Radiographic Positioning:

Head, Shoulders, Knees, and Toes

PART 1

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Liane grew up in Valparaiso, Indiana, on a small hobby farm with horses, goats, pigs, chickens, geese, cats, a dog, and one duck named Daffy. A 10-year member of 4-H, she followed her passion for animals by applying to the veterinary technology program at Purdue University, where she earned not only an associate's degree, but also a bachelor's in applied science, with a minor in organizational leadership and supervision.

After working as a supervisor in private practice for 6 years, Liane returned to Purdue to pursue her love of teaching. In the past 9 years as Purdue's Diagnostic Imaging Instructional Technologist, she has completely remodeled the diagnostic imaging curriculum to include many labs for a more hands-on approach. In 2011, she received a Teaching Excellence award from Purdue University and Elanco Animal Health. In 2013, she spoke at Purdue's fall conference on the topic of dental radiography.

Liane stays busy by spending the evenings outside with her husband and two sons on their 22-acre farm in Attica, Indiana, which is home to horses, dogs, cats, and a donkey!

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Jeannine was born and raised in Logansport, Indiana, where she welcomed any opportunity to spend time with animals. In 2005, she earned a bachelor's degree in English, in pursuit of her passion for reading and writing, but soon realized that something was missing from her life: her love for animals. While working at a private practice, she was introduced to the role of veterinary technician. She graduated from Purdue with an associate's degree in veterinary technology in 2007.

One month after graduation, Jeannine accepted a position at Purdue University as a Versatech, a position created to fill gaps in various departments all over the hospital, including diagnostic imaging. This was how she discovered her love for radiology. She has now been working in diagnostic imaging for 6 years and is PennHIP certified.

In her spare time, Jeannine enjoys reading, writing, cooking, and spending time with her husband, son, two dogs, and adopted blood donor cat. She hopes to combine her love for animals and writing in the future to pursue a career in journalism for the veterinary medicine profession.

Our passion for our patients is what drives our need to be thorough and proficient in our work as veterinary technicians. When it comes to taking radiographs, this means knowing the positioning techniques necessary to achieve diagnostic-quality images in a timely and efficient manner, as well as the safety precautions all staff should follow when working with radiation.

In this first of two articles on radiographic positioning, we provide an overview of the principles and guidelines of radiation safety in the workplace as well as the techniques used to obtain good-quality orthopedic radiographs of the skull, shoulders, and elbows with great efficiency and care for the patient. Part 2 will discuss manual versus chemical restraint, the use of positioning

TECHPOINT

Dosimeter badges should be checked at least quarterly to evaluate the wearer's cumulative radiation dose.

aids, and a step-by-step tutorial to aid in the positioning of the pelvis, stifles, and feet.

OVERVIEW OF X-RAYS AND RADIATION SAFETY

Were you ever told, "Stay away from the microwave when it is cooking, or you will get irradiated"? Now, people are more aware of the risks posed by repeated exposure to radiation, but that wasn't always the case. Up until the 1950s, it was possible to go to a shoe store and use x-rays to determine your shoe size.[1] Fortunately, the principle of being cautious about radiation has improved over the decades.

Although we have advanced in many other ways, the production of x-rays remains the same as when they were first discovered: accelerated electrons interact with a metal target on the anode in the x-ray tube head, heating the target and causing photons to be produced. In this inefficient process, 1% of the electrons' energy is converted to x-rays and 99% to heat (or waste). The photons (x-rays) are then directed at the patient in what is known as the primary beam. However, some subsequently bounce off or "scatter" in all directions after reaching the patient. Scatter radiation, or secondary radiation, poses exposure risks to radiography personnel.[2]

X-rays, like radio waves and microwaves, are part of the electromagnetic spectrum. X-rays differ from some other forms of electromagnetic radiation because their very short wavelength allows them to penetrate matter, including cells. Today, we know that x-rays interact with cells in 4 ways[2]:

1. They can pass through with no damage.
2. They can cause repairable damage.
3. They can cause irreparable damage.
4. They can cause cell death.

