

Pictorial review

Artefacts found in computed radiography

L J CESAR, RT(R)(QM), B A SCHUELER, PhD, F E ZINK, PhD, T R DALY, RT(R)(QM), J P TAUBEL, RT(R)(QM) and L L JORGENSON, RT(R)

Department of Diagnostic Radiology, Mayo Clinic and Foundation, 200 First Street Southwest, Rochester, MN 55905, USA

Abstract. Artefacts on radiographic images are distracting and may compromise accurate diagnosis. Although most artefacts that occur in conventional radiography have become familiar, computed radiography (CR) systems produce artefacts that differ from those found in conventional radiography. We have encountered a variety of artefacts in CR images that were produced from four different models plate reader. These artefacts have been identified and traced to the imaging plate, plate reader, image processing software or laser printer or to operator error. Understanding the potential sources of CR artefacts will aid in identifying and resolving problems quickly and help prevent future occurrences.

Although computed radiography (CR) images are acquired using conventional imaging geometry, buckys and grids, and X-ray tables and tubes, certain aspects of the technology produce artefacts that present differently compared with those found in conventional radiography. These artefacts can be traced to various components of a CR imaging system [1–4]. The imaging plate, the plate reader, image processing and operator errors may all contribute to the artefacts that a typical imaging department may experience. Knowledge of how each of these factors contributes artefacts to the imaging process will assist in troubleshooting.

12 plate readers of four different models (FCR AC-3, FCR AC-3CS/ID, FCR 9501 and FCR 9000; Fuji Medical Imaging, Stamford, CT, USA) have been installed at our institution over the past 3 years. Images acquired during this time have been routinely examined for image quality. During this process, a number of artefacts have been identified and traced to specific parts of the CR equipment chain. Although this study was limited to only one vendor's equipment, nearly all of the artefacts identified could occur in equipment from other vendors under similar circumstances.

Imaging plate artefacts

Imaging plates (IPs) that must bend as they pass through the plate reader are susceptible to cracking (Figure 1). These cracks usually first become visible on the edges of the IP, where

generally they do not interfere with the clinical image. As the deterioration progresses, cracks appear closer to the central area of the IP. Any debris blocking the IP's emission of light when scanned by the laser in the plate reader will cause a white artefact when viewed using a normal grey scale presentation (Figure 2). Backscatter can cause artefacts owing to the high sensitivity of the storage phosphor to scattered radiation. Scatter from objects behind the cassette can expose the IP, creating images of objects behind the cassette. Lead foil applied to the cassette back may eliminate these artefacts, although the backing is not adequate in some cases (Figure 3).

Plate reader artefacts

Artefacts traced to the plate reader are shown in Figures 4–7. Generally, IPs are automatically erased after they are read. They must be manually erased if they are not used for a period of time, or to erase an incorrect exposure. In either case, the correct erasure setting must be used when a manufacturer provides more than one erasure option. For an incorrect radiographic exposure, the erasure cycle should be longer and should expose the plate to a more intense light than is needed for an IP that has been unused for a few hours. Incomplete erasure may produce an image artefact such as that in Figure 7.

Image processing artefacts

Some artefacts traced to image processing are eliminated and controlled with standardized processing parameters and close attention to the level of spatial frequency processing applied to

Received 13 January 2000 and accepted 4 May 2000.

Address correspondence to Beth A Schueler, PhD.

specific anatomical regions. When using unsharp mask processing to enhance image sharpness, the appearance of the processed image will vary depending on selection of the kernel size and the frequency enhancement factor. Improper parameter selection may produce artefacts that interfere with diagnosis (Figure 8), particularly where two structures of markedly different attenuation meet (Figure 9).

Images displaying the types of artefacts mentioned above can be post processed and do not have to be repeated. Other image processing errors, however, are caused by incorrect interpretation of the grey scale histogram (Figures 10 and 11). These images cannot usually be reprocessed after they are acquired and must be repeated.

