Caries Process and Prevention Strategies: Diagnosis

Video Transcript

Hello, and welcome to dentalcare.com's cariology course that focuses on diagnosis. This is part six of a 10-part series entitled Caries Process and Prevention Strategies. This course introduces the dental professional to the importance of caries diagnosis in prevention of the disease, as well as the intricate link between caries diagnosis and treatment. The two main methods of lesion diagnosis used today, the visual-tactile or visual methods and bitewing radiography, are discussed, particularly with regard to their application in the ICDAS system. Topics also include newer approaches to caries diagnosis and management, a brief discussion of why too early caries lesion diagnosis can be counterproductive and the benefits of e-enlisting the help of pediatricians in diagnosing caries in children.

First, let's consider a clinical significance snapshot, the type of question you might encounter in your practice. The question being what is the difference between diagnosis and assessment of dental caries? Dental caries assessment identifies the presence or absence of disease indicators, and 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 the 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.

And once identified, the individual lesion 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. And low, medium and high caries risk patients should receive preventive and behavioral interventions adjusted to their risk status. Lesion severity, whether initial, moderate or extensive, should determine the need for nonsurgical or surgical dental care to control caries or to eliminate it. And the inclusion of non-cavitated lesions is essential in this assessment as the measurement of these lesions is a relevant indicator for long-term dental health.

Upon successful completion of this course, it is expected that you, the dental professional, will be able to understand how a change from surgical repair of caries to prevention has influenced caries diagnosis methods, to explain why caries diagnosis is important, to be able to discuss the difference between the medical and dental perspectives of caries diagnosis, to identify the tools and diagnostic criteria of visual-tactile methods, to be familiar with the benefits and limitations of visual-tactile methods, to identify diagnostic criteria of the bitewing radiography method, as well as its benefits and limitations, and to be familiar with newer methods of caries lesion detection and assessment, including methods based on X-rays, light, and electrical current.

For much of the last century, the diagnosis of dental caries entailed detecting only cavitation.

Over the last few decades, however, the caries process has been recognized as a biofilm disease characterized by prolonged periods of low pH in the mouth, leading to dissolution and net loss of minerals from the teeth. The demineralization of the teeth is now understood as a physiological continuum, and the understanding of caries shifted from a discrete episode of cavitation to an understanding of demineralization as a spectrum that ranges from microporosity to cavitation. Because the emphasis in dealing with caries has shifted from surgical repair to strategies that prevent decay, the challenge now to professionals is to provide better criteria for establishing the true state of a given tooth. Therefore, the primary purpose of caries diagnosis is to identify the biofilm disease process and also early signs of tooth demineralization in order to halt its progression.

The scientific literature points to three main reasons why caries lesion diagnosis is important. One, to achieve the best health outcome for the patient by classifying caries lesions corresponding to the best management options for each lesion type. Two is to inform the patient, and three is to monitor the clinical course of the disease.

So, first, to achieve the best health outcome for the patient by classifying caries lesions corresponding to the best management options for each type of lesion. Lesions are currently classified in the following way. Non-active lesions, which do not require intervention because biofilm metabolic activity is unlikely to lead to mineral loss. Non-cavitated lesions, which may be restored through the use of nonoperative approaches, such as remineralization therapies. In other words, brushing with fluoridated toothpaste. Active lesions, which indicates ongoing mineral loss and may be responsive to nonoperative therapies. And cavitated lesions, where a hole has developed in the tooth that requires restoration via surgical intervention, such as filling.

To inform the patient. The patient is the key to 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.

And finally, to monitor the clinical course of- of the disease. 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.

Next is a discussion of the different methods of caries lesion diagnosis and how diagnosis and management of the disease are intricately linked. In the past, clinicians relied primarily on the use of caries measurement systems that relied solely on the assessment of the incidence and severity of cavitated lesions. As our knowledge of caries has matured, we now recognize that caries is a dynamic process with the ability of non-cavitated lesions to either reverse through remineralization, or progress through demineralization, depending on the conditions occurring with each individual patient. Due to the ability of early lesions to reverse through the use of preventive therapies, such as the use of fluoridated toothpaste, mouth rinses or other remineralization therapies, it's become increasingly important to detect caries at the earliest stage as possible, which maximizes the potential to maintain as much of the natural tooth as possible in the longer term.

