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Caries diagnosis

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PUBLICATION DATE:	MAY 2020
EXPIRATION DATE:	APRIL 2023

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Caries diagnosis

ABSTRACT

Identification of dental caries is the basis of restorative dentistry and key to preventive dental care. Caries has traditionally been diagnosed based on either visual identification or radiographic evidence of decay. Unfortunately, these methods are not definitive until caries has progressed extensively in the tooth. Identification of caries at its earliest stages allows better preservation of tooth structure and improves the long-term prognosis of the tooth. Newer methods and technologies allow for earlier caries identification, allowing better intervention at an earlier stage, thus preserving tooth structure as well as keeping treatment costs lower for the patient.

EDUCATIONAL OBJECTIVES

At the conclusion of this educational activity, participants will be able to:

1. Describe the limitations of caries identification radiographically.
2. Describe the limitations and potential problems using an explorer for identification of incipient lesions.
3. Describe the limitations of caries indicator dyes for identification of carious dentin.
4. Evaluate the different technologies available for caries identification and how they can be incorporated into the practice.

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ENDEAVOR BUSINESS MEDIA

Caries identification and management is the basis of restorative and preventive dentistry. Traditionally, caries identification relied on visualization, radiographic detection, and use of an explorer. Each of these has its downside in the ability to identify caries at an early stage. Dental caries can readily begin on chewing surfaces of posterior teeth where the enamel at the base of pits and fissures is frequently thin and an easy initiation point for caries. With the advent of fluoridation, the enamel becomes more acid resistant, but with an inability to remove microdebris from the bottom of deep pits and fissures, the caries can penetrate the thin enamel at its base and blossom in the underlying dentin. This may not become apparent until sufficient destruction has occurred to be evident radiographically.[1]

Caries are easily identifiable when they have progressed sufficiently, but identification as incipient lesions is difficult, if not impossible.[2,3] Dark stained areas on smooth surfaces of the teeth, such as the cervical area or facial/lingual at the contacts, typically are easy to identify as caries-affected tooth structure. But stain that is present in pits and fissures of posterior teeth does not necessarily indicate presence of caries (figure 1).[4] Stain that is unrelated to caries may accumulate in those pits and fissures, and visualization alone cannot determine if an incipient carious lesion has initiated and needs to be treated. White lesions on the surface of the enamel are indicative of demineralization and may be treated with remineralization and not necessarily require excavation and placement of a restoration (figure 2).

FIGURE 1: Discolored pits and fissures on the molars indicative of stain, with obvious caries on the distal pit of the premolar

FIGURE 2: White spot lesions on the cervical of teeth adjacent to a tooth with definitive cervical caries

RADIOGRAPHS

With the advent of faster (more sensitive) radiographic film to decrease radiation exposure to the patient, caries identification at the early stages has become more difficult. The faster film loses some of the shades of gray in the radiograph, allowing early caries to blend with the unaffected adjacent tooth structure and be missed until it has progressed much further. Digital radiographs have improved this with software interpolation, yet early incipient lesions may still be missed. Radiographs, whether film or digital, work well in caries identification interproximally. However, the majority of caries in the posterior teeth initiate in the pits and fissures, and with overshadowing of thicker tooth structure on the buccal or lingual, this may not be identifiable in its early stages radiographically. When we combine this with fluoridated water and toothpaste, lesions are harder to identify in their initial stages of formation due to the more acid-resistant enamel until they "blossom" in the underlying dentin.

For definitive caries identification radiographically, approximately 60% demineralization needs to occur to the enamel and dentin before the lesion can be seen on a film radiograph, or 50% demineralization for digital radiographs, so actual carious breakdown clinically is greater than what is observed radiographically.[5,6] Additionally, cervical burnout may be mistaken for caries, or root caries may be confused with cervical burnout and ignored at their early stages. Transillumination may be of benefit in detecting interproximal caries

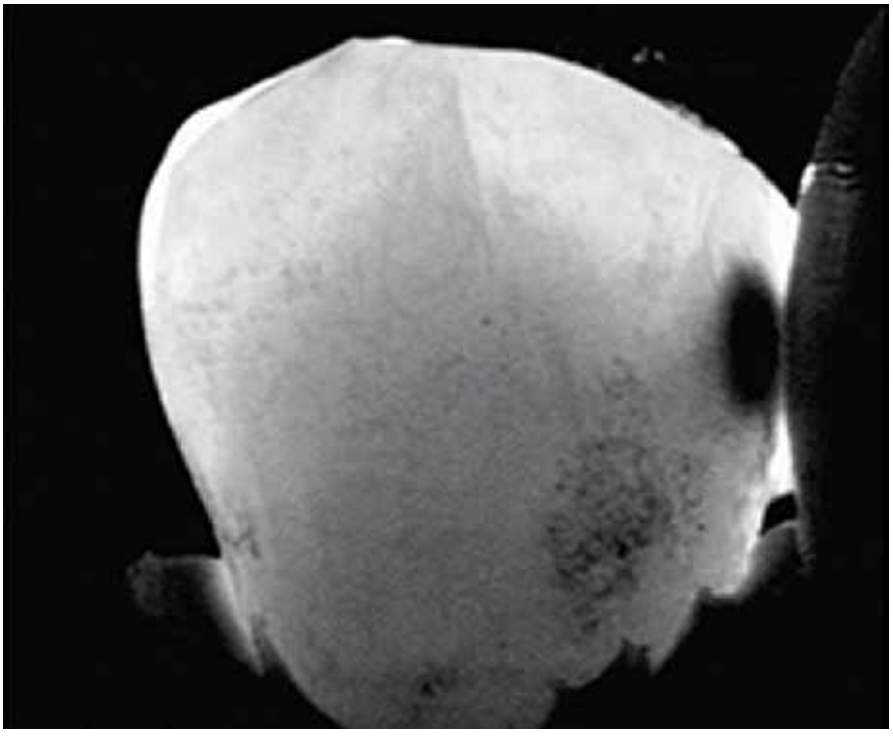

FIGURE 3: Transillumination demonstrating a dark area interproximally, indicative of caries

when a shadow is present clinically but nothing is detected on the radiograph. When transilluminated, a dark area interproximally indicates breakdown of the tooth structure blocking light passage through the area (figure 3). Unfortunately, this has no clinical application on the occlusal, buccal, or lingual surfaces due to the bulk of the tooth structure blocking the light transmission.

