

# Common radiographic faults

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**We commonly take radiographs as a part of a routine diagnostic work-up. But to be of any diagnostic value, these radiographs have to be of adequate quality.**

Poor radiographic technique can lead to underdiagnosis of disease, due to missed lesions, but also to overdiagnosis, where the presence of a lesion is mimicked by inadequate positioning or artefacts.

Therefore, it is essential that the technical quality of a radiograph is critically assessed prior to radiological interpretation.

However, radiographic faults are common in veterinary practice. Severe over and underexposure, suboptimal positioning and poor radiographic contrast (usually caused by underdevelopment) are some of the most common errors.

Sometimes these faults can be subtle and difficult to identify, but they commonly result in repeated exposures and/or a selection of relatively high-exposure factors, thereby compromising radiation safety. Radiographic faults also have an economical impact, due to a prolonged and less efficient examination, as well as wasted films and chemicals - not to mention the frustration a nondiagnostic radiograph can cause.

It is good to document any radiographic faults routinely, especially if they result in repeated exposures. This will help to identify the most common faults occurring in your practice and make trouble-shooting more efficient. Although some of the problems discussed in this article are referring to film processing in conventional radiography, others are also applicable in digital systems such as computed radiography (CR) or direct digital radiography (DR), particularly with regards to correct centring and patient positioning.

## Positioning

It is important to project the area of interest without superimposition of the limbs and tail or objects like leads and radiopaque positioning aids ([Figure 1](#)). If at all possible, standard views should be used.

Unintentional rotation makes image interpretation more difficult and should, therefore, be avoided.

For example, rotation of the thorax can give the false impression of cardiomegaly. If the pelvis is rotated, the acetabulum closer to the cassette appears more shallow, which can give the appearance of subluxation of the coxo-femoral joint. Any radiograph taken in an unorthodox projection will also be difficult to compare with examples in textbooks or radiographic atlases, making radiological interpretation particularly problematic for the less experienced examiner.

Furthermore, rotation complicates the examination of serial radiographs. These are taken over some time, because it is somewhat difficult to obtain the same degree of rotation at each individual examination.

## Further points for patient positioning

- Good radiographs are difficult to obtain from a struggling patient, so make use of sedatives and general anaesthesia - unless the patient is severely depressed or chemical restraint is contraindicated. Remember that manual restraint is only allowed in exceptional circumstances, and then only if the x-ray machine is fitted with a light beam diaphragm.
- Radiolucent foam wedges and troughs, sandbags and ties help with patient restraint and positioning.
- Although there are circumstances where rotation is intentional - such as oblique views of the skull or lesion-orientated views - the standard projections should be obtained first.
- When oblique views are used, the area of interest should be close to the cassette.
- If in any doubt, consult a textbook of veterinary radiography - especially before taking less familiar projections, like a rostrocaudal open mouth view for the tympanic bullae.

## Centring

The area of interest should always be in the centre of the radiograph, to avoid geometric distortion. When radiographing the spine, centring is of particular importance as the intervertebral disc spaces in the periphery of the collimated area often appear more narrowed.

Geometric distortion is also the reason why the inclusion of large patient areas in the primary beam should be avoided in the investigation of joint disease ([Figure 2](#)).

## Collimation

Collimation is an effective way to ensure radiation safety by controlling the area of the primary beam. Therefore, an unexposed rim should be present on all four sides of the film.

This is particularly important in large animal radiography, where relatively high exposures are used. Human extremities, even if covered by lead gloves, are never acceptable in the primary beam.

An unnecessarily large area of primary beam also increases the amount of scattered radiation, which can, in turn, reduce radiographic contrast (see below).

## Control of movement and timing of exposure

Although our patients are not always cooperative, movement blur can usually be controlled by the use of sedatives or general anaesthesia. This is particularly important for thoracic radiography in dogs, where panting is a common problem.

By decreasing the respiratory rate, it is also easier to time the exposure correctly to peak inspiration for thoracic views and the expiratory pause for abdominal views.

Generally, the shortest exposure time possible should be selected, which can be a problem with relatively low-output machines.

Here, the control of movement blur can be difficult in large patients and the use of fast film-screen combinations is recommended.

## Exposure

Although development can also play a role, incorrect exposures are probably the most common reason for too dark (overexposed) or light (underexposed) radiographs ([Figures 3](#) and [4](#)).

It is usually easy to identify incorrect film exposure. Despite this, there is a tendency towards overexposed radiographs.

This might be partially because overexposure can be somewhat compensated by examining the radiograph with a bright light.

However, subtle lesions might be missed and the selection of unnecessarily high exposure factors compromises radiation safety. A radiograph should be exposed so that all structures in the region of interest can be visualised easily ([Figure 5](#)).

However, a radiograph that is adequately exposed for soft tissue structures is often underexposed for bony detail.

In conventional radiography, this sometimes means that the same region has to be radiographed at two different exposures, such as when bony and soft tissue structures of the limb are of interest.

