Critical Appraisal

CURRENT CARIES DETECTION DEVICES

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What are today's most viable dental caries diagnostic/detection tools and what are the pros and cons of each? Why is there so much mystery around how to best diagnose occlusal, especially "hidden," carious lesions? An oft-studied key question: do more years of clinical experience help practitioners make better, more accurate diagnosis of occlusal carious lesions? What tools and skills improve the ability of clinicians to recommend an invasive versus noninvasive dental treatment approach? Can these tools be utilized worldwide, especially in areas that serve high-risk pediatric and adult patients?

TECHNOLOGY-ENHANCED CARIES DETECTION AND DIAGNOSIS

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ABSTRACT

Objective: This clinical assessment sought to explain the current state of oral disease in the United States, and to highlight new diagnostic technology methods available to clinicians as adjuncts to traditional methods for caries diagnosis.

Overview: The prevalence of dental caries in older children and in adults in the United States has declined during the past 40 years. This is because of an increased use of fluoride, improved oral hygiene and better devices, a greater emphasis on disease prevention and control, and better access to professional dental care. Despite this, dental caries continues to be a major public health problem. Approximately 60% of caries occurs in 20% of the population, and fewer than 5% of adults are caries-free. Caries is the single most common chronic disease of childhood.

Caries Diagnosis and Detection: Pit-and-fissure lesions have dramatically changed in the past two decades because of the increased use of fluoride and the fact that correct classification of occlusal lesions has become more difficult. This situation has led to an increase in research and development for better diagnostic tools for pit-and-fissure caries detection. In using these new technologies, clinicians must understand the concepts of caries risk, diagnosis,

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detection, and assessment to formulate a sound clinical diagnosis and treatment plan for their patients. The general consensus today is that the optimal technique should have good diagnostic performance, be noninvasive, allow for a quantification of disease progression and objective monitoring, and be easy to manage at a reasonable cost. It should be noted that while correct recognition of sound and cavitated surfaces is typically not a problem, noncavitated lesions create a considerable challenge.

Risk Assessment: Caries risk is a neglected assessment today and can impact a proper treatment plan—one that is preventive and restorative in nature and ultimately, cost-effective. The clinician should assess whether the patient is at a high, moderate, or low risk for caries. It is advantageous to overtreat incipient lesions with sealants and preventive resin restorations than to not diagnose and allow the lesions to progress. Accurate and early detection and treatment of carious lesions avoids more invasive operative intervention later. Also, accurate diagnosis of noncavitated lesions is critical because an increased prevalence of difficult-to-diagnose caries can be a sign of high caries activity, requiring an overall more aggressive preventive program.

Caries Detection: Traditional methods of caries detection have low sensitivity (rate of true positives) and specificity (true negatives). For example, a sharp-tipped dental explorer would have a relatively high rate of false positives. And traditional visual-tactile and radiographic methods of caries detection can only detect lesions that are more advanced—at least 300 to 500 μm of the enamel. In the past few years, a number of new technologies—both low and high-tech—now supplement traditional methods of caries detection. As with any clinical diagnostic technique, a final diagnosis should not be made based on a single parameter but on the weight of evidence supporting the diagnosis. Some of these tools include:

- Fiber-optic transillumination (FOTI) and magnification
- Digital imaging fiber-optic transillumination (DIFOTI Electro-Optical Science, Irvington, NY, USA)
- Digital radiographic assessment
- Quantified light-induced fluorescence
- LED technology

Conclusions: To mitigate the progression of oral disease as the single most common chronic disease of childhood, dental practitioners should become educated on the variety of new technologies available (as adjuncts to traditional methods) for diagnosing caries lesions. In using these technologies, the clinician must understand the concepts of caries risk, diagnosis, detection, and assessment.

COMMENTARY

Today, clinicians diagnose small caries lesions and subsequently treat them in widely variable ways. Depending on the limitations of caries decision-making investigations or perhaps an incomplete understanding of caries progression or the parameters of a diagnostic device, a clinician's dental assessment can be uniquely influenced. All clinicians should become better educated on the use of adjunctive aids for caries detection as well as the cost-effectiveness and cost-utility of these devices. In the future, it will be critical to assemble evidence-based clinical guidelines for the relationship between diagnosis and treatment decisions. Equally important will be evaluating the effect of diagnostic and treatment decisions—using conventional as well as technologic adjunctive diagnosis aids—for the outcome clinicians hope to see for their patients.

