

CONTRASTING VIEWS – DIGITAL VS CONVENTIONAL RADIOGRAPHY

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Categories : [Vets](#)

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PETRA AGTHE evaluates the pros and cons of the methods and results of digital radiography – which is becoming a more popular and affordable option in veterinary practice – compared to conventional approaches

IN human medicine, digital radiography has been very successful and NHS hospitals now operate almost exclusively on digital systems, using computed radiography (CR) or direct digital radiography (DR).

Most veterinary practices still use conventional radiography, but an increasing number are following the digital trend. So, what exactly are the advantages and limitations of digital compared with conventional radiography? And what is the difference between CR and DR? This article will explore these questions.

Image acquisition

• Conventional radiography

A latent image is formed by exposing a film, inside a cassette, to x-rays (). The film is then developed using chemicals, revealing the captured image. With a standard automatic processor and manual cassette reloading in the darkroom, this process takes between two and five minutes, depending on the processor.

Because the cassettes are mobile, radiographs can be taken at locations outside the practice and returned for development. The resultant image is permanent and cannot be adjusted.

- **Computed radiography**

This technique also uses cassettes, but instead of a film, the latent image is captured on a photostimulable phosphor plate inside the cassette (1).

The image is converted into a visible radiograph by a laser plate reader inside a computed workstation (2), which transforms the captured image into visible light. This analogous information is then digitised, using a processing algorithm.

The algorithm is pre-set by the manufacturer, depending on the body region examined. Minor errors in exposure (over and underexposure) are also automatically corrected.

Depending on the system, image processing takes about one to two minutes, but as additional time is required for data input prior to the examination, overall acquisition time is comparable to conventional systems.

After the image is obtained, it can be further adjusted as necessary before it is sent to an archiving system. The phosphor plate is exposed to very bright light to erase any remaining latent image. CR plates lose the stored latent image relatively quickly and, therefore, should be processed within eight to 12 hours.

- **Direct digital systems** For these systems, cassettes are replaced by an electronic detector device, which is directly connected to the computer workstation (3). The image can be displayed directly, taking as little as three seconds from exposure to image formation.

While this increases the efficiency of busy NHS hospitals significantly, the time saving is probably less essential in most veterinary practices. Data input, image manipulation and archiving are similar to CR systems.

Although most DR systems are for stationary use, mobile units are available, consisting of a detector device that is connected to a laptop computer.

Costs

- **Conventional**

Initial costs for cassettes, films, chemicals and automatic processors are relatively low, but the running costs (mainly for films and chemicals, including the safe disposal of used products) are higher than those for digital systems. Indirect costs can occur due to the time required for

equipment maintenance and image acquisition, including repeated exposures due to undiagnostic radiographs and retrieval of images from the archive.

- **Digital**

CR and DR systems can be acquired for about £20,000 and £50,000, respectively, but costs can be much higher depending on individual practice requirements and the chosen system.

Although the initial costs for a CR system are less than DR, the phosphor plates have a finite lifetime and usually require replacement sooner than DR detector devices. However, with both digital systems, long-term savings can be significant, provided they use film less operation. Although digital images can be printed on laser film, these films are relatively expensive, slow to print and require storage.

Viewing radiographs

- **Conventional**

Conventional films have to be viewed on a light box, with the aid of a magnifying glass and/or a bright light, if desired.

It is possible to write measurements and angles on the radiograph, but these are usually permanent. The advantage of conventional films is that they can be relatively easily handled and switched around on the viewing box for comparison. Also, a large number of films can be viewed simultaneously if a viewing box of adequate size is available. A further advantage of conventional radiography is that the patient's anatomy is represented in a relatively true size, although mild magnification usually occurs depending on the thickness of area of interest and the object film distance. This is an important consideration, especially when dealing with orthopaedic cases, where adequate implant sizes have to be estimated.

- **Digital**

These radiographs can be viewed on a monitor or printed on film.

On the monitor, digital images can be manipulated in various ways including zooming, adjustment of contrast and latitude, flipping and rotation, and greyscale inversion. Measurements and angles can be taken and saved on the image, which can also be viewed without these annotations. However, images cannot be changed as quickly from one to another as real films, and image size is limited by the size of monitor – a significant disadvantage when examining multiple radiographs.

The true size of a digital image on a monitor is unknown, unless the radiograph has been calibrated to a radiopaque object of known size, which was placed on the cassette at time of radiography.

Digital radiographs can be printed on laser film in a way that approximates the patient's true size, and these can be viewed as conventional radiographs.

Image quality: contrast, resolution and latitude

• Conventional

The difference in appearance of conventional and digital radiographs can be striking.