In contrast to this, digital radiography allows the examiner to manipulate the image, with certain limits, in a way that soft tissues and bony structures can be visualised in one radiograph.

If the area of interest is significantly affected by over or underexposure, the radiograph should be repeated at a lower or higher exposure, usually by altering the kilovolt (kV) setting.

However, if the error in exposure is severe, it might also be necessary to change the milliampere seconds (mAs) product. An exposure chart, ideally in centimetres of thickness, is most helpful to avoid incorrect exposures. The exposures in the chart are only valid for the specific film-screen combinations and film-focus distance used and, therefore, adjustments are likely to be necessary if any other components are changed.

Although incorrect exposures can be more easily compensated with CR and DR systems, significant under and overexposure can lead to artefacts and, beyond a certain level, these cannot be corrected.

## Poor radiographic contrast

Poor radiographic contrast results in a “flat” image, with little difference between the radiopaque and more lucent structures of a patient. Radiographic contrast is influenced by several factors. The most important causes include poor development, film fogging (including scattered radiation), and incorrect selection of exposure factors.

- **Underdevelopment**

This is the most common cause of poor contrast. Underdevelopment produces radiographs that are too light overall.

An underdeveloped film can be recognised by examining the exposed background outside the area of the patient’s body.

In a well-exposed and well-developed film, this should be black and when the film is held against light, it should be difficult to see the fingers of a hand behind the film. Underdeveloped films show a lighter background and it is relatively easy to see fingers behind the film ([Figure 6](#)). This fault is commonly seen with conventional film processing and is usually caused by exhausted developer chemicals or by the temperature of the solution being too low.

As with other complex equipment, it is advisable that one member of staff (preferably somebody with an interest in radiography) has the main responsibility for the automatic processor, to ensure consistency. The processor has to be cleaned regularly to allow the full exchange of exhausted chemicals and the removal of dirt and debris. All staff involved in radiography should be familiar with the basic functions of the processor, including how to top up chemicals and water.

True equipment faults, such as inadequate automatic chemical replenishment or a defective thermostat causing suboptimal temperatures, are less common - but it is important that the processor is regularly serviced to ensure adequate technical function.

- **Film fogging**

Film fogging is undesired darkening of film that occurs when the x-ray film is inadvertently exposed to light or x-rays. There are many causes of film fogging, one of which is scattered radiation. Scattered photons leave the patient or objects in a random direction. They can reach nearby personnel, causing a radiation safety concern, or reach the x-ray film in the cassette, causing fogging. Because this affects all regions of the film in an indiscriminate manner, scattered radiation decreases contrast. Scattered radiation is a particular problem in large patients and, therefore, the use of a grid is recommended if the radiographed area exceeds 12cm thickness. However, when using a grid, the mAs product has to be increased by approximately two to three-fold. Film fogging will result in an overall increase in exposure with poor radiographic contrast and a well-exposed (black) background ([Figure 7](#)).

- **Exposure factors**

In conventional radiography, high kV settings result in a radiograph with low contrast (a large scale of grey tones), whereas low kV settings result in a high contrast image (with a short grey scale).

This effect can be used to our advantage, depending on the body region of interest. In the abdomen, there is inherently little patient contrast.

Therefore, the use of a low kV and high mAs technique is advisable. In the thorax, there is a high degree of natural contrast and a high kV, low mAs technique is generally recommended to achieve an image with a high scale of contrast to allow visualisation of subtle structures and lesions. These differences between the abdomen and thorax are one of the reasons why an exposure of the entire animal should not be performed. Although somewhat subject to personal preference, the use of a low-kV, high-mAs technique has also been recommended for the skeletal system. If a high-kV technique is used, the usually high contrast between bone and the soft tissues is lost, which might result in an artefactual impression of osteopenia.

The effect of kV and mAs settings on contrast are much less in digital radiography.

## **Marks on film**

Rough handling of the film can cause artefacts on the radiograph like scratches or crescent-shaped marks where the film was bent ([Figure 8](#)).

