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Essential Radiography for Veterinary Nurses Mini Series

Session One: Basic Principles of Radiography and Orthopaedic Radiography

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Basic Principles of Radiography

Equipment

X-ray machine

Ideally it will have:

- A wide range of kV, and independent selection of mA and seconds.
- Changeable FFD – Film Focus Distance.
- A rotating and tilting head.
- A table of suitable size with integrated Potter-Bucky grid.
- A light beam collimator allowing both longitudinal and transverse restriction of the beam.
- Some method for securing ties –e.g. positioning anchors.
- A cushioned table top mat.

Grids

- Absorb radiation that is not parallel to the main X-ray beam.
- Use if tissue depth superior to 10 cm - e.g. pelvis, shoulders.
- The Potter-Bucky grid is the one of choice, it is easy to use and grid lines are avoided.

Conventional radiography – Cassettes, films and intensifying screens

- Various sizes of cassettes available.
- Various types of cassettes and intensifying screens available to be used in different cases depending in the area being radiographed, etc.
- For instance, the combination of a green rare earth screen with orthochromic film is recommended for orthopaedic radiography. This combination maximises output whilst minimising exposure, as its very efficient at absorbing x-ray photons and fluoresces strongly with little afterglow.
- The slower the film, the smaller the film emulsion crystals and the greater the definition. Slow film/screen combinations are recommended for extremities and joint detail, and medium speed combinations for thicker tissue areas.
- Need for manual or automatic processing of films in a dark room – time consuming.

Computed radiography (CR)

- Imaging plate coated with PSP -photostimulable phosphor - that captures X-rays during exposure.
- A CR reader is used to extract a latent image from the imaging plate.
- A di
- gital image is obtained which can be seen in a monitor and stored.

Digital radiography (DR)

- Uses flat panel detectors connected directly to the image processing system (cable or wireless)
- Eliminates the need to use a reader to extract an image from the imaging plate (which is necessary with CR)
- 2 types: Indirect DR and direct DR

Both CR and DR allow to see the images obtained very quickly after the exposure, since there is no need to process radiographic films in a dark room. These techniques allow computer manipulation of the images after exposure to improve their quality. In some cases this will avoid unnecessary further radiation exposure of the patient and delays caused by the need to repeat radiographs that were initially taken with incorrect settings. With both CR and DR the radiographs are kept in a digital format, which is very convenient for storage and easy access to the images whenever required.

Positioning aids and markers

Sandbags - can be used to pull limbs forward, backward, away from the area of interest and to stabilise the patient. Ideally they will have removable covers for washing or be made of an easy clean material. They should be about 2/3rds full to keep them flexible and of various sizes in width and length.

Foam shapes - are used to support areas and avoid limb/joint rotation. It is useful to have a variety of shapes and sizes including a mini set to use on cats and small dogs. Wrapping in cling film is recommended as an infection control measure. The foam should be checked for radiolucency.

Radiolucent cradles – can be used to support the main body of the animal in conjunction with sandbags.

Ties and markers - Ties can be used with either sandbags or table anchor points to fully extend limbs; L/R markers are used to identify which side/limb is being radiographed.

Figure 1 – Positioning aids and markers.

Preparation and Restraint of Patients

Preparation of patients

Before starting the radiographic examination, adequate preparation of the animal should be undertaken. The coat should be clean and dry as a dirty and/or wet coat can cause radiographic artefacts. Where possible dressings and casts should be removed or reduced to a minimum taking the necessary infection control measures. Collars and harnesses should be removed as they may overlie the area of interest. Some orthopaedic cases may present with metallic external fixators which may require some imaginative positioning and multiple exposures to get the views required.

Restraint

Adequate restraint is necessary to achieve the various views required for each case. This is particularly important when obtaining orthopaedic radiographs. Some views require the use of ties - e.g. stressed views of the carpus/tarsus - and in these cases general anaesthesia is required. The orthopaedic case can often be painful on presentation and therefore adequate analgesia and restraint (sedation or general anaesthesia) will be necessary. Sometimes for clinical reasons it may be necessary to radiograph the animal conscious; this requires time and patience, and will restrict the type of views possible, it will also increase the possibility of movement blur. Regardless of the case you are dealing with, manual restraint must be always avoided.

Radiographic Technique

It is important to always use a standard radiographic technique to ensure you always obtain radiographs of good diagnostic quality. There are several points to consider to achieve this as described below.