However, when good-quality, well-maintained conventional systems and digital radiography are compared, there is little difference in the actual diagnostic quality of the resulting images. In fact, good conventional systems have slightly higher spatial resolution. In reality, however, operator error (such as over or underexposure) and poor equipment maintenance (especially underdevelopment) commonly result in poor radiographic quality of conventional radiographs.

Another relative disadvantage of conventional film is that contrast and latitude are inversely related, which means that a highcontrast image is automatically associated with a low grey scale.

Image contrast and latitude also depend on many factors, including the type of film, processing and the exposure factors, where high KV settings result in a relatively low-contrast image and low KV settings in higher contrast – an effect used for image optimisation in thoracic and abdominal radiography.

Finally, conventional films have a relatively narrow dynamic range. Exposure factors have to be carefully adjusted to the region of interest and its thickness to avoid over or underexposure.

• Digital

One of digital radiography's biggest advantages is that it is somewhat less dependent on exposure settings and maintenance. This is mainly due to the wider dynamic range, which allows a larger range of exposure factors. The amount of radiographs that have to be retaken due to poor exposure selection can be dramatically decreased. However, severe over or underexposure cannot be corrected and these result in artefact formation.

Although spatial resolution can be inferior to conventional films, digital radiography's advantage is the more independent relationship between contrast and latitude, resulting in higher contrast resolution ().

Furthermore, KV and mAs settings have less influence on contrast and latitude, and inconsistent and/or poor film development does not occur due to electronic processing.

Radiation safety

• Conventional

As discussed above, poor exposure selection and underdevelopment can result in a relatively high number of repeated radiographs. However, this can be minimised with good radiographic technique.

An important way to ensure radiation safety is collimation of the primary beam to the film, so an unexposed rim can be seen on all four edges.

• Digital

Digital radiography can potentially reduce retaken radiographs, thereby decreasing radiation.

However, if overexposure occurs, it is largely adjusted automatically and the operator might be unaware of this. Therefore, higher than necessary exposure factors might be used routinely. This can outweigh the advantages of reduced retakes by increasing the overall radiation dose.

To avoid unnecessary radiation exposure of personnel, exposure factors should be regularly monitored and reviewed. Although tight beam collimation is just as important in digital systems, the edges of the primary beam on the images are usually lost during image manipulation.

Image quality: radiographic faults

A full discussion of all faults and artefacts occurring with conventional and digital systems is beyond the scope of this article. Therefore, only the most common radiographic errors are listed. A very important fact to consider is that poor radiographic technique – including inadequate positioning, centring and movement blur – can decrease the radiographic quality in both systems to the same degree.

• Conventional

As discussed above, many film faults are caused by over and underexposure, and underdevelopment (). Further errors include film fogging and extraneous marks like scratches, crimp marks, dirt and screen artefacts. If marks overlay the area of interest, they can interfere with interpretation.

• Digital

– **Overprocessing.** An incorrectly adjusted processing algorithm or excessive manual image manipulation can create artefacts. Excessive edge enhancement, for example, can artefactually

enhance normal lung markings, which can be misinterpreted as an interstitial lung pattern, leading to overdiagnosis ().

– **Ueberschwinger or rebound effect artefact.** This artefact is also caused by excessive edge enhancement, where an artefactual radiolucent halo is created around metal implants. This effect can be misinterpreted as implant loosening or infection. By adjusting the processing algorithm, this artefact can be minimised ().

– **Quantum mottle.** Significant underexposure results in a mottled, grainy image due to the inadequately low number of photons reaching the phosphor plate.

– **Tissue drop-out.** Severe overexposure results in loss of information, which cannot be recovered. In contrast to conventional radiography, this loss of anatomical detail can be very abrupt. Overexposed abdominal radiographs, for example, might provide a normal image of the abdomen (). The implications regarding radiation safety have been discussed ().

– **Marks on the radiograph.** Hair and debris inside CR cassettes can cause artefacts similar to screen artefacts on conventional films. Plate reader artefacts can result in thin white lines on the image, which can appear similar to a scratch on a film. With age, the phosphor plates might crack, leaving white lines on the image.

– **Ghost images and film fogging.** CR plates are very sensitive to extraneous radiation. They should be kept outside the x-ray room and must be erased every 24 hours; otherwise, film fogging and ghost images can occur.

Archiving

• Conventional

Archiving of films requires storage space and is relatively time consuming. Films might be misfiled, lost or mislaid, which can be very frustrating and concerning, as they represent legal documents.

• Digital

With electronic archiving systems, the savings in storage space can be significant, especially in practices with a high workload. Also, if an adequate network and monitors are available, one radiograph can be simultaneously viewed at different locations. Radiographs can be quickly sent via email for a second opinion, which is helpful in emergency situations.