EXPLORER

The use of an explorer in pits and fissures to check for a stick as an indication of early carious breakdown relies on the sharpness of the explorer tip. A dull explorer may be wider than the pit or fissure being examined and not result in a stick. Unfortunately, a sharp explorer may result in initiating structural damage at the pit or fissure, resulting in cavitation of very early incipient lesions. Cavitation with regard to tooth structure is defined as microstructural damage to the enamel, which exposes the dentin to oral bacteria and microbreakdown via acid attack. This in turn leads to caries. Very early demineralization of the enamel at pits and fissures may undergo remineralization related to fluoride in the saliva. The explorer may hamper remineralization by creation of microcavitation. When an explorer is used, light force should be applied with the tip and heavier forces should be avoided to decrease the potential for cavitating the area.[7-10]

CARIES INDICATOR DYES

Caries indicator dyes have their own potential pitfalls. To be effective, they need to contact the dentin, which requires exposure of the dentin. If the dentin is exposed, we know that some structural breakdown has occurred on the tooth. Dyes work better after tooth preparation to ascertain whether any caries remain. The disadvantages of caries dyes are that they stain plaque or other organic matter and are not well suited for identifying caries in pits and fissures during an examination. Dye staining and bacterial penetration are independent phenomena; hence, they have no actual quantification.[11]

TECHNOLOGY IMPROVEMENTS

With improvements in technology, caries detection has become more accurate, allowing the practitioner to identify incipient lesions at an earlier stage than previously possible. This has also eliminated the guesswork with stained pits and fissures, providing better guidance as to what treatment is most appropriate. Additionally, patients tend to accept definitive tests rather than simply trusting a dentist who states that a filling is required when the patient has no sensitivity prior to the exam. The technology utilizes different modes to detect caries, which we will review.

CAMX TRITON HD

The CamX Triton HD (Air Techniques, Melville, New York) is the latest version of the Spectra caries detection system and intraoral camera combined into a single unit for image capture and caries identification (figure 4). The unit has three interchangeable heads to allow intraoral image capture, diagnosis of occlusal and smooth surface caries, and evaluation of the interproximal area. The caries detection (Spectra aspect) uses fluorescence to detect caries in fissures and smooth surfaces that may go unnoticed in radiographs, using four violet LEDs to stimulate metabolic products found in cariogenic bacteria, causing them to glow red while healthy enamel glows green.[12,13] This allows detection of decay in the pits and fissures, smooth surfaces of the teeth, interproximally, and also hidden between the margins of existing composite and amalgam restorations. Both caries detection heads use an 8 mm spacer, so documentation is repeatable and reliable for monitoring progress of caries.[14]

The intraoral camera head provides variable focal distances to enable image capture from full face to macro with storage in the computer to which it is attached. Its Liquid Lens Technology Autofocus delivers clear and accurate HD quality images. Two LEDs

FIGURE 4: CamX Triton HD caries detection device with the Spectra head (left) for smooth surface and pit-and-fissure caries detection, Proxi head (middle) for interproximal detection, and the intraoral camera head (right) on the device

provide ideal lighting intraorally.

When using the occlusal and smooth surface head (Spectra head), the image captured presents as a color map across the tooth with the colors corresponding to the health of the tooth area.[15] The Spectra head provides a 405 nm LED autofluorescent light that illuminates the tooth, wherein porphyrin-producing cariogenic bacteria cause a unique spectral response.[16,17] Caries and plaque filters in the imaging software show caries activity by means of a color scale and numeric evaluation. Healthy enamel appears green while carious regions will appear in blue, red, orange, or yellow, depending on the depth of affected tooth structure. Incipient lesions confined to the enamel appear blue, while deeper enamel caries have a red coloration. When caries has reached the dentin, an orange color is indicated, with deep dentin involvement appearing yellow on the image.[18] Additionally, a numerical indicator will display between 0 and 5, indicating the extent of decay at points on the image. This allows the practitioner a broad vision of the tooth (color) or finite vision at specific points (numbers) (figure 5). The Spectra head may also be used to evaluate the tooth preparation for evidence of residual caries prior to placement of a restoration (figure 6).

Interproximal evaluation is available with a change to the Proxi head using two infrared LEDs to illuminate the tooth with the spacer resting on the teeth over the proximal area. A black-and-white image is captured with healthy tooth structure being permeable to light in the infrared spectrum and appearing dark in the image (transparent). By contrast, carious lesions are white and opaque due to decreased mineralization and breakdown of the tooth structure since the infrared wavelength is refracted differently by lesions and is largely reflected (figure 7).

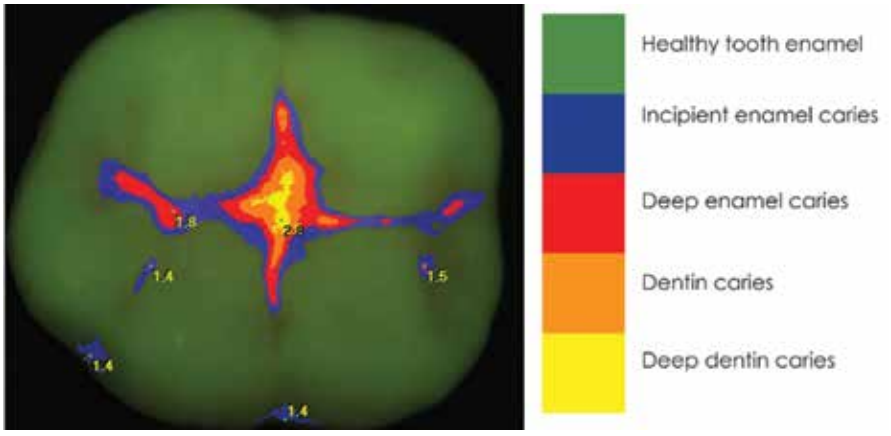

FIGURE 5: Tooth captured with the CamX Triton HD with Spectra head (left) to check the pits and fissures and the color scale indicating caries

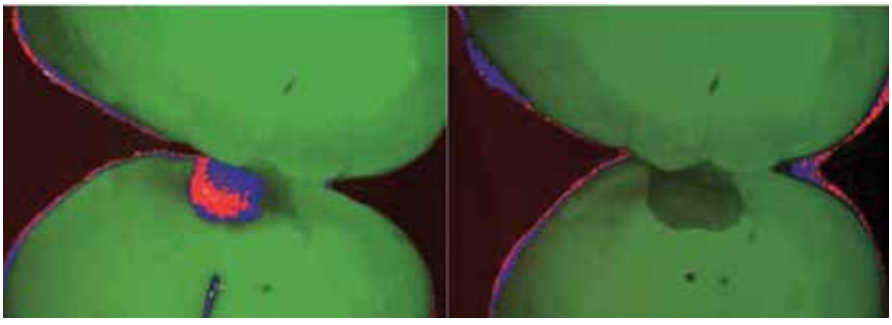

FIGURE 6: CamX Triton HD with the Spectra head to evaluate the preparation for residual caries (left) and reevaluated following further preparation to ensure caries has been removed (right)