Exposure chart
An exposure chart is an invaluable tool. It is specific to each X-ray machine (and film/screen combination used in the case of conventional radiography). An exposure chart should include all the areas likely to be radiographed with exposures for each view and differing sizes - e.g. small through to giant breeds. It is particularly important to remember when taking orthopaedic radiographs that it is the size of the joint or limb and not the size of the dog that needs to be taken into account when choosing settings.

Anatomical landmarks for centring
Each view has its own anatomical landmarks which are used for centring, it is important to become familiar with these and be able to identify them. Practice feeling these landmarks, as often they are difficult to visualise in very hairy animals and difficult to feel if they are obese.

Standard positioning and labelling
The use of standard positioning improves recognition of normal anatomy, makes the radiograph easier to interpret and compare with examples of normal from textbooks and/or previous radiographs of the same patient. It is good practice to position and label the cassette in a standard way, the label should always be cranial/dorsal or lateral. It may be useful to take radiographs of both the affected and healthy limbs for comparison.

Orthogonal views
Two views at 90 degrees to each other (orthogonal) are usually required as a minimum for adequate radiographic evaluation of the area of interest and should be obtained whenever possible. This is particularly relevant in orthopaedic radiography.

Minimize magnification and distortion
These phenomena occur because of divergence of the x-ray beam from the source. The greater the object to film (or detector) distance (OFD) the greater the magnification. The greater the film focal distance (FFD) the smaller the magnification. However increased FFD requires increased exposure and therefore a compromise must be reached. Distortion is seen when the area of interest is not parallel to the table and therefore can produce foreshortening or elongation. In summary the area of interest should be as close and parallel to the cassette as possible to avoid magnification and distortion.

Minimise scatter
Scatter can be minimised at source by avoiding the use of unnecessarily high kV, achieving good collimation, and using a grid when tissue is thicker than 10 cm. The grid will absorb radiation which is not parallel to the main X-ray beam.

Maximise sharpness
Minimize movement blur, which can be achieved by using adequate restraint, taking the exposure at the expiratory pause, and using short exposure times. In the case of conventional film/screen radiography ensure that the cassette used has good film/screen contact, and use a grid when appropriate (less scattered radiation).

The goals of a good radiographic technique include making sure the area of interest is covered and to obtain the best possible exposure with correct positioning and adequate labelling of the views obtained. Ultimately the aim is to obtain a set of radiographs that maximizes the amount of information available, that can then be used by the clinician to reach a diagnosis and choose the best treatment plan, or that at least will help decide which other tests may be required.

Radiation Safety

Radiation safety of all staff involved when taking radiographs is of paramount importance, and should permanently be taking into account when performing a radiographic study. A basic principle to remember is to always use ***A***s ***L***ow radiation ***A***s ***r***easonably ***A***chievable – ALARA. See below a list of the main points to be considered regarding radiation safety.

- No dose limit should be exceeded.
- Exposure to personnel should be kept to a minimum.
- Unnecessary procedures should not be performed.
- The Ionising Radiation Regulations 1999 should be adhered to.
- Someone within the practice should be appointed as the radiation protection supervisor (RPS).
- Every practice should appoint an external radiation protection advisor (RPA).
- Local rules and a system of work should be available for the practice.
- Local rules vary but should always ensure:
    - No animal is manually restrained
    - No unnecessary personnel stays in the room during exposure
    - Suitable protection is used
    - Predetermined guidelines for pregnant members of staff
    - Minimum age of 16 for trainee staff
    - Areas within the practice are classified
    - Guidelines for implementation of warning signs
- Dose limits are specified by legislation to ensure that the dose received by personnel is kept to a minimum.
- Monitoring devices record the amount of doses received by an individual.
- Two types of monitoring devices – film badges and thermoluminescent dosimeters.
- Lead shielding should be worn or used if it is essential for an individual to remain in the controlled area during an exposure.

Figure 2 – Radiation safety related equipment.

Orthopaedic Radiography

Radiography is an essential diagnostic tool for the work-up of cases with orthopaedic disease. It is often required to obtain a diagnosis, decide what is the best treatment plan and to do a follow-up on the progression of the case after treatment. For instance, when dealing with a fracture, radiographs will be required to identify exactly which type of fracture it is and to decide which surgical technique to perform to reduce it. It is also necessary to take radiographs immediately after surgery to verify if the fracture was reduced successfully and repeat the radiographs after a period of time to check that the bone is healing adequately and no complications have occurred.

Nomenclature

The radiographic projections are described in the direction the X-ray beam travels from the X-ray tube, through the animal and into the film or detector. The table below lists the most commonly used views or projections in orthopaedic radiography. Many other specific views can be taken – e.g. oblique views, stressed views, skyline view of the shoulder joint.