RADIATION EXPOSURE LIMITS

Most states require that any person working with radiation-emitting devices wear a personal radiation exposure monitor. These dosimeter badges, as they are often called, should be checked at least quarterly to evaluate the wearer's cumulative radiation dose.[3] According to the US Nuclear Regulatory Commission, occupational personnel should not receive a total effective dose of more than 5 rem per calendar year.[4] There are more specific limits for skin and eyes (**BOX 1**). However, different states may have different guidelines. To learn more about your state's radiation guidelines, go to crcpd.org, and click on Radiation Control Programs on the left-hand side to follow the links to the full map, find your state, and go to the correct website.

The exact level of radiation exposure that causes cell death is not known, so all exposure should be treated as if it is going to produce cell death. All veterinary professionals should practice simple methods of keeping exposure as low as reasonably achievable (ALARA), such as increasing distance from the tube head, using short exposure times, and using their knowledge and understanding of positioning to decrease the number of retakes. Other factors that can help in minimizing radiation exposure include using proper exposure techniques from a professionally developed technique chart, sedation for patients that are in pain or anxious, and positioning aids. These concepts will be described in more detail in part 2.

PERSONAL PROTECTIVE EQUIPMENT

Personnel who work with radiation should protect themselves from all workplace radiation exposure by wearing the appropriate personal protective equipment (PPE). Lead, being a very dense material, is the approved barrier against harmful scatter radiation. It is suggested (but unfortunately not required) that all personnel working with radiation-emitting devices wear a 0.25- to 0.50-mm lead apron or wrap, lead thyroid shield, lead gloves, and even lead-lined goggles.[6] These guidelines can vary by state, but most states have adopted the minimum of 0.25-mm lead equivalent.[7,8]

BOX 1 US Nuclear Regulatory Commission Occupational Dose Limits for Radiation[5]

- Whole body: 5 rem/y
- Any organ: 50 rem/y
- Skin: 50 rem/y
- Extremity: 50 rem/y
- Lens of eye: 15 rem/y
- Embryo/fetus: 0.5 rem/y

Lead aprons or wraps, whether front sided or two sided, should fit appropriately. They should shield the body from the neck to midthigh and wrap halfway around the sides of the body.

PPE is expensive; therefore, it requires appropriate handling and maintenance. To prevent cracks, lead gowns should be draped over a rounded surface and not folded or wrinkled. Lead gloves should be kept on a glove rack or stored on a flat surface with round PVC pipes placed inside the liner to prevent the material from creasing in the same spot over time.

PPE should be inspected routinely for damage. Since gloves sustain the most physical wear, they should be inspected at least every 6 months. Lead gowns should be inspected annually, at minimum. Inspections should include a visual and radiographic assessment. During the visual inspection, all ties, buckles, and Velcro straps should be checked to ensure they are in working condition. No part of the lead should be uncovered or showing through the protective outer layer. The radiographic inspection involves using a fluoroscopy or radiography unit to look for cracks in the lead.[9] Common settings for this inspection are 80 kVp and 5 mAs; the settings can be adjusted based on the desired density of the material.[2] Although there are no federal guidelines for determining when to replace PPE, a general rule is to take equipment out of service if cracks are found over any pertinent organs, including reproductive and endocrine organs, or if the area of the crack is larger than 5.4 cm.[10] Lead should be properly disposed of according to guidelines regulated by each state.

TECHPOINT

Taking at least two orthogonal views is of critical importance when trying to get diagnostic-quality images.

GENERAL GUIDELINES FOR DIAGNOSTIC RADIOGRAPHY

One of the standards we follow at Purdue is to perform a complete radiographic series, no matter what is being imaged. Providing the most information we can to obtain the best possible diagnosis or outcome for the patient is our primary goal! Although certain circumstances (e.g., patient stability) may allow only one radiographic image to be obtained, it is possible to miss metastasis, disease processes, or even fractures based on a single radiograph. Therefore, taking at least two orthogonal views is of critical importance when trying to get diagnostic-quality images.[11] Orthogonal views are images that are taken at 90° to each other.

The following tutorial includes positioning instructions to obtain two orthogonal views for the skull, shoulders, and elbows. Depending on the part of the body being imaged, this may include a mediolateral or lateromedial view, a caudocranial or craniocaudal view, a dorsoventral or ventrodorsal view, and even some oblique views. Basic positioning aids are listed in **BOX 2**; these will be described in more detail in Part 2.