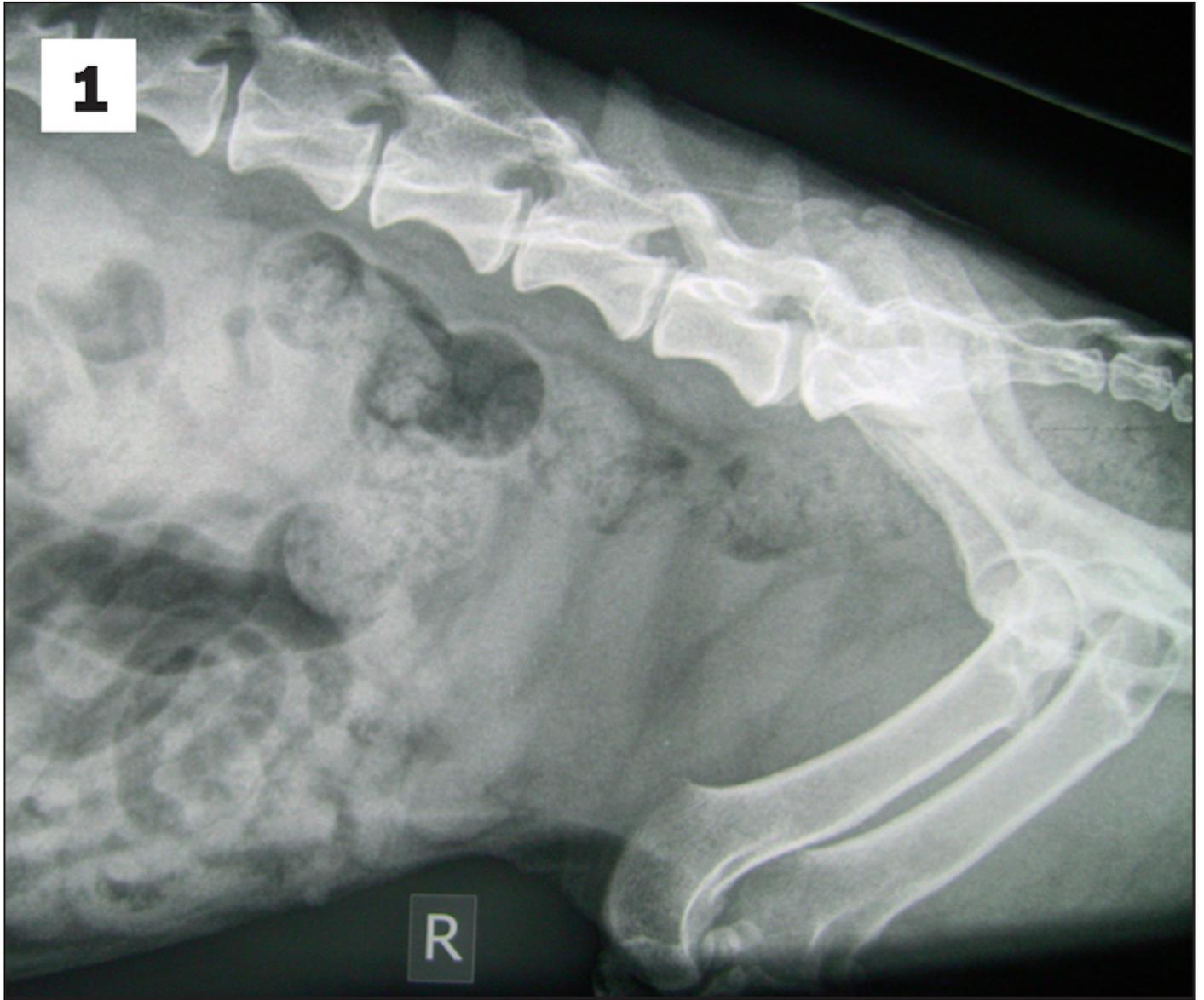
These can interfere with the area of interest and should, obviously, be avoided.

Other common faults are screen artefacts, where the presence of dust particles, hair or other small objects causes sharply delineated white (unexposed) areas on the film ([Figure 9](#)). Screens should be regularly examined and cleaned, according to the manufacturer's recommendations.

Dirt sticking on the film emulsion can also create marks that might interfere with interpretation. This commonly occurs if the automatic processor is not cleaned regularly. Splashes of developer or fixer chemicals on the film, a common occurrence with manual processing, are seen less frequently nowadays.