DETECTION OF OCCLUSAL CARIOUS LESIONS: AN IN VITRO COMPARISON OF CLINICIANS' DIAGNOSTIC ABILITIES AT VARYING LEVELS OF EXPERIENCE

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General Dentistry 2009 (57[1]:60–6)

ABSTRACT

Objective: This in vitro study examined the differences in diagnostic abilities and restorative choices among 21 dental clinicians, based on their amount of clinical experience, using visual and tactile methods to detect occlusal caries.

Materials and Methods: For this study, a total of 94 extracted human teeth (mostly third molars) were obtained from the oral surgery department of an ambulatory dental clinic. The occlusal surfaces in all teeth were intact, there was no visible cavitation, occlusal fissures were stained or discolored, no previous restorations were present, and all teeth had erupted into the oral cavity.

The teeth were subsequently cleaned, stored in a 5% neutral buffered formalin, mounted in dental stone inside an ice cube tray, and randomly assigned a number marked on the stone block next to each tooth.

The occlusal surface of each subject tooth was photographed using a digital camera and placed in sequential order on sheets of paper, providing each examiner an accurate method for documenting the location of suspected carious lesions. Bitewing radiographs were made of each study tooth and sequentially ordered by corresponding number.

The 21 participating dentists, with clinical experience ranging from 1 to 42 years, received (for each tooth): a photograph, a bite-wing radiograph, an explorer, and a red pen to mark suspected lesions. They were asked to relay how they would restore the tooth. If no lesion was detected, the examiner would leave the photo unmarked. They were also asked to list the number of years they had practiced clinical dentistry.

After sectioning, each tooth was examined under loupe magnification to detect the presence of caries. Teeth were considered carious if the caries process had cavitated and/or proceeded to or past the dentinoenamel junction (DEJ). Using this macroscopic examination of individual slices, each tooth was designated as positive or negative for occlusal caries. Sensitivity and specificity was determined for each study participant and data were compiled for how each examiner planned to restore the carious teeth. These restorations fell into one of five categories based on restoration complexity: sealant, a preventive resin restoration (PRR) limited to a single pit or fissure, a composite resin, an amalgam, or a full-coverage restoration (FCR) that would include both onlays and crowns. Examiner choices were plotted and graphed based on the examiner's years of experience.

Results: Sensitivity values ranged from 0.882 to 0.231, with a mean of 0.572. Specificity values ranged from 0.938 to 0.455, with a mean of 0.698. The Pearson product-moment correlation was calculated to determine the relationship between sensitivity, specificity, and years of clinical experience. The correlation of sensitivity and years of experience had a value of $r = -0.55$, and that of specificity and years of experience was $r = 0.12$. The Pearson product-moment correlation was also calculated to examine the connection between sensitivity and specificity without considering years of experience—and this correlation produced a value of $r = 0.48$ and was statistically significant. The examiners recommended a total of 392 restorations: 11 sealants, 103 PRRs, 87 composites, 178

amalgams, and 13 FCRs. The correlation between years of experience and degree of recommended treatment was calculated using the Spearman rank order test, providing a correlation of –0.43.

Conclusions: Based on the results, there is no strong correlation between a dentist's clinical experience and a more accurate diagnosis or more conservative treatment options. This study does suggest, however, that individual dentists may be more prone to over- or underdiagnosis. The quality of training in dental school could be a factor. The study also reaffirmed that traditional occlusal caries diagnostic methods (mirror and explorer) are not highly effective for diagnosing caries accurately and this does not improve with years of clinical experience.

COMMENTARY

Dentistry is a scientific business, but studies such as this indicate that dentists will use their best judgment to make subjective diagnoses, especially in diagnosing occlusal caries or "hidden" caries lesions that have perhaps remineralized. Numerous studies have been published concerning correct caries diagnosis and appropriate treatment. Because these findings have gained wide traction, it is important to continue the research and development for quantifiable, accurate, low-cost and practical diagnostic aids, dental tools that can be widely adopted by the majority of dental practitioners.