Laser printer artefacts

Although artefacts related to the laser printer are not unique to CR, departments that print films may see artefacts caused by the printer. A common laser printer artefact is caused by dirt on the polygon mirror that directs the laser across the film [4]. This presents as a white line running perpendicular to the printer's laser scan lines (Figure 12). The appearance of this artefact is very similar to lines caused by dirt on the plate reader's light guide (Figure 5). To determine

whether the artefact is caused by the laser in the printer or the laser in the plate reader, consider the orientation of the line with respect to the laser scanning direction. Alternatively, if the artefact is caused by the laser printer, it will not appear on the soft copy version of the image.

Operator errors

As in any imaging modality, operator error will cause a share of the artefacts noted. CR cassettes must be stored correctly [1, 5] (Figure 13). The IPs must be protected from heat, low humidity and all sources of ionizing radiation, including scatter. Since IPs are sensitive to scatter, an anti-scatter grid should be used in CR imaging at least as often as one would be used in film/screen imaging [6, 7]. Selection of grid frequency is an important consideration. Low line rate grids will cause a moiré pattern to appear on images if the grid lines are parallel to the reader's scan lines [8] (Figure 14).

Operator errors are especially common when CR equipment is new to a group of users. Cassette orientation for any receptor is a very important detail. Since various cassettes are designed and constructed differently, each version leaves its own pattern of artefacts if the cassette is used upside down (Figure 15).

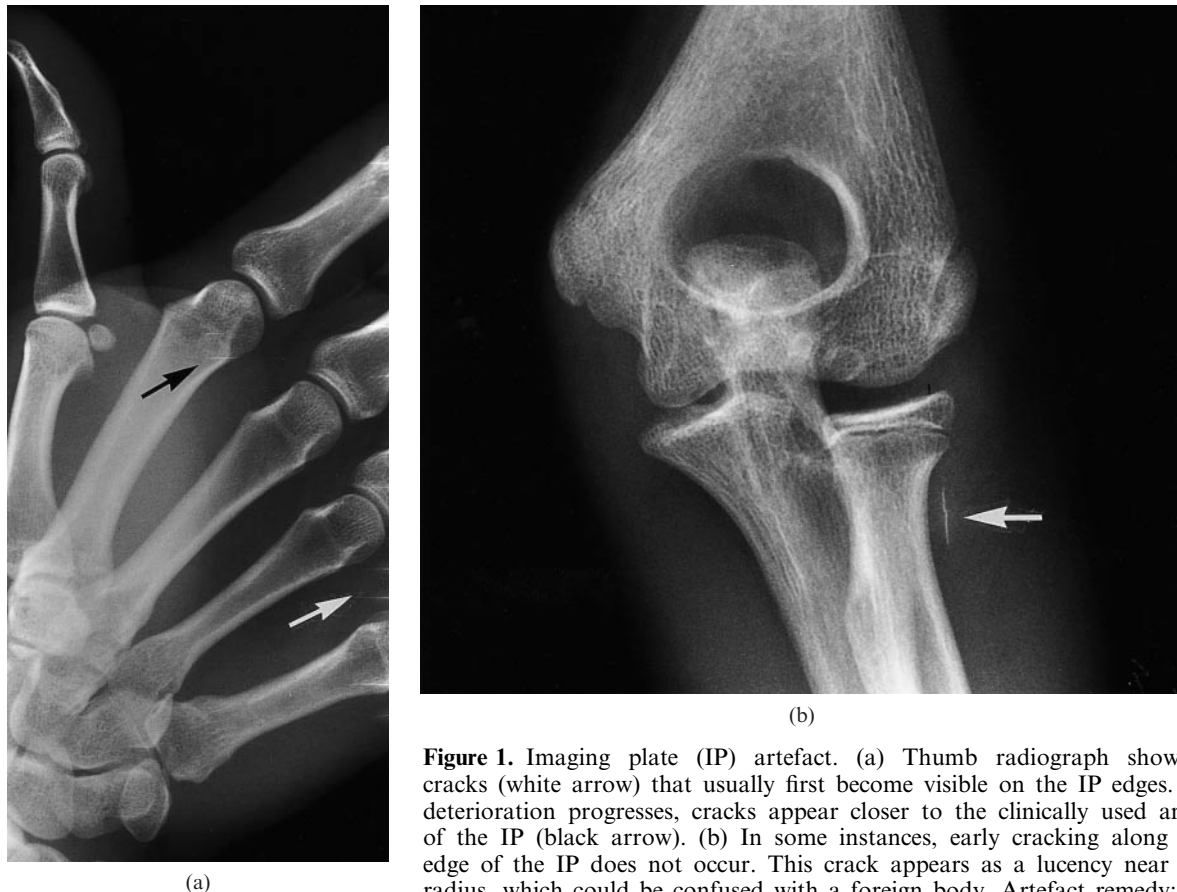
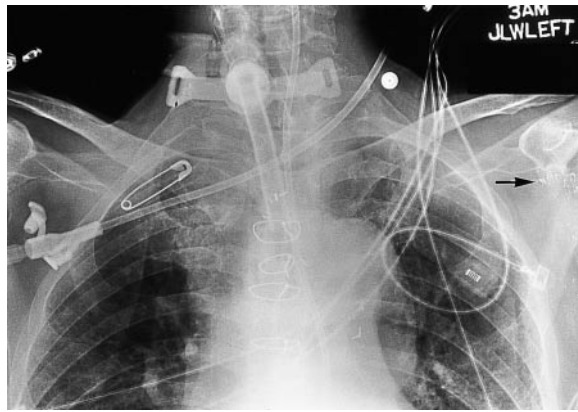


