

Intraoral Digital Radiology: A Safe, Cost-Efficient Imaging Solution

+ Claudio M. Levato | DDS

When incorporating digital radiology into a dental practice, a basic understanding of computer integration in dentistry is needed. In the dental industry, the integration of computers has had numerous challenges,^{1,2} yet the rewards appear to be worth the struggle.³ The question that continues to surface is: Why has the integration of digital radiology been so difficult for many dentists to accept?

It may be that a certain level of infrastructure needs to be in place for this technology to deliver synergistic value. For the past several decades the dental industry has seen the introduction of numerous applications for dentistry that have built on the basic computer infrastructure that was initiated with practice management software, which has led to the gradual introduction of computers into the clinical setting.⁴ The driving force for bringing computers into the operatory has been digital imaging, primarily intraoral digital radiology.⁵

More than 20 years have passed since the first intraoral digital sensor was introduced by French dentist Francis Mouyen at the 1st European Congress of Dental and Maxillofacial Radiology in Geneva,^{6,7} and still there is less than 50% market penetration of this technology in the United States.^{8,9} National market penetration has been difficult to quantify, as noted by the Academy of General Dentistry (AGD) in its April 2010 quarterly newsletter *AGD Transcript*, which said that the use of digital radiographs varied from state to state and ranged from less than 25% in some states to more than 75% in others.

For years there has been debate concerning the quality of digital versus film-based intraoral x-rays. The comparisons are grossly inadequate because it is like comparing a kiwi to a watermelon—they are both fruit

and are both green in color but are not the same. Digital radiographic images are best read and viewed on a medical-grade monitor; using a printed image or an inadequate computer/monitor system will render less-than-optimal diagnostic quality. In numerous controlled studies on x-ray imaging, the quality of digital systems generally has been found to be equivalent to film in terms of diagnostic yield.¹⁰⁻¹⁵ However, digital radiography is eminently superior with regard to recordkeeping, backup, transmission of images, and integration with practice management systems. Digital imaging is a dynamic medium compared to the static film image.

SENSOR HARDWARE

There are two types of solid-state sensors:

› **CCD (charge-coupled device)**—a device for the movement of electrical charge, usually from within the device to an area where the charge can be manipulated; for example, conversion into a digital value.

› **CMOS (complementary metal-oxide-semiconductor)**—a technology for constructing integrated circuits.

The scientific literature finds little difference in terms of physical image properties between the CCD and CMOS chips for solid-state imaging.¹⁶ Most new digital radiographic sensors use CMOS chips versus CCD chips. This is an advantage for manufacturers because they are less expensive, require less energy, and offer a broader dynamic range. This means CMOS technology is more tolerant to overexposure; increasing x-ray exposure improves signal-to-noise ratio, thus reducing noise perception. CCD technology has a narrow dynamic range that will saturate with increased radiation; therefore, blooming occurs (ie, black image). A downside to CMOS

technology is that CMOS sensors require more radiation than CCD because they are less sensitive; 25% more exposure is needed with CMOS. A related benefit, however, is that the electronic interface components can be built into the CMOS chip directly, which allows the sensor to plug directly into a USB (universal serial bus) port. Note that the size of the intraoral sensor limits the amount of built-in electronics. Most manufacturers place a small electronics control box along the USB cable to perform image processing and speed up the image transfer. Furthermore, CMOS technology has permitted the development of wireless sensors; however, this involves the additional cost of disposable batteries. Solid-state sensors typically range in cost from \$5,000 to \$12,000 each, with wireless sensors at the high end. Solid-state x-ray sensors produce an almost immediate radiographic image.

An alternative to solid-state technology is the photostimulable phosphor plate (PSP). The advantage of this technology is that the sizes of the phosphor plates and the technique for acquiring images are almost identical to those of traditional film radiographs (intraoral and extraoral). Disadvantages include the degradation of the phosphor plates from ongoing physical handling, which can lead to scratching and bending; the time needed to prepare and package the plates; and the time needed for laser scanning to process the latent image. Producing an image with PSP is not immediate. The cost of PSP plates varies depending on the size of the plate.

