Seventh Edition

Quality Resource Guide

Digital Radiography

Author Acknowledgements

ANDRÉ MOL, DDS MS PHD

Diplomate of the American Board of Oral and Maxillofacial Radiology
Professor, Department of Diagnostic Sciences
Division of Oral & Maxillofacial Radiology
The University of North Carolina at Chapel Hill
Adams School of Dentistry
Chapel Hill, North Carolina

Dr. Mol discloses that he holds intellectual property rights to stationary intraoral tomosynthesis technology.

Educational Objectives

Following this unit of instruction, the learner should be able to:

1. Identify the basic technologies underlying digital imaging systems.
2. Recognize the benefits of conventional and digital imaging systems.
3. Describe clinically relevant differences between CMOS and PSP based imaging systems.
4. Identify quality assurance issues specifically related to digital imaging.
5. Describe factors to be considered in designing a backup protocol for digital images.
6. Understand the issues to be considered when deciding on a radiographic imaging system.

MetLife designates this activity for **1.0 continuing education credits** for the review of this Quality Resource Guide and successful completion of the post test.

The following commentary highlights fundamental and commonly accepted practices on the subject matter. The information is intended as a general overview and is for educational purposes only. This information does not constitute legal advice, which can only be provided by an attorney.

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The content of this Guide is subject to change as new scientific information becomes available.

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Introduction

Digital technology has become part of everyday life. Many medical applications, including medical imaging, are unthinkable without digital technology. Digital dentistry is no longer a concept for the future, but a reality that has been implemented by many dental offices. The use of digital radiography systems is now mainstream and film-based radiography is currently being used by a minority of practices. Digital radiography eliminates a number of film-related quality assurance issues, but it does introduce a few new ones. The benefits of digital imaging include quick image access, image enhancement and analysis tools, potentially lower patient doses and integration of radiographic images with the practice management software. While most practices just need an intraoral imaging system, even this choice requires consideration of what type of detector to buy and whether to use a wall-mounted or hand-held x-ray source. New technologies, like intraoral tomosynthesis, further expand dental imaging options.[1] Extraoral imaging systems are also fully digital, including panoramic and cephalometric systems as well as cone-beam computed tomography.

The upfront costs for setting up a digital imaging system are generally higher than setting up a film-based imaging system. The dental team is usually less familiar with digital technology and with some of the companies selling and supporting digital products. Moreover, with an increase in the speed of new technological developments, there is a legitimate concern that technologies or products may quickly become obsolete. The decision-making process in setting up a dental radiographic system is more complex than it used to be. The purpose of this guide is to provide insight into the various digital technologies that are currently available and to highlight some of the practical implications.

What is Digital Imaging?

Digital images are so named because they are captured and stored as a string of numbers representing discrete shades of gray. The location of each shade of gray in the image is also discrete and is identified by row and column coordinates. A single location element holding one gray level of the picture is referred to as a pixel. A digital image is made up of many rows and columns of pixels. The pixels are very small (generally 15-50µm) and cannot be seen as individual elements with the unaided eye. The number of shades of gray of a digital image is usually 256. This corresponds to 2^8, which is a convenient number for storage and processing of data within a digital device. Eight bits make up a byte, thus a digital image with 1200 rows, 800 columns and 8 bits per pixel requires 960 kilobytes (kB) of storage space (1200x800x1 bytes). An increase in the number of pixels or in the number of shades of gray (bits per pixel) requires more storage space. Generally, 256 shades of gray are sufficient to depict the anatomic structures imaged on a dental radiograph. Humans are not able to distinguish this many shades of gray and the differences between the discrete values are being perceived as continuous, similar to conventional film images. A number of contemporary digital image sensors use more bits per pixel (10 bits, 12 bits or 14 bits), which increases the number of shades of gray (2^{10} = 1024, 2^{12} = 4096, 2^{14} = 16384, respectively). Whereas a higher bit depth may be of some benefit in mapping optimal display values along the entire dynamic range of the sensor, there is no evidence suggesting a diagnostic advantage of higher bit depth sensors over sensors capturing 256 shades of gray.

