OCCLUSAL CARIES DETECTION

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Strategies to Avoid Underdiagnosing Pit-and-Fissure Caries

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Abstract: Traditionally, testing for whether pit-and-fissure caries should be restored involved probing with a sharp explorer and evaluating resistance to withdrawal (ie, "stick"). Alternative visual methods of evaluation and classification have been proposed, validated, and accepted formally in the core curriculum on caries management in both Europe and North America. This article examines the resistance to occlusal breakdown of fluoride-hardened enamel despite progression of underlying dentin caries with accompanying difficulty in diagnosis. Traditional methods of pit-and-fissure caries diagnosis, including radiographs or fissure probing with an explorer, have been shown to be inaccurate and potentially destructive. The clinical process of using the visual/tactile International Caries Detection and Assessment System (ICDAS) and/or the Caries Classification System (CCS) is described and illustrated through case examples.

LEARNING OBJECTIVES

- Discuss the potential for underdiagnosis of occlusal caries using explorer evaluation techniques and how the use of fluoride affects this issue
- Delineate the sequence for detecting and classifying pit-and-fissure lesions using established classification systems
- Explain how changes in restorative material options have impacted the decision-making process regarding pit-and-fissure caries

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Oftentimes patients present for an examination with the clinical finding of an occlusal fissure similar to that shown in Figure 1, yet there is no clinically perceptible "stick" with an explorer. The clinician thus faces the decision of whether occlusal decay exists requiring a restoration or whether the lesion should merely be "watched" to determine if it progresses further. To make the correct decision, an understanding of the detection and classification of pit-and-fissure lesions is needed.

For nearly a century, American dental schools have taught the technique of evaluating fissure caries by the use of an explorer (often sharpened) to probe firmly into the pit or fissure to determine the amount of tugback. Resistance to removal of the explorer, or "finding a stick," has been considered an indicator of the presence of caries that warrants the surgical intervention of a restoration, and it is a widely used detection method in the United States.[1,2] However, a large body of research-based evidence that has advanced the dental industry's understanding of both tooth structure and the caries process in fissure caries has demonstrated that this traditional explorer test is no longer a valid approach.[3-6]

Why Occlusal Caries Is Underdiagnosed

The use of fluoride to prevent dental caries has a long history of success. Enamel exposed to fluoride in water, dentifrice, and foods has been shown to be more resistant to acid attack than enamel not exposed to fluoride.[7] Fluoride use is especially beneficial in addressing smooth-surface caries; however, it may complicate the detection of caries in pits and fissures. The breakdown from caries of harder, fluoride-treated enamel around pits may be delayed until long after significant dentinal damage has occurred.[7] Occlusal caries may, therefore, be underdiagnosed, facilitating caries progression and further weakening of the tooth. Some fissures may undergo such an extensive progression under such circumstances that the first restoration will risk a pulp exposure (Figure 2).[7] A new approach, therefore, needs to be adopted for the diagnosis of occlusal fissure caries that avoids both the underdiagnosis of occlusal caries and the potential pitfall of merely "watching" a carious fissure rather than restoring it.

"Hidden" Caries

Also called "occult caries" or "non-cavitated caries," "hidden" carious lesions of fluoridated enamel are described as grooves


Fig 1.


Fig 2.


Fig 3.


Fig 4.


Fig 5.

Fig 1. Clinical presentation with no detectable fissure to probing. Blue marks indicate occlusion. **Fig. 2.** After removal of carious dentin in the tooth shown in Fig 1, the extent of disease, including possible compromise of pulp, is revealed. **Fig 3.** Clinical appearance with no perceptible "stick" with an explorer on a patient with tetracycline-stained teeth. **Fig 4.** Extent of caries upon exploration was very broad, undermining cusps. **Fig 5.** Example of explorer tip damaging decalcified tooth structure, possibly accelerating the caries process. Only slight chalkiness was visible when wet, but firm pressure broke through as seen.

that cannot be probed and, thus, appear to be closed, but may show a radiolucency on a radiograph.[8] However, the groove itself represents a developmental defect that functions as a cavitation would on a smooth surface, namely to allow fluid and nutrition to seep down to the bacteria in dentin, where a carious lesion can flourish.

When such a fissure that does not present an explorer "stick" is explored with a small-diameter bur in a procedure called a "caries biopsy," caries is nearly always found in areas with an underlying discoloration or shadow.[9] Any caries discovered can then be excavated where needed. The susceptibility of a fissure to explorer probing for a "stick" is, therefore, irrelevant to the diagnosis of caries within the fissure (Figure 3 and Figure 4).

