

## Caries Process, Prevention, and Management: Epidemiology



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Dentists, Dental Hygienists, Dental Assistants, Dental Students, Dental Hygiene Students, Dental Assisting Students, Advanced Dental Therapists

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### Conflict of Interest Disclosure Statement

- Dr. Malik Chopra is a Board member of the American Academy of Cariology (AAC), and also serves as the Chair elect for American Dental Education Association Section for Cariology and Cariology consultant to the American Dental Association (ADA). She has no conflicts of interest or other relevant financial relationships to disclose.

### Short Description – Forensic Dentistry

This is part 6 of a 10-part series entitled Caries Process, Prevention and Management. This course introduces dental professionals to the importance of caries diagnosis in preventing dental disease and its vital connection to treatment planning. A precise and early diagnosis of caries is fundamental to implementing effective preventive measures, minimizing the need for invasive interventions, and ensuring optimal patient outcomes.

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## Overview

The two main methods of lesion diagnosis used today—the visual-tactile or visual methods and bitewing radiography; are discussed, including recent advancements that improve their sensitivity, as well as their limitations.

Topics also include newer evidence-based approaches to caries diagnosis and management, a brief discussion of why too-early caries lesion diagnosis can be counterproductive and the benefits of enlisting the help of pediatricians in diagnosing caries in children.

## Learning Objectives

**Upon the completion of this course, the dental professional should be able to:**

- Understand the role of caries diagnosis in disease prevention.
- Differentiate between various types of carious lesions and their activity status.
- Utilize both conventional and advanced diagnostic tools effectively.
- Integrate caries diagnosis into comprehensive treatment planning.
- Discuss the difference between the medical and dental perspective of caries diagnosis.
- Identify the tools and diagnostic criteria of visual-tactile methods.
- Be familiar with the benefits and limitations of visual-tactile methods.
- Identify diagnostic criteria of the bitewing radiography method, as well as its benefits and limitations.

## Glossary

**Artificial Intelligence (AI)**- Refers to technology that allows computers and machines to mimic human abilities such as learning, understanding, problem-solving, decision-making, creativity, and independence.

**biofilm** – An aggregation of microorganisms in which cells adhere to each other, forming small communities that are held together by an extracellular polymeric matrix. Different communities are co-dependent on each other, and the whole biofilm forms a defensive mechanism requiring much higher concentrations of antimicrobials to control its growth. Dental plaque is a previous name for what is now called the biofilm. However, recent understanding of the biofilm leads to the development of the “microbiome” ecological model; because bacteria are normally present in the oral cavity.

**bitewing radiography** – The process of creating radiographic images of the posterior teeth, with the specific objective of identifying carious lesions on the proximal surfaces that may be inaccessible to visual and tactile examination. Less mineralized tissues permit more x-rays to pass through (radiolucency) and therefore create greater levels of exposure to radiographic film or a digital transducer.

**demineralization** – The chemical process by which minerals (mainly calcium) are removed from the dental hard tissues - enamel, dentin, and cementum. The chemical process occurs through dissolution by acids or by chelation, and the rate of demineralization will vary due to the degree of supersaturation of the immediate environment of the tooth and the presence of fluoride. Under optimal conditions, the minerals may be replaced through the process of remineralization.

**dental plaque** – An organized community of many different microorganisms that forms itself into a biofilm and is found on the surface of the tongue and all hard surfaces in the oral cavity. Dental plaque is present in all people and can vary from being comprised of totally healthy microorganisms (commensals) to being very harmful (pathogenic), predisposing the patient to dental caries or periodontal diseases. Note: Dental plaque is not food debris, nor does it contain food debris. Dental plaque can only be completely removed by mechanical means such as toothbrushing or prophylaxis. Food debris can be removed by rinsing.

**ICCMS** – An acronym for the International Caries Classification and Management System (ICCMS™) which is a standardized system focused on improving long-term caries outcomes; it combines history taking, clinical examination, risk assessment and personalized care planning at the individual patient level.

**ICDAS** – An acronym for the International Caries Detection and Assessment System, which is an integral aspect of the ICCMS™ approach. While the ICCMS™ represents a new, enhanced approach to the diagnosis and management of caries, the ICDAS System

provides a standardized method for assessing and tracking changes in caries activity.

**lesion** – Any abnormal well-circumscribed change in any tissue due to disease or injury. In terms of dental caries, the lesion is the part of the tooth that has undergone the caries process. Lesions are currently classified in the following ways: 1) non-active lesions (which do not require intervention because biofilm metabolic activity is unlikely to lead to mineral loss); 2) non-cavitated lesions, which may be restored through the use of non-operative approaches, such as remineralization therapies (i.e. brushing with fluoridated toothpaste); 3) active lesions, which indicate ongoing mineral loss, and may be responsive to non-operative therapies; and 4) cavitated lesions, where a hole has developed in the tooth that requires restoration via surgical intervention, such as a filling.

**microbiome** – Normal bacterial species that are present at all the times in the human body and their presence is necessary for maintaining health, especially in the digestion of foods and in keeping away detrimental bacterial species.

**microporosity** – An area of the enamel surface that has developed a level of porosity not clearly visible to the naked eye; the resulting change in surface texture may be detected by a dental probe/explorer. Microporosity is a sign of demineralization and could be indicative of the initiation of a caries lesion.

**remineralization** – The chemical process by which minerals (mainly calcium) are replaced into the substance of the dental hard tissues - enamel, dentin and cementum. The process requires an ideal environment that includes supersaturation with calcium and phosphate ions, and adequate buffering. In the presence of fluoride, the remineralization process is enhanced.

**tomography** – Use of radiography to create a focused image of structures in a defined plane or 'slice,' ignoring all other structures that would normally appear in three dimensions. A series of tomography scans can help build a clearly focused 3D image.

## Introduction

Caries detection and diagnosis involves recognizing the presence of caries based on observable signs and symptoms. This process serves as the foundation for clinical decision-making regarding disease identification, preventive measures, and treatment options.<sup>1</sup> When developing a treatment plan, the stage and progression of dental caries determine the appropriate management approach.<sup>2</sup> In the early stages, preventive or non-restorative methods are typically recommended to halt progression and promote remineralization of affected tissues.<sup>3,4</sup>

For moderate to severe carious lesions, minimally invasive operative treatments combined with caries control strategies are necessary.<sup>5,6</sup> Thus, an accurate and timely diagnosis is essential for selecting the most effective treatment plan and interventions to prevent further caries development.<sup>7</sup> Additionally, in the recent decades, advancements in dental caries management have evolved alongside a growing understanding of the disease. These developments have led to ongoing discussions on the most effective strategies for both prevention and treatment. It is now evident that dentists must integrate new concepts and technologies into their approach to caries diagnosis, assessment, and management.<sup>8</sup>

The scientific literature points to three main reasons why caries **lesion** diagnosis is important:

1. To achieve the best health outcome for the patient by classifying caries lesions corresponding to the best management options for each lesion type. Lesions are currently classified in the following way:

**a. Non-cavitated lesions**, also referred to as pre-cavitated lesions, early lesions, incipient lesions, superficial caries, or commonly known as “white spot” lesions, can often be managed with non-operative approaches, such as remineralization therapies (e.g., brushing with fluoridated toothpaste).<sup>8</sup> (Note: It is important to refrain from using a sharp probe during a clinical examination. The application

of pressure with a sharp tip can lead to permanent damage to the demineralized enamel surface, potentially converting a reversible lesion into a cavitated one. It is recommended to use a probe with a dull end and apply gentle pressure.<sup>8,9,10</sup>