Figure 1. Imaging plate (IP) artefact. (a) Thumb radiograph showing cracks (white arrow) that usually first become visible on the IP edges. As deterioration progresses, cracks appear closer to the clinically used areas of the IP (black arrow). (b) In some instances, early cracking along the edge of the IP does not occur. This crack appears as a lucency near the radius, which could be confused with a foreign body. Artefact remedy: an IP must be replaced when cracks occur in clinically useful areas.



(a)



(b)

Figure 2. Imaging plate (IP) artefact. (a) Residue from adhesive tape used to attach lead markers to the outside of the cassette has caused artefacts (arrow) when the tape came in contact with the IP. (b) Static caused a hair to cling to the IP on this skull image. Artefact remedy: IPs must be cleaned regularly or when artefacts such as these are noted. Cleaning frequency is dependent on the environment in which IPs are stored and used. Specific cleaning methods are available from the manufacturer. Lint-free cotton gauze and lens cleaner is recommended by one vendor [5].

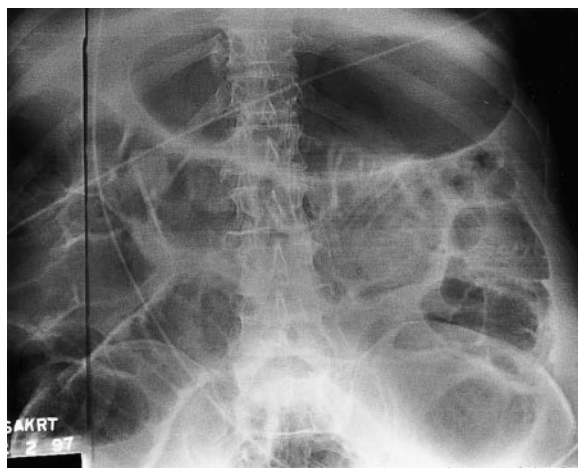


Figure 3. Imaging plate artefact. The dark line along the lateral portion of this upper abdomen is caused by backscatter transmitted through the back of the cassette. The line corresponds to the cassette hinge where the lead coating was weakened or cracked. Artefact remedy: to reduce backscatter, the radiographer should collimate when possible. Since backscatter cannot be eliminated in every case, knowledge of the radiographic appearance of cassette backs is useful.