APPLICATIONS AND BENEFITS

Radiology has been a cornerstone in dentistry since shortly after its discovery by physicist Wilhelm Roentgen in 1895. Despite potentially high capital costs, converting from analog dental film and investing in digital

Claudio M. Levato, DDS



Private Practice,
Bloomington, Illinois

radiographic equipment should be an easy decision for dental practitioners. The applications are virtually the same as with analog film, though there is a slight learning curve for acquiring images with digital sensors. Digital radiology typically pays for itself over time, enabling significant savings in staff time from processing, mounting, filing, retrieving, copying, and sending images. The additional real dollar savings in chemicals, film, and processor repair costs will in time pay for the sensor and computer hardware.

While digital x-ray sensors have long equaled analog film for diagnostic tasks, they have several advantages over film radiography, as outlined in Table 1. It is also worth noting that with the recent push from the federal government for digital medical records, digitizing patient radiographs may soon not be optional.

INTEGRATION INTO THE PRACTICE

The level of integration in a dental practice will depend on the desire and capability of each practitioner. There are essentially four categories into which practitioners fall with regards to digital x-ray imaging integration:

› **Analog only**—Staying with an existing dental film system requires no immediate outlay of capital, but, of course, it will yield none of the benefits of digital technology. The eventual result will likely be obsolescence.

› **Hybrid**—While using both film and a digital system requires less of an immediate financial investment, it also offers decreased access to all the benefits of digital technology and involves the continued costs of maintaining an analog system.

› **Completely filmless** (not a seamless integration with a digital practice management system)—This requires a separate image management software application to acquire, file, and store patient images. Depending on the level of integration with the practice management system, it will

affect the ability to manage the radiographic component of the practice and the benefits of digital radiology applications.

› **Completely digital**—This is a fully integrated digital practice management system within the same software. It usually results in improved efficiency and management of all clinical, administrative, and communication practice applications. The limitations are usually related to the proprietary restrictions on sensor compatibility.

Regardless of how dentists decide to approach technology integration, they need a plan.^{17,18} For an existing practice, a gradual approach is acceptable. For example, the dentist can begin with one sensor attached to a solitary personal computer, which can be used for operative procedures. This approach permits a relatively inexpensive trial of the technology and minimizes the learning curve while stimulating the attention of the dental team. For a new facility or an office that is undergoing a complete renovation, total networking makes the most sense. For a newly opened general practice, the clinician might consider replacing a traditional film full-mouth series as well as bitewings and selected periapical radiographs with digital panoramic images.

As with any new technology, developing competency in digital imaging involves a learning period for the practitioner trained

in film radiography. However, students who have been trained in both analog film and digital x-ray systems often find the latter to be easier to learn.

CONSIDERATIONS PRIOR TO PURCHASE

Because digital radiography is an expensive investment clinicians should “test drive” several systems to determine which sensor and software fulfill the needs and style of their practice. The appropriate place to evaluate such systems is the dentist’s own office, where he or she can compare products in a standardized manner with images that are not preselected. This usually is possible while the vendor’s representative is present. In addition, it is important to work in one’s own office environment to determine whether the existing x-ray generators are acceptable or should be replaced. Only in the dentist’s own office environment can he or she examine the ergonomics of using the system and plan integration.

To determine the total costs of going digital, dentists should consider not just the capital costs of hardware and software but also the continuing costs of disposable items (eg, plastic wraps for sensors) along with the costs of secure data backup, maintenance, and initial and ongoing training. On the other hand, dentists should also understand

TABLE 1 Advantages of Digital Radiograph Sensors Over Film Radiography

Immediate image production with CCD or CMOS solid-state devices
Interactive display with the ability to enhance image features and make direct measurements
Integrated storage, providing access to images through practice management software systems
Security of available backup and off-site archiving
Exact image duplicates for referral or third-party communications
Security mechanisms to identify original image
Ability to tag information such as a patient identifier, date of exposure, and other relevant details
Interoperability of the digital imaging and communications in medicine (DICOM) file format, enabling practitioners with different equipment and software to view and enhance the same images

the costs that would apply if they decided not to go digital, including film, processing solutions, processor maintenance, dark-room space, film mounts, and storage of film radiographs.

