Radiography

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Topic

Artifacts

Article

Pictorial Review of Digital Radiography Artifacts

Speciality

Diagnostic / Medical Technician

Approved for TWO (2) Clinical Continuing Educational Units (CEU’s)
Pictorial Review of Digital Radiography Artifacts¹

Alisa I. Walz-Flannigan, PhD
Kimberly J. Brossoit, RT
Dayne J. Magnuson, RT
Beth A. Schueler, PhD

Abbreviation: AAPM = American Association of Physicists in Medicine

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¹From the Department of Radiology, Mayo Clinic, 200 First St SW, Rochester, MN 55901. Presented as an education exhibit at the 2016 RSNA Annual Meeting. Received March 6, 2017; revision requested October 13 and received November 18; accepted December 6. For this journal-based SA-CME activity, the authors, editor, and reviewers have disclosed no relevant relationships. Address correspondence to A.I.W.F. (e-mail: walzflannigan.alisa@mayo.edu).

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SA-CME LEARNING OBJECTIVES

After completing this journal-based SA-CME activity, participants will be able to:

■ Identify digital radiographic artifacts and the circumstances that resulted in their appearance.
■ Discuss the cause of the artifact.
■ Describe methods to eliminate the artifact and improve image quality.

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Visual familiarity with the variety of digital radiographic artifacts is needed to identify, resolve, or prevent image artifacts from creating issues with patient imaging. Because the mechanism for image creation is different between flat-panel detectors and computed radiography, the causes and appearances of some artifacts can be unique to these different modalities. Examples are provided of artifacts that were found on clinical images or during quality control testing with flat-panel detectors. The examples are meant to serve as learning tools for future identification and troubleshooting of artifacts and as a reminder for steps that can be taken for prevention. The examples of artifacts provided are classified according to their causal connection in the imaging chain, including an equipment defect as a result of an accident or mishandling, debris or gain calibration flaws, a problematic acquisition technique, signal transmission failures, and image processing issues. Specific artifacts include those that are due to flat-panel detector drops, backscatter, debris in the x-ray field during calibration, detector saturation or underexposure, or collimation detection errors, as well as a variety of artifacts that are processing induced.

Introduction

An artifact on an image is a feature that does not correlate with the physical properties of the subject being imaged and may confound or obscure interpretation of that image. In this article, examples of artifacts from flat-panel detector–based digital radiographic systems are presented. The examples of artifacts are paired with their cause and resolution as a means to aid in the future identification, resolution, or prevention of digital radiographic artifacts that may affect the quality of patient care. The artifact examples provided were taken from clinical images as well as routine quality control testing.

Flat-panel detector–based digital radiographic systems differ in their image creation mechanism from computed radiography, having an intrinsic pixel matrix and differences in signal detection and processing. This difference can contribute to artifact types that
TEACHING POINTS

- Some artifacts may be seen clearly at retrospective viewing, but because of inattention bias, they might not be identified during normal quality assurance steps or diagnostic interpretations. This type of artifact may also affect patient care. For example, the residual image of a marker, carried over to subsequent images, could lead to misinterpretation of patient laterality. It is important to understand the conditions under which these artifacts may be created, to either take steps to prevent their clinical appearance or foster a targeted vigilance in quality assurance during situations in which the artifact is more likely to appear.

- Providing technologists with a safe strategy and a demonstration of proper detector bagging, detector cleaning, or holding wireless flat-panel detectors during battery changes may provide additional reduction in detector drop–related failures. For any practice, good communication detailing when detector drops occur and the situations in which they occur can help to identify targets for reducing the number of detector drop–related artifacts.

- If projections of detector electronics are visible on a patient image, options for a repeated image include using tighter collimation (decreasing the field of view), verifying good imaging geometry, or placing additional shielding behind the detector, such as a lead apron or plate to block the backscatter from striking the detector.

- The most basic tool for avoidance of image saturation is to ensure that the designated size-based techniques have been followed. For manual techniques, the source-to-detector distances and the thickness of the anatomy need to be measured.

- Temporary nonuniformities that are present in the x-ray beam during calibration (including lag from previous images) will persist into subsequent imaging as an inverse image. For this reason, it is important to visually validate the quality of a calibration with a flat-field image.