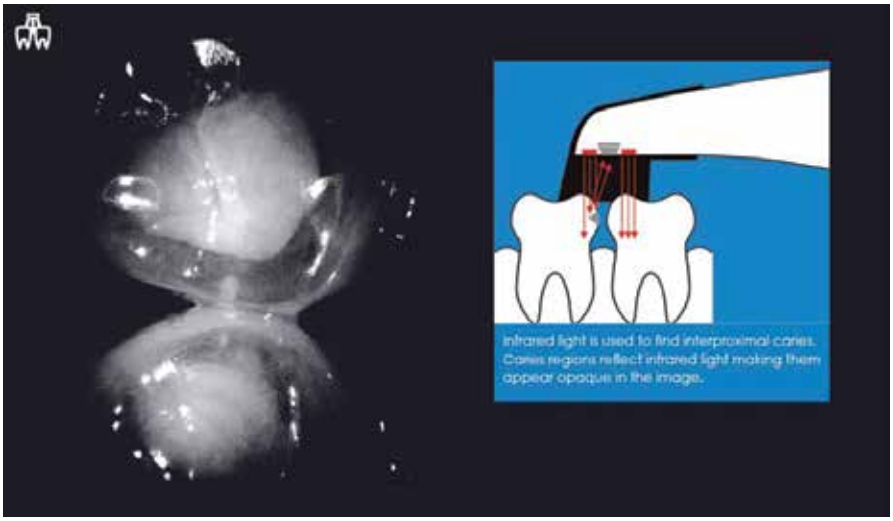

FIGURE 7: Tooth captured with the CamX Triton HD with Proxi head checking interproximal caries, demonstrating initiation of caries confined to the enamel at the contact between the teeth

THE CANARY SYSTEM

The Canary System utilizes a pulsed diode laser (660 nm, <50 mW and 2 Hz) that uses photothermal radiometry and luminescence (PTR-LUM) to identify and quantify demineralization of the tooth at the surface and below (figure 8). When the laser in the Canary System contacts the tooth, it causes the tooth to glow (luminescence, LUM) and releases heat (photothermal radiometry, PTR). Defective tooth crystal structure (enamel) affects the retained heat, and luminescence signatures result. A temperature increase of <1°C results and is not harmful to the tooth or underlying pulpal tissue.

The integrated intraoral camera within the handpiece allows image capture of the tooth surface being scanned. The device detects the mineralization or lack thereof in the tooth structure by scanning for five

FIGURE 8: The Canary System

to seven seconds and provides a number (Canary Number) on a scale of 0 to 100 (figure 9). The scale is then imposed on the image at the appropriate area on the tooth, along with a color designation to indicate the range of demineralization detected. Healthy or well-mineralized tooth structure is indicated by a number 0 to 20 (appears green), and no treatment is advised. A number of 21 to 69 (appears yellow) indicates there has been some demineralization of tooth structure at that area, and conservative treatment such as remineralization treatment, resin infiltration or sealant, or other appropriate treatment is indicated. Those areas greater than 45 often require a conservative restoration. When the number is 70 to 100 (appears red), this indicates significant loss or disorganization of mineral structure within the tooth and is a sign of advanced decay.

Research has demonstrated that Canary's "energy conversion technology" (PTR-LUM) can detect, measure, monitor, record, and diagnose carious lesions and defects 5 mm below the enamel surface.[19] Additionally, the system has proven effective in caries identification and quantification on pits and fissures[20,21] (figure 10), smooth surfaces,[22] interproximal areas[23] (figure 11), root areas,[24] and areas at the margins or under sealants,[25] composite[26] or amalgam[27] restorations (figure 12), and crowns.[28] Additionally, demineralization/remineralization can be monitored over time to verify the area is not undergoing further breakdown or that treatment efforts are succeeding[29] (figure 13). Those areas that have been treated via resin infiltration can be monitored to verify that demineralization has not continued over time.[30]

DEXIS CARIVU

Dexis CariVu (KaVo Kerr, Brea, California) is

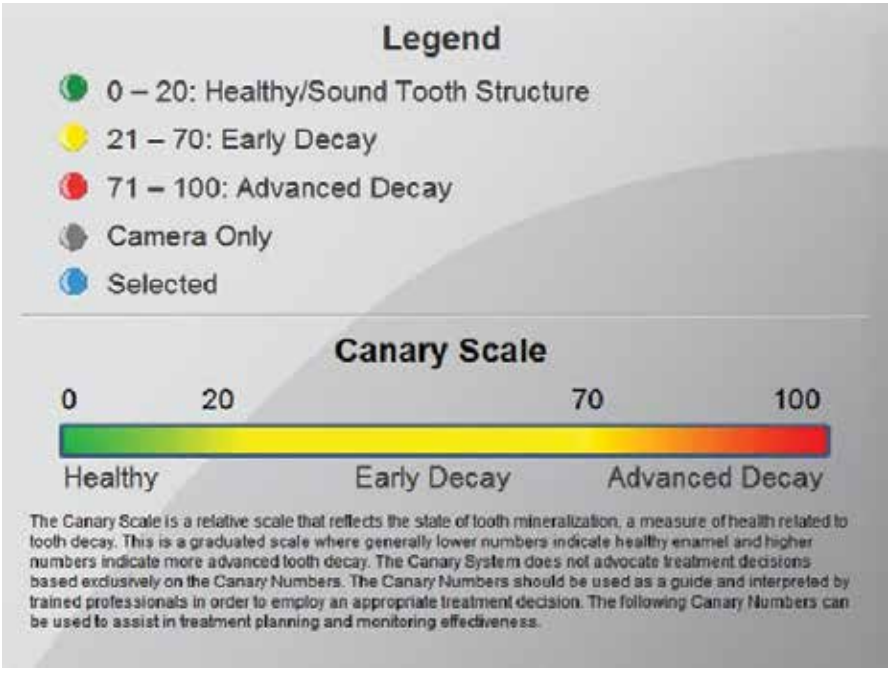

FIGURE 9: Canary System caries scale

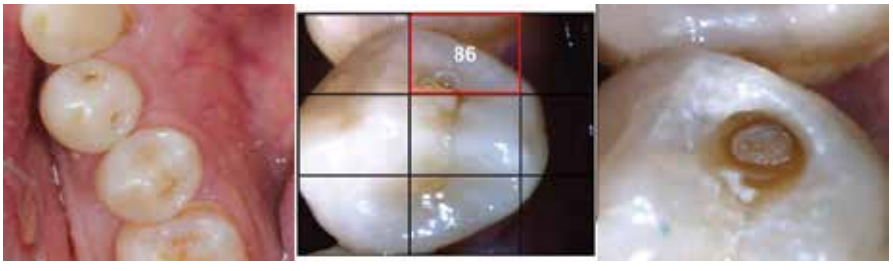

FIGURE 10: Evaluation of the stained pit and fissure of a premolar (left) with the Canary System providing a reading of 86 on the mesial pit of the second premolar indicating advanced decay (middle), and confirmation following preparation of the pit (right)

FIGURE 11: Bitewing radiograph (left) with no discernable caries on the mesial of the lower first molar, showing an interproximal reading of 40 (middle), and confirmation of caries following preparation of the OM surfaces of the molar (right)

