

TECHNOLOGY

Interproximal Caries Detection

How Good Are We?



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Have you ever wished you had a way to be more certain of what you are seeing on radiographs? Something that would enhance your diagnostic abilities while ensuring that your patients receive even better care? In a perfect world, every radiograph would be taken at the ideal angulation with the teeth perfectly aligned, and all the contacts opened for examination and diagnosis. The films would be perfectly developed with the correct shades of gray showing a clear contrast between caries and healthy tooth structure. As a result, interproximal carious lesions would be clearly visible every time. In the real world this often is not the case. Many times we are left in a gray area, letting our experience and our gut feelings make the call. We face the decision of whether to restore a suspicious area or to monitor it over time with possible treatment on a later date.

ROADBLOCKS TO AN ACCURATE CARIES DIAGNOSIS

Diagnosing interproximal carious lesions is hampered by natural variations in tooth shape and alignment, traditional film limitations, less-than-perfect exposure levels, poor angulations, and processing failures. Despite these shortcomings, by the time we get out of dental school, most dentists feel they are very good at diagnosing interproximal caries from conventional radiographs. We also feel that we continue to get better as we gain more experience over our years in practice. Much to our surprise and dismay, studies suggest otherwise. These studies show that interproximal caries detection from traditional films is not an exact science, but rather a combination of both science and art. Digital radiography systems are capable of providing new tools to aid in the accuracy of interproximal caries diagnosis.

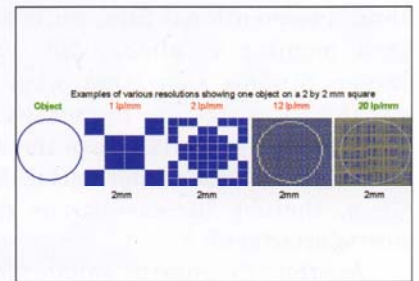


Figure 1. Visual example of comparative resolutions of digital sensors; the higher the resolution, the more the image represents the original object.

A study conducted at the University of California (UCLA) School of Dentistry found that when using traditional film radiographs, caries presence and depth are misdiagnosed up to 40% of the time. In addition, healthy teeth are misdiagnosed as having caries up to 20% of the time.¹ Is it really okay to stay with this technology and the present inaccuracies (as shown by the findings above) now that emerging tools can help us improve our diagnostic

accuracy? When it comes to diagnosing and treating our patients, it is crucial to be as certain as possible of an accurate diagnosis. This in turn allows us to develop and present the most appropriate treatment plan along with the correct treatment. Whether the error in diagnosis is in missing the caries and allowing the lesion to progress without treatment, or possibly treating teeth that really do not need to be treated, both scenarios are dangerous. In the long run, it could be very expensive due to our litigious society.

ADVANTAGES OF DIGITAL RADIOGRAPHY

Digital radiography provides several features that allow for a more accurate diagnosis of interproximal carious lesions and for the incorporation of more science into our diagnostic mix. The first feature is shared by all digital radiography systems: the radiographs' larger size allows us to see caries more clearly. For example, a 15-inch monitor is 58 times larger than a conventional film, while a 19-inch monitor is almost 100 times larger. Studies show that when we see things in a larger format, we see them more clearly and have the ability to gather more information from them, thereby increasing our diagnostic accuracy.^{2, 3}

Another diagnostic enhancement shared by most digital systems is imaging software that allows the computer to manipulate and/or manage the image. This allows one to view the image in different formats while always keeping the original or "raw" image unchanged.

Common enhancements include sharpening filters and colorization. Sharpening filters actually remove some of the information to give a clearer view of the area in question. Colorization allows one to view the image in color. This can allow us a clearer distinction between various densities than possible with only shades of gray. The ability to invert both the gray scale and colorization scale can also make caries more visible, and thus, the diagnosis more

accurate. Looking at an image in several different formats also gives us many more views, which can increase our diagnostic accuracy not only for caries detection but for other pathologies such as periodontal conditions and periapical pathology.⁴⁻⁶

Reading radiographs accurately requires discerning the minor differences or variations in the shades of gray a film image presents. Often there are slight variations in the shades of gray on the film image, and certain areas may look a bit suspect. Until recently, there was no way to be certain if a carious lesion was truly present. If so, the question of whether it extended into the dentin requiring treatment was often a difficult, subjective one. Although most studies to date confirm that digital radiographs are as diagnostic as traditional film,⁷⁻¹⁰ some existing software functions have improved on this.

THE IMPACT OF NEW SOFTWARE IMAGING SYSTEMS

The majority of computer systems are 12-bit systems, which means they are capable of producing 4,096 shades of gray.⁴ Digital sensors today generally are capable of recording 256 shades of gray, with zero being pure black and 255 being pure white. Most monitors display these 256 shades. Studies show that most people can discern only 20 to 40 shades at any one time. Even the best-trained radiologists can only discern about 100 shades. Again, this is another area in which digital radiography can aid in making an accurate diagnosis. The system I use, Kodak Dental Imaging (KDI [Kodak Dental Systems]), has automatic pre-sets that allow me to focus quickly on the shades of gray that are relevant for the particular pathology for which I am screening. One click on the periodontal icon focuses on the shades of gray in the spectrum that highlight the periodontal area of the tooth, including calculus on the teeth and at the soft-tissue level. The next click on the endo icon highlights the lamina dura, the shades of the apex of the tooth, and the surrounding bone.