Some artifacts are easy to spot on a clinical image; their effect may be to obscure parts of an image or to compromise the desired image field of view. Examples of these types of artifacts may arise from the misidentification of the desired image field of view or from detector damage caused by dropping (“detector drop”). In these situations, the need for response is clear, but it may be unclear how to prevent or address the issue without understanding how it was created.

Some artifacts may be seen clearly at retrospective viewing, but because of inattention bias (2), they might not be identified during normal quality assurance steps or diagnostic interpretations. This type of artifact may also affect patient care. For example, the residual image of a marker, carried over to subsequent images, could lead to misinterpretation of patient laterality (3). It is important to understand the conditions under which these artifacts may be created, to either take steps to prevent their clinical appearance or foster a targeted vigilance in quality assurance during situations in which the artifact is more likely to appear.

Other artifacts are more subtle and not as easily seen on a clinical image. These artifacts are most likely to be found during routine quality control testing. Ideally, any artifacts that create deviation from ideal detector performance would be resolved; however, it is more practical to have a threshold for artifact identification to help determine when an effort should be put into resolution. This threshold for an artifact affecting diagnostic interpretation may be rightfully debated and may differ on the basis of the examination, the specific detector exposure, and image processing. The threshold for responding to an artifact may also differ on the basis of whether it can be eliminated through service on the detector or whether elimination of the artifact requires purchase or warranty replacement of a detector. Examples of these more subtle artifacts include flaws in gain calibration, debris interfering with the x-ray beam, or visible detector tiling.

For routine quality control testing with a uniform beam, we have established a strategy that uses a qualitative visual assessment with a viewing window that provides the identification threshold. Our method is similar to what is described in the report from the American Association of Physicists in Medicine (AAPM) Imaging Physics Committee Task Group 151 (4), which uses a qualitative visual evaluation of flat-field images in which anatomic image processing has not been applied (ie, “original data,” as described in international standard IEC 62220-1) (5). Depending on the pixel value window that is used for viewing, qualitative visual
Artifacts from Detector Accidents or Mishandling

Detector Drops
Wireless flat-panel detectors get dropped. Drops can damage the detector system in several ways through fracturing of the flat-panel detector, through disruption of readout electronics, or through shifting gain and offsets. Some vendor systems may have integrated diagnostics software to alert the user when detector drops are of sufficient magnitude for a risk to image quality and may provide follow-up instructions for how to respond. Following instructions that direct a user to seek service or discontinue use of a damaged detector can prevent unnecessary repeated images. However, because drops occur that can be withstood by detectors without apparent damage and because some systems do not provide user feedback about the effect of a detector drop, the truth of the drop’s effect is sometimes found in an image itself. We provide examples of images affected subsequent to detector drops.

Description of Artifact Appearance.—The artifact shown as an example in Figure 1 is from a cesium iodide flat-panel detector. Subsequent to the detector being dropped, a narrow white band appeared at the top of images. Review of the images taken with the detector after the drop showed that the white band grew progressively larger with time, until the detector was pulled from service. Figure 2 shows another example of a detector that was used subsequent to a drop. In this case, a large area of signal dropout with a rounded perimeter was seen, in addition to signal dropout along lines of signal readout. The artifact in Figure 3 was found with a gadolinium oxysulfide flat-panel detector and appears as white speckles that do not correspond to any dirt or surface debris.

Cause.—Although the exact mechanism for the progression from a thin line of signal dropout to what is shown in Figure 1 is not well understood, the known precipitating incident was a detector drop. The appearance of the white band is presumed to be due to the disruption of the readout circuitry but could also be related to a loss of adhesion between the scintillator layer and the thin-film transistor layer of the detector. Because the lines of signal dropout in Figure 2 appear parallel to detector readout, the most likely explanation is the mechanical disruption in the readout circuitry. The large rounded area of signal dropout in Figure 2 likely represents a region of compromised adhesion between the...
scintillator layer and the thin-film transistor layer. The image shown in Figure 3 is presumed to be the result of minute shifts between the scintillator layer and the thin-film transistor layer of a gadolinium oxysulfide flat-panel detector; such shifts affect the effectiveness of the flat-field calibration.

**Avoidance or Remedy.**—Some detector drops might result in shifts in signal gain or offset that can be compensated for with recalibration of the detector. The appearance of a speckle pattern in Figure 3 subsequent to a detector drop was resolved by a detector recalibration. Likewise, we have seen detector artifacts that initially look like dead lines but were able to be addressed through recalibration, indicating that signal readout was affected but not broken. Other detector drops may result in mechanical failures in signal readout, creating artifacts like those seen in Figures 1 and 2. In these circumstances, it is not possible to address the failures through detector calibration. Instead, the detector needs to be replaced.