Figure 4. Plate reader artefact. The pattern of lines seen on this oblique hip view occurred intermittently. The artefact was traced to the plate reader's electronics. Artefact remedy: the electronic board that controlled the photomultiplier tube was replaced.

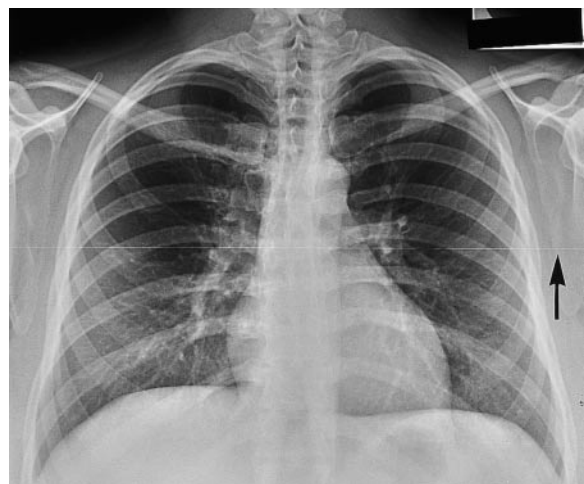


Figure 5. Plate reader artefact. The horizontal white line (arrow) shown on this upright chest radiograph was caused by dirt on the light guide in the plate reader. The light guide collects light emitted from the imaging plate when it is scanned by the laser. Artefact remedy: the light guide of the photomultiplier tube was cleaned by service personnel.



Figure 6. Plate reader artefact. This artifact occurred because the plate reader loaded two imaging plates (IPs) in a single cassette. After an exposure, the bottom IP was extracted, read and replaced as usual, leaving the top IP to be exposed numerous times. Artefact remedy: double-loaded cassettes will be discovered during routine IP cleaning. If a cassette containing two IPs is discovered, the IPs should be erased before being put back into use.



Figure 7. Plate reader artefact. This bilateral knee image was spoiled when the incorrect erasure setting was used to eliminate a previous femur image. Evidence of this is the residual image of the lead marker in the top corner of the image, the tissue line from the previous image (upper arrow) and the additional line of collimation along the bottom of the image (lower arrow). Artefact remedy: radiographers must select the correct erasure setting according to the type of exposure that has occurred.