## References and further reading

- Morgan J P (1993). *Techniques of Veterinary Radiography* (5th ed), Iowa State University Press, Ames.
- Ewers R S and Hofmann-Parisot M (2000). Assessment of the quality of radiographs in 44 veterinary clinics in Great Britain, *Vet Rec* **147**: 7-11.
- Nicholl, R G and Allan, G S (2000). *American College of Veterinary Radiology, Annual Scientific Conference Proceedings 2000*, Chicago, Illinois.
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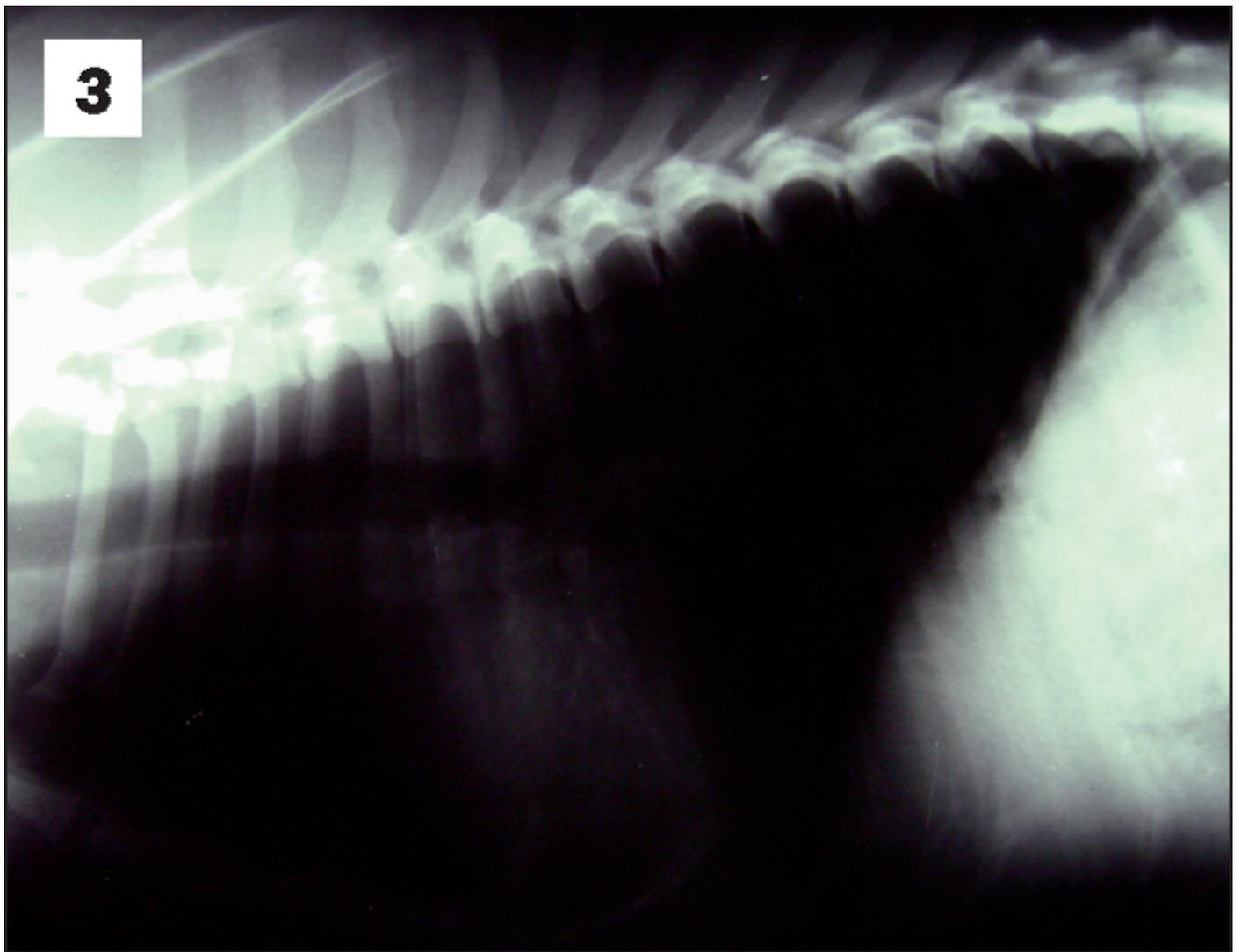


***Figure 1. An example of inadequate positioning of the caudal abdomen for examination. The muscles of the hindlimbs are superimposed on to the area of interest.***