**b. Cavitated lesions**, are when a hole has developed in the tooth as tissue destruction persists, which leads to surface breakdown and the formation of a micro-cavity— a localized defect in the enamel without undermining. If this discontinuity in the enamel continues to progress, eventually exposing the dentin and this then results in what is known as a “cavitated lesion” that requires restoration via surgical intervention, such as a filling after excavation of the carious tissue.<sup>11</sup>

**c.** These lesions are further categorized as either **active** or **non-active** (arrested) lesions:

**I. active lesions**, which indicate ongoing mineral loss, and may be responsive to non-operative therapies.

**II. non-active lesions** (which do not require intervention because biofilm metabolic activity is unlikely to lead to mineral loss).<sup>12</sup>

2. To inform the patient. The patient is the key in the management process because their cooperation is crucial in controlling the disease and slowing or reversing caries progression. Therefore, providing them with as much information as possible about the caries diagnosis is very important.<sup>2</sup>
3. To monitor the clinical course of the disease. Caries development is a dynamic process and long-term monitoring of all stages of caries lesions and recording changes in activity status or surface integrity is the only way to tell if caries is reversing or progressing. An active lesion that becomes inactive is a positive outcome, while active lesions that remain active reflect a lack of compliance or cooperation on the part of the patient, and professional intervention may be needed.<sup>2</sup>

What follows is a discussion of the different methods of caries diagnosis and highlights the close relationship between diagnosis and disease management.

Historically, clinicians primarily relied on the use of caries measurement systems that focused solely on the assessment of the presence and severity of cavitated lesions. However, as our understanding of caries has evolved, we now recognize it as a dynamic process. Non-cavitated lesions have the potential to either reverse through remineralization or progress due to demineralization, depending on individual patient conditions.

Due to the ability of early lesions to reverse through the use of preventative therapies, such as the use of fluoridated toothpastes, mouthrinses or other remineralization therapies, early detection has become increasingly important. Identifying caries at the earliest possible stage maximizes the opportunity to preserve natural tooth structure, leading to better long-term oral health outcomes.

In recent years, significant efforts have been made to develop comprehensive caries measurement systems that assess the disease across its entire continuum, starting from the earliest non-cavitated lesions. These advancements reflect a shift from merely identifying cavitated lesions to a more nuanced approach that considers the dynamic nature of caries development and progression.

The most widely used system now available is the International Caries Detection and Assessment System (**ICDAS**), an evidence based integrated system that includes all of the best understanding of caries to provide a standardized method for monitoring both the initiation and progression of caries across this continuum. Later in this course, we will explore the International Caries Classification and Management System (ICCMS), which is closely linked to ICDAS. While ICDAS primarily focuses on identifying and classifying caries, ICCMS builds upon this by offering a structured, risk-based approach to patient-centered caries management.<sup>13</sup>

## Clinical Significance Snapshots

### What is the difference between Diagnosis and Assessment of dental caries?

Dental caries assessment identifies the presence or absences of disease indicators. Diagnosis links the level of appropriate care to the stage of the disease. Diagnosis is performed at the tooth surface or tooth level. Risk assessment is conducted at the patient level and should include evaluation of medical and dental histories, biological, social and behavioral risk factors, and all clinical evidence gained from a thorough examination using visual and tactile methods. Further evidence gained from other tests such as bitewing radiography is also considered. Once identified, the individual lesions should be assessed for their activity status, which will determine the specific management strategies for each caries lesion. Preventive care should be risk-based and provided for all patients. Low, medium and high caries risk patients should receive preventive and behavioral interventions adjusted to their risk status. Lesion severity (initial, moderate, or extensive) should determine the need for non-surgical or surgical dental care to control caries or eliminate it. The inclusion of non-cavitated lesions in this assessment is essential, as the measurement of these lesions is a relevant indicator for long-term dental health.

## Caries Diagnosis Definition

### The Medical Perspective

Dentistry has often turned to medicine for guidance in clarifying concepts and methodologies, including when it comes to caries diagnosis. From a medical standpoint, caries diagnosis is as such: “the recognition of a disease or a condition by its outward signs and symptoms.”<sup>14</sup> This process involves identifying signs and symptoms, devising tentative hypotheses about the underlying disease based on these signs, gathering information by doing a physical examination, and performing appropriate diagnostic tests. The test results are then used to confirm or refute the tentative diagnosis, and, if necessary,



choose an alternative diagnosis. Physicians are encouraged to repeat this cycle of symptom recognition and testing of alternative hypotheses until the final diagnosis is reached, or if the prescribed treatment does not have the desired effect then to reassess and adjust the diagnosis accordingly.

### The Dental Perspective

However, the medical perspective of caries may not work perfectly when it comes to dental caries. The main task for the dentist is not to find out what disease the patient has, but having identified a patient with dental caries, to determine the best course of treatment for managing the disease process in the biofilm. Also, the dentist needs to identify whether or not individual teeth have caries lesions, with the help of screening even patients who do not have obvious signs of caries, and determine the most appropriate treatment for the patient. Therefore, from a dental perspective, caries diagnosis, involves both identifying caries as a biofilm disease and managing it, as well as recognizing specific signs and symptoms of caries, the continuum of non-cavitated to cavitated lesions, and managing the lesion activity. This approach works under the premise that caries can be prevented, slowed, stopped, or even reversed through the process of remineralization if detected and treated before progressing to a point requiring invasive intervention.

### Diagnosis vs. Detection and Assessment

Caries diagnosis is often described as the process of identifying a disease based on its observable signs and symptoms, while caries detection refers to the identification of these signs and symptoms.<sup>1</sup> The diagnosis of dental caries should be based on known disease indicators and risk factors for the disease. Caries disease indicators include: visible cavitations, active white-spot lesions, interproximal radiographic lesions penetrating to the dentin, and a history of any cavitations in the previous 2 to 3 years.<sup>16</sup> However, there is often ambiguity in the literature regarding the distinction between caries detection and diagnosis.<sup>17</sup> Over the past decade, three key terms have been clarified in relation to preventive caries care: **lesion detection**,

which involves using objective methods to determine the presence of disease;<sup>18</sup> **lesion assessment**, which focuses on characterizing or monitoring a lesion once it is detected;<sup>19</sup> and **caries diagnosis**, which should represent a comprehensive evaluation by a healthcare professional, integrating all available data.<sup>16</sup>

If demineralization at any stage is observed—at whatever stage—it is labeled as dental caries.

### Caries Lesion Diagnosis: Visual - Tactile Methods

Visual and tactile methods typically go hand in hand, because most dentists use dental probes and other tools to examine teeth during the clinical examination. The exam can be annually, twice a year, or more frequently, depending on the dentist's recommendation which should be adjusted based upon the age of the patient and their risk status.<sup>13</sup> The first visual indication of caries in enamel is generally a small white lesion on smooth surfaces or a light to dark brown lesion in pits or fissures, where demineralization has occurred under the **dental plaque**. However, grayish lesions also can be seen at the level of dentin, and in more advanced stages, caries can appear as open cavities on enamel, dentin layers, or all the way to the pulp.

### Tools

The traditional method of detecting caries signs is by visual inspection of dental surfaces, with the aid of a bright light and dental mirror, if necessary, to see the teeth from all angles. Reflecting light onto the mouth mirror also can be done to search for underlying dark shadows that could indicate dentin lesions.