Digital Imaging Systems

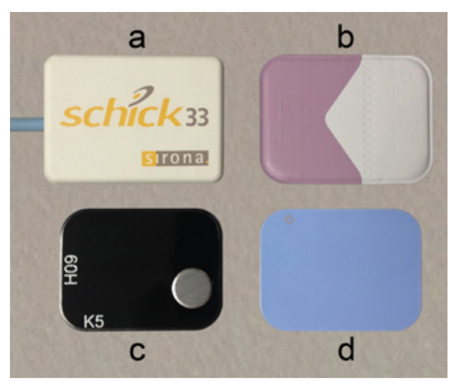
Since the introduction of digital imaging systems in the late eighties, the number of companies offering dental radiography products has increased dramatically. While competition is generally good for the consumer, the pursuit of customers has flooded the dental profession with numerous articles and advertisements about a variety of systems. Whereas each of these systems has unique properties that set them apart, they are all based on only one of two basic technologies that define its character and clinical application. One uses solid-state detectors, the other uses photostimulable phosphor (**Figure 1**). Both technologies are available for intraoral as well as panoramic and cephalometric applications.

Solid-State Detectors

Solid-state detectors provide the most direct approach to digital image acquisition. Initially, intraoral detectors were based on charge-coupled device technology (CCD). Nowadays, virtually all intraoral solid-state detectors are based on complimentary metal oxide semiconductor technology (CMOS).[1] Although technologically different, CCD and CMOS sensors work the same clinically; there are also no meaningful differences in image quality between the two. They are rigid sensors that are linked to the computer through a wired or wireless connection. One of the key features of solid-state detectors is the immediate availability of the image. Not only does this provide instant feedback to the dentist or assistant, it also results in a considerable time savings (**Table 1**). This makes intraoral solid-state detectors particularly useful for endodontic and emergency procedures.

The active area dimensions of intraoral solid-state sensors are very similar to those of intraoral film and the sensors have become much thinner since their first introduction. However, they are still considerably thicker and more rigid than film, making sensor placement more challenging. For example, in some patients it is difficult to capture part of the canine on a maxillary premolar periapical projection as a result of the curvature of the palate. The wired solid-state detectors pose an additional challenge, especially when taking bitewing radiographs. Since these are

Figure 1



Size-2 intraoral receptors: (a) Schick 33 CMOS sensor by Sirona; (b) Kodak Insight film by Carestream (rear view); (c) Soredex Optime PSP plate (rear view); (d) Gendex PSP plate.

reusable devices, barrier protection is required to prevent contamination. As barriers are not always guaranteed to prevent contamination of the detector or the cable, a manufacturer approved disinfectant should be used as these detectors cannot be sterilized.

The lifespan of solid-state detectors appears to be good under normal conditions of use. There are no reports to date that document limited lifespan as a result of image degradation. However, the detector and the connecting cable are susceptible to rough handling. Since they are costly to replace, getting insurance is worthwhile considering.

Solid-state-based panoramic and cephalometric x-ray units are also widely available. The detectors used in panoramic machines are long and narrow and provide excellent image quality. Some manufacturers use an alternative method of image reconstruction based on tomosynthesis. These panoramic units acquire multiple non-tomographic images during one rotation instead of one single tomographic image. The advantage of the tomosynthetic approach is the ability to focus and re-focus the image layer after acquisition. The concept of tomosynthetic panoramic radiography is not new, but its current implementation is. The same type of detectors are used for almost all cephalometric units, which results in image acquisition times similar to panoramic imaging. The use of a cephalostat notwithstanding, this is a drawback compared to conventional imaging as the patient is required to maintain motionless for a longer period. Anecdotal evidence suggests this is not a major clinical issue.

For extraoral imaging, particularly in cone-beam computed tomography, flat panel detectors are commonly used. These detectors provide a relatively large image matrix allowing direct digital imaging of larger body parts. As these detectors are costly, their use is currently limited to advanced 3D imaging modalities.