Figure 2. Original radiograph showing possible caries on 4MO, 5DO, 28DO, and 29MO.

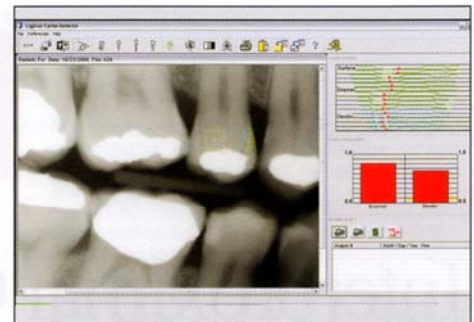


Figure 3. Logicon analysis of 4MO showing depth and probability of caries into dentin—red.

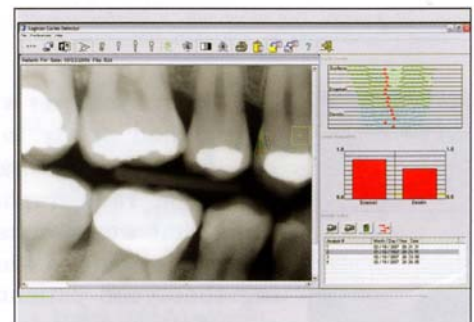


Figure 4. Logicon analysis of 5DO showing depths and probability of caries into dentin—red.

Another click on the DEJ (dentoenamel junction) icon highlights the shades of gray at the DEJ interface and is very helpful in diagnosing caries. This ability to enhance and segment the gray scales makes it easier to identify and diagnosis subtle changes that often are missed on other digital systems as well as the smaller traditional film.^{11,12}

The resolution of the image, whether produced conventionally with a phosphor plate system or with direct digital sensors, is also very important in aiding in the diagnostic process. The traditional films presently available provide a resolu-

tion of 20 line pairs per millimeter (20 lp/mm). This is simply a measure of the detail level that is discernable on the image (Figure 1). Most digital systems do not provide this level of resolution. Rather, they fall into the 9- to 13-lp/mm range, which is one of the reasons some digital images do not seem to be as clear or diagnostic as traditional film. The Kodak 6100 sensors are the only ones that have resolution equal to film at 20 lp/mm.¹³ This becomes especially helpful when viewing the image on a large-screen monitor. The full-size image as taken is larger than the screen so it can be viewed in an even larger format without losing definition, clarity, or becoming pixilated (Figure 1).

NEW DIGITAL TOOLS BRING ACCURACY TO DIAGNOSIS

The most beneficial feature that I have found in achieving accuracy in the diagnosis of interproximal caries detection is the Logicon system, which is available only with Kodak Dental Imaging (KDI). Logicon is a new, revolutionary digital diagnostic tool for finding interproximal caries. It highlights suspicious regions in the radiographs and analytically reads the density level changes in the interproximal areas of the radiographs, giving a probability measure of the caries depth into enamel and dentin.^{9,10,14,15} If there is an area that looks suspicious on a radiograph, it is quick and easy to run the Logicon program on the area to be more certain if there is caries that in fact needs treatment.

In my office, we routinely use Logicon to check all but the most obvious lesions. It is most helpful on the areas that are not obvious or clear cut. Up to this point our choice was to observe questionable areas until the lesion became larger—often much larger, since many carious lesions can grow quickly—or to take a chance and treat the tooth and sometimes find that the decay had not actually extended into the dentin. Because of the larger image size, the software enhancements, and multiple

ways of looking at the images provided by the digital radiographic system, incipient lesions are easily identified. Many times, with traditional methods, the enamel looks as if caries or decalcification has begun, but it is not clearly visible entering into the dentin. The Logicon system will give you the right answer. If the Logicon system shows the decalcification is only partially through the enamel, it is safe to record the reading, put a watch on that area, and to follow it closely through time to determine if the lesion is arrested or continues on to penetrate through the enamel into the dentin. This tool allows us the possibility of accurately tracking and recording the status of potential lesions over time.

In addition to being an electronic second opinion, it is also a powerful patient education tool. Even after almost 30 years in clinical practice, I find that occasionally I have a patient for whom I would have previously chosen to treat a questionable tooth, but Logicon advises me to wait. However, more often the Logicon readings tell me to restore a restoration that I would have previously observed or ignored.