For more than a decade, the use of sharp dental probes in clinical examinations has been challenged as an unsuitable method for evaluating dental lesions.<sup>21,22</sup> The pointed tip of these probes can potentially cause irreversible harm to demineralized enamel, leading to the formation of cavities.<sup>8</sup> While the use of a dental probe continues to be controversial, it is extremely helpful when used correctly and judiciously. A dental probe can be used to remove plaque that may be covering lesion, and when the blunt side of the probe is used, it can help remove biofilm to check for signs of

demineralization and to assess the surface roughness of a lesion. The accuracy of caries detection does not increase if probing is used. A probe is unnecessary if visual inspection detects a cavity.<sup>20</sup> During a visual-tactile examination, the dentist will also use a syringe or drying tool to blast air on to the tooth, which makes it easier to see some lesions.<sup>11</sup>

Despite these concerns, many general dentists continue to rely on sharp probes for tactile assessments.<sup>23</sup> As a safer alternative, the use of a ball-ended explorer has been recommended for caries evaluation. While sharp probes may provide better differentiation of surface roughness, the ball-ended explorer is considered a safer option due to its rounded tip, which minimizes the risk of enamel damage.<sup>24,25</sup>

Other tools used in visual-tactile examination may include magnifying devices to look at teeth, or orthodontic elastic separators to separate teeth over the course of 2 to 3 days for a closer look between teeth prone to caries lesions. Fiber-optic transillumination is also sometimes used. This is a method by which visible light is emitted through the tooth using an intense light source. If the transmitted light reveals a shadow, this may indicate a carious lesion.

## Diagnostic Criteria

### WHO Method

Numerous methods have been suggested for recording lesions and carious lesion activity. In the past, one of the most commonly used visual-tactile or visual criteria that have been used include the WHO method,<sup>26</sup> which limits the assessment to one in which only cavitated lesions are recorded. The rationale for this approach was an assumption that reliable diagnosis of all non-cavitated lesions was unlikely. Because the focus is only on open cavities, it ignores the fact that non-operative interventions (such as fluoride) can help reduce caries risk by enabling reversal of the disease process through the remineralization process. Therefore, most dentists in developed countries today do not rely solely on this criterion.<sup>11,15</sup>

## ICCMS™ and ICDAS Systems

**The ICCMS™ approach.** Over the past few decades, there was a growing recognition of the need for a more standardized and robust method for classifying dental caries—one that extends beyond merely categorizing disease stages. Additionally, a systematic approach was needed to interpret clinical trial results in systematic reviews and align research outcomes with modern caries measurement and management practices. To address these challenges, numerous meetings, workshops, and conferences were held to develop an internationally accepted standard for diagnostic measurement and patient care. A key outcome of these efforts was the International Caries Classification and Management System (ICCMS™) a standardized method based on the current best approaches. This system, which is focused on improving long-term caries outcomes, combines history taking, clinical examination, risk assessment and personalized care planning at the individual patient level.<sup>27</sup>

This system was designed to develop a comprehensive care plan that incorporates:

- Preventing caries initiation (primary prevention)
- Preventive management of early caries (secondary prevention)
- Tooth preserving operative plan (minimally invasive)
- Review, monitoring and recall (Ensuring long-term disease control through recall and follow-up)

This comprehensive care plan takes into account key risk factors for the individual patient, recommends inclusion of caries detection aids and lesion activity assessments and then lays out clear caries management strategies to obtain optimal results.

In certain aspects, such as lesion activity assessments, the ICCMS™ represents an evolution of several classification systems that have been in use since the late 1990s.<sup>28</sup> Additionally, other established systems have been integrated into the ICCMS™ framework whenever they reflected the most effective approaches in their respective areas. The ICDAS System is an integral aspect of the ICCMS™

approach. While the ICCMS™ represents a new, enhanced approach to the diagnosis and management of caries, the ICDAS System provides a standardized method for assessing and tracking changes in caries activity. The ICDAS System was developed in 2002 (ICDAS I) and was later modified to ICDAS II in 2005.<sup>29</sup> The ICDAS I and II criteria incorporate concepts from the research conducted by Ekstrand et al,<sup>30,31</sup> Nyvad<sup>32</sup> and other caries detection systems, as reported in the systematic review of Ismail and colleagues<sup>8</sup> is broadly considered to be the most appropriate and reliable caries reporting system currently available. As a result, the ICDAS lesion evaluation criterion serves as the basis for determining the stages of the caries process and lesion activity for the purpose of caries management within the ICCMS™ approach.<sup>33</sup>

The ICDAS criteria for visual examination and, when indicated, for radiographic examination, should be followed to assess the extent and severity of caries lesions. The ICDAS categories of caries lesion severity correlate well with histological depth of caries demineralization in both enamel and dentin. It is important to note that the histological depth of lesions correlates with demineralization but not necessarily with bacterial penetration.

To provide context, several of the measures used to evaluate lesion activity in ICDAS are derived from earlier research that identified key factors influencing caries activity. These include methods for assessing lesion depth, activity, as well as considerations for root caries and recurrent lesions.

#### **Lesion depth assessment.**

When assessing lesion depth, it's essential to understand the effect of moisture on the tooth surface. White spot lesions appear more opaque when the dental tissue is dry, due to increased light scattering. Generally, non-cavitated lesions visible on a wet tooth have progressed further, while those only visible after drying are typically less advanced.

Based on these concepts, Ekstrand and colleagues<sup>30,31</sup> suggested a visual, ranked

scoring system for lesion depth assessment that is still commonly used. Without using a probe, they examined tooth surfaces according to the following criteria:

- no or slight change in enamel translucency after 5 seconds of air-drying
- opacity or discoloration that is barely visible on wet surfaces, but becomes visible after 5 seconds of air-drying
- opacity or discoloration that is clearly visible without the need for air-drying
- localized enamel breakdown with opaque or discolored enamel, and/or grayish discoloration from the underlying dentin
- cavitation in opaque or discolored enamel exposing dentin.

#### **Lesion activity assessment.**

This method, developed in 1999 by Nyvad et al,<sup>32</sup> emphasizes evaluating the surface characteristics of lesions, particularly their activity as indicated by surface texture, and surface integrity, which is determined by the presence or absence of cavities or microcavities. The rationale behind this approach is that the surface characteristics of enamel change in response to changes in the biofilm covering the tooth surface.

The diagnostic categories are as follows: active, non-cavitated; active, cavitated; inactive, non-cavitated; inactive, cavitated; filling; filling with active caries; filling with inactive caries.

- Active, non-cavitated enamel caries lesions have a whitish/yellowish opaque surface, with a chalky or neon-white appearance, and the surface feels rough when a probe is moved across it.
- Inactive, non-cavitated lesions, on the other hand, are shiny and can vary in color from white, brown, or black, and will feel smooth with gentle probing.
- Active, cavitated lesions feel soft or leathery, while inactive, cavitated lesions are shiny and feel hard with probing.
- In general, active, non-cavitated lesions have a higher risk of progressing to a cavity than inactive, non-cavitated lesions, which have a higher risk of becoming a cavity than healthy surfaces.<sup>11,32</sup>



## Recording root-surface caries.

This is a classification specific to root caries lesions that integrates activity assessment and surface integrity assessment. The diagnostic categories are as follows:

- inactive lesion without surface destruction
- inactive lesion with cavity formation
- active lesion without surface destruction
- active lesion with surface destruction (cavitation), but visually cavity does not exceed 1 mm in depth
- active lesion with a cavity depth exceeding 1 mm, but does not involve pulp
- lesion expected to penetrate into pulp
- filling confined to root surface or extending from a coronal surface to root surface
- filling with an inactive lesion (secondary) confined to the margin.<sup>34</sup>

**Recording recurrent caries.** This refers to caries at the margins of restorations, with recurrent caries reflecting the result of unsuccessful plaque control. These are typically found on the gingival margins of all classes of restorations, with the exception of class I restorations, which affect pit-and-fissure crevices on occlusal, buccal, and lingual surfaces of posterior teeth and lingual surfaces of anterior

teeth.<sup>35</sup> It is essential to distinguish between recurrent caries and stained margins on resin-based composite restorations.<sup>35</sup> Diagnosis is accomplished using the Nyvad criteria in the lesion activity assessment section described previously.