More recently, significant efforts have been directed toward the development of comprehensive measurement systems that include assessment of caries across the continuum of the disease process, beginning with non-cavitated lesions. The most widely used system now available is the ICDAS system, an 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- this- this continuum.

It is important that we understand the definition of caries diagnosis, and there are two different perspectives here. The medical perspective.

Dentistry has often turned to medicine when searching for clarification of concepts and methodology, including when it comes to caries diagnosis. The medical perspective of caries diagnosis is as such, it would be the recognition of a disease or a condition by its outward signs and symptoms. It involves recognition of signs and symptoms, devising tentative hypothesis about the underlying disease based on these signs, gathering information by doing a physical examination, running what are thought to be the most appropriate diagnostic tests, using the test results to confirm or refute the tentative diagnosis, and if necessary, choosing an alternative diagnosis. A doctor is encouraged to repeat the cycle of symptom recognition and testing what alternative hypothesis until the final diagnosis is reached. Or if the prescribed treatment does not have the desired effect, the doctor needs to revise the diagnosis.

The dental perspective is slightly different. 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 controlling the disease process in the biofilm. Also, the dentist needs to identify whether or not the individual teeth have caries lesions with the help of screening, even patients who do not have obvious signs of caries, and determining which treatment can best help the patient. Therefore, in the dental perspective of caries diagnosis, diagnosis consists of both identifying caries as a biofilm disease and managing it, and identifying specific signs and symptoms of caries, the non-cavitated to cavitated lesion continuum, and managing the lesion activity, working under the logic that caries can be prevented, slowed, stopped or even reversed through the process of remineralization, if it is detected and treated before it progresses to a point that requires invasive intervention.

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 a previous two to three years, while diagnosing caries requires a dentist to conduct a thorough examination of all information related to the patient. Lesion detection employs an objective process to establish whether any signs of the disease are present at the time of evaluation. If demineralization at any stage is observed, at whatever stage, it is labeled as dental caries. Once it has been determined that a lesion is present, the function of lesion assessment is to then classify the lesion and observe it over time.

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

The traditional method of detecting caries signs is by visual inspection of the 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 can also be done to search for dark shadows that could indicate dentin lesions.

While the use of a dental probe continues to be controversial, it's extremely helpful when used correctly and judiciously. A dental probe can be used to remove plaque that may be covering a lesion and when the blunt side of the probe is used, it could help remove biofilm to check for signs of demineralization and to assess the surface roughness of a lesion. Studies show that general probing does not disrupt the surface integrity of non-cavitated lesions, while vigorous poking can cause irreversible damage to the surface of a developing lesion. The accuracy of caries detection does not increase

if probing is used. A probe is unnecessary if visual inspection detects a cavity. During a visual-tactile examination, the dentist will also use a syringe or drying tool to blast air on the tooth, which makes it easier to see some lesions.

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

There are three methods commonly used as diagnostic criteria for assessing caries. These include the WHO method, or the World Health Organization method, the ICCMS approach, which is the International Caries Classification and Management System, and the ICDAS system, this is the International Caries Detection and Assessment System. First, we'll talk about the World Health Organization method. Numerous methods have been suggested for recording lesions and caries lesions activity. In the recent past, one of the most commonly used visual-tactile or visual criteria that have been used include the WHO method, 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 nonoperative 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.

The ICCMS approach. Over the past few decades, there was a clear awareness of an urgent need for a more robust, standardized method of classifying caries with a focus on more than just listing the various stages of the disease. In addition, there was a recognized need for making sense of clinical trial results and systematic reviews and for aligning research outcomes with modern clinical caries measurement and management of caries. Numerous meetings, workshops and conferences were held with the goal of developing an international standard of diagnostic measurement and care. A key outcome of these efforts was the International Caries Classification and Management System, or the ICCMS, which is a standard method based on the current best approaches.

