Digital X-ray Decision-making:

Bringing it all into focus

Dale A. Miles BA, DDS, MS, FRCD(C)
Dip. ABOMR, Dip. ABOM

This article is revised and reprinted from "The Electronic Imaging Chain: Its Effect on Your Digital Radiographic Images" from Dr. Miles' digital website www.learndigital.net. It is one of several that can be found in the publication *Going Digital: The Digital X-ray Guidebook to Success* *

In the original article I wrote:

"…if we think of the sensor as a messenger for the image you use to interpret, it may not be the sensor's fault that the image quality you see is less than ideal. The sensor or receptor is not the only component that affects image quality. The digital image (and even the conventional film image) is the result of the sum total of all the parts it took to get it to your monitor effectively."

I talked about the following components: x-ray generator, frame grabber (video board), sensor and monitor. To these we could add "printer", since many of us still need to have a "hard copy" image for the patient, for referral or—in some cases—the insurance carrier. So let's revisit the information I provided back in August 2003 on my website to update information critical to your decision to "Go Digital".

Imaging "Chain" Components

- X-ray generator
- Solid-state Sensor
- Frame Grabber
- Video Monitor
- Printer

The X-ray Generator

When the sales person shows you a new sensor system, the images look great! They used a good x-ray generator, displayed on a high-quality monitor and the images looked as good or better than most of your film images, right? You get your system installed, take your first image and it too looks great (or maybe not). However, once the salesperson leaves, image quality starts to vary and periodically you get images that look awful. Logically, the first thing you blame is your new sensor. In a perfect world it would be that simple. Your old x-ray generator could be the prime "culprit" in the production of an non-diagnostic x-ray image.

Consequently, the first thing to look at in our "imaging chain" is your x-ray. Is it old? Have you had it since you opened your office? When was it last inspected?

Very few of the x-ray generators currently used in dental offices have characteristics that are ideally suited for a solid-state detector device.

Ideally, an x-ray generator to be used with a solid-state detector should have the following characteristics:

- low kV (70 kV or less)
- low mA (5 mA or even less may be ideal)
- an extremely accurate timer
- a timer capable of producing very short exposure times accurately
- the smallest focal spot feasible
- a DC (direct current) circuit
- rectangular collimation

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If your generator is old (and yes, I know it worked well with film for the last 15 years), you may have to consider buying a new generator or even several. Most x-ray machines have inaccurate timers, a higher than needed kV setting, and are AC (alternating current) type generators that produce a more heterogeneous x-ray beam which works less well with contemporary sensors. *We are always loath to change anything that works in our office but, in the case of your x-ray generator, it may be time to "upgrade" your x-ray equipment.*

The Sensor (detector, solid-state detector, CCD, CMOS, CMOS APS, chip, etc.)

In digital imaging when the word sensor is used it means an electronic device or solid-state detector; a silicon chip with an embedded circuit to act as the image receptor. We are NOT talking about a phosphor (reusable phosphor, storage phosphor, photostimulable phosphor) in this imaging chain. Phosphor plates are a "whole other story"!

As the brothers Hans and Frans said on *Saturday Night Live* "Hear me now and believe me later"**…ANY OF THE CURRENT DIGITAL SENSOR SYSTEMS CAN DO AN EXCELLENT JOB WITH ANY IMAGE TASK IN DENTISTRY…**you just have to find the one that's right for you, your staff and your office. It starts with your "Practice Management" (PM) system.

Dentrix Dental Systems, Inc.

Dentrix® offers direct connectivity of their new sensor ImageRAYi or most other solid-state sensors through its software Image 4.0. Systems supported are: Gendex, Trophy, Suni, Schick, Instrumentarium, and ImageRay.

Their software no longer requires "bridging" as was the case in the past.

PracticeWorks

If you are using PracticeWorks (PW), or any software product that they consolidated into their business model, you will be coaxed to adopt the Trophy imaging system—Trophy RVG Ultimate Imaging. You will notice that on the PracticeWorks website the words, "A Kodak Company". Eastman Kodak bought PracticeWorks (and Trophy Imaging because PW had purchased Trophy earlier) last December. Kodak makes more CCD and CMOS imaging sensors than almost anyone, including their new Kodak RVG 6000 CMOS sensor. So, you will get Kodak quality solid-state detectors soon with the Kodak-PracticeWorks-Trophy super company. Furthermore, Kodak has image processing software algorithms (computer programs) for many more imaging "tasks" in medical radiology. Their software engineers/programmers will bring that expertise to the excellent Trophy software which already exists. Thus if you're a PW user, you will have but one sensor choice, but it's a good one with even more improvements on the horizon.

EagleSoft

If your Practice Management system is EagleSoft, then you have several more sensor choices, including: Gendex, GX-S (USB) Sensor; Planmeca, Dixi2 Sensor; Schick, PCI Sensor Schick, USB Sensor, Schick, Wireless Sensor and Sirona, Digital Sensor. EagleSoft is the software company of Patterson Dental Supply, Inc. You have more choices so you must "play" with each sensor type and get a "feel" for how intuitive the software is, how "friendly" the image processing tools are, and how easily each system works in your hands. Remember also that some companies have different relationships with suppliers of these sensors, so there may be a different "margin" for each product. Don't just tell the salesperson, "I'm ready to go digital" without investigating the companies and their products first—usually with colleagues who have purchased the systems you're interested in—you may be "pushed" towards one particular product because the sales representative or client representative gets a larger incentive for one product over another.

The Frame Grabber

The frame grabber (also called a video board) is probably the most important and least understood element in a digital image processing system. A frame grabber converts the captured analog, electronic signal from the sensor and converts it to a digital format for transfer as a digital image to the computer. Some frame grabbers also have technology (image processing capability) to improve the signal before displaying the image on the monitor. This process is termed "input signal conditioning"—some systems may have it, some may not.