Some vendors advertise detectors that have greater robustness with drops or detectors that provide for greater ease of handling to avoid drops, such as incorporation of a handgrip. In addition, protective cases are available, which some practices may find useful. Providing technologists with a safe strategy and a demonstration of proper detector bagging, detector cleaning, or holding wireless flat-panel detectors during battery changes may provide additional reduction in detector drop–related failures. For any practice, good communication detailing when detector drops occur and the situations in which they occur can help to identify targets for reducing the number of detector drop–related artifacts.

**Liquid Contamination**

Although it is not a novel concept that liquids do not mix well with sensitive electronic equipment, unless such an incident is noticed, reported, and addressed, it may result in imaging failures during examination of a patient.

**Description of Artifact Appearance.**—After a leak in a patient’s water mattress during imaging, an image was acquired that shows banding throughout (Fig 4).
**Figure 5.** Backscatter. (a) Radiograph obtained with a portable radiographic unit shows a shadow of detector electronics, created by backscattered x-rays. (b) Image obtained when the detector was exposed upside down shows the detector electronics. (c) Highlighted radiograph shows the matching features (yellow) that appear on the image of the detector electronics (b) and on the patient radiograph with the backscatter artifacts (a), to highlight the similarities.

**Cause.**—Although the detector had been placed into a plastic bag, the bag was not one that could be effectively sealed. A substantial leak from a patient’s water mattress resulted in water getting inside the bag. It is presumed that water infiltration into the detector caused damage or disruption in the readout electronics that resulted in a lack of signal, or false signal, that appears along the readout lines.

**Avoidance or Remedy.**—For both infection control and prevention of liquid infiltration, wireless flat-panel detectors are often bagged. Using watertight protection, such as a sealable plastic bag, can better protect a detector from liquid exposure such as that resulting in the failure shown in Figure 4. Vendors of newer models of flat-panel detectors also advertise better water sealing to prevent damage. The detector cannot recover from the damage demonstrated in Figure 4, and the detector needed to be replaced.

**Artifacts Related to Acquisition Technique**

**Backscatter**

Image artifacts can be created when backscattered radiation reaches detector elements through the back of the detector (3).

**Description of Artifact Appearance.**—The shadow image of detector electronics appears superimposed on a patient image in Figure 5a. Corresponding features between an image of the detector electronics and the backscatter projection of the electronics on the patient image are shown in Figure 5b and 5c.

**Cause.**—Backscatter artifacts are more likely to appear in situations with more scatter (ie, with large patients or wide-open collimation) or if the x-ray beam is not fully intercepted by the detector. This backscatter-related artifact is more possible with certain imaging geometries that use a wireless detector outside a table or upright holder, a situation in which it may be more challenging to properly angle the detector or use tight collimation (as in some cross-table imaging).

**Avoidance or Remedy.**—If projections of detector electronics are visible on a patient image, options for a repeated image include using tighter collimation (decreasing the field of view), verifying good imaging geometry, or placing additional shielding behind the detector, such as a lead apron or plate to block the backscatter from striking the detector.

**Image Saturation**

Information may be lost (“clipped”) from an image when an exposure exceeds the dynamic range imposed by an image processing algorithm or in some circumstances in which the exposure exceeds the dynamic range of the image receptor. It can be difficult to tell which is the source of the problem unless one is able to access an unprocessed (“for-processing”) image. Although either computed radiography or digital radiography provides greater exposure latitude than film, thus reducing the likelihood of image receptor saturation within the anatomy of a patient image, such saturation may be more likely with digital radiography than with computed radiography. The saturation point for digital radiography is typically much lower than that for computed radiography.
Figure 6. Image saturation. (a) Abdominal radiograph obtained with a portable radiographic unit shows the effect of excessive image exposure that resulted in a patient’s femurs and surrounding soft tissue being lost from the image. (b) Upper abdominal radiograph shows image saturation (arrow) at the diaphragm, a location in which image saturation is more commonly seen. For both images, a simulated-grid acquisition was used. Both acquisitions used manual techniques for one size above what would have ideally been recommended on the basis of patient thickness, as listed on the technique charts. The exposure was approximately double what was recommended for the patient in a and was 40% greater than what was recommended for the patient in b.