The 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. The system was designed to develop a comprehensive care plan that incorporates preventing caries initiation, or primary prevention, preventive management of early caries, secondary prevention, tooth preserving operative plan, minimally invasive, and review, monitoring and recall. 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 some respects, such as in the area of lesion activity assessments, the ICCMS system is a further evolution of several criteria systems that have been in place since the late 1990s. Other systems have also been incorporated into the new structure whenever they represent the best thinking in a particular area.

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, it was called ICDAS One and was later modified to ICDAS Two in 2005. The ICDAS One and Two criteria incorporate concepts from the research conducted by Ekstrand et al., Nyvad, and other caries detection systems, as reported in the systematic review of Ismail and colleagues. It's broadly considered to be the most appropriate, 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 ICDAS approach.

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 categorize … Categories of caries lesion severity correlate well with a histological depth of caries demineralization in both enamel and dentin. It should be noted that the histological depth of lesions correlates with demineralization, but not necessarily with bacterial pe- penetration. For background, some of the measurement … Measures of lesion activity that have been incorporated into ICDAS are based on previous studies that help define key aspects of caries activity, such as ways to assess lesion depth, lesion activity and considerations regarding root caries and recurring caries.

To understand the classification for lesion depth assessment, it's important to know how moisture on the tooth surface affects the visibility of a lesion. White spot lesions become more opaque and dry dental tissue compared to wet dental tissue because of increased light scattering. Typically, non-cavitated lesions, if are visible on a wet tooth, have penetrated deeply, while a non-cavitated lesion that is only visible after drying has penetrated less deeply into the tooth.

Based on these concepts, Ekstrand and colleagues suggested a visual, ranked scoring system for lesion depth assessment that is still commonly used. Using no probe, they examine two surfaces according to the following criteria. No or slight change in enamel translucency after five seconds of air-drying, opacity or discoloration that is hardly visible on wet surfaces, but visible after five seconds of air-drying, opacity or discoloration that is visible without air-drying, localized enamel breakdown with opaque or discolored enamel and/or grayish discoloration from underlying dentin, or cavitation in opaque or discolored enamel exposing dentin.

Lesion activity assessment. This method, developed in 1999 by Nyvad et al., focuses on the surface characteristics of lesions, namely activity as reflected in the surface texture of the lesion and surface integrity as indicated by the presence or absence of a cavity or microcavity in the surface. The rationale behind this method is that the surface characteristics of enamel change in response to changes in the biofilm covering the tooth's surface. The diagnostic categories are as follows, active, non-cavitated, active, cavitated, inactive, non-cavitated, inactive, cavitated, filling, filling with active caries, and 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 general 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.

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, or cavitation, but visually the cavity does not exceed one millimeter in depth, an active lesion with a cavity depth exceeding one millimeter, but does not involve pulp, lesion expected to penetrate into the pulp, a filling confined to root surface or extending from the coronal surface to the root surface, and a filling with inactive lesion, secondary, confined to the margin.

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 one restorations, which affect pit and fissure crevices on occlusal, buccal and lingual surfaces of posterior teeth and lingual surfaces of the anterior teeth. Diagnosis is accomplished using the Nyvad criteria in the lesion activity assessment section described previously.

Diagnosis criteria for assessing coronal caries activity. Based on the outcome of numerous symposia on the topic of caries diagnosis and assessment, the ICDAS criteria were developed to describe various aspects of caries activity. The following figure and tables provide a summary of these criteria, along with six different ICDAS codes used to identify each of the occlusal conditions. 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. And second, an inactive or arrested lesion is considered to have a lesser likelihood of transition than an active lesion. A slightly simpler summary is shown here, that highlights all of the key diagnosis parameters as well as the various preventive approaches that are recommended.