A further advantage is that no time will be wasted searching for misplaced or lost radiographs

(provided, of course, that images have been saved under the correct patient identification in the first place).

Conclusions

Digital radiography can be a valuable and affordable imaging technique that can offer some advantages over conventional radiography, provided the operator is aware of its limitations.

To use digital radiography to its best potential, it is important for clinicians to be familiar with the imaging system, principles of image processing, and commonly occurring artefacts.

DEFINITION OF TERMS

Contrast. All radiographic images are composed of varying shades of grey, including white and black at the extreme ends of the scale. Contrast refers to the difference between the individual grey shades in an image. In conventional radiography, high image contrast (a large difference between grey shades) is inevitably associated with a narrow latitude (a low number of grey steps). With digital radiographs, it is possible to display an image with a wide latitude, while preserving high image contrast.

Latitude. Image latitude is defined as the number of different grey shades in an image. An image has high latitude if it contains a high number of different grey steps. Image latitude also refers to the range of exposure settings that can be employed and result in a diagnostic image (this is also called dynamic range).

Spatial resolution. This is the ability to distinguish two objects from one another, depending on their size.

Contrast resolution. This refers to the ability to distinguish two structures from one another, depending on their differences with regard to grey shade.

Edge enhancement. This refers to an image processing function in digital imaging, which enhances the margins of structures in an image, thereby making the edges of organs or bones more apparent.

References and further reading

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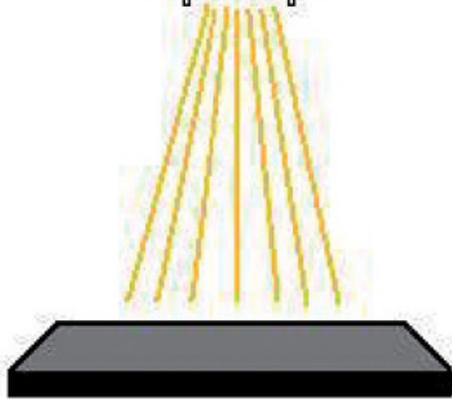
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1



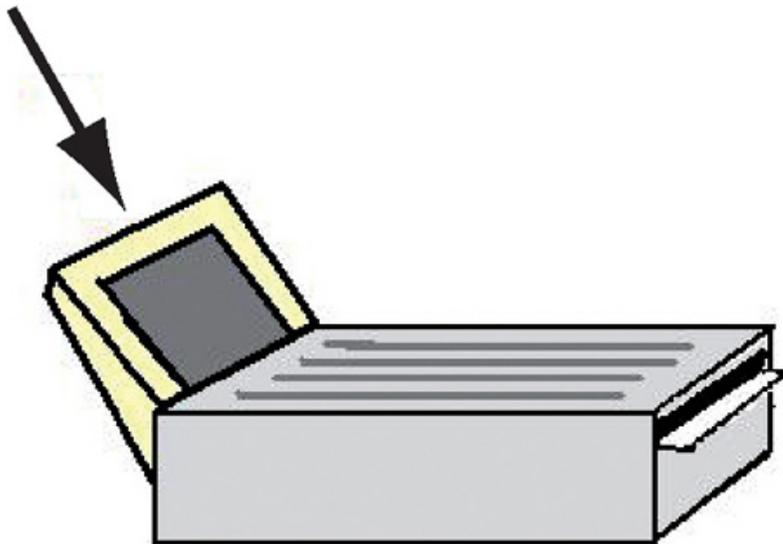
X-ray tube

2



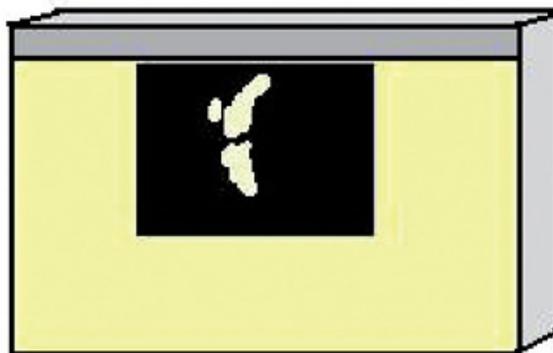
Film in
cassette

3



Automatic
processor

4



Light box

Figure 1. Image acquisition using conventional radiography.

