The anatomy of the skull, temporomandibular joints (TMJ), and region of the tympanic bullae in the dog and cat is complex because of superimposition of cavities, sinuses, mandible, maxilla, dental arcades, and neurocalvarium. Radiography of specific areas requires close attention to the details of normal anatomy that will aid in proper positioning for each image, based on the type of study being done.

Improperly positioned radiographs can lead to anatomic distortion of the skull anatomy, resulting in potential false positive diagnoses.

**THE NEED FOR ANESTHETIA**

Although some basic skull views may be obtained with heavy sedation, general anesthesia is required to obtain diagnostic skull radiographs for several reasons:

- During each imaging series of the skull, one of the projections requires the mouth of the dog or cat to be open when an exposure is made.
- The oblique and skyline projections require exact positioning that is not possible in an awake dog or cat, even if heavily sedated.

**RADIOGRAPHIC EXPOSURE**

Exposures should be made using:

- **High mAs**: Lowest mA that, if there is an option, allows use of a small focal spot in order to improve geometric sharpness and, thus, ability to see fine osseous detail.
- **Grids**: Use if areas thicker than 10 cm are being imaged; otherwise, **tabletop technique** is recommended.

**ROUTINE PROJECTIONS:**

**SKULL, TMJ, & TYMPANIC BULLAE**

**LATERAL PROJECTION** (Figure 1, page 54)

**Positioning**

1. For the right lateral projection, place the patient in right lateral recumbency, with the nose and skull in an extended position.
2. In dolichocephalic and mesaticephalic dog breeds, place a small rectangular sponge under the tip of the nose to keep it parallel with the table. For brachycephalic dog breeds and cats, use a 45-degree oblique sponge (wide end away from the head).
3. Place the cervical spine, thoracic limbs, and thorax in a lateral straight position relative to the skull.
4. Pull the thoracic limbs caudally.

To ensure the patient is straight in a lateral position:

- Place your hand along the ventral mandibles, positioning your hand perpendicular to the table and the mandibles.
- Feel for the external occipital protuberance along the caudodorsal margin of the skull (not as prominent in brachycephalic breeds).
- Compare the relative level with the middorsal aspect of the nasal cavity; this imaginary line should be parallel to the table.
Collimation
1. Set the central beam to the mid cranium, with the collimator opened to just include the cranium and nasal cavity (cross hairs just caudal and ventral to the eyes).
2. Place an external radiopaque marker ventral to the caudal mandible on the table or radiographic cassette.
3. If the area of interest is lateralized to one side, place the side of interest closest to the detector, in which case, the marker indicates which recumbency the patient has been placed.
4. If the area of interest is at the level of the maxilla or mandible, the upper and lower jaw can be separated (opened) by placing a syringe case between the mandibular and maxillary canines.

Ensuring Image Quality
The lateral projection of the skull should extend from the rostral end of the nose (nasal planum) through the first cervical vertebra (C1). The wings of the atlas and C1 should be even and superimposed, and all aspects of the skull should be superimposed, such as the zygomatic arches, mandibles, and tympanic bullae.
Superimposition is more difficult in brachycephalic breeds because their skulls are much wider—geometric distortion from the divergent nature of the x-ray beam may make superimposition of all structures impossible.

VENTRODORSAL/DORSOVENTRAL PROJECTION (Figure 2)
Ventrodorsal (VD) or dorsoventral (DV) positioning is dependent on the breed of dog or cat; while deep-chested dogs are better imaged in VD position, brachycephalic and small breed dogs and cats may be better imaged in a DV position.
The area of interest should be as close to the film/cassette/detector as possible for the best overall detail and to reduce geometric magnification. The radiograph should be reviewed to ensure that the right and left sides of the skull are symmetrical for evaluation.

Positioning
To obtain the VD projection:
1. Place the patient in dorsal recumbency.
2. Extend the skull, with the external occipital protuberance resting on a thin sponge.
3. Ensure the ventral aspect of the mandibles and the hard palate, which cannot be visualized because the animal’s mouth is closed, are parallel to the table.
4. Use a V-trough to help maintain the patient in a straight position.