In alignment with these figures, the characteristics of active coronal lesions, not all characteristics need to be present to decide activity status are as follows. For the initial to moderate stage caries, one to four, signs of an active lesion are that the surface of enamel is whitish, yellowish, opaque with loss of luster and feels rough when the tip of the probe is moved gently across the surface. The lesion is in a plaque stagnation area. In other words, in the entrance of pits, fissures or near the gingiva and in approximal surfaces below the contact point. It's likely the lesion was covered by thick plaque prior to cleaning.

And for an inactive lesion, the 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. Likely, the lesion was not covered by thick plaque prior to cleaning. For extensive stage caries, five to six, the dentin feels soft, leathery on probing for an active lesion and when inactive, the 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. For sound surfaces, no visible caries when viewed clean and dry. For non-carious surfaces, white or brown marks on tooth surfaces must be differentiated from early caries lesions. These surfaces are characterized in the ICDAS system as a zero. Initial stage caries, which are ICDAS one and two, are characterized by the first visual changes in enamel seen only after prolonged air-drying or restricted to the confines of a pit or fissure, or as a distinct visual change in the enamel seen on a wet or dry surface.

Moderate stage caries, ICDAS level three, is characterized visually by either localized enamel breakdown without visual signs of dentinal exposure, keeping in mind that enamel breakdown is often viewed best when the tooth is air-dried, or when an underlying dark shadow is noted, that comes from dentin, which is ICDAS four. Shadowing from dental caries is often best seen with the tooth surface wet. And finally, with extensive stage caries, ICDAS levels five and six, these are characterized by distinct cavitation exposing visible dentin. Lesions exhibiting cavitation involving less than half of the tooth surface are rated ICDAS five, and lesions involving half of the tooth surface or more are listed as ICDAS six.

For mesial and distal surfaces, the evaluation criteria are as follows. For sound surfaces, ICDAS score of zero, there are no visible caries when viewed clean and dry, and non-carious white or brown marks on tooth surfaces must be differentiated from early caries lesions. Initial stage caries is characterized by the first visual change in enamel seen only after prolonged air-drying, which is recorded as ICDAS one, or is a distinct visual change in enamel seen on a wet or dry surface, ICDAS two. 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 the enamel.

Moderate stage caries is characterized visually by either localized enamel breakdown without visual signs and dentinal exposure. Again, the enamel breakdown is often viewed best when the tooth is air-dried and is rated as ICDAS three, or as an underlying dark shadow from dentin, which is ICDAS four. Shadowing from dentinal caries is often best seen with the tooth surface wet. In the event of extensive stage caries, these are characterized by distinct cavitation exposing visible dentin. Lesions exhibiting cavitation involving less than half of the tooth surface are recorded as ICDAS five, and those involving half the tooth surface or more are recorded as ICDAS six.

For buccal-lingual smooth surfaces, the evaluation is as follows. For sound surfaces, an ICDAS score of zero is given if there is no visible caries when viewed clean and dry. Developmental defects, like enamel hypoplasias, fluorosis, tooth wear, attrition, abrasion and erosion and intrinsic or extrinsic stains, should be recorded as sound in the absence of other signs of caries lesions, as described below. Initial stage caries is characterized by the first visual change in enamel seen only after prolonged air-drying, which is ICDAS one, or as a distinct visual change in enamel seen on a wet or dry surface, which is ICDAS two. Initial stage lesions on free smooth surfaces are located in close proximity, in touch or within one millimeter, to the gingival margin or adjacent to orthodontic or prosthetic attachments to the tooth surface.

Moderate stage caries characterized visually by the localized enamel breakdown without visible signs of dentinal exposure. ICDAS score of three is given when enamel breakdown is viewed best when the tooth surface is air-dried, or ICDAS four when an underlying dark shadow is seen from the dentin. Shadowing from dentinal caries, again, is often best seen when the tooth surface is wet. Extensive stage caries is characterized by distinct cavitation exposing visible dentin. As previously, ICDAS five lesions exhibit cavitation involving less than half of the tooth surface, and ICDAS six lesions are those involving half of the tooth surface or more.