Photostimulable Phosphor

Digital imaging systems based on photostimulable phosphor (PSP), also called storage phosphor (SP), offer an alternative approach to digital image acquisition. The PSP plates are dimensionally comparable to film and handle quite similarly. Exposure of the plates creates a latent image in the phosphor. The exposed plates are scanned in an external laser scanner, which sends the images to the computer. After scanning, much of the latent image is still present and the plates need to be erased before they are being repacked. A barrier protection serves to prevent contamination of the plate and also to protect the phosphor from ambient light.

There are only a few companies that offer a line of dental PSP products. Current scanners use direct-feed systems, where the plates are inserted into the scanner one by one. Some scanners offer a semi-automatic feeding mechanism, whereas others allow parallel feeding similar to automatic film processors. Most PSP systems allow the operator to preset the spatial resolution prior to scanning, *i.e.* how detailed the image will be. Higher resolutions require more scanning time but do not necessarily improve the diagnostic quality of the image.

Drawbacks of the PSP systems include the sensitivity of the exposed plates to bright ambient light and the effort involved in scanning and repackaging the plates (**Table 1**). New products have entered the market that address some of these issues, providing auto-erase functions and even ultraviolet disinfection of the plates. Scanners from Soredex (Milwaukee, WI) and Air Techniques (Melville, NY), as well as the Carestream (Atlanta, GA) CS 7600 scanner and the Planmeca (Helsinki, Finland) ProScanner, include automatic plate clearance after scanning. Automatic plate clearance improves workflow and reduces potential plate damage from manual erasing.

Extraoral applications of PSP are straightforward. Film-screen combinations can easily be replaced by a PSP plate in conventional panoramic and cephalometric x-ray units. Patient exposure is identical to conventional radiography. Even though the plates can be reused many times, it is likely that scratches will limit their useful life as PSP plates are susceptible to damage. Replacing a PSP plate is far less costly than replacing a sold-sate detector, but careful handling remains a prerequisite.

Table 1 - Clinical steps for taking a single intraoral radiograph with approximate time (m:ss) for three imaging modalities.[1]

Film	Time	CCD/CMOS	Time	PSP	Time
Position receptor	0:30	Position receptor	0:40	Position receptor	0:30
Expose		*Expose*		*Expose*	
Wipe Unpack	0:05	*Image Available*		Wipe	0:05
Process	0:05	Remove barrier	0:05	Remove barrier	0:05 - 1:30
Image Available	5:00	Replace barrier	0:05	Scan[2]	
				Image Available	0:00 - 1:30
				Erase[3]	0:10
Total	**5:40**	**Total**	**0:50**	**Total**	**0:55 - 3:50**

1 Times are not based on measurements and are estimates for illustration purposes only. Actual procedure times are dependent on system and operator variables.

2 Scan time varies dramatically as a function of the type of scanner (drum-based versus direct feed), the number of plates being scanned and the selection of scanning resolution

3 Automated in some systems.

Detector Sensitivity

Intraoral film sensitivity is classified according to speed groups using criteria developed by the International Organization for Standardization (ISO). Extraoral screen-film combinations use a classification system developed by Eastman Kodak. Currently there are no classification standards for dental digital x-ray receptors. PSP systems for intraoral imaging require about the same dose as F-speed film. However, PSP plates have a very large dynamic range, which means that the plates tolerate underexposure as well as extreme overexposure. While this is convenient for the radiographer, it poses a potential risk for the patient in terms of increased exposure to ionizing radiation without a diagnostic benefit. Underexposure of PSP plates does not result in images that are too light, but rather in images that are noisy. This is the result of post-processing techniques that can ensure proper brightness and contrast, but that cannot compensate for insufficient signal. Although manufacturers have put safeguards in place, exposure tables or calibrated x-ray unit preset buttons remain important for consistent selection of the minimum exposure time required to obtain a high-quality image.