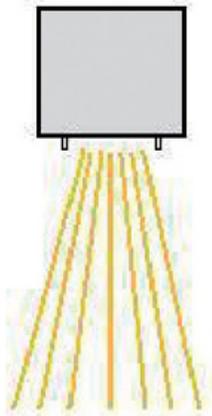


Figure 10. *The same area seen in Figure 9, taken with a lower exposure.*



Figure 11 (right). *In conventional radiography, the overexposure is more continuous and the image may still be seen with a bright light.*

1



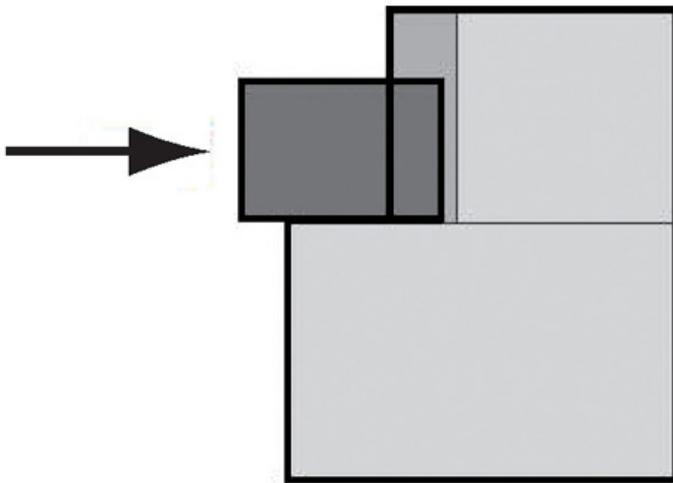
X-ray tube

2



CR plate in cassette

3



CR plate reader

4

Computer monitor

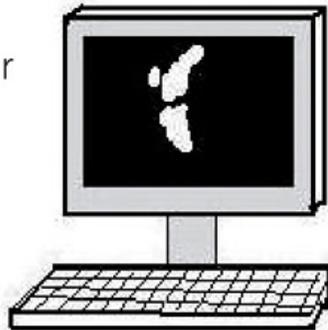


Figure 2. Image capture using computed radiography.



Figure 3a (left). The workstation includes a plate reader and a computer for data input and image processing.

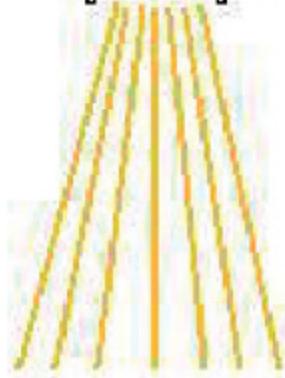


Figure 3b (right). The workstation includes a plate reader and a computer for data input and image processing.

1



X-ray tube



2



Electronic detector device

3



Computer monitor

Figure 4. Direct digital radiography.