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 general probing. Is it soft, leathery, or hard? Active root caries lesions are usually located within two millimeters of the crest of the gingival margin.

Evaluation criteria for assessing root caries are as follows. If, for any reason, a root surface cannot be visualized directly or with the assistance of general air-drying, code E, excluded, can be recorded on the dental chart. A code of zero is recorded when 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. In this case, the root surface has a natural anatomical contour.

Or the root surface may exhibit a definite loss of surface continuity or anatomical contour that is not consistent with the dentinal caries process. This loss of surface integrity usually is associated with dietary influences or habits such as abrasion or dental erosion. These conditions usually occur on the facial, labial, surface, with the area's being typically smooth, shiny and hard. Abrasion is characterized by a clearly defined outline with a sharp border, whereas dentinal erosion has a more diffuse border. Neither condition shows discoloration.

When there is clearly a demarcated area on the root surface or at the cemento-enamel junction, the CEJ, that is discolored, light, dark brown or black, but there is no cavitation, loss of anatomical contour, the area is recorded as a code one. Finally, when there is clearly a

demarcated area on the root surface or at the cemento-enamel junction that is discolored, light, dark brown or black, and there is cavitation or loss of anatomical contour greater than half a millimeter, the area is recorded as a code two.

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 its thickness. The data indicate the dental caries infection occurs due to a shift in the microbial ecology within the oral cavity and further suggests that there is increased caries risk associated with plaque and biofilm accumulation. Therefore, an ongoing evaluation of the biofilm is recommended to monitor for any significant changes that may be indicative of lesion activity.

There is unanimous agreement that more caries lesions can be identified by combining radiographic information with clinical findings compared to visual inspection alone. For this reason, the ICCMS recommends the inclusion of radiographic examination, if possible and appropriate, based on local safety standards. Radiographic examination is used 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. For this system, the initial, or RA stages, of caries are recorded as an ICCMS score of one when the radiolucency is limited to the outer half of the enamel, and is recorded as a two when radiolucency in the outer one half of the enamel plus or minus the enamel-dentin junction.

In the moderate stage, or RB stage, a score of three is assigned when there is radiolucency limited to the outer third of the dentin, and four when the radiolucency extends to the middle third of dentin. For extensive, or RC, stages, a score of five is recorded when the radiolucency reaches the inner third of dentin, or clinically cavitated, and a score of six when the radiolucency extends into the pulp and is clin- clinically cavitated. 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 described later in this course.

Visual diagnosis is quick and easy to perform. It does not require expensive equipment and it can be accomplished without unnecessary radiation. Currently, activity assessment according to the criteria suggested by the ICDAS, ICCMS is considered the best choice for performing a caries diagnosis. Surprisingly, data show that when non-cavitated lesions are included in the classification, the yield of visual or visual-tactile caries examination is greater than that of radiographic examination because minor mineral losses cannot be detected by the radiographs.

There are limitations of visual and 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 un- undetected because teeth are typically examined by the naked eye. And there is a need for supplemental analysis when faced with clinical signs, it will leave a dentist uncertain, including dark occlusal or approximal shadows.

The most commonly used radiographic method for detecting caries lesions is the bitewing technique. It is meant to find lesions that are hidden from a clinical visual examination, such as when a lesion is hid- hidden by an adjacent tooth, as well as to help the dental professional estimate how deep the lesion is. To get the radiographic images, a central beam of X-rays is positioned to pass at right angles to the long axis of the tooth. If film is used, a beam-aiming device on the film holder guides the position, directing the beam at right angles to the film. However, digital radiography is replacing radiography-based film. It has been proven as accurate as traditional radiography for detecting caries and it comes with additional

advantage- advantages of using a lower radiation dose, being less time-consuming and does not require wet chemicals in the processing of the image.