## Diagnostic Criteria for Assessing Coronal Caries Lesion Activity

Based on the outcome of numerous symposia on the topic of caries diagnostics and assessment, ICDAS criteria were developed to describe various aspects of caries activity. The following figure and tables provide a summary of these criteria, along with the six different ICDAS codes used to identify each occlusal condition.

In general, the following criteria apply:

- An **Active Lesion** is considered to have a greater likelihood of transition (progression, arrest or regression) than an inactive lesion.
- An **Inactive (arrested) Lesion** is considered to have a lesser likelihood of transition than an active lesion.

In alignment with Figure 1, the characteristics of active coronal lesions (not all characteristics need to be present to decide activity status) are as follows.<sup>33</sup>

Occlusal Protocol ***							
ICDAS code	0	1	2	3	4	5	6
							
Definitions	Sound tooth surface; no caries change after air drying (5 sec); or hypoplasia, wear, erosion, and other noncaries phenomena	First visual change in enamel; seen only after air drying or colored change "thin" limited to the confines of the pit and fissure area	Distinct visual change in enamel; seen when wet, white or colored, "wider" than the fissure/fossa	Localized enamel breakdown with no visible dentin or underlying shadow; discontinuity of surface enamel, widening of fissure	Underlying dark shadow from dentin, with or without localized enamel breakdown	Distinct cavity with visible dentin; frank cavitation involving less than half of a tooth surface	Extensive distinct cavity with dentin; cavity is deep and wide involving more than half of the tooth
Histologic depth		Lesion depth in P/F was 90% in the outer enamel with only 10% into dentin	Lesion depth in P/F was 50% inner enamel and 50% into the outer 1/3 dentin	Lesion depth in P/F with 77% in dentin	Lesion depth in P/F with 88% into dentin	Lesion depth in P/F with 100% in dentin	Lesion depth in P/F 100% reaching inner 1/3 dentin
Sealant/restoration Recommendation for low risk	Sealant optional DIAGNOdent may be helpful	Sealant optional DIAGNOdent may be helpful	Sealant optional or DIAGNOdent is 20-30	Sealant or minimally invasive restoration needed	Minimally invasive restoration	Minimally invasive restoration	Minimally invasive restoration
Sealant/restoration Recommendation for moderate risk	Sealant optional DIAGNOdent may be helpful	Sealant recommended DIAGNOdent may be helpful	Sealant optional or DIAGNOdent is 20-30	Sealant or minimally invasive restoration needed	Minimally invasive restoration	Minimally invasive restoration	Minimally invasive restoration
Sealant/restoration Recommendation for high risk *	Sealant recommended DIAGNOdent may be helpful	Sealant recommended DIAGNOdent may be helpful	Sealant optional or DIAGNOdent is 20-30	Sealant or minimally invasive restoration needed	Minimally invasive restoration	Minimally invasive restoration	Minimally invasive restoration
Sealant/restoration Recommendation for extreme risk **	Sealant recommended DIAGNOdent may be helpful	Sealant recommended DIAGNOdent may be helpful	Sealant optional or DIAGNOdent is 20-30	Sealant or minimally invasive restoration needed	Minimally invasive restoration	Minimally invasive restoration	Minimally invasive restoration
* Patients with one (or more) cavitated lesion(s) are high-risk patients. ** Patients with one (or more) cavitated lesion(s) and xerostomia are extreme-risk patients.							
*** All sealants and restorations to be done with a minimally invasive philosophy in mind. Sealants are defined as confined to enamel. Restoration is defined as in dentin. A two-surface restoration is defined as a preparation that has one part of the preparation in dentin and the preparation extends to a second surface (note: the second surface does not have to be in dentin). A sealant can be either resin-based or glass ionomer. Resin-based sealants should have the most conservatively prepared fissures for proper bonding. Glass ionomer should be considered where the enamel is immature, or where fissure preparation is not desired, or where rubber dam isolation is not possible. Patients should be given a choice in material selection.							

**Figure 1.** The International Caries Detection and Assessment System (ICDAS).<sup>36</sup>

**Figure 1.** The International Caries Detection and Assessment System (ICDAS).<sup>36</sup>

ICDAS Code	Characteristics of Lesion	
	Signs of Active Lesion	Signs of Inactive Lesion
Initial to Moderate Stage Caries (1-4)	Surface of enamel is whitish/yellowish; opaque with loss of luster; feels rough when the tip of the probe is moved gently across the surface. Lesion is in a plaque stagnation area, i.e. in the entrance of pits and fissures, or near the gingiva, and in approximal surfaces below the contact point. Lesion was covered by thick plaque prior to cleaning.	Surface of enamel is whitish, brownish or black. Enamel may be shiny and feels hard and smooth when the tip of the probe is moved gently across the surface. For smooth surfaces, the caries lesion is typically located at some distance from the gingival margin. Lesion was not covered by thick plaque prior to cleaning.
Extensive Stage Caries (5-6)	Dentin feels soft or leathery on probing	Dentin is shiny and hard on probing

For the purpose of caries management, individual tooth surfaces are categorized and described, based on an evaluation of each surface affected, using the following criteria:

For pits and fissures, the evaluation criteria are as follows:

**Figure 2.** Pits and Fissures Evaluation Criteria.

Tooth Surface Description	Evaluation Criteria	ICDAS Code
Sound surfaces	No visible caries when viewed clean and dry. Non-carious white or brown marks on tooth surfaces must be differentiated from early caries lesions.	0
Initial stage caries	Characterized by the first visual change in enamel (seen only after prolonged air drying or restricted to the confines of a pit or fissure).	1
	OR A distinct visual change in enamel (seen on a wet or dry surface).	2
Moderate stage caries	Characterized visually by either localized enamel breakdown (without visual signs of dentinal exposure). • Enamel breakdown is often viewed best when the tooth is air dried.	3
	OR An underlying dark shadow from dentin. • Shadowing from dentinal caries is often best seen with the tooth surface wet.	4
Extensive stage caries	Characterized by distinct cavitation exposing visible dentin. • Lesions exhibiting cavitation involving less than half the tooth surface. • Lesions involving half of the tooth surface or more.	5

For mesial and distal surfaces, the evaluation criteria are as follows:

**Figure 3.** Mesial and Distal Surfaces Evaluation Criteria.

Tooth Surface Description	Evaluation Criteria	ICDAS Code
Sound surfaces	No visible caries when viewed clean and dry. Non-carious white or brown marks on tooth surfaces must be differentiated from early caries lesions.	0
Initial stage caries	Characterized by the first visual change in enamel (seen only after prolonged air drying).	1
	OR  A distinct visual change in enamel (seen on a wet or dry surface). • These lesions are usually seen directly from the lingual or buccal directions but may be viewed from the occlusal direction as a shadow confined to enamel.	2
Moderate stage caries	Characterized visually by either localized enamel breakdown (without visual signs of dentinal exposure). • Enamel breakdown is often viewed best when the tooth is air dried.	3
	OR  An underlying dark shadow from dentin. • Shadowing from dentinal caries is often best seen with the tooth surface wet.	4
Extensive stage caries	Characterized by distinct cavitation exposing visible dentin. • Lesions exhibiting cavitation involving less than half the tooth surface. • Lesions involving half of the tooth surface or more.	5
		6

For buccal-lingual smooth surfaces, the evaluation criteria are as follows:

**Figure 4.** Buccal-lingual Smooth Surfaces Evaluation Criteria.

Tooth Surface Description	Evaluation Criteria	ICDAS Code
Sound surfaces	No visible caries when viewed clean and dry. Developmental defects like enamel hypoplasias, fluorosis, tooth wear (attrition, abrasion and erosion), and extrinsic or intrinsic stains should be recorded as sound in the absence of other signs of caries lesions, as described below.	0
Initial stage caries	Characterized by the first visual change in enamel (seen only after prolonged air drying).  OR  A distinct visual change in enamel (seen on a wet or dry surface). • Initial stage lesions on free smooth surfaces are located in close proximity (in touch or within 1 mm) to the gingival margin or adjacent to orthodontic or prosthetic attachments on a tooth surface.	1
		2
Moderate stage caries	Characterized visually by either localized enamel breakdown (without visual signs of dentinal exposure). • Enamel breakdown is often viewed best when the tooth is air dried.  OR  An underlying dark shadow from dentin. • Shadowing from dentinal caries is often best seen with the tooth surface wet.	3
		4
Extensive stage caries	Characterized by distinct cavitation exposing visible dentin. • Lesions exhibiting cavitation involving less than half the tooth surface. • Lesions involving half of the tooth surface or more.	5
		6

### Diagnostic Criteria for Detection of Root Caries and Assessing Root Lesion Activity

- For the purpose of root caries detection, removal of calculus and plaque is recommended.
- The characteristics of the base of the discolored area on the root surface can be used to determine whether or not the root caries lesion is active.
  - These characteristics include texture (smooth, rough), appearance (shiny or glossy, matte or non-glossy) and perception of texture on gentle probing (soft, leathery, hard).

- Active root caries lesions are usually located within 2mm of the crest of the gingival margin.

In addition to the use of these diagnostic criteria for evaluating both coronal and root caries, the ICCMS™ system calls for an assessment of surfaces surrounding restorations and sealants, to ensure that no surface is overlooked. Another important diagnostic aspect of the ICCMS™ system is an evaluation of the biofilm, particularly with regard to its location and thickness. The data indicate that dental caries infection occurs due to a shift in the



microbial ecology within the oral cavity and further suggest there is increased caries risk associated with plaque/biofilm accumulation. Therefore, an ongoing evaluation of the biofilm is recommended to monitor for any significant

changes that might be indicative of lesion activity.

Evaluation criteria for assessing root caries are as follows:

Code	Evaluation Criteria
E	If for any reason a root surface cannot be visualized directly, or with the assistance of gentle air drying, code E (excluded) can be recorded on the dental chart.
0	<p>The root surface does not exhibit any unusual discoloration that distinguishes it from the surrounding or adjacent root areas nor does it exhibit a surface defect either at the cemento-enamel junction or wholly on the root surface. The root surface has a natural anatomical contour,</p> <p><b>OR</b></p> <p>The root surface may exhibit a definite loss of surface continuity or anatomical contour that is not consistent with the dental caries process. This loss of surface integrity usually is associated with dietary influences or habits such as abrasion or erosion. These conditions usually occur on the facial (labial) surface. These areas typically are smooth, shiny and hard. Abrasion is characterized by a clearly defined outline with a sharp border, whereas erosion has a more diffuse border. Neither condition shows discoloration.</p>
1	There is a clearly demarcated area on the root surface or at the cemento-enamel junction (CEJ) that is discolored (light/dark brown, black) but there is no cavitation (loss of anatomical contour).
2	There is a clearly demarcated area on the root surface or at the cemento-enamel junction (CEJ) that is discolored (light/dark brown, black) and there is cavitation (loss of anatomical contour $\geq 0.5$ mm) present.



### Radiographic Examination in the ICCMS™

There is a unanimous agreement that more caries lesions can be identified by combining radiographic information with clinical findings, compared to visual inspection alone. For this reason, ICCMS™ recommends the inclusion of radiographic examination, if possible and appropriate based on local safety standards. Radiographic examination is useful to confirm the extent of caries, to detect lesions where visual examination of the tooth surface is hampered and to serve as an aid in making appropriate clinical decisions.

In addition to the use of radiographic evaluation, the ICCMS™ recognizes the potential benefits that can be gained by the use of additional, supplemental detection aids as a means of enhancing caries detection. These can include Fiber-optic Transillumination (FOTI), electrical conductivity measures and optical fluorescence techniques and are briefly discussed later in this course.

### Benefits of Visual Diagnosis

Visual diagnosis is a fast and simple method that does not need expensive equipment and avoids unnecessary radiation. Currently, assessing caries activity based on the criteria proposed by ICDAS/ICCMS™ is regarded as the most effective approach for caries diagnosis. Since radiographs cannot detect minor losses, it has been documented that visual or combination of visual-tactile examination outperforms radiographic examination for diagnosing non-cavitated lesions.<sup>37,38</sup>

### Limitations of Visual or Visual - Tactile Lesion Diagnosis

These include the fact that visual or visual-tactile diagnosis requires subjective evaluations to be made by the practitioner. Lesions can go undetected because teeth are typically examined by the naked eye, and there is need for supplemental analysis when faced with clinical signs that will leave a dentist uncertain, including dark occlusal or approximal shadows.<sup>11</sup>

**Figure 6.** The ICCMS™ Radiographical Scoring System.

	ICCMS Score	
RA (Initial Stages)	1	Radiolucency in the outer 1/2 of the enamel
	2	Radiolucency in the outer 1/2 of enamel ± EDJ
RB (Moderate Stages)	3	Radiolucency limited to the outer 1/3 of dentin
	4	Radiolucency reaching the middle 1/3 of dentin
RC (Extensive Stages)	5	Radiolucency reaching the inner 1/3 of dentin, clinically cavitated
	6	Radiolucency into the pulp, clinically cavitated

## Caries Lesion Diagnosis: Bitewing Radiography

For much of the last century, the conventional method for caries detection and treatment planning in dentistry relied on a combination of visual, tactile, and radiographic assessments.<sup>37,39</sup> The difficulty of detecting proximal lesions at an early stage through clinical examination resulted in the increased use of radiographic exams, particularly bitewing radiographs.<sup>8</sup> Bitewing radiographs help detect lesions that are hidden from a clinical visual examination, such as when a lesion is hidden by an adjacent tooth, as well as help the dental professional estimate how deep the lesion is.<sup>11</sup> However, the American Dental Association (ADA) in 2024 published evidence-based recommendations focusing on radiation safety, the use of appropriate imaging techniques, and strategies for minimizing radiation exposure.<sup>41</sup> Digital radiography is replacing radiography based on film due to the advantage of being more efficient as well as using a lower radiation dose.<sup>11,40,41</sup> It also does not require wet chemicals in the processing of the image.<sup>11,40</sup>

### Concerns about Radiation

Possible health risks of exposure to low-dose radiation in children, who appear to be more at risk than adults, include parotid, bone marrow, and thyroid cancer.<sup>40</sup> Even though there is no conclusive evidence that the small, infrequent doses of radiation from dental radiographs increase risk of malignant disease, unnecessary radiation to the patient should be avoided, and care used to reduce radiation exposure if radiography is necessary.<sup>11,41</sup> Although the American Dental Association (ADA) previously recommended using thyroid collars to protect the thyroid gland during intraoral radiography in children, these collars are no longer advised for any imaging procedures.<sup>41,42,43</sup> Thyroid collars, as well as abdominal (gonadal) shielding, can interfere with the primary beam, potentially causing artifacts and leading to the need for additional radiographs and it does not provide protection against internal scatter radiation.<sup>41,43,44,45</sup> The most effective way to minimize patient radiation exposure and protection against thyroid radiation is through the proper use of rectangular

collimation, accurate patient positioning during imaging, employing appropriate dose-reduction techniques and selecting patients appropriately for imaging.<sup>41,46</sup> The principle for safely using radiograph-based imaging emphasizes that the clinical benefit should be achieved at the as low as reasonably possible (ALARA) radiation dose and as low as diagnostically acceptable (ALADA) dose.<sup>47,48</sup>