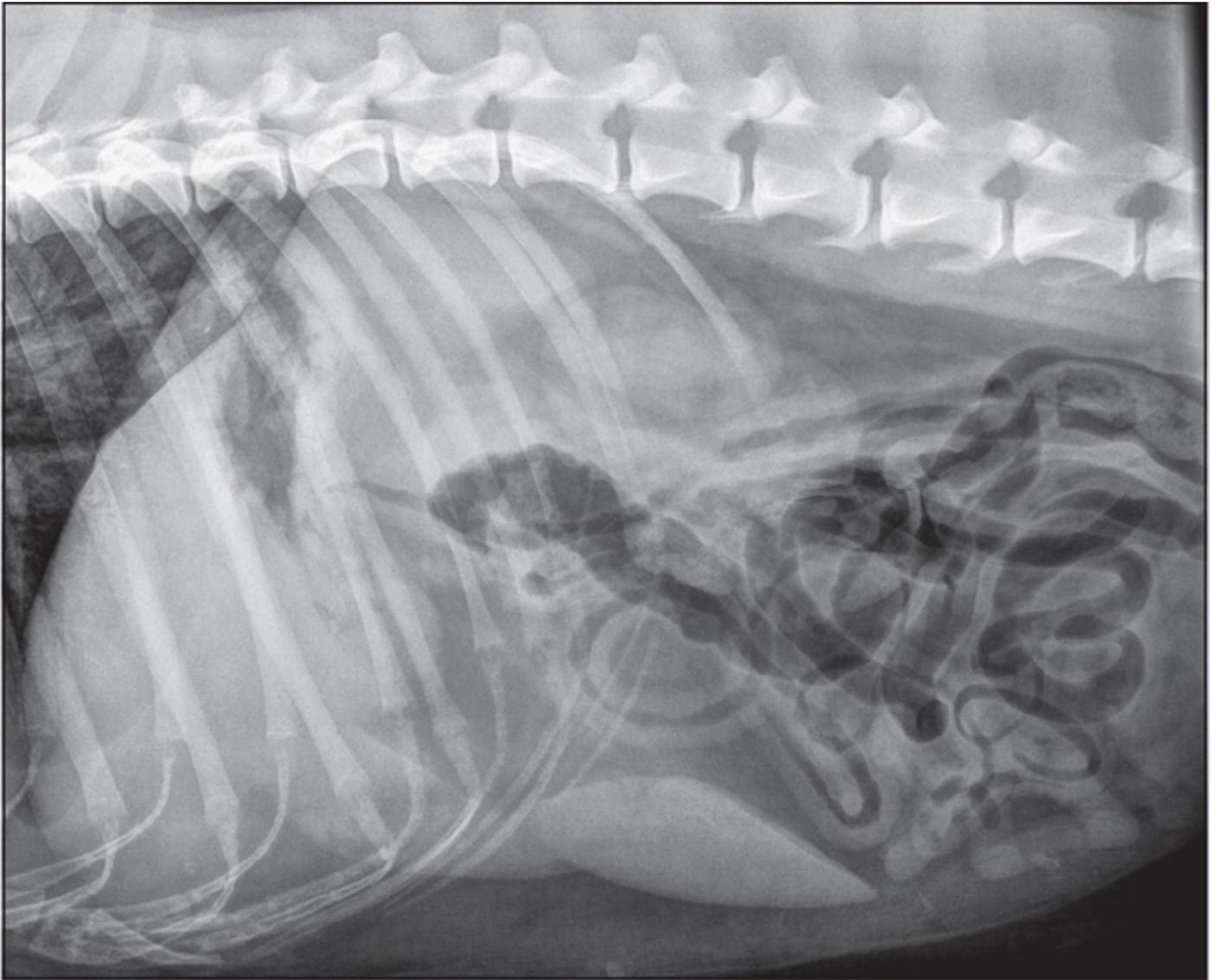


Figure 5a (left). Digital radiographs have a higher contrast resolution and latitude. This is seen by comparing the differences in appearance of this digital abdominal radiograph with that of Figure 5b (above), a conventional radiograph.