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 cancers. Even though there is no conclusive evidence that the small and frequent doses of radiation from dental radiographs increase the risk of malignant disease, unnecessary radiation to the patient should be avoided and care to reduce radiation exposure if radiography is necessary. This can include the use of a thyroid shield, use of a rectangular collimation, which limits the shape of the X-ray beam and reduces radiation exposure by 50 percent, or use of the fastest film type, the F-type films, or digital radiography.

There are a number of factors that affect the usefulness and quality of the radiographic examination. 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 minimal amount of mineral loss. 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.

The direction of the X-rays can also affect the image. Most dentists now use film holders or beam-aiming devices that prevent deviations of the X-rays that cause a decreased image contrast and could result in o ... Under or overestimation of the extent of a lesion. 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's also the possibility of overdiagnosis and overtreatment if a dentist assumes that almost all patients have caries. Therefore, it's important to understand caries prevalence of the population undertreatment, meaning that not all patients should be handled in the same way.

The most commonly used criteria for assessing the depth of caries lesions are as follows. The 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. 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 three years between bitewing radiographs do not jeopardize dental health.

Based on epidemiological data, four key ages have been identified when bitewing examinations are beneficial. These are at age five, when it gives a considerable diagnostic yield of otherwise undetected approximal lesions in primary molars. Age eight to nine, when the first permanent molar has been in contact with the second primary molar for about two years and these surfaces are therefore at risk of approximal caries. Age 12 to 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. And age 15 to 16, when it is the first three to four years after tooth eruption and the establishment of approximal contacts create the risk of new approximal lesions.

In adults, the caries process is slow compared to children and adolescents, but rapid behavior and lifestyle changes can quickly increase caries risk in 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 difficulties.

Occlusal caries lesions, which develop on surfaces that contact on opposing surface of

a tooth and the opposing jaw, are difficult to diagnose by visual examination only. Visual-tactile examination alone also fails to detect a number of occlusal and approximal caries lesions in deciduous teeth in children. Using bitewing radiography raises the sensitivity of the diagnosis if obvious dentinal caries activity is to be detected, but can be inaccurate if diagnosing enamel-occlusal caries activity. Complementing the clinical examination with bitewing radiography has also been found to increase the sensitivity of detecting caries lesions in these teeth. Another way in which bitewing radiography complements the visual-tactile examination is in the diagnosis of recurring caries lesions. A radiolucent area typically indicates that residual caries tissues was left behind when the restoration was placed.

There are also 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.

There are, of course, limitations of bitewing radiographs. Besides concerns about low-dose radiation and variation 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 depth of lesions. So a lesion that appears confined to the inner enamel of an image is often actually in the dentin, and this can lead to insufficient or improper treatment.

This section will briefly address some of the newer methods being used to detect and diagnose caries lesions. They can be d- divided into methods that are based on X-rays, methods based on light emission, and methods based on electrical current. First, we'll discuss methods based on X-rays. These include digital radiography, which increasingly is 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 this takes a significant amount of technical skill. Digital subtraction radiography, which is not typically used clinically, although because of the high level of technical skill needed to perform it correctly. And tuned aperture computed tomography, which shows improved diagnostic accuracy in caries lesion detection, but with equipment that is- that is too expensive for most clinical practices.

Methods based on light. These include laser light-induced fluorescence based on the phenomena that caries lesions, plaque and micro-organisms all contain fluorescent substances that can be distinguished from each other in the autofluorescence of enamel and dentin. An example of this type of product is the Canary System. Quantitative light light-induced fluorescence, such as the Inspektor QLF system, 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 uses handy tools and probes, such as the DIAGNOdent pen, which can fit into smaller spaces and fissures in approximal surfaces of teeth and capture differences in fluorescence that could indicate a lesion. And fiber-optic Transillumination, FOTI, and the more sensitive digital imaging fiber-optic transillumination, which is DIFOTI, which are qualitative diagnostic methods by which teeth are transilluminated to detect shadows, which has been associated with the presence of caries lesions.