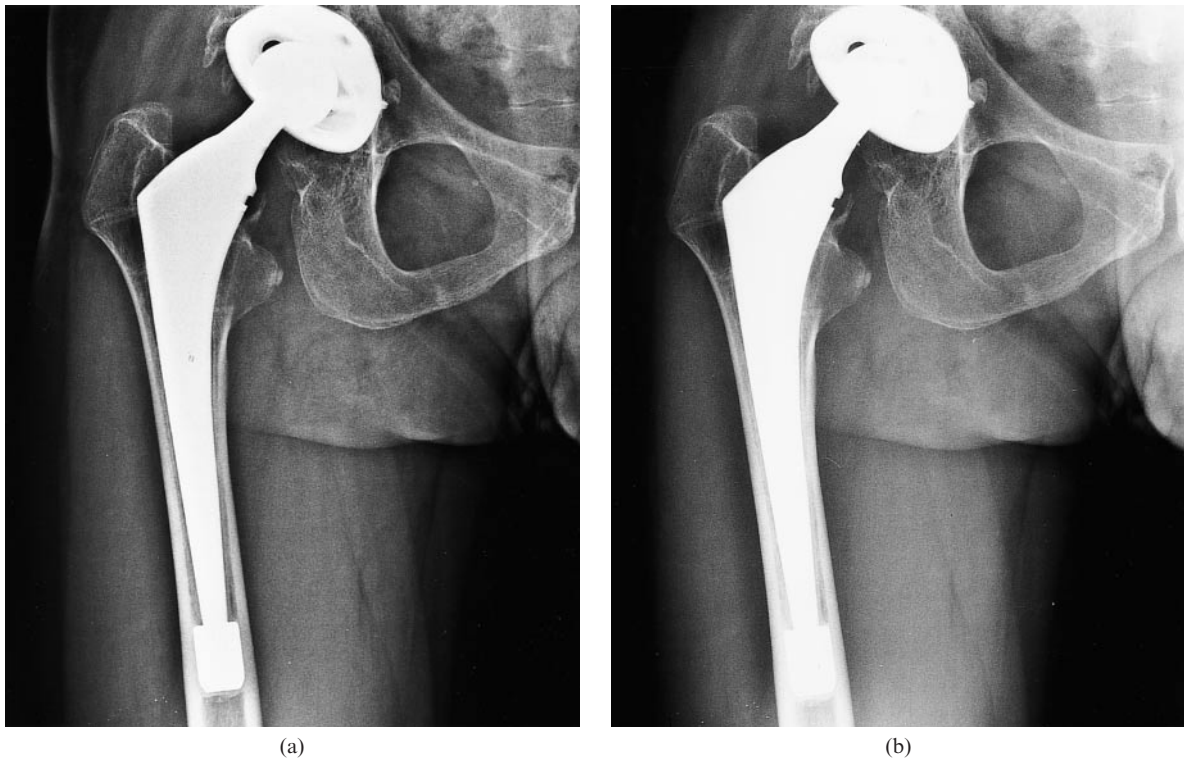


Figure 8. Image processing artefact. (a) When too large a kernel size is selected for image enhancement, artefacts like the black halo surrounding the prosthesis can create the appearance that the prosthesis is loose. (b) The same image as (a) processed with a smaller kernel size.

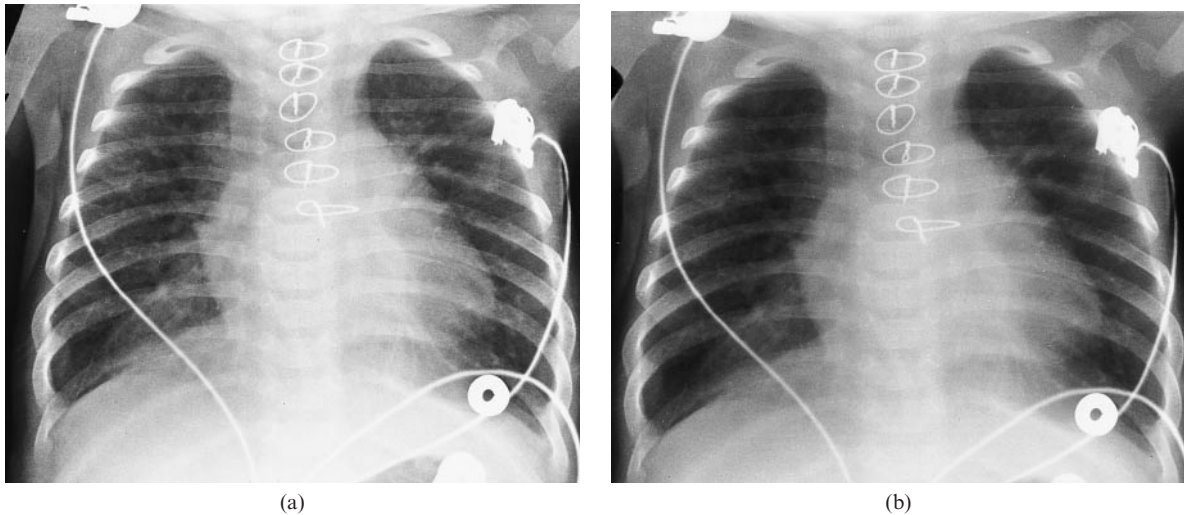


Figure 9. Image processing artefact. (a) Edge enhancement was increased from the default level for this paediatric chest image. Notice the marked increase in lung markings, which could indicate interstitial infiltrates. (b) The same image processed with normal edge enhancement. Artefact remedy: select a standard set of image processing parameters, especially for frequency and edge enhancement, with the help of applications specialists. Once a standard set of processing parameters are selected, post-processing changes should not be needed frequently.