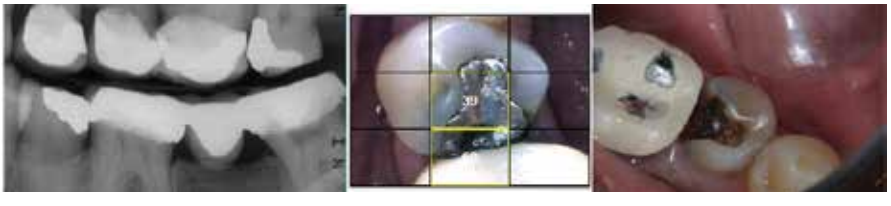

FIGURE 12: Bitewing radiograph of an OD amalgam in the lower second premolar with no discernable caries around the old restoration (left), showing a reading of 60 on the distal with the Canary System (middle), and confirmation of recurrent decay following removal of the old amalgam restoration (right)

FIGURE 13: Initial reading of the discolored cervical area (left) with the Canary System, and checking the area a year later (right) following ongoing remineralization treatment to verify improvement of the area with a decrease in the reading

FIGURE 14: The Dexis CariVu unit

a compact, portable caries detection device that uses patented transillumination technology (laser fluorescence) to support identification of occlusal, interproximal, and recurrent carious lesions and cracks (figures 14 and 15).[31] The technology uses a digital imaging fiber-optic transillumination (DIFOTI) method. The transillumination technology makes unaffected enamel appear transparent, while porous lesions (affected) trap and absorb the light. Areas that block light transmission, such as carious lesions or cracks, show up clearly as well-delimited dark areas with a digital camera capturing the image. The device is indicated for detection of demineralization of the smooth surface, occlusal,[32] and interproximal[33] (figure 16), indicating caries on those surfaces. It also is useful in identifying cracks in the coronal portion of the tooth. CariVu is contraindicated for detection of caries around crowns and onlays, very large existing restorations, and subgingival areas.

CariVu provides an edge over fluorescent imaging technologies since there is no need to clean the tooth of bacteria prior to scanning it. The device straddles the tooth, illuminating it from the buccal and lingual and capturing the image on the occlusal surface. CariVu images read like radiographic images, where lesions will appear as dark areas. As no ionizing radiation is used, it's ideal for children, pregnant women, and patients who are averse to x-rays. The DEXIS CariVu device connects to the computer by a USB 2.0 cable. Compatible DEXIS software must be installed on the computer, with the add-on CariVu acquisition software.

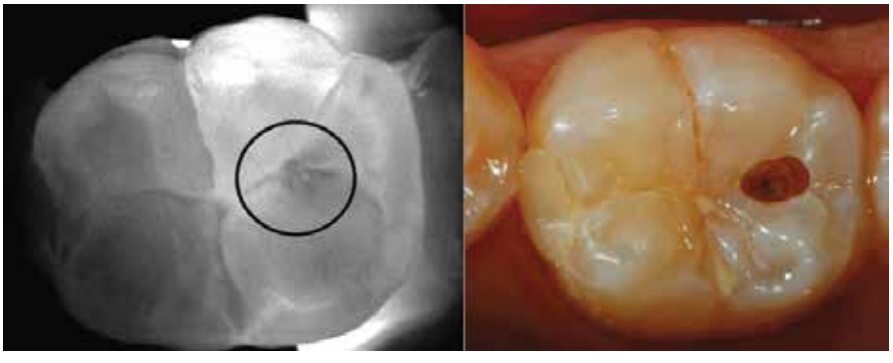

FIGURE 15: Examination of the pits and fissures of a molar with the Dexis CariVu unit identifying a dark area on the distal pit (left), and confirmation of decay present following preparation of the area (right)

FIGURE 16: Identification of interproximal caries using the Dexis CariVu of a visually darker area at the mesial of the molar

DIAGNODENT PEN

The DIAGNOdent pen is the most recent version of the original DIAGNOdent unit, which uses laser fluorescence to aid in the detection of caries within the tooth structure (figure 17). Laser light is dispersed into the area of the tooth being examined, with carious tooth structure exhibiting fluorescence proportionate to the degree of caries present. The result is presented in an elevated scale reading on the display. Clean, healthy tooth structure exhibits little or no fluorescence and will result in very low scale readings on the display.

Using a small laser, the system produces

FIGURE 17: DIAGNOdent pen with stand

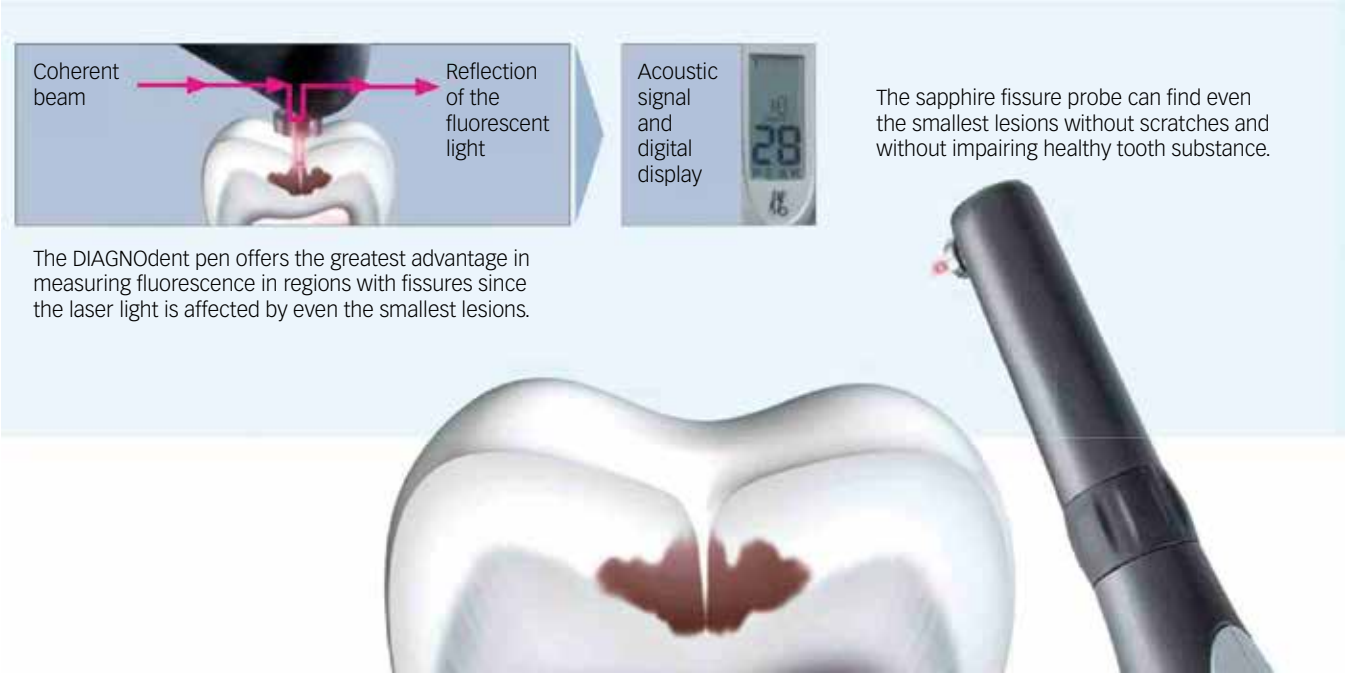

FIGURE 18: DIAGNOdent pen utilized to evaluate pit and fissures for possible incipient lesions