BOX 2 Basic Positioning Aids

- V trough
- Sandbags
- Cotton
- Tape
- Radiolucent blocks and paddles
- Foam wedges

FIGURE 1

FIGURE 2

FIGURE 3

FIGURE 4

FIGURE 5

The terms used to describe radiographic positioning can be confusing and depend on the area being imaged. When describing the way the beam enters and exits the body or head, it is appropriate to use *ventrodorsal* or *dorsoventral*. The terms *caudocranial* and *craniocaudal* are used to describe the way the beam enters and exits a forelimb or hindlimb. Markers should always be placed to indicate patient position and/or beam direction.

To reduce the amount of equipment in the images, most of the photographs in this article feature cadavers or well-trained healthy dogs that could be taped and positioned without sedation. Sedated patients should always be appropriately maintained with oxygen and monitoring.

POSITIONING THE PATIENT: STEP BY STEP

Head

Lateral View

The patient is positioned in lateral recumbency. The forelimbs should be pulled caudally to aid in positioning the skull, and the affected side of the skull is placed closest to the plate or cassette. The goal of this view is to superimpose the mandibular rami, so it is essential to place some cotton padding or a radiolucent wedge under the mandible. The nose should be parallel to the table, so padding also needs to be applied under the nose (FIGURE 1). The view must include the entire head from the base of the skull to the tip of the nose (FIGURE 2). The marker should indicate the patient's recumbency.

Ventrodorsal View

The patient is positioned in dorsal recumbency. The forelimbs should be pulled caudally to aid in getting the patient's head straight. A positioning aid such as a V trough can be used to get the patient as straight as possible (FIGURE 3). If a V trough is not available, sandbags or lead blocks can be placed near the shoulders to prop up the patient. Cotton or radiolucent material can be placed under the cervical region around C1–C3 to help extend the spine and straighten the head if needed (FIGURE 4). If needed, tape can be applied across the rostral portion of the mandible or behind the canine teeth on the maxilla to position the nose parallel to the table. If the patient has a prominent occipital protuberance, it can be difficult to balance the head symmetrically. In these cases, place a small piece of cotton under the head to keep it from tipping to the side. The view must include the entire head from the base of the skull to the tip of the nose (FIGURE 5). The marker should be placed on one side of the patient to indicate right or left.

Rostral Caudal Open Mouth Tympanic Bullae View

The patient is positioned in dorsal recumbency. The forelimbs should be extended caudally and secured with tape. The patient's nose should be pointing upward. Tape is applied behind the maxillary canine teeth to pull the nose 10° to 15° cranially (FIGURE 6). Tape is also applied around the mandibular canines and pulled caudally to open the mouth wide; how wide the mouth needs to be open depends on the species or breed of animal. It should be possible to visualize the bullae without the mandible or maxilla superimposed over them. The field of view includes the entire nasopharyngeal region (FIGURE 7). The marker should be placed on one side of the patient to indicate right or left.

Rostral Caudal Frontal Sinus View

The patient is positioned in dorsal recumbency. The forelimbs should be extended caudally and secured with tape. For this view, the patient's nose should be perpendicular to the plate or cassette, so the nose should be pointing up at a 90° angle from the table and wrapped with tape to secure it in this position (FIGURE 8). This view needs to be collimated down to just include the top of the head (FIGURE 9). Center the beam between the eyes just under the frontal sinus. The marker should be placed on one side of the patient to indicate right or left (FIGURE 10).


FIGURE 6


FIGURE 7

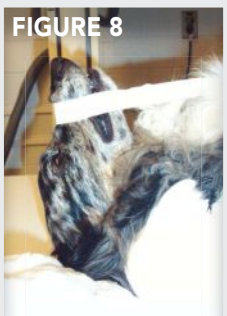
FIGURE 8


FIGURE 9


FIGURE 10

Rostral Caudal Occipital View

Positioning for this view is very similar to the frontal sinus view. The patient is positioned in dorsal recumbency. The forelimbs should be extended caudally and secured with tape. The patient's nose should still be perpendicular to the plate or cassette; however, instead of securing the tape around the muzzle to make a 90° angle with the table, pull a little more caudally and secure the tape. The nose is now between 100° and 105° when the patient is viewed from the side **(FIGURES 11 and 12)**. In patients with an endotracheal tube in place, be sure not to bend the tube. Center the beam on the top of the cranium and collimate to include only the entire cranium **(FIGURE 13)**. The marker should be placed on one side of the patient to indicate right or left.