View	Nomenclature	Area
Mediolateral, or Lateromedial	ML or LM	Appendicular skeleton
Dorsoventral, or Ventrodorsal	DV or VD	Pelvis and Spine
Craniocaudal, or Caudocranial	CrCd or CdCr	Proximal forelimbs and hindlimbs
Dorsopalmar, or Palmarodorsal	DPa or PaD	Forelimb, distal to and including the carpus
Dorsoplantar, or Plantarodorsal	DPl or PlD	Hindlimb, distal to and including the tarsus

Table 1 – Common views used in orthopaedic radiography.

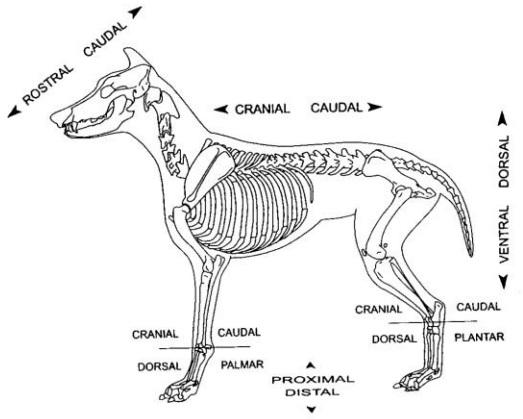

Figure 3 – Diagram illustrating the different directions/planes used to name radiographic views.

Radiographic positioning

Shoulder joint

A standard examination of the shoulder joint requires two views ML and CdCr. If tendon or muscle involvement is suspected then the skyline view may be also required. Where depth of tissue is superior to 10cm, the ML and CdCr views should be taken using a grid. General anaesthesia or deep sedation is required.

Medio-lateral view (ML)

- With the animal in lateral recumbency, affected limb down secure limb in cranial ventral traction using a tie.
- Secure the contralateral limb caudally and dorsally; avoid over rotation.
- Extend the head and neck dorsally to avoid superimposition of the trachea.
- Centre on the scapular acromion.
-

Caudo-Cranial view (CdCr)

- With the animal supported in dorsal recumbency draw the limb cranially in full extension and secure with a tie. A foam wedge under the carpus may be required for support.
- Feel for the cranial edge of the scapular body, this should be perpendicular to the table top. Ensure the forelimb is not abducted which would open the shoulder joint.
- Centre on the scapular acromion.

Skyline view (tangential)

- With the animal in sternal recumbency raise the head and healthy limb, turning away from the mid-line.
- The elbow and shoulder of the affected limb should be supported and held in maximum flexion whilst being kept parallel to the body.
- Abduct the foot and carpus of the affected limb away from the area of interest.
- Centre on the intertubercular (biceps) groove of the humerus.

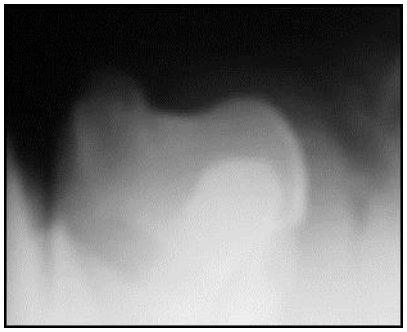

Figure 4 – Skyline view of a shoulder joint.

Elbow joint

The elbow joint is complex and can be positioned in a number of ways to view all the structures radiographically. Table top technique with no need for grid. General anaesthesia or sedation is required.

Mediolateral view (ML)

- With the animal in lateral recumbency, affected limb down, draw the contralateral limb dorsally and caudally avoiding rotation.
- Position and secure the leg cranially to produce the required angle, a foam wedge under the carpus and sometimes the olecranon will be required to avoid rotation.
- Extend the head and neck dorsally.
- Centre on the epicondyle of the humerus.

Craniocaudal view (CrCd)

There are two ways of positioning for this radiographic view.

Dorsal recumbency:
This method is good for examining condylar fractures.

- With the animal supported in dorsal recumbency extend the limb caudally and secure with sandbags or ties.
- To keep the joint straight and avoid superimposition of the thoracic wall a foam wedge can be placed between the limb and body wall.
- Centre midline of the humeral epicondyles.

Sternal recumbency:
This method is useful when assessing deformities of the forelimb, especially in chondrodystrophic breeds - e.g. Basset hounds - the whole antebrachium should be included whilst still centring on the elbow.