IN VITRO PERFORMANCE OF METHODS OF APPROXIMAL CARIES DETECTION IN PRIMARY MOLARS

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ABSTRACT

Objective: This study compared the performance of a novel pen-type laser fluorescence device in detecting approximal caries lesions primary molars ex vivo compared with radiographic and visual inspection methods.

Materials and Methods: For this study, 131 approximal surfaces of the primary molars of children in São Paulo, Brazil (0.7 mg/L fluoride in water supply), were examined by two observers with visual inspection (VI) using the International Caries Detection and Assessment System (ICDAS),[1] radiographic interpretation, and clinical use of the DIAGNOdent pen (LFpen, KaVo, Biberach, Germany).

The tested molars had recently been exfoliated or extracted for orthodontic purposes, frozen until use, defrosted at room temperature for 4 hours, and cleaned (maintaining fluorescence). The molars were then placed in arch models in the following order: a primary canine, a first primary molar, a second primary molar and a first permanent molar. Care was taken to simulate the contact points as closely as possible.

Evaluations were performed on the approximal surfaces of primary molars only. Two examiners carried out all examinations independently, unaware of each other's results. For VI, specimens were positioned about 30 cm from the examiners' eyes, with no magnification and with the aid of a light reflector. The examiners used a mouth mirror and a ballpoint probe. The teeth were first examined wet, and then dry, and examiners used the ICDAS-II method.[1]

[1] Ismail AI, Sohn W, Tellez M, et al. The International Caries Detection and Assessment System (ICDAS): an integrated system for measuring dental caries. Comm Dent Oral Epidemiol 2007;35:170–8.

For the radiographic method, bitewing radiographs were taken from each series of teeth using bitewing holders. The X-ray machine was set to 70 kV, 8 mA, and the exposure time was 0.3 seconds. Radiographic films (22 × 35 mm, Eastman Kodak, Rochester, NY, USA; film speed unspecified) were used, the focus-to-film distance was 40 cm, and the films were manually developed using standard processing times. The radiographs were examined on a backlit screen at ×2 magnification.

The third method used LFpen, a DIAGNOdent pen device attached to probe tip 1 for approximal surfaces. For each tooth, the laser device was calibrated against the porcelain reference object and on a sound smooth surface. The laser fluorescence reading was electronically subtracted from the readings of the approximal site under examination. The highest value from the two measurements of each surface was recorded. To achieve a reference standard, surfaces were directly examined for the presence of white spots or cavitations, and lesion depth was verified after sectioning. In addition to calculating interexaminer reproducibility, the area under the receiver operating characteristic curve (Az), sensitivity, specificity, and accuracy were also calculated.

Results: Using the cavitation threshold, all methods presented similar sensitivities. Higher Az values were achieved with VI at white spot threshold, and VI and the LFpen had higher Az values at cavitation threshold. VI presented higher accuracy and Az than radiographic and LFpen at both enamel and dentin depth thresholds. Higher reliability values were achieved with VI.

Conclusions: Visual inspection performs better, but both radiographic and LFpen methods show good performance in detecting more advanced approximal caries lesions.

COMMENTARY

Clinicians and researchers will likely always be searching for practical, cost-effective, and quantitative methods for detecting approximal-surface caries. To date, in vivo and in vitro studies have been controversial, likely because of the difficulty in simulating the proximal contact. Whereas this well-designed study affirmed the clinical visual inspection method as precise and distinctive, its sensitivity and reproducibility remain inferior to other methods. Also, like the radiographic method, VI is not quantitative and both methods are dependent on clinical interpretation—thus reducing their reliability. The new ICDAS scoring system has helped increase the validity and reliability of VI; however, this new system has not been validated in detecting approximal caries lesions. Further studies are warranted using ICDAS to determine whether the better performance is really because of the new visual scoring system or to the limitation of the in vitro design.

Quantitative methods—such as the laser fluorescence device—give dentists a metric for interpreting the value using a predetermined cut-off point scale independent from clinician opinion. Also, other authors have claimed that the LFpen could be useful in monitoring caries lesions and should present a good reliability and a high correlation with mineral loss.