Description of Artifact Appearance.—The abdominal radiograph in Figure 6a represents a dramatic case of image saturation (“clipping”) in which the lower part of the patient’s anatomy is completely missing from the image. Figure 6b is an example of saturation-related clipping at the diaphragm in an upper abdominal radiograph. Attempts to reasonably recover the image content and quality with image processing were unsuccessful for each example. Both images in Figure 6 were acquired by using simulated-grid imaging, which does not use a grid but employs a scatter-suppression image processing algorithm.

Cause.—The manual technique used to obtain the image in Figure 6a was approximately twice what was recommended for the measured abdominal thickness but was only one size step larger on the manual technique chart that was provided to the technologists. The image in Figure 6b also used a technique one size step larger than might have been recommended on the basis of the patient thickness, which resulted in using a setting of 40% more milliampere-seconds than would have been desired.

We saw an increase in image saturation artifacts with the initial use of simulated-grid acquisition, most frequently along the diaphragm at abdominal imaging, as shown in Figure 6b. The increased occurrence of image saturation artifacts with simulated-grid images, compared with gridded images, can be logically related to a higher recommended detector air kerma relative to gridded techniques. (A higher recommended target detector air kerma is inferred from the default technique guides provided by the manufacturer, which show a 0%–35% reduction in the milliampere-second setting between gridded and simulated-grid chest and abdomen techniques for the same detector for a medium patient.) Technique recommendations, as provided by the vendor, suggested between a 0% and 35% reduction in the milliampere-second setting between grid use and simulated-grid use in acquisitions. However, maintaining the same...
detector exposure without a grid would require a reduction of approximately 75% in technique. The net effect is that the recommended image receptor air kerma for simulated-grid imaging is higher than that for imaging with a grid. Aiming for a higher detector target in effect increases the likelihood of image saturation, creating a greater need for technique optimization and careful technique selection.

**Avoidance or Remedy.**—The most basic tool for avoidance of image saturation is to ensure that the designated size-based techniques have been followed. For manual techniques, the source-to-detector distances and the thickness of the anatomy need to be measured. In addition, we found that we needed to provide more size-specific tailoring and further optimization to avoid image clipping with the simulated-grid acquisition technique. Technique optimization involved extensive review of patient images, acquisition techniques, and technologist-recorded patient sizes. With guidance from radiologists, techniques that provided adequate noise properties with a lower risk of artifacts were determined.

**Artifacts from Limitations or Flaws in Detector Calibration**

**Detector Calibration Limitations**

**Description of Artifact Appearance.**—The image in Figure 7 shows vertical striping in the area of raw radiation. The lines are seen only in the background on the image and do not extend into the anatomy.

**Cause.**—The artifact lines demonstrate the limits of gain and offset corrections of the detector calibration when the exposure is far from the calibration conditions (as is the case when the detector is exposed to the unattenuated x-ray beam). This evidence of detector structure disappears at lower exposures. The threshold for the appearance of detector structure will differ for detectors that have different offset tolerances between detector elements.

**Avoidance or Remedy.**—Some degree of limitation in flat-field correction may be anticipated when the detector receives exposures outside its dynamic range. Because this type of artifact has caused some confusion in the past, it has been important to educate technologists about what this artifact looks like, so they understand that it is not related to a failure in grid movement or suppression and so they learn to not reject images unless the artifact extends into the anatomy. This type of artifact is also less likely when well-optimized target exposures are used for the images.

**Inverse Focal Spots and Calibration Artifacts**

Debris in the x-ray beam creates an image on the detector, as might be expected of any x-ray–attenuating object found between the x-ray source and any image receptor. In particular, a small speck of x-ray–attenuating material near the head of the x-ray tube can create an inverse image of the focal spot, acting as a pinhole camera as described by Walker (8).

**Description of Artifact Appearance.**—A single trapezoidal opacity can be seen in the flat-field image in Figure 8a, surrounded by the magnified and offset appearance of its inverse (the area of lucency around the opacity). Figure 8b shows similarly appearing artifacts but of different sizes, locations, and orientations. Both images were acquired as part of quality control testing of portable x-ray units, with no added material in the x-ray beam, at 80 kVp, and with an image receptor air kerma of 17.5 μGy.