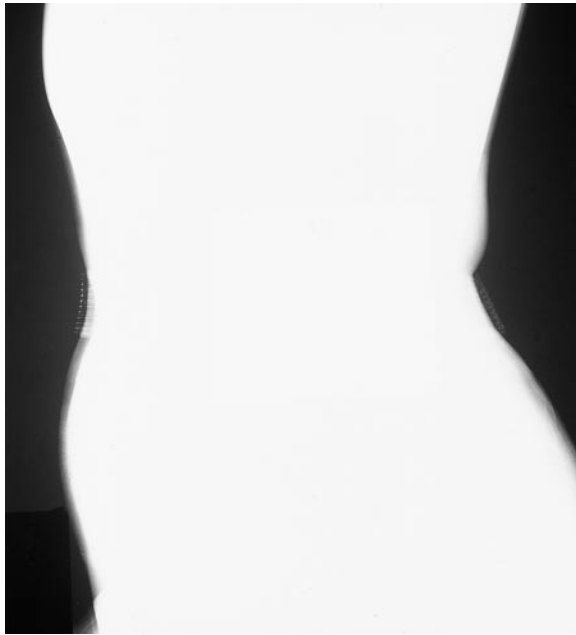


Figure 10. Image processing artefact. Owing to lack of primary beam collimation on this lateral lumbar spine, the amount of unattenuated radiation striking the imaging plate (IP) (anterior and posterior to the patient) altered the histogram so that it was outside the normal range for that body part selection. Artefact remedy: use the smallest IP practicable and collimate the beam to the body part. This is particularly important on small or slim patients.



Figure 11. Image processing artefact. The prosthesis in this knee adds too many extreme pixel values to the image histogram. This results in an image where the difference between prosthesis and glue, or glue and bone is not well demonstrated. Artefact remedy: in computed radiography systems that provide different modes of operation, use of a different image processing mode will alleviate this problem. For example, a semi-automatic or fixed mode will cause the image histogram to be analysed differently from a fully automatic mode and will produce a more acceptable image in cases such as this.



Figure 12. Laser printer artefact. This oblique foot image demonstrates two different artefacts. The fine white line (black arrow) running parallel with the long dimension of the film is an artefact from the laser printer. The line running perpendicular to the long dimension of the film (white arrow) is caused by dirt on the light guide of the photomultiplier tube in the plate reader, as in Figure 5. Artefact remedy: service personnel can use a camel hair lens brush to clean the mirror.

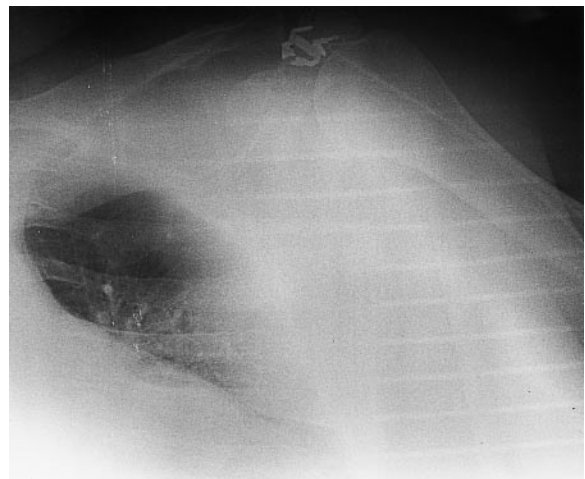


Figure 13. Operator error. A wire mesh cart loaded with unexposed imaging plates (IPs) was placed too near a source of scatter radiation. Because of the high sensitivity of the phosphor to scatter, exposure that may have been minimally seen on a film/screen image was well demonstrated on this portable image. Artefact remedy: protect IPs from sources of scatter radiation. Erase IPs that have been unused for an unknown period of time. One vendor recommends that IPs be erased if left unused for more than 8 h [5]. We have had good results using 1 week as the time limit.



