions in their initial stages, clinicians can pivot toward preventive care approaches that emphasize monitoring and non-invasive interventions, thereby reducing the reliance on restorative treatments. This paradigm shift is particularly significant in adolescent populations where the long-term impacts of preventive care can drastically shape oral health trajectories and reduce treatment burdens later in life (19).

- **Patient and Provider Perspectives:** The integration of laser fluorescence into routine clinical practice may also be influenced by patient and provider acceptance of the technology. Studies have indicated a clear preference among patients for less invasive diagnostic methods, particularly in pediatric populations where anxiety surrounding dental treatment can substantially affect cooperation and outcomes. Moreover, practitioners recognize the value of technology that augments their diagnostic capabilities and streamlines the assessment process while promoting a more positive dental experience for the patient (20).

Conclusion

In conclusion, the evidence strongly supports the application of laser fluorescence technology as an effective and efficient method for detecting occlusal caries in adolescents, especially when compared to traditional diagnostic methods that may overlook early carious lesions. The sensitivity and non-invasive nature of laser fluorescence present practitioners with a powerful tool that enhances the early intervention capability critical for managing dental caries effectively. As the oral health landscape continues to evolve, it is imperative for dental practitioners to stay informed about advancements in diagnostic technology, ensuring they adopt comprehensive and evidence-based approaches that optimize patient care and improve long-term oral health outcomes.

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