a 655 nm excitation wavelength, producing a red light that is carried to the tip on the unit (figure 18). The original version was able to test only pits/fissures and smooth surfaces, with the pen version also allowing interproximal testing. Different tips are available depending on whether pits and fissures or a smooth surface is being examined. The interproximal tip is made of a prismatic-shaped sapphire fiber, with the light being directed laterally to the longitudinal axis of the tip. The tip is rotatable around the axis of its length, enabling the operator to assess mesial and distal surfaces from both sides (buccal and lingual). A cylindrical tip is recommended for occlusal surfaces, and the direction of its light is perpendicular to the axis of the tip.

The tip both emits the excitation light and collects the resultant fluorescence. Unlike some other systems discussed here, the DIAGNOdent pen does not produce an image of the tooth but instead displays a numerical value of the peak value detected and the moment value on two LED displays (pen and base). After excitation, the tip collects the fluorescence and translates it into a numerical scale from 0 to 99 (figure 19). A reading of 0 to 13 indicates healthy tooth structure with no treatment indicated. Preventive care is recommended with a reading of 14 to 20, indicating minimal enamel demineralization. A reading of 21 to 29 is indicative of incipient caries involving the enamel and possibly contact with the DEJ; in this case minimally invasive treatment would be indicated. A reading greater than 30 indicates evidence of dentin involvement, requiring a more extensive restorative treatment.

The device has shown accuracy in detecting carious breakdown on or below the occlusal surface when no restoration is present.[34,35] Unfortunately, it is not helpful when checking around a previously placed restoration or sealant, as the restorative materials block the laser from evaluating the tooth structure under or adjacent to it at the margins.[36] Interproximal lesions are also detectable with the DIAGNOdent pen, helping to evaluate shadowing when nothing is apparent radiographically.[37]

DIAGNOdent has proven to provide

Values of measurement	Treatment recommended
0–13	No enamel or dentin involvement
14–20	Enamel demineralization, preventive care indicated
21–29	Enamel caries, minimally invasive treatment recommended
> 30	Dentin involvement, more extensive treatment needed

FIGURE 19: DIAGNOdent pen readings, their relation to caries identification, and recommended treatment

FIGURE 20: SorproLIFE unit

reproducible results with similar performance in the detection of occlusal carious lesions in dentin. Its ability to detect initial enamel lesions was higher, but with low specificity.[38] The DIAGNOdent pen indicated significantly higher specificity values for the enamel than for dentin.[39] The unit works well and predictably in evaluating possible incipient lesions in primary and permanent teeth.[40]

SOPROLIFE

The SoproLIFE is an LED camera with built-in autofluorescence designed to capture intraoral images and diagnose demineralization and caries as well as cracks within the tooth (figures 20 and 21). The unit utilizes light-induced fluorescence evaluator (LIFEDT) for diagnosis and treatment, which provides an anatomical image superimposed on an autofluorescence image emitted by the illuminated teeth.[41] This camera can detect and locate differences in density, structure, and/or chemical composition of a biological tissue subjected to continuous lighting in one frequency band, while making it generate a fluorescence phenomenon in a second frequency band. Fluorescence corresponding to the more or less damaged parts of a tooth is amplified selectively to accentuate the specificity of the fluorescence images, which varies according to the density and chemical composition of the tissue on its surface and subsurface.[42] As a result, any carious lesion or demineralization will be detected by a variation in the autofluorescence in relation to the surrounding healthy areas of the same tooth.[43] Some molecules in the body give off fluorescence with light excitation as the only external stimulus; this is known as autofluorescence. SoproLIFE employs this stimulation of endogenous fluorophores, which are present in dental tissue, for noninvasive imaging (figure 22).

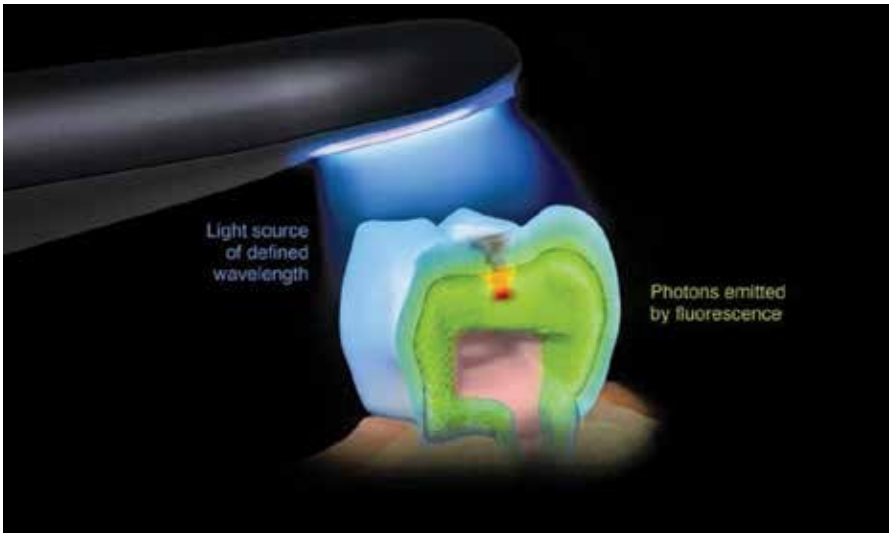

FIGURE 21: Fluorescence under blue light of the tooth with the SoproLIFE to identify caries

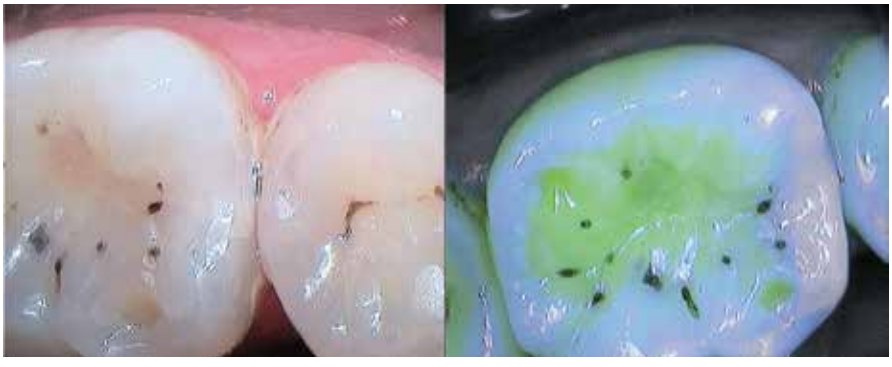

FIGURE 22: Tooth examined with the SoproLIFE under white light, showing some areas of occlusal wear, a crack, and some opacity change at the marginal ridge (left); and illuminated using the blue light, demonstrating healthy tooth structure on the occlusal surface (green areas) with an opaque area on the mesial marginal ridge that indicates demineralization and subsurface caries (right)