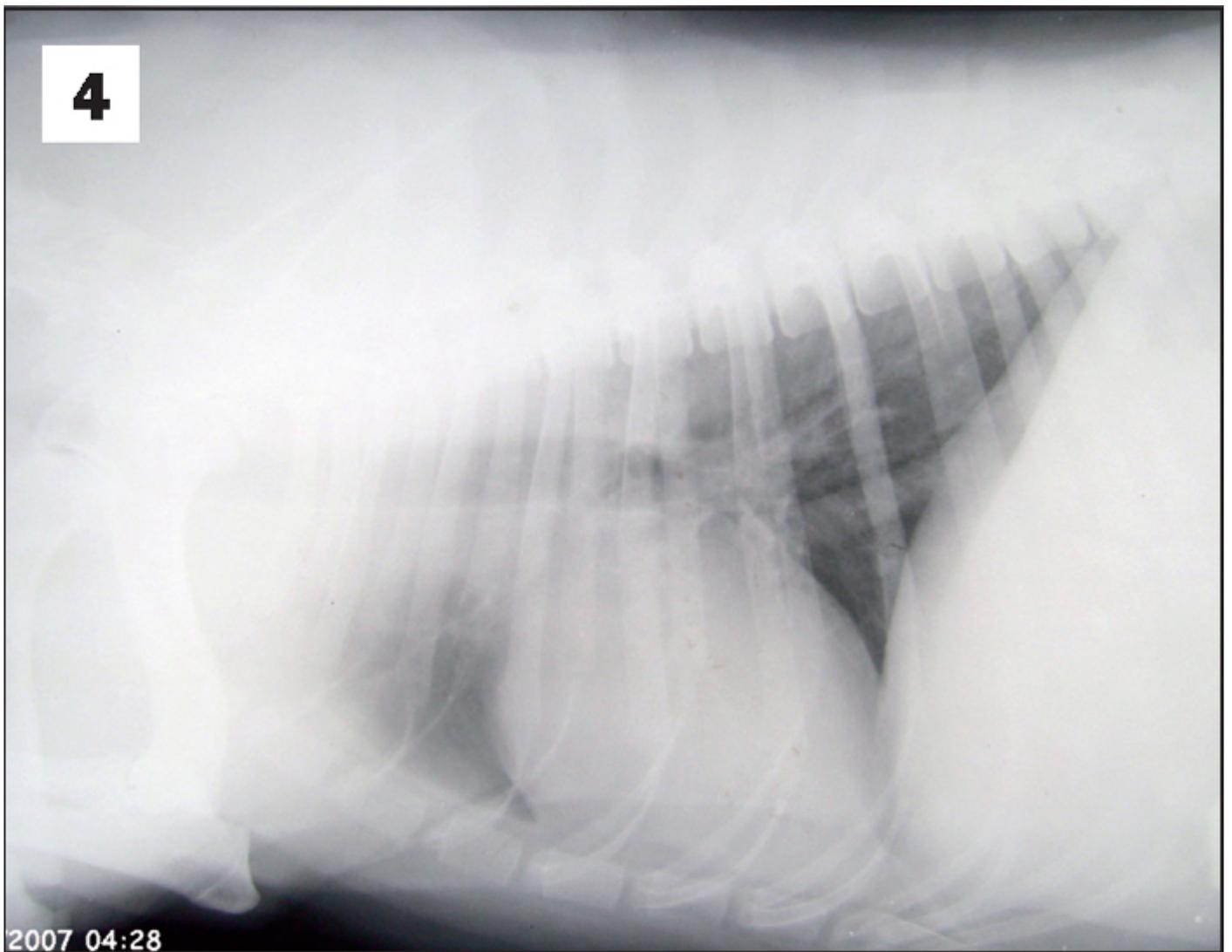
**2**



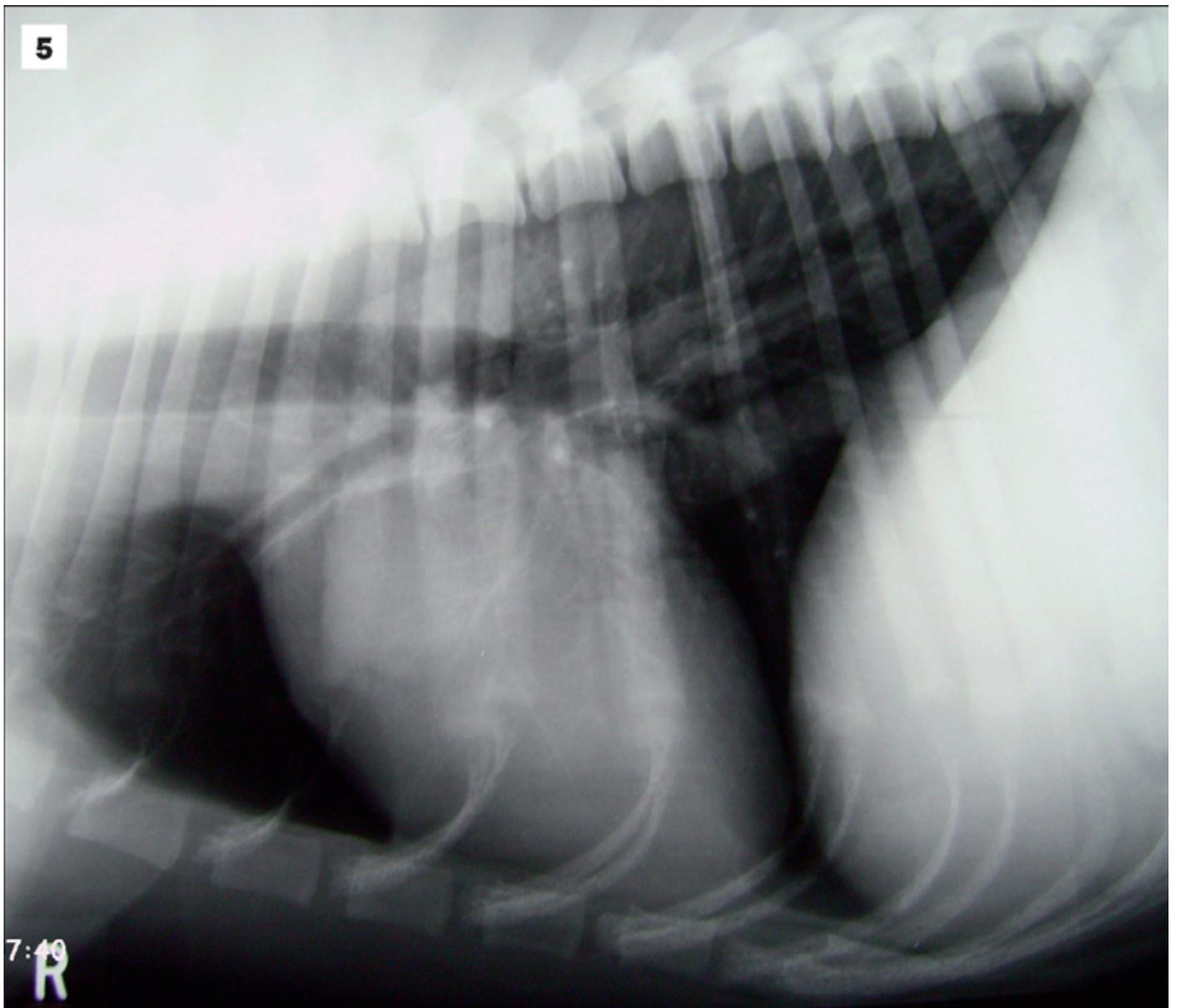
**Figure 2.** For an investigation into a suspected joint disease, this radiograph is inadequately centred and collimated. However, centring and positioning are satisfactory for the investigation of lesions of the humerus (such as panosteitis), although the collimation should have still been closer to the area of interest.