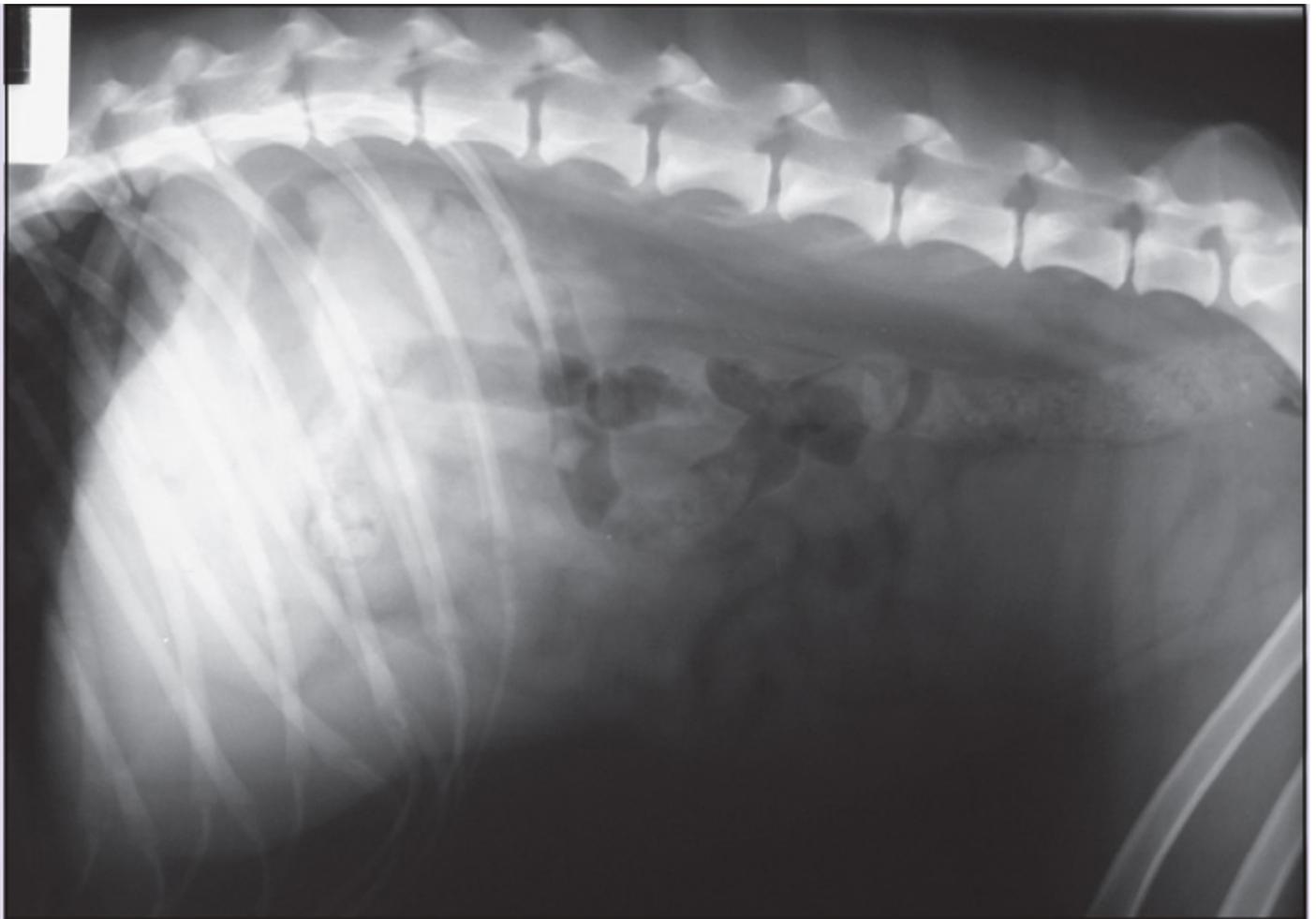


Figure 5a (left). Digital radiographs have a higher contrast resolution and latitude. This is seen by comparing the differences in appearance of this digital abdominal radiograph with that of Figure 5b (above), a conventional radiograph.



Figure 6 (left). Underdevelopment is a common processing fault in conventional radiography. It is characterised by an image that is too light overall, with poor contrast. When held against the light, a finger behind the film can be easily seen (arrow).