Rostral Caudal Open Mouth Maxilla View

As with the previous views, the patient is placed in dorsal recumbency and the forelimbs are extended caudally and secured with tape. This view requires the maxilla to be parallel to the table, so it is best to secure the maxilla with tape across the hard palate. Place tape around the mandible behind the canine teeth and pull caudally to open the mouth wide **(FIGURE 14)**. If the patient is under general anesthesia, be sure to either tie the tube to the mandible or remove the tube briefly for the exposure to prevent the tube from being superimposed over the maxilla. The tube head will need to be angled about 20° to direct the beam inside the mouth **(FIGURE 15)**. The maxilla should be centered on the plate or cassette, and the field of view should include the rostral maxilla to the pharynx region or to C2 **(FIGURE 16)**. The marker should be placed on one side of the patient to indicate right or left.

Maxillary Obliques

The position of the patient for these views depends on the level of sedation being used. If the patient is under heavy sedation or general anesthesia, it may be placed in lateral recumbency with the affected dental arcade closest to the plate or cassette. The head is rotated ventrally at a 45° angle, using a radiolucent wedge or foam padding to lift the mandible off the table **(FIGURE 17)**. This position helps to isolate one side of the maxilla by avoiding superimposition of the opposite dental arcade. The mouth is propped open with a radiolucent object such as a syringe casing or a tongue depressor. The tube head is not angled for this view but is aimed ventrodorsally. The field of view can be collimated to include only the maxilla from the tip of the nose to the ear or to include the entire skull, depending on the clinician's preference **(FIGURE 18)**. Two markers are placed in this view, one indicating the recumbency of the patient and the other the beam direction. For example, VDLR means the beam is traveling ventrodorsally from the left side of the patient to the right side **(FIGURE 19)**. To isolate the opposite arcade (the left maxilla), a VDRL view would be needed.

Mandibular Obliques

The position of the patient for these views may depend on anesthetic depth. The patient can be placed in sternal


FIGURE 11


FIGURE 12

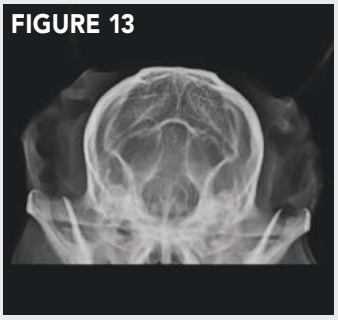
FIGURE 13


FIGURE 14

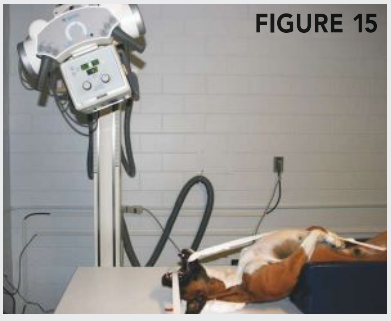
FIGURE 15


FIGURE 16

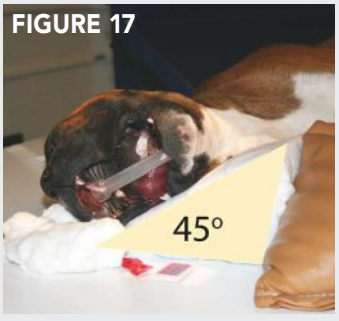

FIGURE 17


FIGURE 18

or lateral recumbency. Depending on the patient position, the head is rotated in an oblique position as close to 45° as possible, with the affected mandibular arcade closest to the table (FIGURE 20). This position helps to isolate one side of the mandible by avoiding superimposition of the opposite dental arcade. The mouth is propped open with a radiolucent object such as a syringe casing or a tongue depressor. The tube head is angled for this view but is aimed dorsoventrally. The field of view can be collimated to include only the mandible from the tip of the jaw to the ear or to include the entire skull, depending on the clinician's preference (FIGURE 21). Two markers are placed in this view, one indicating the recumbency of the patient and the other the beam direction. For example, DVLR means the beam is traveling dorsoventrally from the left side of the patient to the right side. To isolate the opposite arcade (the right mandible), a DVRL view would be needed.