Manufacturers of solid-state detectors report dose reductions of up to 90% compared to film. These dose savings usually relate to the dose reduction per image in comparison with D-speed film. Although there are few reports on the actual reduction in absorbed dose per patient as a result of digital imaging, the reported dose reduction is somewhat less when the results are compared to F-speed film.

Solid-state and PSP systems for extraoral imaging require exposures similar to those needed for 400 speed screen-film systems.

Systems Integration and Compatibility

The development of digital imaging systems for dental radiography has largely been driven by industry. Manufacturers have adopted and developed technologies according to individual needs and philosophies. As a result, image formats among systems from different vendors are not standardized and image archival, retrieval and display systems are not compatible. One can always export and import images in generic image formats, such as JPEG (Joint Photographic Experts Group) and TIFF (Tagged Image File Format), however, such processes are cumbersome, and information associated with the image is lost. It has long been recognized that the adoption of a standard for transferring images and associated information between different digital imaging devices is necessary. Through the efforts of a large number of professional organizations the Digital Imaging and Communications in Medicine (DICOM) standard was developed. The DICOM standard addresses the interoperability of medical and dental imaging and information systems. Images saved in DICOM format store pertinent image information, patient information and system information. This assures a higher level of data integrity and allows seamless transfer of images and related information between DICOM conformant devices. Most dental imaging systems now conform to at least part of the DICOM standard.

Quality Assurance

The use of digital imaging systems implies significant changes in how radiographs are acquired, stored, retrieved and displayed. Quality assurance (QA) issues specifically related to film and chemistry became obsolete. Other QA issues stayed the same, such as the need for correct detector positioning and proper beam alignment. The use of exposure tables or preset exposure times for specific sites also remains important, despite the ability to adjust image brightness and contrast. Whereas digital imaging eliminates a number of significant QA issues, it also introduces a number of new ones. The most important of these are addressed below.

Electronic Image Display

Viewing dental radiographs as an electronic image on a monitor is now well-established and many dental professionals have not known it any other way. When setting up a digital imaging system, the selection of display hardware and software requires some thought and evaluation. A host of technical properties define the ultimate image quality of a monitor. Most mid-range and high-end desktop computers are configured with flat panel monitors that are suitable for digital radiography. Besides properties as size, resolution and refresh rate, the brightness and contrast of a monitor are important factors in a dental office that is typically well-lit. Current laptop displays are of sufficient quality to be used for typical dental diagnostic tasks, but their brightness is sometimes inferior to stand-alone monitors. Also, the viewing angle of some laptop displays is limited and the observer needs to be positioned squarely in front of the display for optimal viewing.

The software interface used for presenting radiographic images as well as other diagnostic and demographic information is an important element of a digital imaging system. The requirements vary according to the diagnostic task and practice pattern. Important functions such as zooming, scrolling and multiple image comparison must meet the needs and preferences of the practitioner. These functions are generally not as fast or flexible and vary from one vendor to the other. Comparing the different approaches of the various vendors is an important aspect in selecting a digital imaging system.

The visibility of electronic displays is degraded by many of the same elements which degrade viewing of any other image. Bright background illumination from windows or other sources of ambient light reduce visual contrast sensitivity. It is not always easy to block ambient light around a monitor , but images are best viewed in an environment where lighting is subdued and indirect.

Performance Assessment

The diagnostic imaging chain, from exposure to interpretation, contains a number of links, each of which has the ability to be the limiting factor. Whereas each of the components, like the x-ray source, the detector and the image display, requires individual quality control protocols, it is also good practice to assess the imaging system as one. The American Dental Association has published a valuable standard on digital quality assurance that is available for download Using objective methods to measure sensitivity, spatial resolution, contrast resolution, dynamic range, noise and artifacts can help clinicians monitor their imaging system over time and detect potential degradation. Although not mainstream in most practices, test phantoms have been developed specifically for this purpose.[2]

Hard Copies

As digital technology has become mainstream, the need to print digital images for sharing with other clinicians or with third parties is decreasing rapidly. When images must be printed, it is imperative to use a printing system that is designed for its intended use and to follow the manufacturer's recommendations. It is always preferable to transfer images digitally when possible.