The unit provides two modes based on the light emitted from the unit. In mode I (white light), daylight mode, it is possible to detect damage at various clinical stages in very high resolution and without loss of consistency. Cracks in the enamel may be apparent under this mode as well as opaque areas in the enamel, indicating areas of demineralization. Daylight mode allows image capture as an intraoral camera. Mode II (blue light) offers the choice to use it for diagnosis or treatment. Diagnostic mode allows the practitioner to identify the development of occlusal and interproximal carious lesions. Treatment mode is performed for minimally invasive treatment by identifying residual caries, allowing preservation of healthy, unaffected dentin. Diagnostic and treatment modes utilize a blue light for fluorescence of the tooth structure.

FIGURE 23: SoproLIFE used to verify caries have been removed and demonstrating additional decay on the pulpal floor that will require additional excavation or other appropriate treatment

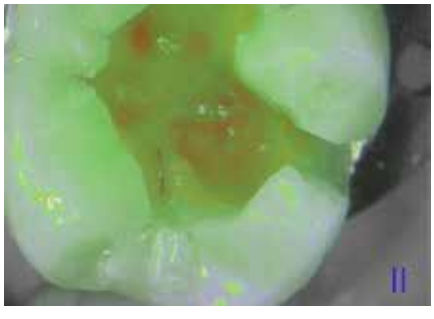

FIGURE 24: When fluoresced, caries will appear as dark red areas

When using SoproLIFE for diagnosis, a healthy tooth, when fluoresced, will appear to have a blue tint at the cusps due to the thicker enamel in that area, and a green tint where the enamel is thinner. A lack of fluorescence on the tooth indicates demineralization in that area (figure 23). A red spot surrounded by a lack of fluorescence indicates the presence of a carious lesion for which conservative restorative treatment is indicated. A black zone during fluorescence is indicative of more extensive demineralization involving the underlying dentin, which will require more extensive restorative treatment.

Treatment mode would be used during restorative treatment to verify caries removal before placing the restoration. When illuminated on the prepared tooth structure, the dentin will fluoresce green, indicating active caries has been completely removed. The presence of bright red indicates active caries in that spot, requiring further excavation of affected dentin (figure 24). A dark red area when fluoresced is indicative of arrested decay and can be treated accordingly. Abnormal dentin (sclerotic) will appear gray-green and is distinguished from affected dentin that is either active or arrested.

CONCLUSION

Long-term success restoratively is related to identification of caries as early as possible to aid in preservation of tooth structure. Unfortunately, radiographic identification of demineralized and carious tooth structure requires a fair degree of breakdown of the enamel and dentin to be visible on a radiograph. The explorer has been used to identify caries in pits and fissures, but it may lead to cavitation in incipient lesions. Technology has provided various options to aid in caries identification at an earlier stage, allowing conservative treatment or aid in monitoring the situation over time. Additionally, this technology may help guide restorative treatment by identifying residual areas of decay during preparation.

REFERENCES

1. Ritter AV, Ramos MD, Astorga F, Shugars DA, Bader JD. Visual-tactile versus radiographic caries detection agreement in caries-active adults. *J Public Health Dent.* 2013;73(3):252-260. doi:10.1111/jphd.12024
2. Innes NPT, Schwendicke F. Restorative thresholds for carious lesions: systematic review and meta-analysis. *J Dent Res.* 2017;96(5):501-508. doi:10.1177/0022034517693605
3. Walsh LJ, Brostek AM. Minimum intervention dentistry principles and objectives. *Aust Dent J.* 2013;58(suppl 1):3-16. doi:10.1111/adj.12045
4. Omar SM, Meguid SH. The role of the fissure morphology in caries prevalence of the first permanent molar in Libyan children. *J Indian Soc Pedod Prev Dent.* 1998;16(4):107-110.
5. Ferreira RI, Haiter-Neto F, Tabchoury CPM, de Paiva GAN, Bóscolo FN. Assessment of enamel demineralization using conventional, digital, and digitized radiography. *Braz Oral Res.* 2006;20(2):114-119. doi:10.1590/s1806-83242006000200005
6. Ricketts DN, Kidd EA, Beighton D. Operative and microbiological validation of visual, radiographic and electronic diagnosis of occlusal caries in non-cavitated teeth judged to be in need of operative care. *Br Dent J.* 1995;179(6):214-220. doi:10.1038/sj.bdj.4808874
7. Caries diagnosis and risk assessment: a review of preventive strategies and management. *J Am Dent Assoc.* 1995;126(suppl):1S-24S.
8. Bader JD, Brown JP. Dilemmas in caries diagnosis. *J Am Dent Assoc.* 1993;124(6):48-50. doi:10.14219/jada.archive.1993.0150
9. Dodds MW. Dilemmas in caries diagnosis—applications to current practice and need for research. *J Dent Educ.* 1993;57(6):433-438.
10. van Dorp CS, Exterkate RA, ten Cate JM. The effect of dental probing on subsequent enamel demineralization. *ASDC J Dent Child*. 1988;55(5):343-347.
11. McComb D. Caries-detector dyes—how accurate and useful are they? *J Can Dent Assoc.* 2000;66(4):195-198.
12. Shuman I. *Light assisted caries detection: 21st* century technology. INeedCE. 2015;1-11.
13. Graye M, Markowitz K, Strickland M, Guzy G, Burke M, Houpt M. In vitro evaluation of the Spectra early caries detection system. *J Clin Dent.* 2012;23(1):1-6.
14. Markowitz K, Stenvall RM, Graye M. The effect of distance and tooth structure on laser fluorescence caries detection. *Oper Dent.* 2012;37(2):150-160. doi:10.2341/10-179-L
15. Diniz MB, Boldieri T, Rodrigues JA, Santos-Pinto L, Lussi A, Cordeiro RCL. The performance of conventional and fluorescence-based methods for occlusal caries detection: an in vivo study with histologic validation. *J Am Dent Assoc.* 2012;143(4):339-350. doi:10.14219/jada.archive.2012.0176
16. Volgenant CM, van der Veen MH, de Soet JJ, ten Cate JM. Effect of metalloporphyrins on red autofluorescence from oral bacteria. *Eur J Oral Sci.* 2013;121(3 Pt 1):156-161. doi:10.1111/eos.12045
17. Lennon AM, Buchalla W, Brune L, Zimmermann O, Gross U, Attin T. The ability of selected oral microorganisms to emit red fluorescence. *Caries Res.* 2006;40(1):2-5. doi:10.1159/000088898
18. Karlsson L. Caries detection methods based on changes in optical properties between healthy and carious tissue. *Int J Dent.* 2010:270729. doi:10.1155/2010/270729
19. Abrams SH, Sivagurunathan KS, Silvertown, JD, et al. Correlation with caries lesion depth of the Canary System, DIAGNOdent and ICDAS II. *Open Dent J.* 2017;11:679-689. doi:10.2174/1874210601711010679
20. Carey C, Coleman SS. PLM validation of WSL assessment by photothermal radiometry-modulated luminescence technology. Paper presented at: 2014 AADR/CADR Annual Meeting; 2014; Charlotte, NC.
21. Jeon RJ, Han C, Mandelis A, Sanchez V, Abrams S. Dental depth profilometric diagnosis of pit and fissure caries using frequency-domain infrared photothermal radiometry and modulated laser luminescence. In: Stookey GK, ed. *Proceedings of the 6th Annual Indiana Conference Indiana School of Dentistry*. Indianapolis, IN; 2003:49-67.
22. Wong B, Sivagurunathan K, Silvertown JD, et al. A comparison of methods for the detection of smooth caries. IADR/AADR/CADR General Session and Exhibition. Boston, MA. *J Dent Res.* 2015:0305.
23. Jan J, Wan Bakar WZ, Mathews SM, et al. Proximal caries lesion detection using the Canary Caries Detection System: an in vitro study. *J Investig Clin Dent*. 2016;7(4):383-390. doi:10.1111/jicd.12163
24. Jeon RJ, Hellen A, Matvienko A, Mandelis A, Abrams SH, Amaechi BT. In vitro detection and quantification of enamel and root caries using infrared photothermal radiometry and modulated luminescence. *J Biomed Opt*. 2008;13(3):034025. doi:10.1117/1.2942374
25. Wong B, Abrams S, Abrams T, et al. Accuracy of the Canary System with opaque dental sealants. International Association of Dental Research (IADR) 91st General Session. Seattle, WA; *J Dent Res*. 2013:7.
26. Abrams SH, Silvertown JD, Wong B, et al.