To obtain the DV projection:
1. Place the patient in ventral or sternal recumbency.
2. Extend the skull, with the mandibular rami placed on the table/cassette/ detector.
3. To ensure stabilization, place a thin radiolucent sponge between the patient’s ventral skull and the table/cassette/detec-
tor, as needed.
To ensure the patient is properly positioned, place your hands:
- On either side of the skull, feeling for the symmetry of the mandible and/or zygomatic arches.
- Relative to either anatomic location to be equidistant from the table on the right and left sides.

**Collimation**
1. Set the central beam to the level of the caudal zygomatic arch (at a level just caudal to the eyes) with the collimator opened to include C1/C2, the neurocranium, and the caudal portion of the nasal cavity (approximate level of maxillary premolar 3).
2. Place the radiopaque marker on the right side of the dog or cat, taking care to avoid superimposition of the marker over any part of the skull.

**Ensuring Image Quality**
For VD or DV images of the skull, the rostral extent of the image should be the nasal planum, while the caudal extent is C1. Make sure the various parts of the skull are symmetrically positioned right and left, and not obliqued. This may be impossible in patients that have skull trauma with multiple fractures.

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**Breed-Based Positioning**
Although positioning for many of these projections is similar, use of sponges and tape will vary based on skull size and shape:
- **Dolichocephalic** breeds (eg, Doberman pinscher) have long, narrower heads
- **Mesaticephalic** breeds (eg, beagle) have medium sized and shaped heads
- **Brachycephalic** breeds (eg, bulldog) have short, wide heads, with foreshortening of the nasal cavity and absence of frontal sinuses
- **Cats** have more standard sized and shaped heads; however, some brachycephalic cat breeds (eg, Persian) require the same considerations as brachycephalic dog breeds.

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**Figure 3.** Dog positioned for an open-mouth rostrocaudal oblique radiograph of the TMJ and tympanic bullae (A) and corresponding radiograph (B).

**Specific Projections: TMJ & Tympanic Bullae**

**Open-Mouth Rostrocaudal Oblique Projection (Figure 3)**

**Positioning**
1. Place the patient in dorsal recumbency.
2. Flex the neck, positioning the hard palate and mandibles perpendicular to the table and x-ray collimator system.
3. Place small triangle sponges under the external occipital protuberance to help maintain a symmetric position on the table.
4. Place tape—starting from one side of the table at the level of the abdomen—and pass it around the patient’s nose, fastening it to the other side of the table at the same level.
5. Angle the hard palate approximately 10 degrees rostral to the perpendicular plane of the body.
6. Extend the mandible caudally (open mouth) with the endotracheal tube secured to the mandible, taking care to avoid kinking the tube and stopping the flow of oxygen/inhalation of anesthetic agent.

**Collimation**
1. Set the central beam through the open mouth at the level of the soft palate.
2. Take care to ensure the cranium is straight, without lateral rotation.
3. Assess this positioning by standing at the patient’s head and placing your hands on either side of the cranium, at the level of mandibular rami, verifying both rami are equidistant to the table.

**Ensuring Image Quality**
The open-mouth projection should include both TMJ and tympanic bullae without rotation or superimposition of the endotracheal tube. Collimation should extend caudally from C1 to include the full tympanic bullae rostrally.
LATERAL 30-DEGREE OBLIQUE PROJECTION (Figure 4)

**Positioning**

For a complete study, both right lateral and left lateral oblique projections are needed.

1. Place the patient in lateral recumbency, with the nose and skull in an extended position.
2. Ensure the mouth remains open, which can be accomplished with a syringe case, and secure the endotracheal tube to the mandible.
3. Place a 30-degree wedge sponge under the maxilla to ventrally oblique the skull.

When the initial projection is finished, take the opposite oblique projection by:

1. Rolling the patient over, with the original nonrecumbent side now on the table.
2. Placing a wedge sponge under the maxilla to ventrally rotate the head by 30 degrees.