There are also 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 the porous or lesioned enamel is more

conductive than sound enamel, measuring the electrical conduct- conductance of the tooth can detect demineralized sites in enamel, sites that have become more porous, indicating a lesion and cavities. Also, with the knowledge that every material has different electrical impedance determined by its molecular composition, it's theoretically possible to detect caries lesions because they have lower electrical impedance than sound tissue.

A recent study that compared the results of the DIAGNOdent pen and the CarieScan PRO using the ICDAS methods in both in vitro and in vivo conditions reported, quote, "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. 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."

The limited use of newer methods in dental practice. Here's a short video by Doctor Margherita Fontana of the University of Michigan School of Dentistry, who- who will provide a short description of several of the newer caries diagnostic methods available that you might want to consider for use in your practice.

Regarding new instruments and techniques that are available nowadays, there's a wide range available in the United States to practitioners. Uh, there's instruments that are based on fluorescence. So you have instruments, for example, that use light in the blue end of the spectrum.Many of those use the acronym of QLF, that's quantitative light fluorescence. You will find a wide range of instruments out there in the market. Some provide quantification, numbers, attached to the measurements, some just provide an image on the screen for you to detect the area that might be different. Then you have instruments that are based on the red end of the spectrum. For example, the DIAGNOdent. It's a very popular instrument that got into the US market, many years ago that uses infrared light, to detect caries lesions.

You have instruments that are based on light reflection. For example, the caries, uh ... Midwest Caries ID system by Dentsply is available. It doesn't provide numbers, but it's based on differences in- in reflection of tooth surfaces, uh, sound or caries. Then you have instruments that are based on- on conductivity, electrical conductivity. Uh, the newest one in the US market, uh, is called CarieScan and it's really a measurement of impedance or resistance to electricity on a tooth surface based on whether it's sound or has caries lesions. Then you have, of course, transillumination. Uh, that has been around for a while. There's a wide range of, uh, technologies out there, uh, to be able to transilluminate the tooth with very focused light. Uh, and- and you can go, uh, outside of the digital images to radiographic images, et cetera. So, uh, the- the scope is very ample in practice, uh, not only to detect lesions, but hopefully to monitor the lesions over time.

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. The DIAGNOdent pen tends to be used in some practices as a second opinion during the diagnostic process on occlusal surfaces. However, the other methods tend to be used mostly in a research setting.

There are several important points to consider with regard to caries diagnostics, such as 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 nonoperative 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 diagnosis because caries lesion detector or diagnosis, like any other measurement process,

is prone to certain levels of error and this could lead to unnecessary nonoperative treatment. Also, many subclinical lesions regress without active intervention thanks to the natural remineralization process that takes place in the biofilm.

In order to avoid the potential for unnecessary treatment of any kind, the use of advanced techniques that are more advanced than a visual-tactile examination should continue to be used with caution, with the clinician recognizing that 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.

And another question, 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's important to educate the healthcare providers about how to detect early signs of caries because this will help to increase the opportunity for nonoperative 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 two 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. A more recent study reported that the American Academy of Pediatrics recommends periodic oral health risk assessments, or OHRAs, for young children to prevent early childhood caries and promote oral health. 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.

In conclusion, as signs of the caries process become 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 nonsurgical intervention. To that end, improvements have been made on current caries 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's 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.

And one final piece, here's one additional video that you might find useful. It's a short animation that highlights key steps in the initiation and development of the proximal lesion and how it can progress further if left unchecked.

Let's conclude this section by discussing how this information can help you in your practice. First, fully understanding information regarding caries diagnosis as well as the appropriate prevention strategies involved in the caries process will help you identify evidence-based and scientifically-supported interventions to reduce subsurface mineral loss and making decisions regarding your patients' at-home care and reduction of caries risk.

Second, information about the caries diagnosis, along with appropriate prevention strategies, when communicated at the level of the patient, can be a powerful tool in driving compliance and overall adherence to your at-home oral care recommendations. Describing how caries develop, as well as how they are recorded and tracked over time, while making the connection to your specific recommendation instills a strong sense of trust and confidence in patients and can be far more powerful than simply instructing patients to brush more often. Thank you very much.