**Figure 3. This is an example of an overexposed radiograph of the thorax - it is difficult to assess the intrathoracic structures such as the heart, mediastinum and great vessels.**



**Figure 4. This thoracic radiograph has been taken in expiration and it is underexposed. Underexposure leads to an image being “too light” with poor contrast. Note the black periphery outside the patient, indicating adequate development.**

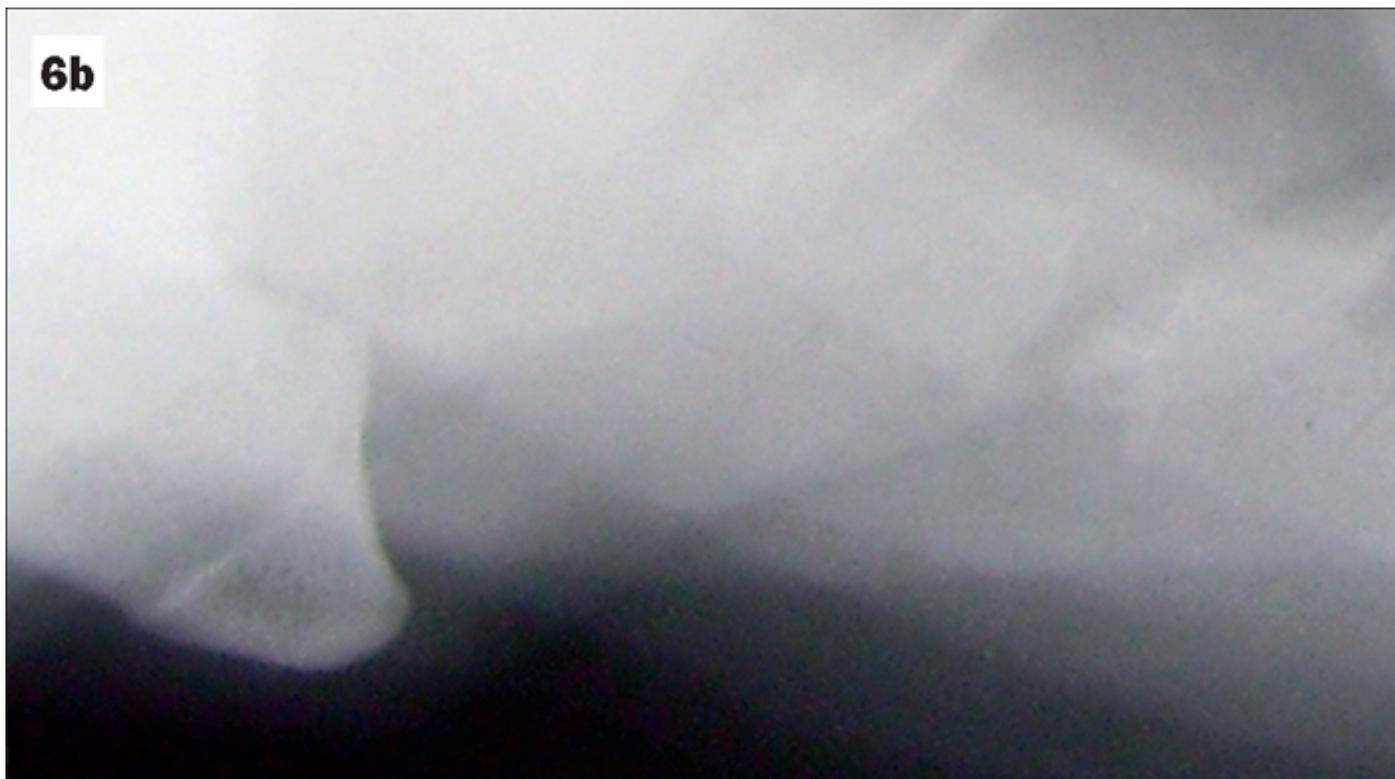


***Figure 5. In a well-exposed thoracic radiograph, the intrathoracic structures are easily visualised.***

**6a**



**Figure 6a.** This radiograph of the left femur shows poor contrast and a grey background outside the patient, indicating that the film is underdeveloped. Compare this with the black background of a close-up of Figure 2 seen in Figure 6b.