Detection of caries around restorations with the Canary System. International Association of Dental Research 90th General Session. Iguaçu Falls, Brazil; *J Dent Res.* 2012:1824.
27. Abrams TE, Abrams SH, Sivagurunathan KS, et al. In vitro detection of caries around amalgam restorations using four different modalities. *Open Dent J.* 2017;11:609-620. doi:10.2174/1874210601711010609
28. Kim J. In vitro examination of secondary caries using infrared photothermal radiometry and modulated luminescence. [master's thesis]. Toronto, ON, Canada: University of Toronto (Canada); 2012.
29. Silvertown JD, Wong BPY, Sivagurunathan KS, Abrams SH, Kirkham J, Amaechi BT. Remineralization of natural early caries lesions in vitro by P11-4 monitored with photothermal radiometry and luminescence. *J Investig Clin Dent.* 2017;8(4):e12257. doi:10.1111/jicd.12257
30. Wong B, Abrams S, Silvertown J, Sivagurunathan K, Amaechi BT, Hohnk HD. Using the Canary System to evaluate the resistance of resin infiltration to demineralization. European Organization for Caries Research 62nd Annual Conference. Brussels, Belgium; *Caries Res.* 2015:297-369.
31. Berg SC, Stahl JM, Lien W, Slack CM, Vandewalle KS. A clinical study comparing digital radiography and near-infrared transillumination in caries detection. *J Esthet Restor Dent.* 2018;30(1):39-44. doi:10.1111/jerd.12346
32. Schneiderman A, Elbaum M, Shultz T, Keem S, Greenebaum M, Driller J. Assessment of dental caries with digital imaging fiber-optic transIllumination (DIFOTI): in vitro study. *Caries Res.* 1997;31(2):103-110. doi:10.1159/000262384
33. Abogazalah N, Eckert GJ, Ando M. In vitro visual and visible light transillumination methods for detection of natural non-cavitated approximal caries. *Clin Oral Investig.* 2019;23(3):1287-1294. doi:10.1007/s00784-018-2546-3
34. Sürme K, Kara NB, Yilmaz Y. In vitro evaluation of occlusal caries detection methods in primary and permanent teeth: a comparison of CarieScan PRO, DIAGNOdent pen, and DIAGNOcam methods. *Photobiomodul Photomed Laser Surg.* 2020;38(2):105-111. doi:10.1089/photob.2019.4686
35. Luczaj-Cepowicz E, Marczuk-Kolada G, Obidzinska M, Sidun J. Diagnostic validity of the use of ICDAS II and DIAGNOdent pen verified by micro-computed tomography for the detection of occlusal caries lesions—an in vitro evaluation. *Lasers Med Sci.* 2019;34(8):1655-1663. doi:10.1007/s10103-019-02762-z
36. Mortensen D, Ekstrand KR, Twetman S. Detection of occlusal caries with impedance spectroscopy and laser fluorescence before and after placement of fissure sealants: An in vitro study. *Am J Dent.* 2016;29(4):229-233.
37. Lussi A, Hack A, Hug I, Heckenberger H, Megert B, Stich H. Detection of approximal caries with a new laser fluorescence device. *Caries Res.* 2006;40(2):97-103. doi:10.1159/000091054
38. Castilho LS, Cotta FVMD, Bueno AC, Moreira AN, Ferreira EF, Magalhães CS. Validation of DIAGNOdent laser fluorescence and the International Caries Detection and Assessment System (ICDAS) in diagnosis of occlusal caries in permanent teeth: an in vivo study. *Eur J Oral Sci.* 2016;124(2):188-194. doi:10.1111/eos.12257
39. Marczuk-Kolada G, Luczaj-Cepowicz E, Obidzinska M, Rozycki J. Performance of ICDAS II and fluorescence methods on detection of occlusal caries—an ex vivo study. *Photodiagnosis Photodyn Ther.* 2020;29:101609. doi:10.1016/j.pdpdt.2019.101609
40. Jablonski-Momeni A, Rüter M, Röttker J, Korbmacher-Steiner H. Use of a laser fluorescence device for the in vitro activity assessment of incipient caries lesions. *J Orofac Orthop.* 2019;80(6):327-335. doi:10.1007/s00056-019-00194-6
41. Terrer E, Raskin A, Koubi S, et al. A new concept in restorative dentistry: LIFEDT–light-induced fluorescence evaluator for diagnosis and treatment: part 2–treatment of dentinal caries. *J Contemp Dent Pract.* 2010;11(1):E095-E102.
42. Doméjean S, Rongier J, Muller-Bolla M. Detection of occlusal carious lesion using the SoproLife Camera: a systematic review. *J Contemp Dent Pract.* 2016;17(9):774-779. doi:0.5005/jp-journals-10024-1928
43. Sukumaran P, Sakroni SN, Abu Bakar NA. Preliminary study assessing remineralisation of early caries on posterior teeth using SoproLife. *Saudi Dent J.* 2019;31(2):270-276. doi:10.1016/j.sdentj.2019.01.013