Deficiencies of Explorer Test

The fact that caries can progress in a groove or pit that is seemingly intact and cannot be penetrated with an explorer makes the explorer test imprecise. The ongoing use of the explorer test and the lack of better caries diagnostic criteria may lead conscientious practitioners to either intervene too soon when little disease exists or avoid exploring or restoring these lesions due to the concern of weakening the tooth by the placement of a large restoration. If diagnosis is delayed inappropriately, more extensive loss of tooth structure, with the accompanying increased risk of insult to the pulp, may then create a requirement for more advanced treatment, which could even involve endodontic therapy.

Further, research has long shown that not only is the explorer "stick" inaccurate, but that attempted or actual penetration of a suspected lesion by an explorer can actually damage tooth structure (Figure 5) and even transmit caries bacteria into it. In fact, sharp explorers have been shown to create defects in completely healthy enamel, which can lead to future caries.[10,11] Additionally, probing the microbiomes of fissures from tooth to tooth can carry specific bacterial species from a given fissure to other fissures not previously infected by those bacterial species.[12]

Interestingly, dentistry's current system of classifying carious lesions, devised by G.V. Black more than a century ago, is based not upon characteristics or severity of the lesion but upon the surface based on the planned treatment.[13] As newer options for managing early carious lesions with composite resin have come into widespread use, more precise descriptions of these lesions have become essential and have promoted more conservative restorations. An additional advantage of conservative preparation design when using conventional and flowable composite placement is the allowance for a more detailed approach to caries diagnosis.

Shortcomings of Radiographs for Evaluating Occlusal Caries

Unlike interproximal lesions, where mineral structure in a single layer of enamel can be reliably detected on a bitewing radiograph,[14] occlusal lesions occur between cusps, where thicker, multiple layers of occlusal enamel tend to block radiographic evidence of dentin caries until extensive damage has occurred. Usually, if an occlusal lesion is detected on a bitewing, it is relatively large, while false positives are also common.[15-17]

Validated Diagnostic Systems

Several decades ago, an international group combined an in-depth review of all of the evidence supporting practices in fissure diagnosis with their own extensive clinical experience to develop a diagnostic algorithm that is based upon visual evaluation. After undergoing clinical validation in multiple countries by numerous investigators, this approach was codified[18] and published[19] as the International Caries Detection and Assessment System (ICDAS). ICDAS consists of a clinical pathway for evaluation of fissures using a set of visual criteria instead of the traditional explorer "stick." The original "full code" system identifies six categories of disease that are still used in clinical research. However, after

deployment of the system in clinical practice, a simpler "merged codes" classification was developed consisting of only three categories of disease.

ICDAS was first adopted as the standard curriculum in many European[20] and then South American[21] dental schools. More recently, a consensus meeting of representatives of a majority of North American schools took place, resulting in the development of a similar curriculum framework for caries management that includes ICDAS as the diagnostic model. Following its publication, this framework was reviewed and accepted by most American dental schools and has been published as a curricula framework for North American dental schools.[22]

The American Dental Association subsequently convened a panel of experts who reviewed the cumulative work done to date and then developed a simplified diagnostic system based on the same clinical approach. The resulting Caries Classification System (CCS)[23] consolidates the six categories of disease into three (similar to the ICDAS merged codes system). This system has been published and validated as well, with at least one pilot study showing better clinical concordance and provider acceptance than within the original framework of ICDAS.[24] The ICDAS and CCS classifications are summarized in Table 1.

Appropriate Diagnostic Technique in Light of Current Evidence

It has long been observed that subtle changes in the appearance of a fissure correspond to the extent of caries.[15,25] Current evidence indicates that the optimal approach to evaluating pit-and-fissure caries is to conduct the evaluation with the teeth clean and with adequate light and magnification, using a ball-ended periodontal probe[26] or explorer as required to only evaluate open cavitation or surface roughness rather than probe for lesions. As a baseline reference, Figure 6 and Figure 7 show a sound groove, and Figure 8 through Figure 16 show progression of disease.

To diagnose pit-and-fissure caries, clinically the tooth being assessed should first be wet, and the practitioner evaluates its pits and grooves for any decalcification, which typically presents as a chalky white area that follows the depth of the groove (Figure 10 and Figure 11). This finding with the tooth being wet defines an *ICDAS code 2 lesion*. Next, the grooves are dried completely using a 5-second air stream, and the clinician notes any areas of chalkiness in the now-dry grooves. Any such area of chalky decalcification noted only after drying would represent an *ICDAS code 1 lesion* (Figure 8 and Figure 9). Code 1 and/or code 2 lesions are classified as *CCS code 1 initial lesion*. If no chalkiness is noted in either a wet or dry groove or pit, the tooth structure is classified as sound and documented as *ICDAS and CCS code 0 sound structure* (Figure 6 and Figure 7). The presence of stain and hypocalcification should be disregarded.