### Factors that Influence the Quality and Interpretation of Radiographic Images

There are a number of factors that affect the usefulness and quality of the radiographic examination.<sup>11</sup>

1. A certain amount of mineral must be lost before it can be detected in a radiograph. Technical aspects, such as film contrast and viewing conditions, determine this minimum amount of mineral loss.
2. The shape, extent, and location of the lesion, together with the anatomy of the tooth, also influence the radiographic depiction. A shallow, widespread lesion may create an image of being deeper than a deep lesion that is narrowly spread on the surface.
3. The direction of the X-rays affects the image. Most dentists now use film-holders or beam-aiming devices that prevent deviations of the rays that cause a decreased image contrast, and could result in the under- or over-estimation of the extent of a lesion.
4. An important aspect of correctly diagnosing caries using radiography is the interpretation by the professional. Having no expectation to detect caries may result in insufficient examination of the image, a neglected diagnosis, and insufficient treatment. On the other hand, there is also the possibility of over diagnosis and overtreatment if a dentist assumes almost all patients have caries. Therefore, it is important to understand caries prevalence of the population under treatment, meaning that not all patients should be handled in the same way.

## Diagnostic Criteria Bitewing Radiography

The commonly used criteria for assessing the depth of caries lesions are as follows:

### Timing of Bitewing Radiography

For populations with low caries prevalence, or in individuals who are at low risk for caries based on their medical and dental history, yearly **bitewing radiographs** are no longer justified.<sup>49</sup> Instead, the decision to use radiography should depend on the benefit to the individual patient as it relates to the risk and cost of low-dose radiation exposure. Studies have confirmed that in low-risk populations, intervals of up to 3 years between bitewing radiographs do not jeopardize dental health.<sup>50</sup> Based on epidemiological data, four key ages have been identified when bitewing examinations are beneficial.<sup>51</sup>

These are at:

- **Age 5**, when it gives a considerable diagnostic yield of otherwise undetected approximal lesions in primary molars.<sup>11</sup>
- **Age 8-9**, when the first permanent molar has been in contact with the second primary molar for about 2 years, and these surfaces are, therefore, at risk of approximal caries.<sup>11</sup>
- **Age 12-14**, when even in low caries-prevalence populations, one in five children has at least one approximal lesion that has been overlooked without bitewing radiography.<sup>11</sup>
- **Age 15-16**, when it is the first 3 to 4 years after tooth eruption and the establishment of approximal contacts create the risk of new approximal lesions.<sup>11</sup>

In adults, the caries process is slow compared to children and adolescents, but rapid behavior and lifestyle changes can quickly increase caries risk and progression. Keeping an eye out for these changes by taking a patient's medical and dental history can help a dentist decide when it might be useful to do a bitewing examination. Special attention should be paid to the third molar and distal surface of the second molar because the location is usually associated with plaque removal difficulty.<sup>11</sup>

## Bitewing Radiography as a Complement to the Visual-Tactile Examination

Bitewing radiographs play a crucial role in complementing the visual and tactile examination in the detection of dental caries, especially in areas that are difficult to assess through conventional methods. While visual and tactile exams rely on the clinician's ability to detect surface-level changes, bitewing radiography provides a more detailed view of interproximal areas, where caries often develop and are difficult to detect early.

The visual-tactile examination is essential for assessing the overall health of the teeth and gums, but it has limitations, and alone also fails to detect a number of occlusal and approximal caries lesions in deciduous teeth in children.

Bitewing radiographs offer a more accurate assessment of these areas, allowing for the identification of hidden caries that may not be visible or palpable during a routine exam. This is especially important for detecting approximal caries and monitoring the progression of lesions that are not yet symptomatic. Another way in which bitewing radiography complements the visual-tactile examination is in the diagnosis of recurrent caries lesions.

Using bitewing radiographs in conjunction with a thorough visual-tactile examination enhances diagnostic accuracy, improves early detection of caries, and supports better treatment planning. By providing a comprehensive view of both the tooth surface and interproximal areas, bitewing radiographs help clinicians make more informed decisions regarding the need for intervention and the appropriate timing for restorative treatments.

### Benefits of Bitewing Radiography Diagnosis

As mentioned previously, bitewing radiography allows accessibility to surfaces that may not be seen in the clinical visual-tactile examination, and it allows the depth of lesions to be assessed. Other advantages are that it is not invasive and does not damage tooth structure like an incorrectly used dental probe might. Radiographs can also be filed and re-examined at a later date to compare with a more recent image to detect whether a lesion is progressing or not.<sup>11</sup>

## Limitations of Bitewing Radiography Diagnosis

Besides concerns about low-dose radiation and variations in how images are interpreted by dentists, the main limitation is that the validity in diagnosing early lesions is rather low. Also, the bitewing radiograph cannot always distinguish between sound surfaces, those with initial caries activity and cavitated lesions, or non-carious demineralizations; so clinical inspection is still needed to determine what is happening to the tooth. Bitewing radiographs also tend to underestimate the depths of lesions, so a lesion that appears confined to the inner enamel on an image is often actually in the dentin, and this can lead to insufficient or improper treatment.<sup>11</sup>

## Caries Lesion Diagnosis: Newer Methods of Caries Detection and Assessment

This section will briefly address some of the newer methods being used to detect and diagnose caries lesions. They can be divided into methods that are based on X-ray, methods based on light emission, and methods based on electrical current.

### Methods Based on X-Ray

These include:

- **Digital radiography** – which is increasingly replacing bitewing radiography and that is as accurate as film for the detection of caries lesions.
- **Digital image enhancement** – which studies show can provide superior results to radiographs when enhanced correctly but takes a significant amount of technical skill.
- **Digital subtraction radiography** – which is not typically used in a clinical setting, also because of the high level of technical skill needed to perform correctly.
- **Tuned aperture computed tomography** – which shows improved diagnostic accuracy in caries lesion detection, but with equipment that is too expensive for most clinical practices.

### Methods Based on Light

These include:

- **Laser light-induced fluorescence**, based on the phenomenon that caries

lesions, plaque, and microorganisms all contain fluorescent substances that can be distinguished from each other and the autofluorescence of enamel and dentin. An example of this type of product is the **Canary System™**.

- **Quantitative laser-light induced fluorescence**, such as the **Inspektor QLF™**, which can quantitatively detect the difference in fluorescence between sound tissue and that of a caries lesion.
- **DIAGNOdent**, which uses red light to induce fluorescence and handy tools/probes, such as the **DIAGNOdentpen**, which can fit into smaller spaces and fissures in occlusal and approximal surfaces of teeth to capture differences in fluorescence that could indicate a lesion.
- **Fiber-optic transillumination (FOTI)** and the more sensitive **digital imaging fiber-optic transillumination (DIFOTI)**, which are qualitative diagnostic methods by which teeth are trans illuminated to detect shadows, which has been associated with the presence of carious lesions.

### Methods Based on Electrical Current

These include **electrical conductance** and **electrical impedance**, such as the **CarieScan PRO** system. With the understanding that dentin is more conductive than enamel, and that porous (lesioned) enamel is more conductive than sound enamel, measuring the electrical conductance of the tooth can detect demineralized sites in enamel, sites that have become porous (indicating a lesion), and cavities. Also, with the knowledge that every material has different electrical impedance determined by its molecular composition, it is theoretically possible to detect carious lesions because they have lower electrical impedance than sound tissue.