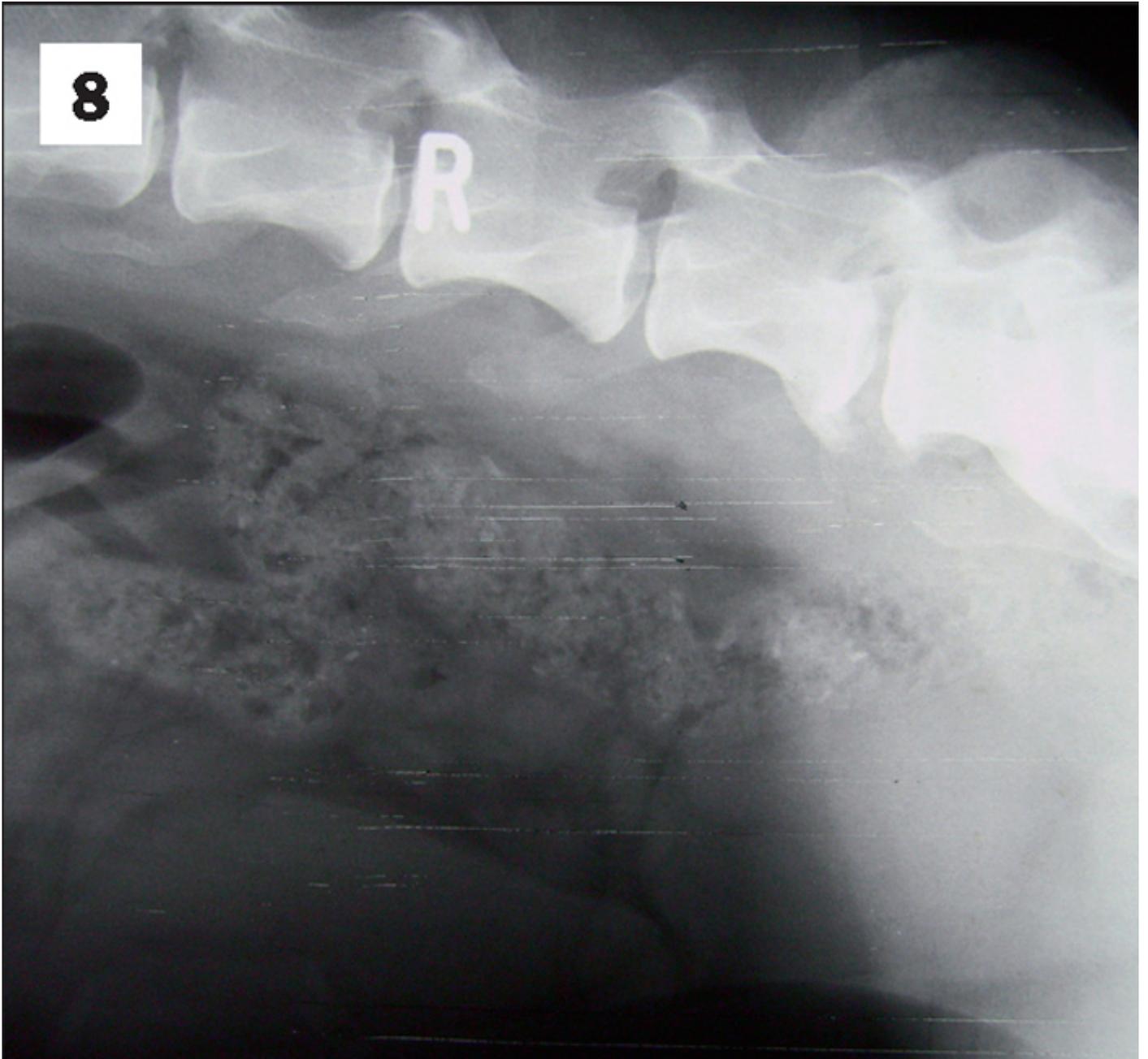
**Figure 6b.** The author says this fault is often seen with conventional film processing and is usually caused by exhausted developer chemicals or by the temperature of the solution.