Next, regardless of chalkiness, the clinician examines the dry grooves for the presence of any areas of localized enamel breakdown, or microcavitations, which represents *ICDAS code 3 lesions* (Figure 12 and Figure 13). Additionally, the presence of an underlying shadow, which indicates dentin caries showing through, is considered an *ICDAS code 4 lesion* (Figure 14). Either or both of these findings results in a classification of the tooth structure as *CCS code 2 moderate*.

Finally, if enamel is lost and carious dentin is visible, the tooth structure is classified as *CCS code 3 advanced*. The ICDAS system describes extent of the lesion by percentage of involved tooth surface. If less than half of the surface is involved, the lesion is an *ICDAS code 5 lesion* (Figure 15); when more than half of the surface is involved, the lesion is classified as an *ICDAS code 6 lesion* (Figure 16).

The case presented in Figure 17 and Figure 18 demonstrates significant pit-and-fissure caries that can be readily identified even though no clinical explorer "stick" was found.

TABLE 1

Summary of ICDAS and CCS Classification Systems for Pit-and-Fissure Caries

	ICDAS System			
CCS System	Merged Codes	Full Codes	Characteristics	Histologic Correlation
0 Sound	0 Sound	0	Same appearance wet or dry, no surface breakdown or underlying color change	No carious demineralization of enamel or dentin
1 Initial	A Initial	1	Chalkiness visible on drying, confined to fissure	Demineralization in outer half of enamel
		2	Chalkiness visible wet, wider than natural fissure or groove	Demineralization in inner half of enamel, outer third of dentin
2 Moderate	B Moderate	3	Areas of localized enamel breakdown (microcavitation) present in walls or base of groove, but no discontinuity	Localized enamel breakdown, extension to middle third of dentin
		4	Shadow visible from occlusal, more easily seen when tooth is wet	Middle third dentin ± microcavitation
3 Advanced	C Extensive	5	Carious dentin visible, but less than half of tooth surface	Inner third dentin; may involve pulp
		6	Visible dentin, cavitation involving more than half of tooth surface	Inner third dentin; may involve pulp


Fig 6.


Fig 7.


Fig 8.

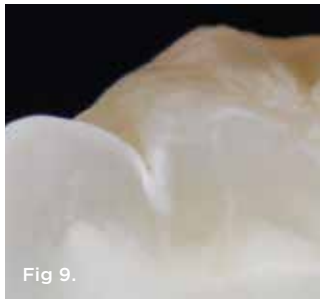
Fig 9.


Fig 10.


Fig 11.


Fig 12.


Fig 13.

Fig 6. ICDAS code 0: Clinical appearance of stained fissure with no evidence of shadow or decalcification after drying. **Fig 7.** ICDAS code 0: Sectioned tooth confirms stain not indicative of carious penetration of fissure. **Fig 8.** ICDAS code 1: Decalcified area in fissure visible after 5-second air drying. **Fig 9.** ICDAS code 1: Indicated groove on Fig 8 sectioned to show enamel decalcification in outer half of enamel. If caries risk assessment indicates disease, a sealant or preventive resin restoration could halt its progression. **Fig 10.** ICDAS code 2: Decalcified enamel is visible when wet and is notably wider than the natural fissure. **Fig 11.** ICDAS code 2: Tooth in Fig 10 sectioned to show penetration into outer third of dentin. **Fig 12.** ICDAS code 3: Area of localized enamel breakdown (microcavitation) indicated. **Fig 13.** ICDAS code 3: Section showing penetration of caries into middle third of dentin.

Role of Caries Risk Assessment

Unlike previous classification systems, which were focused on the planned restoration, ICDAS and CCS classifications describe the current level of carious presentation. However, a crucial additional dimension—caries risk—should be evaluated before a treatment decision is made. Validated caries risk assessment instruments are available to provide this essential context for the clinical presentation.[27-30]

Caries is a disease of the whole mouth that is influenced by various factors, including diet, specifically the frequency of simple carbohydrate intake; salivary flow, with special attention given to medications that restrict flow; and, to a lesser extent, oral hygiene. As manifestations of this whole-mouth disease, carious lesions must therefore be considered within the context of overall caries risk. From this perspective, it stands to reason that treatment of, for example, an early lesion in a 60-year-old patient with no other active carious lesions, no salivary restriction, and low frequency of carbohydrate intake will require a different approach than an identical lesion in a 16-year-old patient who consumes sugary sports drinks four times per day and has several other active lesions.[31,32] *(Editor's note: The authors intend to submit an article to* Compendium *later this year discussing the treatment planning of pit-and-fissure lesions.)*

Summary

Evidence has accumulated showing that occlusal caries is frequently underdiagnosed and consequently progresses unimpeded toward the pulp, and that the use of an explorer to detect caries is both unreliable and potentially damaging. As a result, clinicians may benefit from adopting either of the two validated visual detection and classification systems for pit-and-fissure caries into their routine practice in conjunction with a validated caries risk assessment instrument. By adopting this approach, clinicians may reduce the amount of occlusal caries they either miss or dismiss as not significant enough to require restoration, thereby increasing opportunities to intervene at an earlier stage of the disease process and preserve more tooth structure.