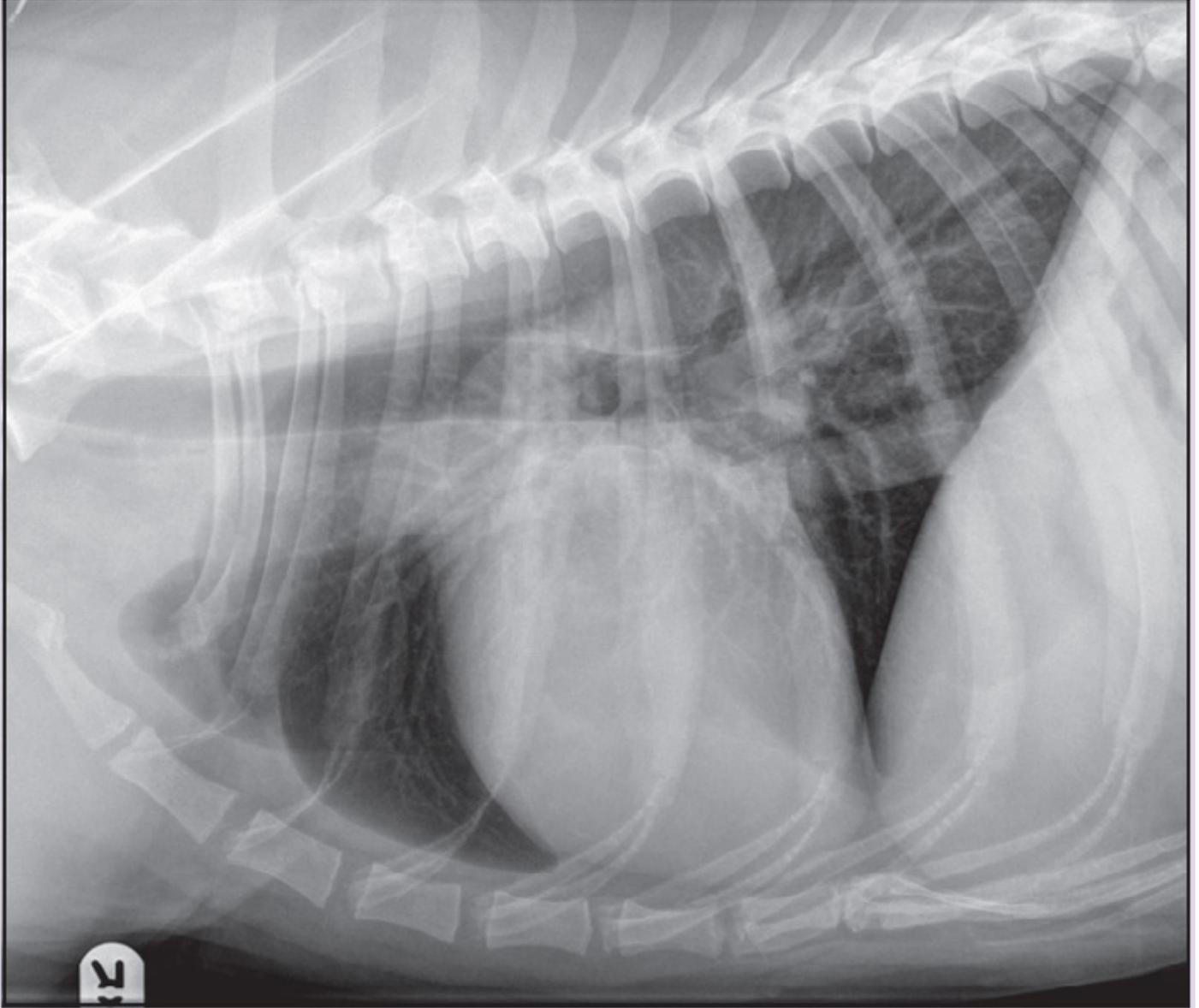


Figure 7a (below left). Edge enhancement makes normal anatomical structures in the background more apparent. Compare the lung markings on this digital thoracic radiograph with Figure 7b (below right), a conventional image.

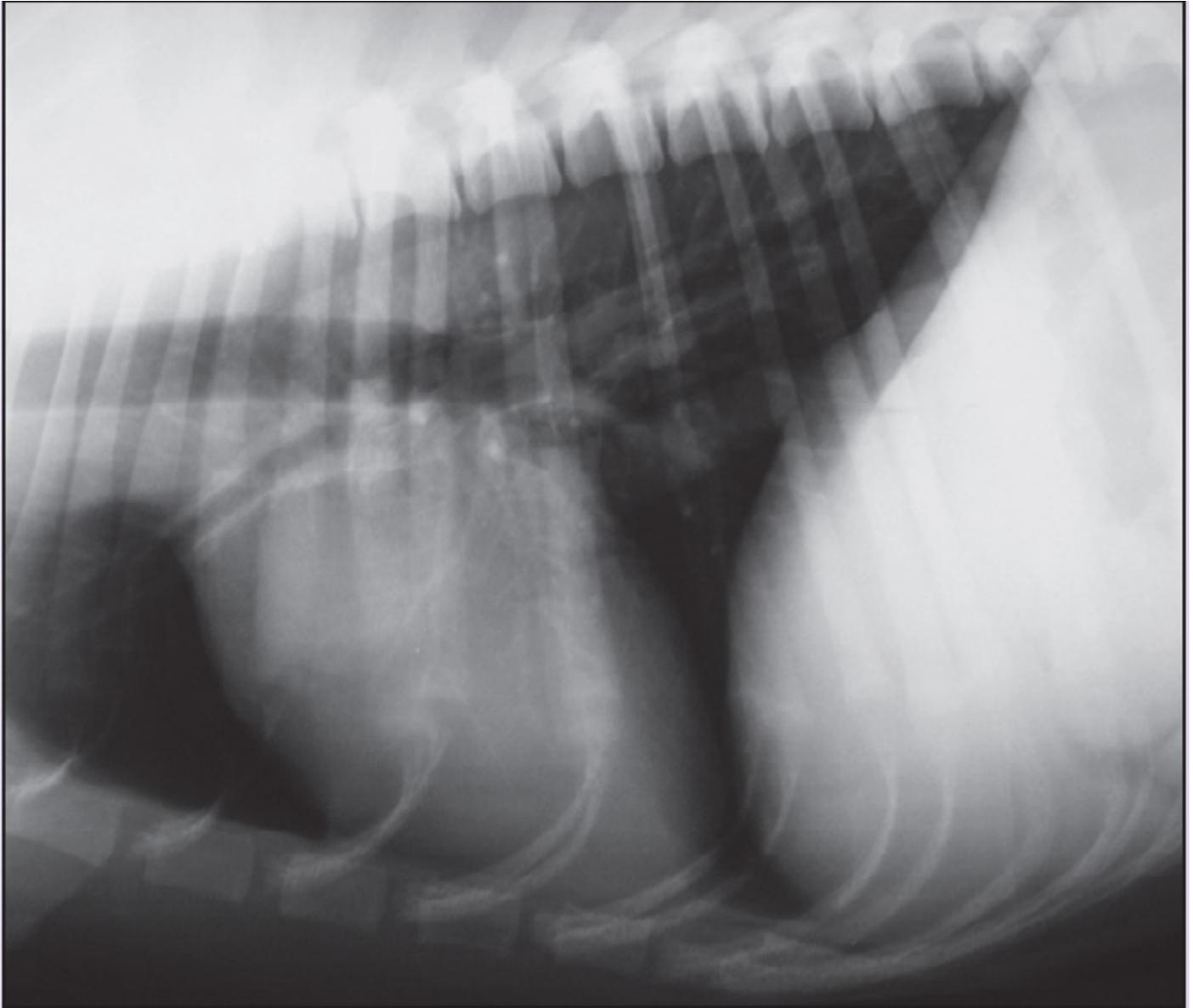


Figure 7a (below left). Edge enhancement makes normal anatomical structures in the background more apparent. Compare the lung markings on this digital thoracic radiograph with Figure 7b (below right), a conventional image.