Image Archival and Backup

The use of digital imaging in dentistry requires an image archiving and management system that is very different from conventional radiography. Storage of diagnostic images on magnetic or optical media raises a number of new issues that need to be considered. The file size of dental digital radiographs varies considerably, ranging from approximately 200 kB for intraoral images to up to 6 MB for extraoral images. Storage and retrieval of these images in an average size dental practice is not a trivial issue. Fortunately, the development of new storage media and the continuing decrease in the price of a unit of storage has alleviated the capacity issue in dental radiography. Hard drive capacities of modern computers already exceed the storage needs of most dental practices. The use of online practice management systems using cloud-type technologies has gained popularity in recent years. Online systems provide location-independent access. The technology has matured to the point that data security and integrity are acceptable for day-to-day clinical operations.

The simplicity with which digital images can be modified through image processing poses a potential risk with respect to ensuring the integrity of the diagnostic information. Once in a digital format, critical image data can be deleted or modified. It is important that the software prevents the user from permanently deleting or modifying original image data, whether intentional or unintentional. Not all software programs provide such a safeguard. As the use of digital imaging in dentistry continues to expand, the implementation of standards for preserving original image data becomes urgent.

The use of computers for storing critical patient information mandates the design and use of a backup protocol. The backup hardware, software and protocol need to be considered while setting up a digital system, not some time later. **Table 2** shows some issues that need to be considered when designing a backup protocol. A number of media options are available for external storage of digital radiographs including backup servers, external hard drives, DVDs and web-based services. When clinical operations depend on access to digital data, it is imperative that backup data are generated continuously and that an off-site copy is available when needed. Catastrophes such as fires and floods are fortunately relatively rare, but malfunctioning of computer hardware is quite common. Thus, a secure and user-friendly backup system needs to be part of every practice that relies on digital data for its clinical and administrative operations.

Table 2 - Digital Image Backup Considerations

• Type of Media	*DVD, server, hard disk, cloud?*
• Method	*Selective, full, compressed, uncompressed?*
• Timing	*Continuous, daily, weekly?*
• Storage Location	*On-site and off-site!*
• Recovery Time	*Minutes, hours, days?*
• Recovery Reliability	*Test!*
• Future Compatibility	*Requires regular upgrading*
• Security	*Safeguarding protected health information*

Image Compression

The purpose of image compression is to reduce the size of digital image files for archiving or transmission. Especially the storage of extraoral images in a busy clinic may pose a challenge to storage capacity and speed of image access. The purpose of file compression is to significantly reduce the file size while preserving critical image information.

Compression methods are generally classified as lossless or lossy. Lossless methods do not discard any image data and an exact copy of the image is reproduced after decompression. The maximum compression rate for lossless compression is usually less than 3:1. Lossy compression methods achieve higher levels of compression by discarding image data. Empirical evidence suggests that this does not necessarily affect the diagnostic quality of an image. Compression rates of 12:1 and 14:1 were shown to have no appreciable effect on caries diagnosis. Version 3.0 of the DICOM standard adopted JPEG (Joint Photographic Experts Group) as the compression method, which provides a range of compression levels. Although the use of low and medium levels of lossy compression appear to have little effect on the diagnostic value of dental images, the application of lossy compression should be used with caution and only after evaluating its effect for specific diagnostic tasks. With the continuing increase in the capacity of storage media and the widespread use of high-speed data communication, lossy compression of dental radiographs is not urgent. At the same time, new digital image receptors are generating images with more and more pixels and more bits per pixel, thus increasing storage needs. Image compression negates to some extent the gain from such high-end detectors. Whether or not we need high resolution detectors and whether or not we can use image compression should be dictated by diagnostic criteria. Current evidence suggests that detector quality and moderate image compression have a very limited impact on diagnostic outcomes.