In addition, frame grabbers may also employ LUTs (Look Up Tables) to improve image quality prior to display. All vendors "preprocess" the image captured to display the optimum image. Some vendors capture higher resolution images like 10 and 12-bit images (1024 and 4096 gray shades), but all vendors reduce the image to the "best 8 bits" since typical computer monitors and flat panel displays only display an 8-bit image (256 shades of gray). LUTs are extremely effective tools for equalizing or normalizing images captured under poor exposure conditions. I'm assuming that most digital x-ray system vendors would employ a high quality video board in their system; however, if you already have a computer with a "board" they may tell you that you can use your own. If you have a poor quality frame grabber/video board, you may not get the best image quality the system can produce.

The Monitor

In December 2002 I posted an article on www.learndigital.net about "Flat Panels Vs. CRTs". Most of us would prefer a flat panel monitor to a boxy CRT (cathode ray tube). Please re-read my article to determine which display best suits your needs. However, if you prefer a flat panel, like I do, because their both ergonomic and "sexy", there are a couple of "specs" you need to remember. These are:

- Contrast ratio (at least 400:1)
- DPI (less than 0.27mm)

Most monitors meet the first criterion well. Contrast ratios in LCD (flat panel) monitors are quite high. Fewer LCD monitors meet the second criterion. Inexpensive monitors are usually 0.29 or even higher dpi and are not suitable for viewing, processing gray scale, radiographic images. Buy a GOOD flat panel monitor if you're going to view x-ray images in the operatory and make decisions off of them! I listed several that have these characteristics back in December 2002. I'm sure there are even more choices now and that the prices are even better than posted. Some good brands to research are:

- Viewsonic
- Samsung
- NEC
- Sony

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Flat panel Vs. CRT "Pros and Cons"

(adapted from http://www.viewz.com/shoppingguide/monitor.shtml)

Flat Panel Monitors/Displays

Pros:

- Desktop space-saver
- Good picture quality
- Prices are falling
- Environmentally friendly
- 15" flat panel gives you the same viewable screen as a 17"

Cons:

- Viewing angle is much less than that of CRT monitors
- One single resolution.

CRT (cathode ray tube):

Pros:

- Great quality for the price
- More detailed graphics
- 100 years of technology
- Works at multiple resolutions
- Can view screen from different angles

Cons:

- Bigger and bulkier than a flat panel.

The Printer

While I understand the need for "hard copy", we can now substitute paper for film. Images you work from, to make clinical decisions, can be interpreted on computer monitors or flat panel screens. This is the best solution. You see bigger, brighter, better images on the computer compared to conventional film, and when you see feature of the disease process you're looking for, you can even enhance the feature (called feature extraction) to verify your suspected finding. This is what our medical radiology colleagues have done for years with CT and MR.

There are many, many printer choices out there including: dot matrix, laser, ink jet and dye subliminal. Today's ink jet and dye subliminal printers are the "printer's of choice" for dental x-ray imaging needs. However, when you want (or need) a hard copy image, for whatever reason, a good quality printer is essential. Don't buy cheap. You'll get what you pay for!

Ink Jet Printers

High quality ink jet printers can do a good job with grayscale radiographic images. Companies like Epson (www.epson.com) make several models that could be used in the dental office for x-ray printing. For $399 you can buy the Epson Stylus Photo R800 (up to 8"x 10") or the Stylus 1280 (11" x 14"). If you want a high-end Epson for photographic and x-ray, the Epson Stylus Photo 2200 at $699 would be a great buy. Good ink jet printers are also available from Hewlett Packard.

Dye Subliminal Printers

Even higher level grayscale printers (called medical imagers) are available from Codonics (www.codonics.com). Several models like the horizon series Ci, GS or NP series represent a class of medical grade printers using "dye subliminal" technology. These printers are expensive, but can do grayscale, color prints or even x-ray transparencies. Eastman Kodak also makes a dye subliminal printer photographic printer, the Kodak 8500 Digital Photo Printer ($600-900 on the Internet), which would be ideal for x-ray printing.

Conclusions

As you can see, there are multiple components to an "imaging system". Your decision to "Go Digital" is not as simple as it first appears. You cannot simply pick a system and substitute the sensor for film. You must consider your Practice Management software, your current x-ray generator, space requirements, monitor placement your imaging "needs", and the rest of the components described above. The vendors have tried to simplify some of this decision-making by testing frame grabbers for their particular systems, improving their software and providing good quality monitors, computers and printers. But, in the end, YOU must do your "homework", understand the various components and make your decision intelligently based on your own (and your staff's) imaging needs. You may even need to consider re-training for yourself and your staff for sensor placement, and receiving training yourself in "image processing".

Dr. Miles is Associate Dean for Clinical Affairs and Professor of Oral and Maxillofacial Radiology at the Arizona School of Dentistry & Oral Health. He is a diplomat of the American Board of Oral and Maxillofacial Radiology and the American Board of Oral Medicine. He has been a test construction consultant for the National Dental Examining Board for the ADA, and on occasion serves as consultant to the FDA on radiological devices. Dr. Miles is a featured CE speaker for "digital radiology" and for teaching "PowerPoint" in the ADA's Seminar Series. He has authored over 120 scientific articles and four textbooks, and has given over 300 invited presentations. He has two websites for teaching dentists and auxiliaries about digital imaging at www.learndigital.net and www.edts.net.

Dr. Miles offers a book entitled "Going Digital—The Digital X-ray Guidebook to Success" $39.95 available through Dentrix 1-800-336-8749