**Collimation**

1. Position the central beam just ventral to the nonrecumbent external auditory canal (that closest to the tube head).
2. Adjust collimation to include only the tympanic bulla and TMJ from the level of the third maxillary premolar to C1/C2.
3. If the patient is in right lateral recumbency, for example, the left TMJ, tympanic bulla, and ear will move ventrally when positioned correctly.
4. Place the radiopaque markers outside soft tissue structures: For the right lateral projection, place the right marker ventral to the oblique, recumbent bulla and the left marker just dorsal to the skull. For the left lateral projection, the opposite is true, with the left marker placed ventral to the oblique, recumbent bulla.

**Ensuring Image Quality**

The lateral oblique projection should extend from mid mandible to C1. One of the TMJs and tympanic bulla should appear ventral but without superimposition of the cranium. Care should be taken to avoid over rotating the patient, causing foreshortening of the vertical mandibular ramus and tympanic bulla.

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LATERAL 25- TO 30-DEGREE ROSTROCAUDAL OBLIQUE PROJECTION (Figure 5, page 57)

**Positioning**

For a complete study, both right lateral and left lateral oblique projections are needed.

1. Place the patient in lateral recumbency, with the cranium and nasal passages in true lateral position.
2. Place a triangular- or wedge-shaped radiolucent sponge under the rostral aspect of the nose and mandible, which lifts the nasal planum, nasal cavity, and mandible 25- to 30-degrees away from the table.
3. Ensure the mouth remains open, which can be accomplished by placing a syringe case between the upper and lower canines.

When the initial projection is finished, take the opposite oblique projection by rolling the patient over, with the original, nonrecumbent side now on the table.

It is important to note that, in left lateral recumbency, the:

* Right TMJ and tympanic bulla are caudal and, therefore, best visualized by this projection
* Left TMJ and tympanic bulla appear superimposed over the caudoventral aspect of the skull.

The opposite is true for right lateral recumbency.

**Collimation**

1. Direct the central beam just rostral to the TMJ (that closest to the tube head).
2. Adjust collimation to include only the tympanic bulla and TMJ.
3. Mark the recumbent side, which will appear more rostral on the radiograph.

**Ensuring Image Quality**

The rostrocaudal oblique projection should extend...
from mid mandible to C1. One of the TMJs and tympanic bulla should appear rostral to the other; the more rostral structures should be those on the recumbent side of the patient.

CLOSED-MOUTH ROSTROCAUDAL OBLIQUE PROJECTION (Figure 6)
This projection is used for rostrocaudal evaluation of the tympanic bulla in brachycephalic dogs and cats, and replaces the open-mouth rostrocaudal projection described earlier.

Positioning
1. Place the patient in dorsal recumbency, supporting the body in a V-trough, as needed.
2. Flex the neck, tilting the hard palate and mandibles 10- to 15-degrees rostral to the perpendicular plane of the table and x-ray collimator system.
3. Use small triangle sponges under the external occipital protuberance to help maintain symmetry of the skull on the table.
4. Flex the skull—then take tape, and start-

Collimation
1. Direct the central beam to the tympanic bulla.
2. Take care to ensure the cranium is straight, without lateral rotation.
3. Assess this positioning by standing at the patient’s head and placing your hands on either side of the cranium, at the level of mandibular rami, verifying both rami are equidistant to the table.

Ensuring Image Quality
This closed-mouth rostrocaudal oblique projection should include the tympanic bullae without rotation or superimposition of the endotracheal tube.

Figure 5. Dog positioned in left lateral recumbency for a 30-degree rostrocaudal oblique radiograph of the nonrecumbent, right tympanic bulla (A) and corresponding radiograph that depicts caudal position of the nonrecumbent tympanic bulla, which is best visualized in this position (B). The marker in this image denotes that, despite the left lateral recumbency position of the dog, the right tympanic bulla is caudal and, therefore, better visualized in this projection.

Figure 6. Positioning for a closed-mouth 10- to 15-degree rostrocaudal oblique radiograph of the TMJ and tympanic bullae in a boxer/mixed breed dog (A) and corresponding radiograph (B). This view can be used for brachycephalic dog breeds and in cats for evaluating the tympanic bullae.
How Supplied:
NEXGARD™ (afoxolaner) is available in four sizes of beef-favored chewables.

Dosage and Administration:
NEXGARD™ is to be given orally once a month, at the minimum dosage of 1.14 mg/kg (2.5 mg/kg).