**Cause.**—The cause of these artifacts was found when the collimator was removed from the x-ray tube (Fig 9). Lead shavings seen near the head of the x-ray tube were created by the collimator scraping against the beam-shaping port cylinder. The lead shavings created opaque-appearing pinhole images of the focal spot, with the size and location depending on the location of the speck relative to the focal spot and the detector. The darker trapezoids (Fig 8) represent the former
Figure 9. Lead debris was created near the head of the x-ray tube in a portable x-ray unit when fully opened collimator blades rubbed against the lead beam-shaping port cylinder (arrow). This issue was discovered during the investigation of the cause of the image artifacts shown in Figure 8.
location of the inverse focal spot images that have been recorded into the detector gain calibration.

**Avoidance or Remedy.**—The artifacts were eliminated by removing the debris and recalibrating the detector. Adjustment of the collimator prevented further rubbing with the lead port cylinder, reducing the appearance of these artifacts.

The gray-scale magnitude of the inverse focal spot image created by the debris near the head of the x-ray tube can vary. Typically, these artifacts are minimally visible on patient images and instead are found during quality control testing. However, several incidents in which the artifact was visible on clinical images led to a practice of further investigation to ensure that artifacts viewable in a quality control viewing window were addressed.

### Flawed Detector Calibration

**Description of Artifact Appearance.**—The image in Figure 10 shows irregular lines that appear to be radiolucent relative to the surrounding material. These lines did not correspond to anything that was being imaged. Subsequent images with this detector showed that the radiolucent wavy line artifact remained in a fixed position on the detector when the detector was rotated with respect to the tube.

**Cause.**—The projection of a pillow edge on the detector during calibration became recorded in the flat-field correction. Although we adopt a quality control practice similar to that described in the AAPM Imaging Physics Committee Task Group 151 report (4) to perform an artifact test after detector calibration, this test had only been done in the “free-detector” mode with the wire-free detector outside the table. For this particular digital radiographic system, detector flat-field calibrations are done separately for imaging with the detector in the table or in the wall stand. As a result, the artifact associated with the table calibration was not found until clinical use.

**Avoidance or Remedy.**—Temporary nonuniformities that are present in the x-ray beam during calibration (including lag from previous images) will persist into subsequent imaging as an inverse image. For this reason, it is important to visually validate the quality of a calibration with a flat-field image. Since finding this artifact, we have used a quality control strategy that tests all detector calibration configurations to ensure that no artifacts have been recorded into a flat-field correction.

Figure 10. Flawed detector calibration. Radiograph shows radiolucent lines near the top of the image (rectangle). Inset: Magnified view shows the inverse image of a pillow edge as radiolucent wavy lines (arrow). The pillow edge had been left in the field of view during detector calibration, creating an artifact that remained until the detector was recalibrated.

Figure 11. Evolving detector defect. Radiograph shows that in addition to several trapezoidal inverse focal spot artifacts on this flat-field image, many bloblike artifacts (arrow) are depicted. These bloblike artifacts are differentiated from inverse focal spot images because they are stationary when the detector is rotated and do not change size with source-to-detector distance. The artifacts appeared within 6 months after a flat-field calibration in which the detector had been observed to be artifact free.
Failure of Detector Offset Correction

Description of Artifact Appearance.—Shown in Figure 12, superimposed on an abdominal radiograph obtained with a portable x-ray unit shows a superimposed inverse image from a previous acquisition: the previous patient abdominal outline (black arrow) and the previous laterality marker (white arrow). This artifact occurred when an offset calibration was skipped after replacement of a detector battery.

Cause.—After replacement of the battery in a wireless digital radiographic detector, technologists are prompted to perform a detector offset calibration. In this case, when a detector battery needed replacement during the middle of an examination, the technologists bypassed the calibration in “urgent” mode. When the offset calibration is bypassed in urgent mode, the residual signal on the detector becomes incorporated into the applied signal offsets until the next offset calibration is done. Bypassing the detector calibration resulted in an image proportional to the inverse of this residual signal appearing on a subsequent image (Fig 12).

Avoidance or Remedy.—A new offset calibration removed the residual image artifact. To avoid the

Evolving Detector Defect

Description of Artifact Appearance.—A unique and subtle artifact was found regularly during quality control testing with one particular type of detector. As shown in Figure 11, the artifacts appear as bloblike areas of opacity. The blobs are often visible with our quality control window (30 times the noise magnitude) but are generally not seen on clinical images. The artifacts remain stationary when the detector is rotated with respect to the head of the x-ray tube and hence are located on the detector itself. Although not seen immediately after detector flat-field calibration, the artifacts have been seen to show up again 6 months later.