TESTING THE CLAIMS OF DIAGNOSTIC ACCURACY

Does the Logicon program perform as it claims to do? Is it really that accurate? In the beginning I was a bit skeptical, as we often hear many claims that turn out to be untrue or misleading. To satisfy my curiosity and doubts, I did several things. I forwarded radiographs along with my readings to the Logicon office to have them check and confirm my readouts and analyses. I did this to be sure that I was learning and using the program correctly. I would run the Logicon analysis on each virgin interproximal lesion, record it, and then take photos with a digital intraoral camera of what I found inside the tooth. Each and every time I have done this, I have found that if Logicon gave a positive probability that the caries extended into dentin, it did. I have photographed hundreds

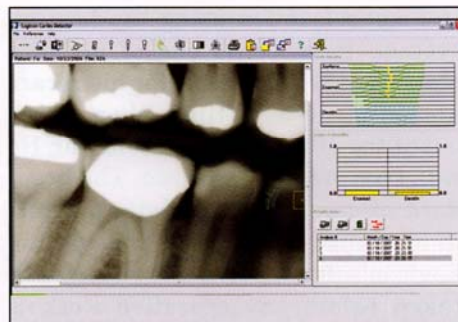


Figure 5. Logicon analysis of 28DO showing decalcification not yet through the dentin—yellow.



Figure 6. Logicon analysis of 29MO showing depth and probability of caries into dentin—red.

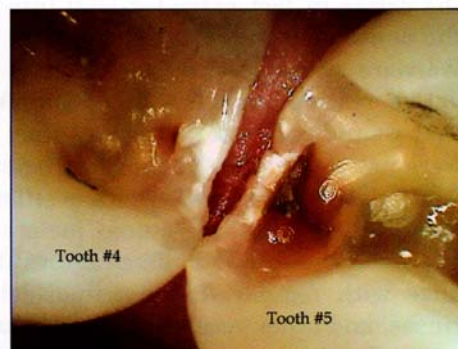


Figure 7. Decay visible in teeth 4MO and 5DO.

of these cases and found it to be 100% accurate. Another dentist, Dr. S.D. Benjamin, in an article he had recently published said, "I've examined over 1,000 surfaces with Logicon and have treated several hundred interproximal surfaces that would not have been treated at this early stage without it." He went on to say, "I have yet to prepare a tooth that did not have caries extending into the dentin."¹⁶

A CLINICAL EXAMPLE INVOLVING LOGICON APPLICATION

I wish to share a clinical example that highlights the point of certainty

in diagnosis when using the Logicon system. It concerns one of my own children. My son was in for his recare appointment at a time when I was out of the office leading a seminar. He was seen by my associate. The standard of care and diagnostic protocol in our office is to review and run the Logicon software on every radiograph taken before any operative work is initiated. In this instance, there were several suspicious areas between my son's molars bilaterally. The results of the Logicon analysis showed that of 8 areas of interest, 5 were decayed into dentin and 3 were superficial and in the enamel only. I was comfortable treating these 5 teeth because I have great confidence in how accurate Logicon is from my experience with the system. Without the Logicon system, I would have been more inclined to watch them to see if they were growing or not. When preparing these teeth, we found that the caries in fact extended well into the dentin. I was glad I did not wait! We were still able to do very conservative restorations. The other three that we did not restore, because they were not into dentin at the time, are being closely monitored. There is still a chance that the unrestored incipient lesions might stabilize/remineralize with regular flossing, fluoride rinses, and other recalcification regimens. Furthermore, the Logicon system will provide the ability to track any changes in lesion size and depth over time (Table).

CONCLUSION

When we remember the statistics that 40% of interproximal caries are missed and allowed to continue growing, often leading to very large restorations, pulpal necrosis, or even tooth loss, and when 20% of the teeth

Table. How We Use the Logicon System.

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| Step 1: | Start with radiograph (Figure 2). |
| Step 2: | Run Logicon on any suspicious areas (Logicon 4, 5, 28, 29) (Figures 3 to 6). |
| Step 3: | Record findings. |
| | Tooth 4: caries deep into dentin—restore (Figure 3) |
| | Tooth 5: caries deep into dentin—restore (Figure 4) |
| | Tooth 28: caries not penetrating enamel—observe for now (Figure 5) |
| | Tooth 29: caries just through enamel—restore (Figure 6) |
| Step 4: | Take photograph of decay inside teeth (Figure 7). |

are restored unnecessarily because interproximal lesions (at the time) were not into dentin and possibly could have been stabilized with proper treatment protocols, it should be a clear-cut decision to add this feature to your diagnostic toolbox. Now, there truly is a better way for all of us to improve our accuracy in interproximal caries detection. Accurate diagnosis of caries is still a combination of art and science, but the Logicon system adds to the scientific and quantifiable component of that process. ♦

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Dr. Dykstra started his solo dental practice in 1978 in Hudsonville, a small town in western Michigan. His original office was expanded 3 times, and in 1994 he built his dream office with just more than 3,800 square feet of working room. Dr. Dykstra's practice is in the top tier of production and collection of dental practices in the United States. He went paperless in the fall of 2002, and has successfully incorporated total electronic records with digital clinical charting, digital radiography, digital intraoral and extraoral photography, and digital imaging. He added a laser to his practice in 2003. In addition to working full time in his practice, he speaks and consults through Anchor Dental Consulting, which he founded to help dentists successfully integrate technology into the dental office. He can be reached at info@anchordentalconsulting.com.

Disclosure: Dr. Dykstra speaks for PracticeWorks and receives an honorarium.