**7**

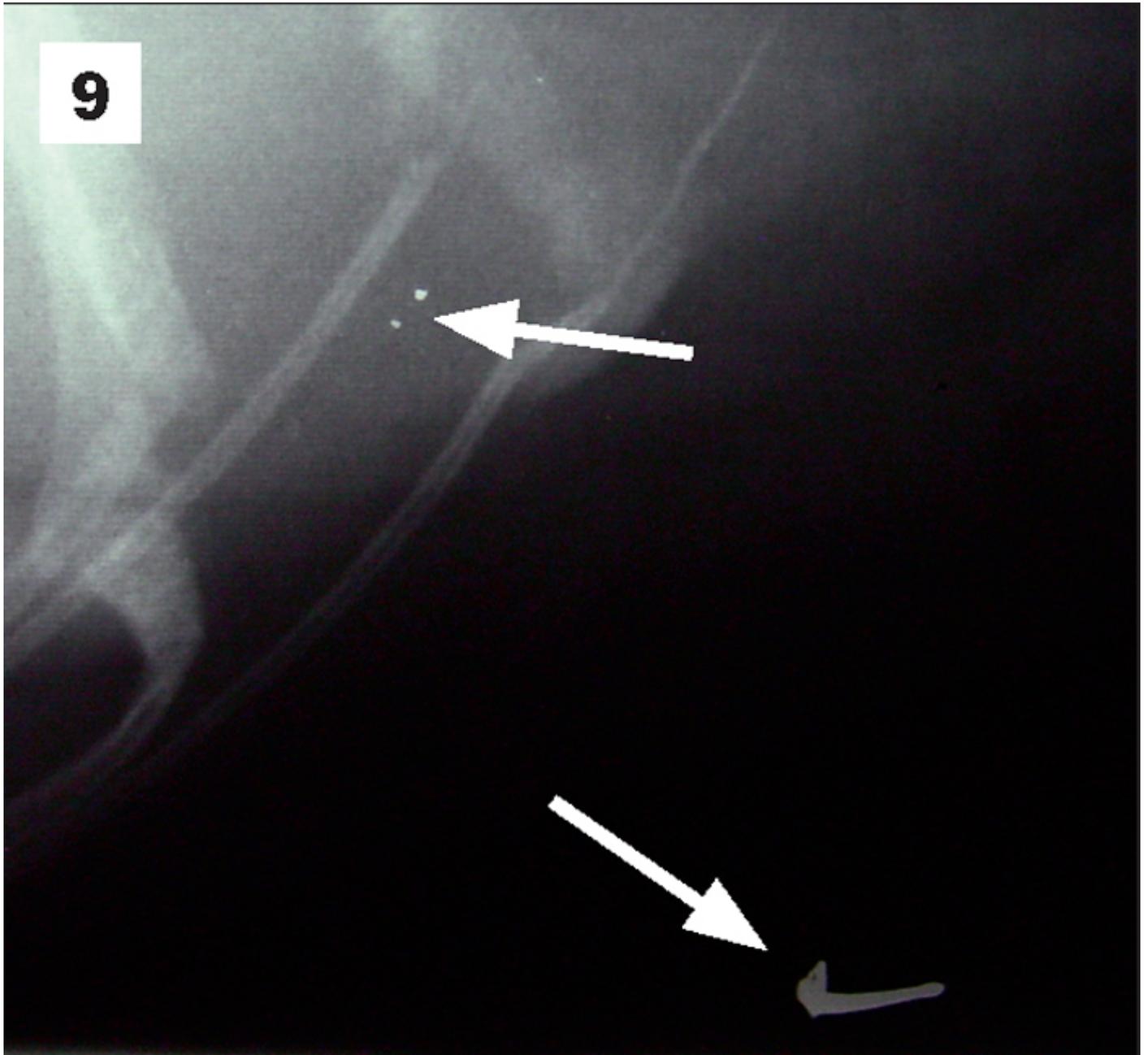


*Figure 7. A radiograph of a dog's skull, which is, overall, very dark - including the area*

***outside the primary beam. This fault can have different causes, such as over development or film fogging.***



***Figure 8. This close-up of the dorsal abdomen of a dog shows linear scratches on the emulsion, which are most likely to have been caused by dirty or defective rollers of the automatic processor.***



***Figure 9. Here is a close-up of screen artefacts (indicated by the arrows). If they are sufficiently large and positioned over the patient, they can be misinterpreted as pathological lesions, like urinary calculi or foreign bodies. Screens should be regularly cleaned and***

**examined.**

Image appearance	Radiographic fault	Underlying cause
Radiograph too dark	Overexposure	kV +/- mAs setting too high.
	Overdevelopment	Developer too concentrated. Developing time too long. Developer temperature too high.
	Film fogging	Film in box: <ul style="list-style-type: none"> <li>◆ Old film.</li> <li>◆ Exposure to light.</li> <li>◆ Exposure to x-rays if film box stored in x-ray room.</li> </ul> When the film is in a cassette: <ul style="list-style-type: none"> <li>◆ Light leakage into cassette.</li> <li>◆ Exposure to x-rays if the cassette is in the x-ray room.</li> </ul> During processing: <ul style="list-style-type: none"> <li>◆ Light leakage into darkroom.</li> <li>◆ Inadequate safe light (incorrect filter or wattage too high).</li> <li>◆ Safe light too close to work surface.</li> </ul>
Radiograph too light	Underexposure	kV +/- mAs setting too low.
	Underdevelopment	Developing time too short. Diluted developer. With an exhausted developer: <ul style="list-style-type: none"> <li>◆ Inadequate replenishment rate.</li> <li>◆ Automatic processor not cleaned regularly.</li> <li>◆ Reflux of old developer from waste container.</li> </ul> Developer temperature too low: <ul style="list-style-type: none"> <li>◆ Faulty thermostat.</li> <li>◆ Processor not given enough time to warm up.</li> </ul>
Poor radiographic contrast	Underdevelopment (see above).	
	High kV setting.	
	Film fogging (see above).	
	Scattered radiation.	
	Film out of date.	

**TABLE 1.** Summary of causes of some common film faults

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