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Fig 14.


Fig 15.

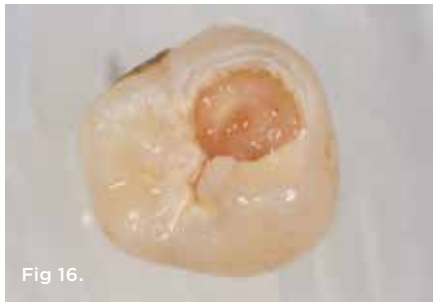
Fig 16.

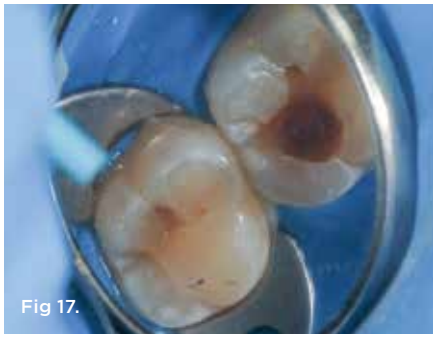
Fig 17.


Fig 18.

Fig 14. ICDAS code 4: Dark gray shadow visible in dentin in indicated area. **Fig 15.** ICDAS code 5: Carious dentin visible in less than half of the occlusal table. **Fig 16.** ICDAS code 6: Carious dentin visible in more than half of the occlusal table. **Fig 17.** Tooth No. 14 with visible shadow on central and distal pits with no explorer "stick," corresponding to ICDAS code 4. Patient has a high caries risk from frequent candy intake. **Fig 18.** Preparation shows significant penetration into dentin in both central and distal pit areas. Because composite was the planned restorative material, other grooves were only prepared to depth of decalcification.

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QUIZ

Strategies to Avoid Underdiagnosing Pit-and-Fissure Caries

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1. **When probing for fissure caries, resistance to removal of the explorer is also known as:**
   A. finding hidden caries.
   B. finding a stick.
   C. underdiagnosing the caries.
   D. closely watching a lesion.

2. **Fluoride use is beneficial in addressing smooth-surface caries, but it may complicate the detection of:**
   A. caries in pits and fissures.
   B. an explorer stick.
   C. radiolucency on a radiograph.
   D. interproximal lesions.

3. **What are described as grooves that cannot be probed and, thus, appear to be closed?**
   A. occult caries
   B. non-cavitated caries
   C. hidden carious lesions of fluoridated enamel
   D. All of the above

4. **Caries is usually found in areas with underlying discoloration when a fissure that does not present a "stick" is explored with a small-diameter bur in a procedure called:**
   A. a tugback technique.
   B. a caries biopsy.
   C. tooth bleaching.
   D. dental prophylaxis.

5. **Because caries can progress in a groove or pit that is seemingly intact and cannot be penetrated with an explorer, the explorer test is:**
   A. imprecise.
   B. highly reliable.
   C. foolproof.
   D. appropriate in light of current evidence.

6. **Dentistry's current system of classifying carious lesions was devised by:**
   A. G.V. Black.
   B. A. Lussi.
   C. P.I. Brånemark.
   D. None of the above

7. **What type of lesions that occur between cusps tend to block radiographic evidence of dentin caries?**
   A. interproximal lesions
   B. occlusal lesions
   C. buccal lesions
   D. early lesions

8. **The ADA's diagnostic system that consolidates six categories of disease into three is the:**
   A. International Caries Detection and Assessment System (ICDAS).
   B. Caries Classification System (CCS).
   C. Dental Practice-based Research Network (DPBRN).
   D. Rationale and Evidence for Caries Detection (RECD).

9. **When diagnosing pit-and-fissure caries, after the grooves are dried completely, any areas of chalky decalcification noted would represent:**
   A. ICDAS code 1 lesion.
   B. CCS code 2 moderate.
   C. ICDAS code 3 lesion.
   D. ICDAS code 4 lesion.

10. **When diagnosing pit-and-fissure caries, if enamel is lost and carious dentin is visible, the tooth structure is classified as:**
    A. CCS code 0 sound structure.
    B. CCS code 2 moderate.
    C. CCS code 3 advanced.
    D. ICDAS code 3 lesion.

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