Shoulders

Mediolateral View

The patient should be positioned in lateral recumbency with the affected forelimb on the table closest to the plate or cassette. Position the opposite limb out of the way by taping around the carpus and pulling it across the body in a caudodorsal direction, and attach the tape to the edge of the table. Pull the affected limb cranially and position it in a normal walking motion, using tape or a sandbag to secure it in place (FIGURE 22). Extend the head back as far as it can go to prevent the trachea from being superimposed over the joint space on the radiograph. Center the beam over the thoracic inlet (FIGURE 23) and collimate down to include the scapulohumeral joint, the distal scapula, and the proximal humerus (FIGURE 24). The marker should be placed cranial to the joint indicating which leg is being imaged.

Supinated Shoulder View

This view is used in patients being evaluated for osteochondritis dissecans (OCD). The positioning is identical to that for the mediolateral view, with one addition: a radiolucent material such as cotton or a foam wedge is placed under the elbow to elevate it and rotate the shoulder into a supinated position (FIGURE 25). The marker should be placed cranial to the joint indicating which leg is being imaged (FIGURE 26).

Caudocranial Shoulder View

The patient is positioned in dorsal recumbency. A V trough or other positioning device should be used to ensure the patient is as straight as possible (FIGURE 27). Use tape around the carpi and fully extend the limb of interest or both forelimbs cranially so that each humerus appears parallel to the cassette or plate. Secure the tape. Place tape around one or both forelimbs at the level of the proximal antebrachium to ensure that the elbows are pointing upward. If the elbows are rotated, tape around them and pull in either direction to ensure that they point straight up.


FIGURE 19

FIGURE 20

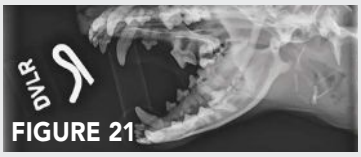

FIGURE 21

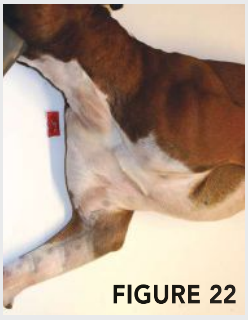
FIGURE 22

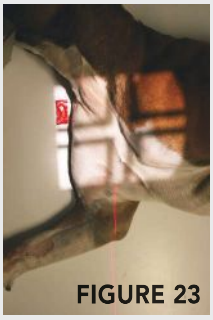
FIGURE 23


FIGURE 24


FIGURE 25


FIGURE 26

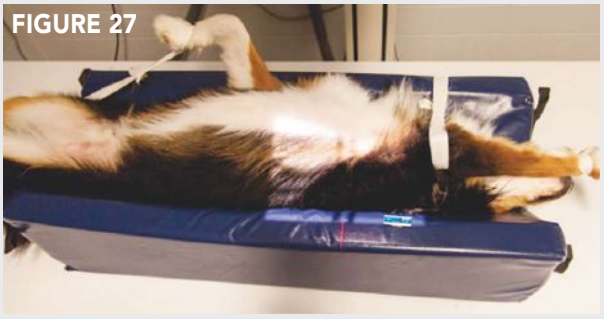
FIGURE 27

Center the beam over the axillary joint space of the leg of interest (FIGURE 28). Collimate to include about half of the scapula and about half of the humerus (FIGURE 29). The marker should be placed lateral to the joint indicating which leg is being imaged.