Imaging Processing

The use of digital imaging in dental radiography involves a variety of image processing operations. Some of these operations are integrated in the image acquisition and image management software and are hidden from the user. Others are controlled by the user with the intention to improve the quality of the image or to analyze its contents. Any operation that acts to improve, restore, analyze or in some way change a digital image is a form of image processing.

The term image enhancement is often used to describe adjustments to the image that make the image visually more appealing (subjective enhancement). This can be accomplished by increasing contrast, optimizing brightness and reducing unsharpness and noise. Subjective image enhancement does not necessarily improve the accuracy of image interpretation. Image enhancement operations are often task-specific: what benefits one diagnostic task may reduce the image quality for another task. For example, increasing contrast between enamel and dentin for caries detection may make it more difficult to identify the contour of the alveolar crest.

By far the most useful image enhancement tool is contrast and brightness adjustment. This allows the clinician to optimize the image for specific tasks in an interactive manner. Some studies show substantial benefits of contrast enhancement operations, while others have found only limited value or no improvement at all. Images that have been captured with the proper exposure generally need very little adjustment. As a result, routine image adjustments should only be minor.

Virtually all software packages included with digital imaging systems provide additional tools for image processing, such as sharpening, smoothing, color conversion, pseudo-3D or embossing. None of these tools have been shown to improve the diagnostic quality of dental radiographs. In fact, frivolous use of these tools is likely to discard important diagnostic information and distract the observer from seeing the real content of the image. The promotion and use of these tools do not serve the dentist or the patient.

This does not mean that image processing has no place in dentistry. A large number of scientific studies have been devoted to developing and testing image processing tools for dental applications. Some of these have been quite successful, yet very few are commercially available at this point.

Other Clinical Considerations

The use of digital receptors instead of film implies consideration of some fundamental differences in clinical radiography. Digital receptors are reusable, thus they must be handled with great care. PSP plates are susceptible to bending and scratching, which produces permanent artifacts in the receptor. These artifacts can obscure potentially important diagnostic information and may result in disposal of the receptor. Digital detectors cannot be bent to accommodate patient anatomy, which requires new imaging strategies for some patients.

A significant potential problem with PSP systems is the inability to identify images that have been acquired with the plate exposed backwards. A PSP plate does not cause any meaningful x-ray attenuation itself and a plate that was exposed backward will show a mirror image of the anatomy. It is easy for inattentive radiographers to mount these digital images on the contralateral side, resulting in misdiagnosis and possibly wrongful treatment. The mechanism used for plate intake in the Soredex OpTime scanner requires a metal disk on the back of the plate. This disk also serves as a marker to indicate when a plate was exposed backwards. Carestream and Planmeca use radio-frequency identification (RFID) technology to link patient information to the plates. While this is designed to prevent plates from being scanned into the wrong patient file, the RFID chip also serves to alert the operator when a plate is accidentally exposed backwards.

As digital receptors are reusable, infection control is a new issue that requires attention. Digital receptors cannot be sterilized by conventional means. Barriers must be used to prevent cross-contamination and receptors can be disinfected by wiping with mild agents such as isopropyl alcohol.

Conclusion

The future of oral and maxillofacial radiology is being shaped by digital technology and the adoption of digital imaging is now widespread. Both solid-state and photostimulable phosphor (PSP) detectors will continue to evolve. However, no matter how revolutionary the developments and improvements in detector technology, digital detectors do not represent a fundamentally different approach to intraoral and extraoral imaging. The costs associated with setting up a digital system are relatively high. While the cost of digital systems can be amortized over time, the life expectancy of newer digital systems is speculative. Mishandling of digital system components can catastrophically shorten any projected life expectancy. In addition, advances in digital technology result in equipment becoming obsolete at a greater rate.

Most studies suggest that the performance of digital systems is not different from film for typical diagnostic tasks such as caries diagnosis.[3] Comparison of imaging systems based on technical properties like resolution, contrast and latitude is somewhat confounded by a lack of standardization in the assessment of these characteristics. Whereas most clinicians lack the basic training and knowledge to judge the quality and reliability of digital imaging systems, there are some good resources available that can help in understanding the technology as well as its clinical implications.[1,2,4,5,6] Knowledgeable consumers are more likely to optimize the cost-benefit ratio of new technologies and maximize the health benefit for the patient.