Cause.—The presumed cause is related to detector delamination “bubbles” that develop between the scintillator layer and the thin-film transistor layer of the detector. This change in coupling affects signal transfer in the detector.

Avoidance or Remedy.—The artifacts appearing as bloblike areas of opacity seem to remain subclinical with regular detector recalibration.

Failure of Detector Offset Correction

Description of Artifact Appearance.—Shown in Figure 12, superimposed on an abdominal radiograph, are inverse images that show the outline of an abdomen and a laterality marker from a previous image acquisition.

Cause.—After replacement of the battery in a wireless digital radiographic detector, technologists are prompted to perform a detector offset calibration. In this case, when a detector battery needed replacement during the middle of an examination, the technologists bypassed the calibration in “urgent” mode. When the offset calibration is bypassed in urgent mode, the residual signal on the detector becomes incorporated into the applied signal offsets until the next offset calibration is done. Bypassing the detector calibration resulted in an image proportional to the inverse of this residual signal appearing on a subsequent image (Fig 12).

Avoidance or Remedy.—A new offset calibration removed the residual image artifact. To avoid the
need to change batteries during an examination, when a technologist may not feel that there is time to wait for the offset calibration, it is advisable to have a procedure for either scheduled detector battery changes or monitoring battery life. In addition, it was helpful for technologists to understand the effect of choosing the urgent mode and to avoid doing so, if possible.

**Artifacts Related to Image Processing**

A predominant variation between different digital radiographic (or computed radiographic) systems relates to their image processing algorithms and the image processing settings that are used. Failures in image processing or a substantial lack of robustness in image processing outcomes can create image artifacts that limit or complicate viewers’ ability to see the imaged anatomy in a consistent way.

**Electronic Shutter Failure**

**Description of Artifact Appearance.**—A cross-table lateral hip radiograph that was acquired according to the standard procedure is shown in Figure 13a. Interpreting the image problem as an acquisition failure, the technologist repeated the acquisition, with the result obtained with proper shuttering shown in Figure 13b.

**Cause.**—The image processing algorithm incorrectly identified the collimator blades and incorrectly applied electronic shutters.

**Avoidance or Remedy.**—An imaging failure of this type caused by electronic shutter failure can be fixed through reshuttering and reprocessing the image, rather than requiring a new acquisition. It is important that the image be reprocessed after the correct shutter is applied because the values of interest for processing have an effect on the final image appearance.

**Poor Identification of Values of Interest**

**Description of Artifact Appearance.**—The image in Figure 14a appears washed out, giving the impression that the anatomy was poorly penetrated despite the use of a higher (large-patient) technique for a small- to medium-sized patient. Another version of the same image, reprocessed after shuttering to the area within the dashed lines, is shown in Figure 14b. Figure 14b is more consistent with the anticipated appearance of patella radiographs.

**Cause.**—Processing outcomes are dependent on what values of interest are used by the image processing algorithm. In this case, there appears to have been a failure of proper exposure recognition or perhaps an improper use of pixels outside the anatomy in setting contrast enhancement (9). The processing outcome was seen to vary depending on the amount of raw radiation area in the image, indicating that raw radiation was being included in the values of interest used for image processing.

**Avoidance or Remedy.**—Generally, image processing algorithms should not include large areas of raw radiation in the values of interest used for processing. If a correctly acquired image appears to have inappropriate contrast and/or opacity, it is wise to check that only appropriate pixels are contributing to the values of interest. Some vendor systems may display which pixels have been included as relevant, or the user may be able to...
constrain what is considered relevant by selecting a particular image region for processing.

**Midgray Clipping**

*Description of Artifact Appearance.*—The image examples in Figure 15a and 15b show a loss of information in parts of the knee radiographs where multiple pixel values and structures are anticipated but not visible. This loss is seen in the loss of detail in the cement and cement-implant boundary in Figure 15a and a loss of detail along the anterior edge of the tibia in Figure 15b.

*Cause.*—The artifacts in Figure 15a and 15b appear to be related to poor optimization of the signal equalization processing, also known as contrast enhancement (9–11). The image processing that had previously been set for the lateral knee, shown in Figure 15b, was chosen for overall contrast and detail preference with a clinical image sample. The loss of image information with this particular processing setting was not immediately appreciated and was found after more patient images demonstrated the problem. The outcome of signal equalization also depends on the selection of values of interest. For Figure 15a, it was seen that the poor processing outcome related to a change in collimation between the image shown and the images for which the processing was optimized (knee images with a larger field of view).