A recent study that compared results of the **DIAGNOdent** pen and the **CarieScan Pro** to ICDAS in both *in vitro* and *in vivo* conditions reported: “The *in vivo* results of ICDAS and **DIAGNOdent** pen were satisfactory and comparable to those obtained *in vitro*, with ICDAS performing better. The **CarieScan PRO** performed poorly under both conditions.”<sup>152</sup> These results suggest that, although some of

the diagnostic methods might provide some level of useful information, they should be used with caution. At present, the ICDAS criteria are the most clinically relevant approach available for accurate assessment of caries.

### Methods Based on Sound Waves Ultrasound Devices

Ultrasound technology is being explored for caries detection by measuring the reflection of sound waves from different layers of the tooth structure. This approach has potential for detecting deep caries and monitoring lesion progression. However, a limitation of this technique is that it can only identify dental caries once the tooth has undergone a certain level of damage, after structural changes in the enamel and dentin have already occurred.<sup>53</sup>

### Methods based on Artificial Intelligence (AI) and Machine Learning

#### AI-Powered Radiograph Analysis

Artificial intelligence is being integrated into diagnostic tools to analyze digital radiographs more efficiently. AI algorithms can detect caries lesions, assess their severity, and provide more accurate, objective diagnostic assistance, reducing human error.

#### Benefits of AI in Radiograph Analysis:

- **Enhanced Diagnostic Accuracy:** AI can detect very subtle signs of caries that may be difficult for the human eye to see, ensuring that lesions are detected early and treatment is provided promptly.
- **Consistency and Objectivity:** AI-powered systems analyze radiographs based on predefined algorithms, providing consistent and objective results that do not depend on the clinician's experience or subjective judgment.
- **Early Detection and Prevention:** By identifying early-stage lesions, AI allows for preventive interventions, potentially reversing enamel demineralization and preventing more severe decay.
- **Cost-Effectiveness:** Over time, AI-powered systems can reduce the need for unnecessary radiographs or repeat imaging, which can save both time and money for dental practices and patients alike.

#### Challenges and Considerations:

- **Data Quality and Quantity:** AI systems require large, high-quality datasets of annotated radiographs to train their algorithms. If the data is incomplete or biased, the system's accuracy could be compromised.
- **Integration into Clinical Workflow:** While AI offers great promise, its integration into everyday clinical practice can be challenging. Dentists need to become familiar with the new tools, and practices must ensure that AI systems work seamlessly with existing digital radiography systems.
- **Regulatory and Ethical Concerns:** The use of AI in healthcare is subject to strict regulatory standards to ensure patient safety and data privacy. Regulatory bodies, such as the FDA, must approve AI systems for clinical use, and concerns over the security of patient data must be addressed.

#### Future Directions:

As AI technology continues to evolve, it is likely that AI-powered radiograph analysis will become more advanced. Future systems may not only detect caries but also identify other oral health issues, such as periodontal disease, cracks, or early signs of oral cancer. Additionally, as more data becomes available, AI could enhance its predictive capabilities, allowing for even earlier intervention and more personalized dental care.

In conclusion, AI-powered radiograph analysis is revolutionizing the way caries lesions are detected and assessed in dental practices. By improving diagnostic accuracy, reducing human error, and streamlining workflows, AI can significantly enhance patient care and overall outcomes in dentistry. As technology advances, the potential for AI in dental diagnostics will continue to grow, offering new opportunities for early detection and prevention of oral health issues.

#### Deep Learning-Based Convolutional Neural Network Algorithm

- Deep convolutional neural networks (CNNs) are an emerging area of medical research, achieving notable success in diagnostic and predictive tasks within radiology and pathology.<sup>53</sup> In the context of dental diagnostics, they have been developed to



efficiently detect and locate carious lesions by learning the spatial and morphological changes associated with dental decay.<sup>53,55</sup>

- Furthermore, advanced deep learning models, like ResNet and CapsNet, are continuously evolving.<sup>55,56</sup> These models, which feature deeper or more expansive layers, or employ modified layer structures, have significantly improved the accuracy of object detection and image segmentation. CapsNet, a recent advancement, is particularly effective for processing visual attributes such as size, direction, location, texture, and hue. Its ability to handle these factors has made it a valuable tool for analyzing complex visual data and encoding essential features in various applications, including caries detection.<sup>53,56</sup>

### The Limited Use of Newer Methods in Dental Practice

It should be noted that because of the high level of technical skill needed to use some of these methods, or the expense of the necessary equipment, the only technique that is currently widely used in dental practice is digital radiography.<sup>11</sup> The DIAGNOdent tends to be used in some practices as a second opinion during the diagnostic process on occlusal surfaces. The other methods tend to be used mostly in a research setting.

### Caries Diagnosis: Important Points to Consider

#### How early is too early when it comes to caries detection?

It has been established that the signs and symptoms of caries form a continuum of changes ranging from barely discernible at the ultrastructural level to overt cavities. This has led to the development of diagnostic methods that aim to identify caries lesions at the earliest stage of development possible, in order to increase the opportunity for success with non-operative interventions, such as fluoride treatment. However, some argue that there may be consequences to “too early” detection. These include the possibility of more false-positive diagnoses because caries lesion diagnosis (like any other measurement process) is prone to certain levels of error, and this could lead to

unnecessary non-operative treatment.<sup>11</sup> Also, many subclinical lesions regress without active intervention thanks to the natural remineralization processes that take place in biofilm.<sup>57</sup> In order to avoid the potential for unnecessary treatment of any kind, the use of techniques more advanced than the visual-tactile examination should continue to be used with caution, with the clinician recognizing these are tools to help them determine the best approaches to follow. By following the ICDAS criteria closely, coupled with any assessment tools they have available, it is likely that better clinical outcomes can be achieved for all ages of patients.

### Should pediatricians help in diagnosing caries?

Caries is the most common American chronic childhood disease, yet not all pediatricians are trained in oral care and oral health of infants and children. It is becoming increasingly evident that it is important to educate healthcare providers about how to detect early signs of caries, because this will help to increase the opportunity for non-operative interventions. Pediatricians see children more frequently than dentists because of nationally and internationally recommended vaccination schedules, and because of the frequency of well-visits in infancy and early childhood. One study conducted in the United States found that pediatric primary-care providers who did 2 hours of training on the oral health of infants were able to identify a cavitated lesion with a level of accuracy similar to that of pediatric dentists.<sup>58</sup> A more recent study reported that “the American Academy of Pediatrics recommends periodic oral health risk assessments (OHRAs) for young children to prevent early childhood caries and promote oral health.”<sup>59</sup> It would be advisable for pediatricians to be familiar with the ICDAS scoring criteria, as their partnership with pediatric dentists could prove to be even more beneficial.

### Conclusion

As signs of the caries process became recognized as a physiological continuum ranging from microporosity to cavitation, caries lesion diagnosis made an important shift from

focusing only on cavitation (and expensive, time-consuming surgical repair) to identifying early signs of demineralization to allow the opportunity for non-surgical intervention. To that end, improvements have been made on current methods of diagnosis. The ICCMS™ approach, coupled with the ICDAS criteria for visual examination and, when indicated, for radiographic examination, should be

followed to assess the extent and severity of caries lesions, represents the most current approach for diagnosing and managing caries; it is a dynamic approach that is open to change as new information comes available. Further research and progress in the classification of caries lesions can continue to improve diagnosis for all ages of patients.