References

1. Yoon DC, Mol A, Benn DK, Benavides E. Digital Radiographic Image Processing and Analysis. Dent Clin North Am 2018; 62(3): 341-359. Doi: 10.1016/j.cden.2018.03.001.
2. Mah P, McDavid WD, Dove SB. Quality assurance phantom for digital dental imaging. Oral Surg Oral Med Oral Pathol Oral Radiol and Endod 2011; 112: 632-639.
3. Wenzel A. Bitewing and digital bitewing radiography for detection of caries lesions. J Dent Res 2004; 83 Spec No C: C72-75.
4. Vandenberghe B, Jacobs R, Bosmans H. Modern dental imaging: a review of the current technology and clinical applications in dental practice. Eur Radiol 2010; 20(11):2637-55.
5. Ludlow JB, Mol A. Digital Imaging. In: White SC, Pharoah ML. Oral Radiology: Principles and Interpretation. Seventh Edition. Mosby, St. Louis 2014.
6. Mol A, Yoon DC. Guide to Digital Radiographic Imaging. J Calif Dent Assoc 2015. 43(9): 503-511.

POST-TEST

Internet Users: This page is intended to assist you in fast and accurate testing when completing the “Online Exam.” We suggest reviewing the questions and then circling your answers on this page prior to completing the online exam.

(1.0 CE Credit Contact Hour) Please circle the correct answer. 70% equals passing grade.

1. **The diagnostic accuracy of digital imaging systems compared to conventional film-based radiography is:**
   a. Worse
   b. About the same
   c. Better
   d. Not comparable

2. **How many shades of gray does a 12-bit image contain?**
   a. 256
   b. 1024
   c. 4096
   d. 16384

3. **Which statement is <u>TRUE</u> regarding intraoral solid-state detectors?**
   a. They can be sterilized if contaminated.
   b. They are thicker than film or photostimulable phosphor (PSP) plates.
   c. The dimension of the active area is much smaller than film.
   d. They are inexpensive to replace.

4. **Image acquisition time of a cephalometric radiograph with a CCD detector is the same as with film.**
   a. True
   b. False

5. **Which surface is sometimes difficult to image with a solid-state detector?**
   a. Distal surface of the second premolar in the molar periapical radiograph.
   b. Distal surface of the canine in the premolar periapical radiograph.
   c. Mesial surface of the first molar in the premolar periapical radiograph.
   d. Mesial surface of the canine in the incisor periapical radiograph.

6. **Which of the following is an advantage of photostimulable phosphor (PSP) plates relative to solid-state detectors (CCD/ CMOS)?**
   a. The images appear on the screen almost instantaneously
   b. There is no need for exposure tables or preset buttons.
   c. PSP plates are thinner and slightly flexible.
   d. PSP images can be enhanced once they have been captured.

7. **Which of the following statements is <u>TRUE</u> regarding photostimulable phosphor (PSP) plates?**
   a. They cannot be reused.
   b. They should be exposed to bright light before scanning.
   c. They should be shielded from bright light before scanning.
   d. Scanning erases all of the latent image.

8. **An underexposed PSP plate results in an image with**
   a. Low brightness
   b. High brightness
   c. Low noise
   d. High noise

9. **Which of the following is the best safeguard for identifying a PSP plate that has been exposed backward?**
   a. A radiopaque marker on the front of the plate
   b. A radiopaque marker on the back of the plate
   c. A radiolucent marker on the front of the plate
   d. A radiolucent marker on the back of the plate

10. **Which of the following represents best practice for monitoring the quality of the imaging system?**
   a. Exposure of a dedicated quality control phantom at set-up
   b. Exposure of a dedicated quality control phantom at regular intervals
   c. Subjective assessment of image quality at set-up
   d. Subjective assessment of image quality at regular intervals

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