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NOTES

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QUESTIONS

1. Caries most commonly initiates where on the tooth?

A. Interproximal
B. Pits and fissures
C. Cervical
D. Incisal edge

2. Fluoridation of municipal water causes what dentally?

A. Increase in acid resistance of the enamel
B. Increase in acid resistance of the enamel and dentin
C. Changes to the oral flora
D. Increase in salivary flow

3. Dark stains on what part of the tooth are indicative of caries?

A. Cervical area
B. Smooth coronal surfaces
C. Occlusal fissures
D. Occlusal pits

4. Use of an explorer to check for decay in the pits and fissures may:

A. Not be necessary with proper radiographs
B. Only be accurate with adequate force
C. Increase sensitivity on the tooth
D. Lead to cavitation in an incipient lesion

5. Stain in pits and fissures:

A. May be indicative of caries
B. Is not indicative of caries
C. May not be related to caries
D. Is found on all posterior teeth

6. How much demineralization needs to occur to be noticeable on radiographic film?

A. 30%
B. 40%
C. 50%
D. 60%

7. How much demineralization needs to occur to be noticeable on a digital radiograph?

A. 30%
B. 40%
C. 50%
D. 60%

8. What may be mistaken for decay on a radiograph?

A. Radiolucent restorative materials
B. Voids under composite restorations
C. Cervical burnout
D. All of the above

9. A dark area interproximally when transilluminated is indicative of:

A. Greater mineralization of the tooth structure
B. Area of demineralization
C. Presence of a crack
D. B and C

10. A dull explorer:

A. May be too wide to check the pits and fissures
B. May decrease the potential for cavitation
C. Should be used to check stain
D. Should be used to prevent cavitation

11. Caries indicators:

A. Are not accurate as dye staining and bacterial penetration are independent phenomena
B. Work best following preparation of the tooth
C. Must contact the dentin
D. All of the above

12. With the caries detection aspect of the CamX Triton HD, the spacer is:

A. Necessary to assure repeatability
B. Not necessary for repeatability
C. Optional per the manufacturer
D. Only used with the Spectra head and not the Proxi head

13. The violet LED in the Spectra head of the CamX Triton HD:

A. Is used to identify intraoral plaque
B. Makes caries glow green
C. Makes caries glow red
D. Identifies demineralization

14. Violet light:

A. Stimulates metabolic products found in cariogenic bacteria
B. Illuminates composite resin
C. Aids in crack identification
D. Is used for interproximal detection

15. Porphyrin-producing bacteria:

A. Are indicative of caries
B. Cause a unique spectral response
C. Glow red when autofluoresced
D. All of the above

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QUESTIONS

16. When using the Proxi head on the CamX Triton HD:

A. Demineralization will appear lighter than surrounding tooth
B. Demineralization will appear darker than surrounding tooth
C. The tooth should be dry
D. The tooth should be wet

17. When using the Spectra head on the CamX Triton HD and the area is blue on the image, this is an indication of:

A. Incipient caries
B. Caries through the enamel
C. Caries at the DEJ
D. Caries into the dentin

18. The CamX Triton HD may be used for:

A. Evaluation of caries on smooth surfaces
B. Evaluation of pit and fissure caries
C. Evaluation of interproximal caries
D. All of the above

19. The Canary System uses:

A. A continuous-wave diode laser
B. A pulsed-wave diode laser
C. A pulsed-wave erbium YAG laser
D. Infrared light

20. Defective enamel activated by the Canary System results in:

A. Retained heat
B. A temperature change of less than 1 degree
C. Luminescence signatures
D. All of the above

21. A reading of 16 on the Canary System's numerical scale indicates:

A. Healthy tooth structure
B. Incipient caries
C. Enamel caries
D. Dentinal caries

22. A reading of 82 on the Canary System's numerical scale indicates:

A. Healthy tooth structure
B. Incipient caries
C. Enamel caries
D. Dentinal caries

23. In areas of root exposure with discoloration, the Canary System can:

A. Check for caries
B. Verify caries removal if prepared for a restoration
C. Monitor demineralization or remineralization over time
D. All of the above

24. The Dexis CariVu uses what type of technology?

A. Laser fluorescence
B. DIFOTI
C. Spectral activation
D. Ionizing imaging

25. Transillumination of the tooth will:

A. Make unaffected enamel appear transparent
B. Make affected enamel appear opaque
C. Aid in identification of cracks
D. All of the above

26. The DIAGNOdent uses what technology?

A. Pulse-wave diode laser
B. Continuous-wave diode laser
C. DIFOTI
D. Pulsed-wave erbium YAG laser

27. A reading of 25 with the DIAGNOdent pen indicates:

A. Healthy tooth structure
B. An incipient lesion
C. Caries at the DEJ
D. Deep caries in the dentin

28. When examining an existing restoration for recurrent decay, the DIAGNOdent pen is:

A. Useful around amalgam restorations
B. Useful around composite restorations
C. Useful around sealants
D. Not useful

29. The SoproLIFE can:

A. Detect and locate differences in density and tooth structure
B. Detect chemical composition of the bacteria in the tooth
C. Generate fluorescence in unaffected tooth structure
D. All of the above

30. Which color indicates active caries when examining a prepared tooth with the SoproLIFE unit?

A. Green
B. Red
C. Gray-green
D. Black

PUBLICATION DATE:	MAY 2020
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ANSWER SHEET

Caries diagnosis

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EDUCATIONAL OBJECTIVES

1. Describe the limitations of caries identification radiographically.
2. Describe the limitations and potential problems using an explorer for identification of incipient lesions.
3. Describe the limitations of caries indicator dyes for identification of carious dentin.
4. Evaluate the different technologies available for caries identification and how they can be incorporated into the practice.

COURSE EVALUATION

1. Were the individual course objectives met?

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Objective #3: Yes No Objective #4: Yes No

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2. To what extent were the course objectives accomplished overall?	5	4	3	2	1	0
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4. How would you rate the objectives and educational methods?	5	4	3	2	1	0
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_____

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5.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	20.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
6.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	21.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
7.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	22.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
8.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	23.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
9.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	24.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
10.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	25.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
11.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	26.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
12.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	27.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
13.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	28.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
14.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	29.	Ⓐ	Ⓑ	Ⓒ	Ⓓ
15.	Ⓐ	Ⓑ	Ⓒ	Ⓓ	30.	Ⓐ	Ⓑ	Ⓒ	Ⓓ

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