*Avoidance or Remedy.*—Image processing settings were adjusted to avoid the loss of information. This adjustment required adding another processing option for the images with a small field of view, which resulted in the image in Figure 15c, and modifying the default processing setting for lateral knees, as shown in Figure 15d.

**Metal Interface Artifacts**

For certain image processing algorithms, an attempt to emphasize bone detail in the presence of metal may lead to an artifact in the image of the metal or the metal-bone interface (10,12). Given the importance of being able to visualize
Figure 16. Metal interface artifacts. (a) Knee radiograph shows artifacts at the metal-bone interface (rectangle). Inset: Magnified view shows artifacts at the metal-bone interface, creating a false lucency (arrow) as well as a stairstep edge that does not correspond to the structure of the object being imaged. (b) Knee radiograph was obtained with the same source image data but with the use of an alternative processing setting to address the lucency artifact (rectangle). Inset: Magnified view shows elimination of the lucency artifact depicted in a.

Figure 17. Grid-line suppression failure. Chest radiograph obtained with a portable radiographic unit shows a failure of the grid-line suppression software (square). Inset: Magnified image shows detail of grid lines.

In the image in Figure 16a, the processing creates a false appearance of lucency between the bone and metal, a finding that might be suggestive of a loosening (Fig 16a, inset). In addition, the edge of the implant appears falsely serrated.

Cause.—Lucency artifacts (Fig 16a, arrow) are presumed to be related to excessive edge enhancement. The processing setting had worked well for knee images with a larger field of view but did not work well with the small field of view.

Avoidance or Remedy.—In Figure 16b, the image processing was adjusted to eliminate the false lucency; however, the adjustments did not satisfactorily resolve the false structure on the edge of the hardware.

Grid-Line Suppression Failure

Description of Artifact Appearance.—Grid lines appeared on the chest radiograph obtained with a portable radiographic unit shown in Figure 17.

Cause.—The example in Figure 17 shows a failure of a grid-line suppression algorithm related to using a grid with a line frequency that was incompatible with the grid-line suppression software algorithm.

Avoidance or Remedy.—Proper functioning of the grid-line suppression software may depend on automatic recognition that a grid is present.
Moreover, the grid-line suppression algorithm may be designed for a specific grid-line frequency. Ensure that when a fixed grid is used, the grid-line frequency matches that recommended by the system manufacturer.

Conclusion

It is extremely important, to the extent that it is possible, that the radiologist is able to have confidence that image information relates to the patient anatomy rather than being false information pertaining to an image artifact. A visual familiarity with radiographic artifacts can help in identifying when image information cannot be trusted. In addition, understanding the mechanisms for the formation of various artifacts can help in being able to resolve or prevent their appearance, to improve the consistency and quality of radiographic imaging. Certain types of artifacts may appear uniquely with flat-panel detector–based digital radiographic systems, and these types include any artifact related to a detector gain calibration or to a disruption of readout circuitry. Other artifacts related to image processing can be found in common with both flat-panel detector–based and computed radiography–based digital radiographic systems.

References

**INTRODUCTION**

**Question 1:** What are the learning objectives of this study?

A: To discuss how flat-panel detectors are used in digital radiographic image creation  
B: To identify digital radiographic artifacts  
C: To identify the circumstances that result in digital radiographic artifacts  
D: To describe how to use a flat-panel detector  
E: To discuss the methods to eliminate the artifacts

**Detector drops**

**Question 2:** Your colleague tripped over a broken floor tile on the way to a patient. She was carrying a wireless flat-panel detector that slipped out of her hands when she tripped. After you helped her get back up, she proceeds to walk over to her patient, since the detector appears to be in perfect condition. You stop her to mention that the detector system could have been damaged in which of the following ways:

A: Through fracturing of the flat-panel detector.  
B: Through disruption of readout electronics.  
C: Through radiation reaching the elements at the back of the detector.  
D: Through shifting gain and offsets.

**Liquid contamination**

**Question 3:** Why are wireless flat-panel detectors often placed in plastic bags?

A: For infection control  
B: To prevent liquid infiltration  
C: To prevent overexposure to natural light  
D: For patient handling control

**Backscatter**

**Question 4:** After taking a radiograph of a patient you see that there is a projection of detector electronics on the image. What are your options for a repeated image?