CONCLUSION

Intraoral digital radiology is a mainstay of clinical dentistry. With the advancements in extraoral 2-dimensional (2-D) and 3-dimensional (3-D) digital radiographic imaging, some dentists feel that intraoral sensors may become obsolete. Technology is continuing its rapid growth, and when the resolution of extraoral and 3-D imaging units can meet or exceed that of intraoral sensors, use of intraoral sensors may decline, but, nonetheless, the issue of radiation exposure must also be considered.

For years techniques have been available that reduce radiation exposure to patients; the use of rectangular collimation has existed for many decades. But in spite of its being taught in most dental schools, it has never found significant acceptance. Digital radiology by itself reduces the amount of radiation exposure, but combined with rectangular collimation the reduction is even greater. A new technology, TruAlign® (Interactive Diagnostic Imaging, LLC, www.idixray.com) has simplified the process, resulting in clear, crisper images with improved image resolution.

Diagnostic imaging is not limited to radiographic applications; research in other modalities is ongoing. The future may be a blending of ultrasound, visible light, lasers, and radiographic applications for the diagnosis of dental lesions, but for now intraoral direct digital radiology provides the safest and most cost-efficient solution for the needs of most general practitioners.

References

1. Levato CM. Integrating computers: a front line perspective. *Dent Today*. 1997;16(4):124-127.
2. Levato CM. How to profit from computers. Intangible benefits of climbing new peaks. *Dent Econ*. 1998;88(8):90-94.
3. Levato CM. Technology integration: a journey, not a destination. *Compend Contin Educ Dent*. 2002;23(10 Suppl 2):4-10.
4. Schleyer TK. Why integration is key for dental office technology. *J Am Dent Assoc*. 2004;135 Suppl:4S-9S.
5. Farman AG, Levato CM, Gane D, Scarfe WC. In

practice: how going digital will affect the dental office. *J Am Dent Assoc*. 2008;139 Suppl:14S-19S.

6. Mouyen F, Benz C, Sonnabend E, Lodter JP. Presentation and physical evaluation of RadioVisioGraphy. *Oral Surg Oral Med Oral Pathol*. 1989;68(2):238-242.

7. Wenzel A. Two decades of computerized information technologies in dental radiography. *J Dent Res*. 2002;81(9):590-593.

8. Brian JN, Williamson GF. Digital radiography in dentistry: a survey of Indiana dentists. *Dentomaxillofac Radiol*. 2007;36(1):18-23.

9. Brady DT. Digital radiography: a survey of dentists in Hawaii. *Hawaii Dent J*. 2007;38(4):10-13.

10. Van der Stelt PF. Modern radiographic methods in the diagnosis of periodontal disease. *Adv Dent Res*. 1993;7(2):158-162.

11. Wenzel A, Pitts N, Verdonschot EH, Kalsbeek H. Developments in radiographic caries diagnosis. *J Dent*. 1993;21(3):131-140.

12. Sanderink GC, Huiskens R, van der Stelt PF, et al. Image quality of direct digital intraoral x-ray sensors in assessing root canal length. The RadioVisioGraphy, Visualix/VIXA, Sens-A-Ray, and Flash Dent systems compared with Ektaspeed films. *Oral Surg Oral Med Oral Pathol*. 1994;78(1):125-132.

13. Farman AG. Fundamentals of image acquisition and processing in the digital era. *Orthod Craniofac Res*. 2003;6(Suppl 1):17-22.

14. Farman AG. Image-guidance ... the revolution in dental treatment facilitated by digital radiology. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 2006;101(3):273-275.

15. Farman AG, Scarfe WC. Digital dental radiography is not an "all or nothing" decision. *Contemp Esthet Restor Pract*. 2006;10(3):12-15.

16. Kitagawa H, Scheetz JP, Farman AG. Comparison of complementary metal oxide semiconductor and charge-coupled device intraoral X-ray detectors using subjective image quality. *Dentomaxillofac Radiol*. 2003;32(6):408-411.

17. Levato CM. New technologies: their implementation and the future. *Alpha Omegan*. 2001;94(4):20-23.

18. Levato CM. Putting technology in place successfully. *J Am Dent Assoc*. 2004;135 Suppl:30S-37S.