IN VIVO EVALUATION OF DIAGNODENT FOR THE QUANTIFICATION OF OCCLUSAL DENTAL CARIES

M.A. Khalife, J.R. Boynton, J.B. Dennison, P. Yaman, J.C. Hamilton
Operative Dentistry 2009 (34:136–141)

ABSTRACT

Objective: The purpose of this in vivo study was to assess the correlation DIAGNOdent (DD) readings with depth and volume of caries removed using traditional rotary instruments, and to assess the determined sensitivity and specificity of the device at different cut-off points.

Materials and Methods: A study conducted by Spitzer and Bosch[2] suggested that caries lesions, when exposed to certain wavelengths of light, emit more intense fluorescence that sound tissue. This work led to the development of DD, a laser-based device used to detect and quantify dental caries on occlusal surfaces. DD produces a single-digit reading (ranging from 0 to 99), offering an objective measurement of the fluorescence recorded by the device.

For the study, 31 patients (between 18 and 45 years old) from the Graduate Operative Dentistry Clinic at the University of Michigan, provided 60 permanent maxillary and mandibular molars and premolar occlusal surfaces with suspected dentinal caries. Each tooth received standard visual and tactile examinations, exposure of a bitewing radiograph (if needed), and a DD evaluation. Examinations were conducted independently by two operators.

Following manufacturer's instructions, calibration of the DD was performed with a ceramic standard (provided by the company), and using a conical tip A, each occlusal surface was measured. For each tooth, two sets of DD readings were recorded, as well as lesion depth (measured by periodontal probe) and volume measurements (calculated by measuring the mass of a polyvinyl siloxane impression of the cavity, divided by the material's calculated density). If peak values differed between readings, the numbers were averaged to determine the surface's DD reading. The clinical detection of decay at the DEJ was employed as the gold standard to help calculate an appropriate cutoff.

All of the operative and restorative treatments were performed by one investigator. Following a standard injection of local anesthesia as needed (prior to caries removal), each tooth was isolated with a rubber dam, and an impression of the occlusal surface was taken using ply vinyl siloxane (PVS) impression material before operative intervention to serve as a matrix for volume measurement. A conservative dissection of the carious lesion was performed.

Results: After operative intervention, 78% of the lesions extended into dentin and 22% were limited to enamel. The DD values ranged from a minimum value of 14 to a maximum value of 99, with an average value of 50. Lesion volume ranged from 0.002 to 0.1 cc, with an average of 0.01 cc.

Conclusions: Using Pearson correlation coefficients, the indications were that DD readings were weakly correlated with lesion depth ($r = 0.47$) and lesion volume (also $r = 0.47$). Mean DD readings significantly differed between caries limited to enamel and caries extending into dentin. For this study, the appropriate cutoff point for the sample was calculated between 35 and 40. The study concluded that the DIAGNOdent device should be

[2] Spitzer D, Bosch JT. The absorption and scattering of light in bovine and human dental enamel. Calcif Tissue Res 1975;17:129–37.

used by dental clinicians as a relevant adjunct in the caries diagnosis and treatment planning process.

COMMENTARY

This study legitimizes the clinical use of an objective caries detection method such as DIAGNOdent to complement traditional clinical assessment methods in determining whether invasive therapy or a more conservative noninvasive approach is best for the oral health of the patient. Also, it is agreed that the use of the DD could serve as a quantifiable detection method in the longitudinal measurement of teeth in monitoring the progression of caries over time.

SUGGESTED READINGS

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THE BOTTOM LINE

Dental practitioners should become educated on the variety of new technologies available as adjuncts to traditional methods for detecting/diagnosing dental caries lesions. Practitioners should be familiar with the strengths, weaknesses, sensitivity, and specificity of the various detection methods. There is not a strong relationship between a dentist's clinical experience and more accurate diagnosis or conservative treatment options. Visual inspection is better, but both radiographic and LFpen methods show good performance in detecting more advanced interproximal caries lesions. The challenge is that they have good sensitivity (i.e., they detect disease when it is actually present), but poor specificity (i.e., they detect disease when it is not actually present). Look for rapid development of new and various forms of caries detection technologies, as new ideas from other disciplines are brought into the dental arena, and outcome measures show the abilities of various devices to predict the progression of caries lesions.

Editor's Note: We welcome readers' suggestions for topics and contributors to Critical Appraisal. Please address your suggestions to the section editor:

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