Figure 14. Operator error. The moiré pattern seen in this knee image was caused by using a grid with a frequency of 33 lines cm^{-1} , which was oriented with the grid lines parallel to the plate reader's scan lines. Artefact remedy: use grids with no less than 60 lines cm^{-1} . In addition, grid lines should run perpendicular to the plate reader's laser scan lines.

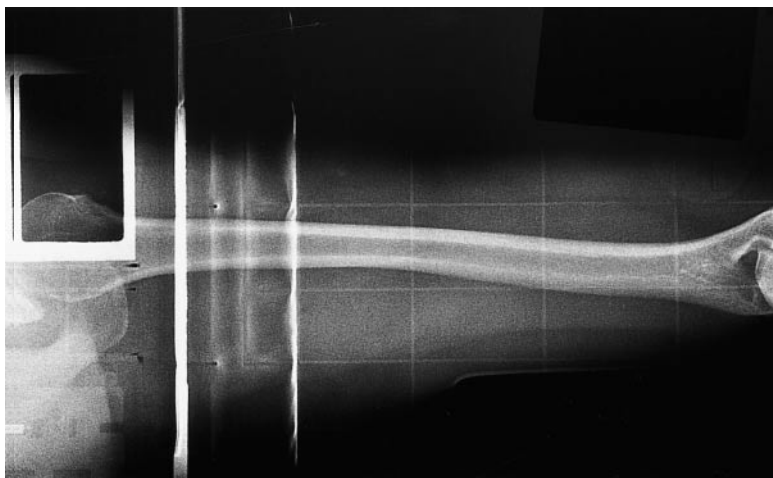


Figure 15. Operator error. This axillary shoulder was exposed through the back of a cassette. Artefact remedy: be sure radiographers are well educated about how to use the entire computed radiography system.

Conclusions

Imaging artefacts are distracting and can cause diagnostic inaccuracies. Although some of the artefacts found in early-generation CR systems have been addressed, such as those caused when collimation was not parallel to cassette edges [2, 6], CR imaging continues to have its own set of artefacts. These artefacts can present differently on a CR image when compared with other, more traditional, modalities. If CR system users are aware of the probable causes of artefacts, it will be easier to efficiently eliminate them.

References

1. Solomon SL, Jost RG, Glazer HS, Sagel SS, Anderson DJ, Molina PL. Artifacts in computed radiography. *AJR* 1991;157:181–5.
2. Ostemann JW, Prokop M, Schaefer CM, Galanshi M. Hardware and software artifacts in storage phosphor radiography. *Radiographics* 1991;11:795–805.
3. Seibert JA. Computed radiography technology and quality assurance. In: Frey GD, Sprawls P, editors. *The expanding role of medical physics in diagnostic imaging*. Madison, WI: Advanced Medical Publishing, 1997.
4. AAPM Report. Acceptance testing and quality control of photostimulable storage phosphor imaging systems. Report of the Task Group No. 10: diagnostic x-ray imaging committee, JA Seibert, chair. New York, NY: Am Assoc Physicists Med; in press.
5. FCR AC-3CS/ID operation manual. Stamford, CT: Fuji Photo Film Co. Ltd., 1996.
6. Burns C. Effective computed digital radiography. *Semin Radiol Technol* 1993;1:24–36.
7. Cesar LJ. Computed radiography: its impact on radiographers. *Radiol Technol* 1997;68:225–32.
8. Seibert JA. Photostimulable phosphor system acceptance testing. In: Seibert JA, Barnes GT, Gould RG, editors. *Specification, acceptance testing and quality control of diagnostic X-ray equipment*. Woodbury, NY: American Institute of Physics, 1994.