Dosing Schedule:

<table>
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<tr>
<th>Weight</th>
<th>NEXGARD chewable</th>
<th>NEXGARD chewable</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.5 to 10 lb</td>
<td>1.0 mg</td>
<td>0.5 mg</td>
</tr>
<tr>
<td>11 to 25 lb</td>
<td>2.0 mg</td>
<td>1.0 mg</td>
</tr>
<tr>
<td>26 to 50 lb</td>
<td>4.0 mg</td>
<td>2.0 mg</td>
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<tr>
<td>51 to 88 lb</td>
<td>6.3 mg</td>
<td>3.2 mg</td>
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<tr>
<td>&gt;181 lb</td>
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<td>7.5 mg</td>
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</tbody>
</table>

Adverse Reactions:
Table 1: Dogs With Adverse Reactions

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<th>Treatment Group</th>
<th>Abnormality</th>
<th>Cessation</th>
<th>N</th>
<th>Proportion</th>
<th>% (n=200)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEXGARD 5 mg/kg</td>
<td>Anorexia</td>
<td>None</td>
<td>15</td>
<td>7.5%</td>
<td>3.0%</td>
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<tr>
<td>NEXGARD 10 mg/kg</td>
<td>Anorexia</td>
<td>None</td>
<td>10</td>
<td>5.0%</td>
<td>1.0%</td>
</tr>
<tr>
<td>Placebo</td>
<td>None</td>
<td>None</td>
<td>25</td>
<td>12.5%</td>
<td>2.5%</td>
</tr>
</tbody>
</table>

Effectiveness:

- In a well-controlled US field study, NEXGARD demonstrated 100% effectiveness against adult fleas 24 hours post-treatment for 35 days, and was ≥ 90% effective at 12 hours post-treatment through Day 21, and Day 28. On Day 35, NEXGARD was ≥ 81% effective 12 hours post-treatment. Dogs in both the treated and control groups that were infested with fleas on Day 1 generated flea eggs at 12- and 24-hour post-treatment (0.1-1 eggs and 1-5 eggs) in the NEXGARD-treated dogs, and 4-66 eggs and 0-118 eggs in the control dogs, at 12- and 24-hours, respectively. At subsequent evaluations post-predose, new fleas from dogs in the treated group were essentially unable to produce any eggs (1-5 eggs) while fleas from dogs in the control group continued to produce eggs (11-142 eggs).

- In a 90-day US field study conducted to evaluate with existing fleas of varying severity, the effectiveness of NEXGARD against fleas on the Day 30 and 60 weeks post-treatment with Merial’s Comfortis. NEXGARD demonstrated ≥97% effectiveness against Dicentrarchus labrax 48 hours post-infestation for 30 days.

- In a well-controlled laboratory study, NEXGARD demonstrated 90% effectiveness against Dicentrarchus labrax 48 hours post-infestation with L3 larvae, maximum exposure dose (30 mg/kg) for three treatments every 28 days, followed by three treatments every 14 days, for a total of 6 treatments. Dosage of canned goods varies with body weight. There was no clinical evidence of any adverse reaction related to treatment of fish with NEXGARD. In each of the 24 treatment groups, serum biochemical tests were conducted 48 hours post-infestation for 30 days.

Animal Safety:

- In a 3-month safety study, NEXGARD was administered for 28 days, to 6 to 14-week-old Border Collie puppies, and 28 weeks of age, weighing 4 pounds of body weight or greater, for one month.

Storage Information:

- Store at 59°F to 86°F (15°C to 30°C) with excursions permitted up to 40°F (4°C) for up to 6 months.

Canadian Use:

- NEXGARD™ is available in four sizes of beef flavored chewables:
- 11.3, 28.3, or 136 mg afoxolaner.
- 136 mg afoxolaner: each chewable contains 136 mg afoxolaner.
- 40°C (104°F).

NEXGARD™ is effective for the treatment and prevention of flea infestations (Ctenocephalides felis), and the treatment and control of American dog tick (Dermacentor variabilis) infestations in dogs and puppies 8 weeks of age and older, weighing 4 pounds of body weight or greater, for one month.

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