Lateromedial Scapula View

There are two ways to position for this view[12]:

1. The patient is positioned in lateral recumbency with the affected limb up. This is very different from lateral positioning for other joints or bones. The down limb is pulled perpendicular to the body, while the limb of interest is extended cranially in full extension and secured to the table (FIGURE 30). This displaces the scapula dorsally above the dorsal spinous processes of the thoracic vertebrae. Padding may need to be added under the elbow to position the scapula in true lateral (FIGURE 31). Center the beam over the scapula and collimate to include the entire bone (FIGURE 32). The marker is placed on the dorsal aspect of the patient indicating recumbency. This view helps to visualize the spine of the scapula and the proximal border.

2. The patient is positioned in lateral recumbency with the affected limb down on the table and pulled caudally. The opposing limb should be pulled cranially out of the view (FIGURE 33). The sternum of the patient can be rotated up from the table to better visualize the entire scapula. This view superimposes the scapula over the cranial portion of the thorax and helps to better visualize the distal scapula. (FIGURE 34).

Caudocranial Scapula View

The positioning for this view is identical to the caudocranial view of the shoulder. Center the primary beam over the scapula (FIGURE 35) and collimate to include the entire bone and approximately one-third of the proximal humerus (FIGURE 36). The marker should be placed lateral to the joint indicating which leg is being imaged.

Elbows

Mediolateral Elbow View

The patient is positioned in lateral recumbency with the affected leg closest to the cassette or plate. Similar to the mediolateral shoulder view, tape around the unaffected carpus, pull the leg across the body caudodorsally, and secure the tape to the table (FIGURE 37). Extend the head and neck slightly dorsal so that they are out of the view. Place tape around the carpus of the affected limb and pull the limb forward in a natural position. Cotton or a foam wedge may be used under the carpus or elbow to enable a true lateral position through the radiohumeral joint space. Center the beam over the elbow (FIGURE 38) and collimate to include half of the humerus and half of the radius and ulna (FIGURE 39). The marker should be placed cranial to the joint indicating which leg is being imaged.

Craniocaudal Elbow View

The patient is placed in sternal recumbency. A foam pad may be placed under the hips to make this position more comfortable. Pull the affected limb cranially, extending the


FIGURE 28


FIGURE 29


FIGURE 30

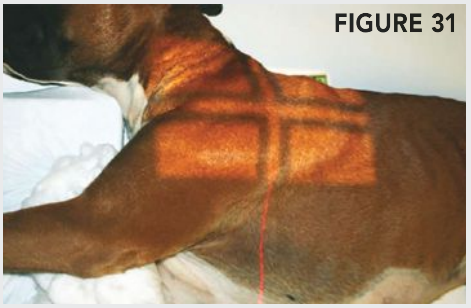
FIGURE 31


FIGURE 32


FIGURE 33


FIGURE 34


FIGURE 35

elbow, and secure it with tape (FIGURE 40). If the patient is not heavily sedated, a staff member wearing the required PPE may be needed to restrain the patient's head. For sedated patients, a large foam pad can be used to elevate and rest the head and extend it away from the forelimb of interest. When pulling the head to one side, be careful not to rotate the elbow too far medially or laterally. Palpate the elbow. The olecranon should remain centered between the medial and lateral epicondyles of the humerus. Center the beam over the elbow and collimate to include half of the humerus and half of the radius and ulna (FIGURE 41). The marker should be placed lateral to the joint indicating which leg is being imaged.

Hyperflexed Elbow View

The patient is positioned as for the mediolateral elbow view, with the affected leg down and the opposite limb taped across the body. A heavy positioning aid can be placed under the carpus of the affected limb to push it up toward the head and hyperflex the elbow. If such an aid is not available, tape around the affected carpus, pull the carpus cranially under the head, and secure the tape to the table (FIGURE 42). Be sure the keep the elbow in a true lateral position through the joint. Center over the elbow and collimate to include half of the humerus and half of the radius and ulna (FIGURE 43). If possible, the marker should be placed cranial to the joint indicating which leg is being imaged.

CONCLUSION

There are many important things to keep in mind when taking radiographs, but first and foremost, it should be the duty of the veterinary technician to do what is best for the patient. We will continue this discussion in part 2. ■

Recommended Reading

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FIGURE 36


FIGURE 37


FIGURE 38

FIGURE 39


FIGURE 40

FIGURE 41


FIGURE 42

FIGURE 43