- Place the animal in sternal recumbency.
- Extend the affected limb cranially and support the elbow with a foam wedge.
- Raise the contralateral forelimb and head with a foam pad to avoid rotation and superimposition
- Centre as above.

Caudocranial view (CdCr)

This view is often preferred by clinicians when suspecting problems with the medial coronoid process or osteochondrosis of the medial condyle of the humerus; however the increased OFD will mean that the image is magnified.

- With the animal supported in dorsal recumbency draw the limb cranially in full extension avoiding rotation and secure with a tie, keep the elbow as close as possible to the table. The carpus may need to be supported with a foam pad.
- Centre as above.

Carpus

Mediolateral view (ML)

- Place in lateral recumbency affected side on the table.
- Pull limb cranially; can secure with tie.
- Retract other limb caudally and dorsally; secure with sandbag or tie.
- Check for any rotation.
- Centre on the carpus.

In some animals we may need to place a foam wedge under the foot to correct rotation. Stressed views are often done on this area when suspecting ligament damage, luxations, etc. These should be done placing ties above and below the joint and pulled tight in opposite directions and then secured on anchoring pegs.

Dorsopalmar view (DPa)

- Positioning similar to CrCd elbow in sternal recumbency.
- Make sure that the carpus is parallel to the cassette and is not rotated, it will not be in-line with the elbow.
- Centre on the carpus.

Foot

Lateromedial view (LM)

- Position of the foot is similar to that of the LM carpus, centring on the metacarpo-phalangeal joint
- Often worth doing obliques to avoid superimposition or use tape to pull toes apart.

Dorsopalmar view (DPa)

- The positioning is exactly the same as the DPa carpus centring on the metacarpophalangeal joint
- Useful to separate the toes with cotton wool or similar

Hip/ Pelvis

The standard view used for assessment of the hips/pelvis is the ventro-dorsal extended view. A grid should be used except for very small dogs and cats where table top technique can be used. General anaesthesia or sedation is required.

Ventrodorsal extended view (VD)

- Support the animal in dorsal recumbency avoiding longitudinal rotation
- Fully extend the legs, adduct and inwardly rotate so that the femora are parallel and secure. The limbs may need support with a foam pad under the hocks.
- Ensure the tail is central.
- Centre midline between the greater trochanters of the femur.

It is advisable to maintain the animal in position whilst the quality of the radiograph obtained is checked, so that adjustments can be made if axial rotation has occurred. To correct axial rotation raise the hip on the side on which the obturator foramen is smaller. Often ensuring that the head/neck end of the dog is straight will correct rotation at the pelvis.

Stifle joint

The most commonly used projections for the stifle joint and associated structures are the ML and the CdCr. If cranial cruciate rupture is suspected then the hock is included (TPLO -Tibial plateau levelment - osteotomy views). Table top technique with no need for grid. General anaesthesia or sedation is required.

Mediolateral view (ML)

- With the animal in lateral recumbency, affected side down abduct the contralateral limb so that it doesn't overlay the area of interest.
- The stifle should be allowed to rest on the cassette in a neutral position, to achieve the desired superimposition of the femoral condyles a foam wedge under the caudal aspect of the hock may be required.
- Centre over the femoral condyles.

If the animal has well developed musculature on the hind limbs - e.g. Staffordshire Bull terrier - it may be easier to draw and secure the contralateral limb cranially or place a foam wedge under the hip.

Caudocranial (CdCr)

- With the animal in sternal recumbency extend the affected limb caudally supporting the patella with a foam wedge.
- Flex and raise the contralateral limb so that the trochlear groove of the affected limb is central. Avoid the tail obscuring the area of interest.
- Centre on the distal part of the patella.

Moving the tail to the side of the affected limb will aid positioning and avoid medial rotation.

Tarsus

- The positioning for the tarsus – both ML & DPl is the same as the stifle.
- Centring is on the distal tibio-tarsal joint.

Common orthopaedic diseases

Radiographs are essential for the correct work-up of fractures, but are also very useful in many other orthopaedic conditions. Common orthopaedic diseases that you will come across in general practice that will require radiographs include:

- Shoulder osteochondrosis (OCD) – young dogs.
- Elbow dysplasia – young dogs; often on radiographs we will see signs of secondary osteoarthritis.
- Panosteitis – young dogs.
- Cranial cruciate ligament disease/rupture – vidence of stifle joint effusion +/- new bone formation will often be visible in radiographs.
- Hip dysplasia.
- Osteosarcoma – most common locations for this type of tumour are the distal radius and proximal humerus, followed by the proximal and distal femur and tibia.