Figure 8. Ueberschwinger artefact: metatarsal fractures have been stabilised with intramedullary pins connected to an external fixator. The large connecting bar crossing the metatarsal bones horizontally is outside the patient's body, but appears to be surrounded by a dark rim.

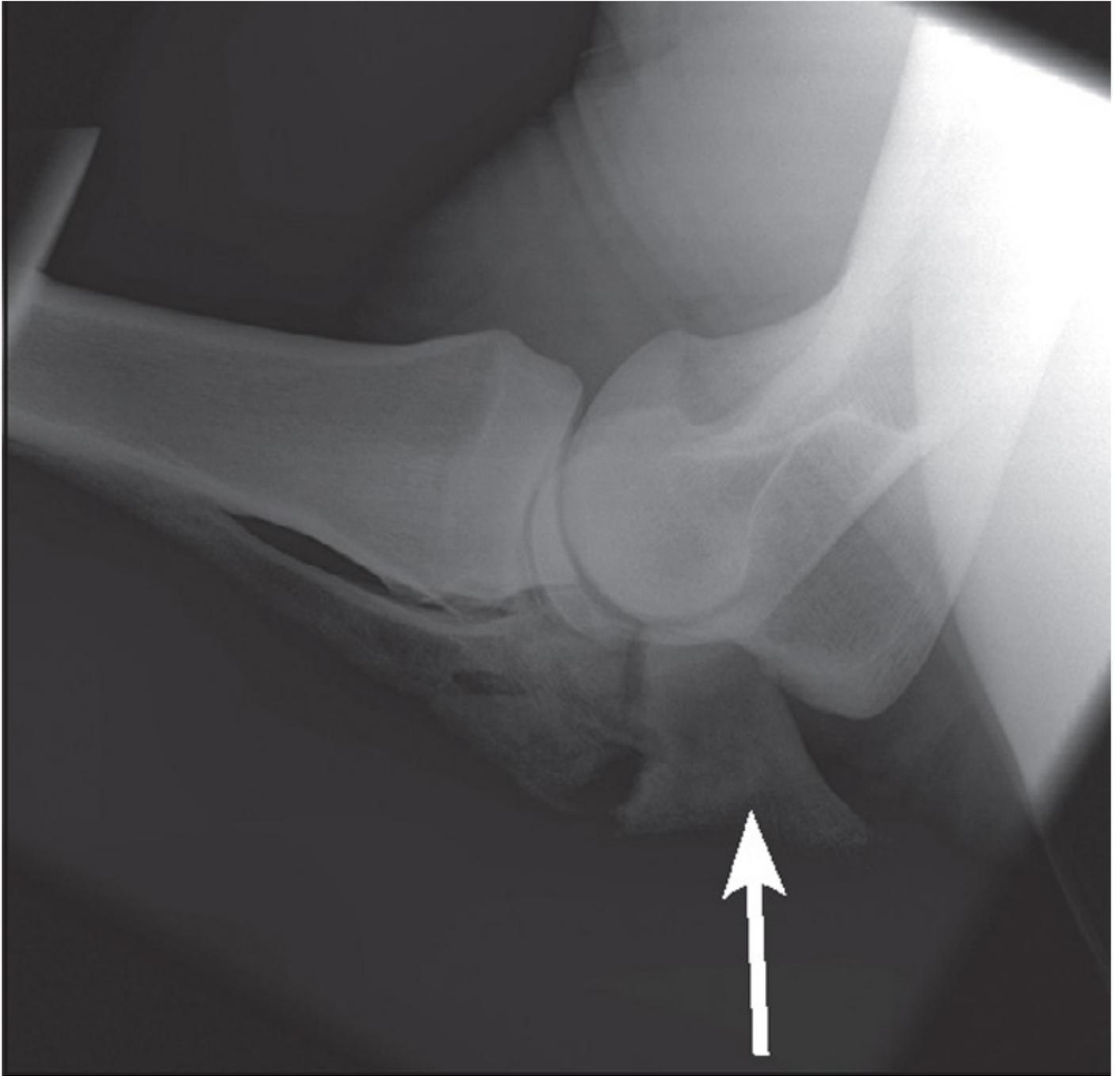


Figure 9 (left). A severely overexposed digital radiograph showing the elbow of a horse. The caudal portion of the olecranon and overlying soft tissues (arrow) cannot be seen despite adjustment of contrast and latitude.