## Course Test Preview

To receive Continuing Education credit for this course, you must complete the online test. Please go to: [www.dentalcare.com/en-us/ce-courses/ce715/start-test](http://www.dentalcare.com/en-us/ce-courses/ce715/start-test)

### 1. Which of the following statements best reflects the importance of accurate caries detection and diagnosis in clinical dentistry?

- A. It mainly helps identify cosmetic issues in the teeth for aesthetic treatment.
- B. It serves as a foundation for clinical decisions regarding prevention, diagnosis, and treatment planning.
- C. It is only important in cases where caries has reached the pulp.
- D. It eliminates the need for any restorative treatment once detected early.

### 2. Which of the following best describes the relationship between ICDAS and ICCMS in modern caries management?

- A. ICDAS focuses on treatment planning, while ICCMS is used only for early lesion detection.
- B. ICDAS and ICCMS are unrelated systems used for different types of dental diseases.
- C. ICDAS classifies caries stages, while ICCMS provides a risk-based framework for managing them.
- D. ICDAS is a cosmetic assessment tool, and ICCMS measures patient satisfaction.

### 3. Which of the following best distinguishes between caries detection and caries diagnosis?

- A. Detection involves treatment planning, while diagnosis is only about identifying early lesions.
- B. Detection is based on subjective judgment, while diagnosis relies only on X-rays.
- C. Detection identifies signs and symptoms, while diagnosis integrates those findings with risk factors to evaluate the disease.
- D. Detection and diagnosis are interchangeable terms with no clinical difference.

### 4. What is a traditional method used for detecting signs of dental caries?

- A. Using thermal imaging to detect temperature changes in teeth.
- B. Visual inspection with bright light and a dental mirror to identify surface changes and shadows.
- C. Performing a blood test to check for oral bacteria.
- D. Using ultrasound to measure enamel thickness.

### 5. Why has the use of sharp dental probes in caries detection been challenged in recent years?

- A. They are too expensive and difficult to sterilize.
- B. They often provide inaccurate caries detection result.
- C. They can cause irreversible damage to demineralized enamel, potentially creating cavities.
- D. They are ineffective at removing plaque or biofilm.

### 6. What is a key advantage of the International Caries Classification and Management System (ICCMS™) compared to older methods like the WHO criteria?

- A. It focuses solely on detecting and restoring cavitated lesions
- B. It ignores patient history and clinical trial evidence in care planning
- C. It offers a comprehensive, risk-based approach that includes prevention, early management, and long-term monitoring
- D. It eliminates the need for visual-tactile examinations in caries detection

- 7. What role does the ICDAS system play within the ICCMS™ approach to caries management?**
- A. It provides treatment protocols for advanced periodontal disease
  - B. It standardizes the assessment of caries severity and activity, forming the basis for management decisions
  - C. It replaces the need for radiographic examination in all cases
  - D. It focuses only on detecting bacterial penetration in tooth structures
- 8. What is the key difference between ICDAS Code 1 and ICDAS Code 2 in caries detection?**
- A. Code 1 indicates a cavity in dentin, while Code 2 shows a restored surface.
  - B. Code 1 represents a distinct cavity, while Code 2 is for non-cavitated white spots.
  - C. Code 1 shows the first visual change in enamel only after drying, while Code 2 shows a visible change in enamel when wet or dry.
  - D. Code 1 requires radiographic confirmation, while Code 2 does not.
- 9. Which of the following best describes the difference between active and inactive (arrested) caries lesions?**
- A. Active lesions are fully remineralized, while inactive lesions require urgent restorative treatment.
  - B. Active lesions are more likely to change over time, while inactive lesions are more stable with less likelihood of progression.
  - C. Inactive lesions always appear as deep cavities, while active lesions are surface-level discolorations only.
  - D. Inactive lesions are more likely to progress into the dentin than active lesions.
- 10. Which of the following is a key factor that can influence the accuracy of caries detection using radiographic examination?**
- A. The color of the tooth enamel
  - B. The patient's age and gender
  - C. The amount of mineral loss, lesion characteristics, and interpretation by the clinician
  - D. The speed of the X-ray machine
- 11. What is a primary advantage of using bitewing radiographs in caries detection?**
- A. They eliminate the need for visual-tactile examinations altogether.
  - B. They provide a detailed view of interproximal areas, improving early detection of hidden or recurrent caries.
  - C. They are only useful for diagnosing gum disease, not dental caries.
  - D. They can detect enamel color changes more effectively than visual methods.
- 12. Which of the following is an advantage of bitewing radiography in caries detection?**
- A. It allows assessment of lesion depth, is non-invasive, and enables comparison over time.
  - B. It is invasive but offers highly detailed color images.
  - C. It replaces the need for all clinical examinations.
  - D. It physically removes plaque to reveal hidden lesions.
- 13. What is a key limitation of bitewing radiographs in diagnosing dental caries?**
- A. They provide overly detailed images that confuse diagnosis.
  - B. They tend to overestimate lesion depth, leading to unnecessary treatment.
  - C. They cannot reliably differentiate between early caries, cavitated lesions, and non-carious demineralization.
  - D. They replace the need for clinical inspection in most cases.

**14. Which caries detection method is currently the most widely used in everyday dental practice?**

- A. DIAGNOdent
- B. Fiber-optic transillumination
- C. Quantitative light-induced fluorescence (QLF)
- D. Digital radiography

**15. Why is it important to train pediatricians in early caries detection?**

- A. Pediatricians are legally required to perform dental procedures.
- B. Pediatricians see children more often than dentists and can help identify early signs of caries.
- C. Dentists no longer treat children under five years old.
- D. Pediatricians use more advanced dental tools than general dentists.



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## Additional Resources

- No Additional Resources Available

## About the Author

### Anchal Malik Chopra, BDS, MHA



#### **Assistant Professor, University of Pittsburgh School of Dental Medicine**

Dr. Anchal Malik Chopra is an Assistant Professor in the Department of Dental Public Health at the University of Pittsburgh School of Dental Medicine. She plays a key role in predoctoral education, serving as the course director for Contemporary Cariology Foundations of Prevention and Intervention as well as for both the didactic and preclinical laboratory courses in Dental Anatomy and Morphology. Dr. Malik also developed and leads an online course on the Coursera platform titled Introduction to Dental Terminology. In addition to her primary teaching responsibilities, she regularly contributes as participating faculty in multiple other courses and helps coordinate the cariology and caries management curriculum. Dr. Malik leads initiatives at Pitt Dental Medicine focused on evidence-based caries detection and assessment, including training and calibrating faculty and students in the International Caries Classification and Management System (ICCMS), which is based on the International Caries Detection and Assessment System (ICDAS).

Beyond teaching, Dr. Malik is actively involved in institutional service and maintains membership in several professional organizations, including the American Dental Education Association (ADEA) and the American Academy of Cariology (AAC). She currently serves on the board of the AAC and is the Chair-Elect of the ADEA Section on Cariology. Previously, she chaired the ADEA Section on Minority Affairs, Diversity, and Inclusion.

Prior to joining the University of Pittsburgh, Dr. Malik served as a full-time faculty member at Case Western Reserve University School of Dental Medicine, with joint appointments in the Departments of Pediatric Dentistry and Community and Preventive Dentistry. There, she contributed to NIH-funded research on oral health issues in very low birth weight (VLBW) and normal birth weight (NBW) infants, and participated in community-based trials on xylitol use for caries prevention and Head Start outreach programs.

Her broad research and academic interests include dental caries management, evidence-based dentistry, educational innovation, curriculum and professional development, and interprofessional education. Dr. Malik earned her Bachelor of Dental Surgery from Rajiv Gandhi University of Health Sciences, India, and a Master of Health Administration (MHA) in Health Policy and Management from the University of South Carolina, Columbia.

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