A: Using tighter collimation  
B: Measuring the thickness of the anatomy  
C: Verifying good imaging geometry  
D: Placing additional shielding behind the detector  
E: Removing debris and recalibration

**Image saturation**

**Question 5:** Is it TRUE that the most basic tool for avoidance of image saturation is to reshutter and reprocess the image?

A: YES  
B: NO

**Detector calibration limitations**

**Question 6:** You have taken a clavicle radiograph of a patient. You immediately notice that there is something wrong with the image and you suspect that it might be due to the limitations of detector calibration. Which of the following statements are incorrect with regard to this artifact?

A: It happens as a result of a failure in grid movement or suppression.  
B: Images showing this artifact need to be rejected, whether the lines extend into the anatomy or not.  
C: It is less likely to happen when well-optimised target exposures are used.

**Inverse focal spots and calibration artifacts**

**Question 7:** If you find that there is debris in the x-ray beam, what are the steps you can take to rectify the problem?

A: Remove the debris  
B: Adjust the imaging processing settings  
C: Recalibrate the detector  
D: Bypass the calibration in urgent mode  
E: Verify good imaging geometry

**Flawed detector calibration**

**Question 8:** You have been shown an image that contains an artifact. Your colleague is of the opinion that it is as a result of flawed detector calibration. Which of the following appearances would support his opinion?

A: The shadow image of detector electronics appears superimposed on the image  
B: There are irregular lines that appear to be radiolucent relative to the surrounding material  
C: There are vertical lines that appear in the background in the raw-radiation portion of the image and do not extend into the anatomy  
D: The artifact remained in a fixed position on the detector after it was rotated with respect to the tube
**Evolving detector defect**

**Question 9:** Is it TRUE that artifacts appearing as bloblike areas of opacity seem to remain subclinical with regular detector recalibration?

A: YES  
B: NO

**Failure of detector offset correction**

**Question 10:** During an examination the battery of the detector dies. Since you are in the middle of an examination, you want to insert a new battery and then bypass the calibration in “urgent” mode. One of the other radiographers mentions that this might not be a good idea due to which of the following reasons:

A: The residual signal might become incorporated into the applied signal offsets  
B: A new offset calibration will need to be done to remove the residual image artifact  
C: The image processing algorithm might incorrectly identify the collimator blades

**Electronic shutter failure**

**Question 11:** If an image processing algorithm incorrectly identifies the collimator blades and incorrectly applies electronic shutters, what can be done to remediate the problem?

A: Perform a new offset calibration  
B: Reshutter the image  
C: Reprocess the image  
D: Perform a new acquisition

**Poor identification of values of interest**

**Question 12:** What can be the cause of an image that appears to be washed out or underexposed?

A: Failure to perform an offset calibration  
B: Failure of proper exposure recognition  
C: Improper use of pixels outside the anatomy in setting contrast enhancement  
D: Liquid infiltration

**Midgray clipping**

**Question 13:** The artifacts in Figures 15a and 15b appear to be related to ..........?

A: An attempt to emphasize bone detail  
B: An incompatible line frequency  
C: Poor optimization of the signal equalization processing

**Metal interface artifacts**

**Question 14:** In an attempt to emphasize bone detail in the presence of metal, the following may happen:

A: There may be a false appearance of lucency between the bone and metal  
B: Bloblike areas of opacity may appear between the bone and metal  
C: The false appearance of lucency between the bone and metal may be suggestive of loosening  
D: The edge of the implant may appear falsely serrated

**Grid-line suppression failure**

**Question 15:** Is it TRUE or FALSE that grid lines may appear on an image as a result of using a grid with a line frequency that was incompatible with the grid-line suppression software algorithm?

A: TRUE  
B: FALSE

END
**PERSONAL INFO**
(If your personal details have not changed, only complete the sections marked with an asterisk *)

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**ANSWER SHEET**

**A11 (20)**
Pictorial Review of Digital Radiography Artifacts

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This activity is accredited for **TWO CLINICAL** (2 CEU’S)

I hereby declare that the completion of this document is my own effort without any assistance.

Signed: __________________________ Date: __________________________

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(YOU WILL RECEIVE A CONFIRMATION OF RECEIPT SMS WITHIN 12-24 HOURS, IF NOT RECEIVED PLEASE SEND AGAIN)

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