

CONTINUING EDUCATION

IMAGING ESSENTIALS

Interpretation of Dental Radiographs in Dogs & Cats

Part 1: Principles & Normal Findings

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Dental radiography is considered part of the standard of care for dogs and cats undergoing dental intervention.^{1,2} Radiographs are essential for identifying and documenting the nature and severity of dental disorders and conditions.³⁻⁵ Dental radiographs often reveal relevant clinical information that would be missed based solely on an oral examination (ie, visual examination and periodontal probing), underscoring the critical role of radiographs as part of a systematic diagnostic approach.^{4,5}

QUALITY OF RADIOGRAPHS

The diagnostic quality and potential utility of dental radiographs are influenced by many factors, including:^{6,7}

- Patient positioning
- Radiographic projections
- Radiographic exposure time
- Quality of processing.

All of these purely technical aspects of radiography can be optimized by following standard procedures, as have been described elsewhere.^{7,8} Diagnostic-

quality radiographs can be achieved with relative ease via proper training, practice, and experience. Specialized equipment is also required, including a dental X-ray generator and an analog or computerized dental radiograph processing system.⁹

DIAGNOSTIC POTENTIAL

From a purely medical perspective, it is the clinician's ability to identify lesions of potential clinical interest and interpret them in the context of the individual patient's signalment, history, and clinical findings, which ultimately leads to an accurate diagnosis and adequate treatment planning.

Normal radiographic findings are defined as those consistent with what is considered typical, average, or expected and are free of any indicators of disease.

Normal variations are defined as radiographic findings that deviate from what is considered typical, average, or expected but that would not otherwise indicate any preventive or therapeutic medical or surgical intervention, monitoring, or maintenance recommendations.

Abnormal radiographic findings are any findings considered pathologic.

Proper dental radiographic interpretation requires knowledge of normal anatomic structures and a solid understanding of the pathogenic mechanisms involved with dental diseases, disorders, and conditions that affect dogs and cats. This article describes the most basic skills and knowledge required for radiographic interpretation, as well as the radiographic characteristics of teeth and surrounding tissues and structures during health and disease.

Interpretation of Dental Radiographs in Dogs & Cats

Part 1 of this article series:

- Describes appropriate mounting and display of radiographic films/plates for reviewing purposes
- Explains a recommended workflow to review radiographs and record findings
- Presents radiographic examples of normal relevant structures.

Part 2 focuses on common normal radiographic variations, as well as abnormal findings, including explanations of the underlying disease processes when pertinent, comments on the diagnostic limitations of dental radiography, and current imaging alternatives.

The articles in this series assume the reader is familiar with basic dental radiographic acquisition techniques, concepts, and skills.

ORIENTING & MOUNTING DENTAL RADIOGRAPHS

Dental radiographic interpretation starts with the correct display and mounting of the

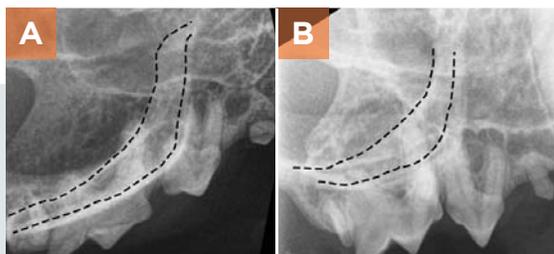


FIGURE 1. Intraoral radiograph (A) of the right maxillary premolar and molar teeth in a 5-year-old cat; extraoral radiograph (B) showing the same teeth in 3-year-old cat. The **dotted lines** show the trajectory of the zygomatic arches on both radiographs, illustrating how more superimposition with structures of interest occurs in the intraoral view than in the extraoral view.

images. Radiographs are typically obtained intraorally, although some clinicians prefer an extraoral view when imaging the maxillary premolar/molar region in cats (**Figure 1**).

Display

Whether using films or plates, ensure that the radiograph is displayed on the correct side.

With film, a raised dot (or bubble) can be observed or felt with the fingers at one of its corners. Except when using extraoral technique, this dot marks the plate's exposed side; it should be on the top side when viewing the film.

With computerized systems, the image usually is displayed automatically on the computer screen in the way it was exposed. However, care must be taken not to accidentally invert the radiograph (most software programs have this function) because the mirror image created may be confused as a radiograph from the opposite side of the mouth (**Figure 2**).

Because the dental radiographic software assumes the radiographs are obtained intraorally, the only time a radiograph should be inverted intentionally is when an extraoral projection is used.

Mounting

In the majority of patients, a full-mouth study is obtained preoperatively; individual images are usually obtained only under specific circumstances (eg, during after surgery, for follow-up studies of individual teeth).

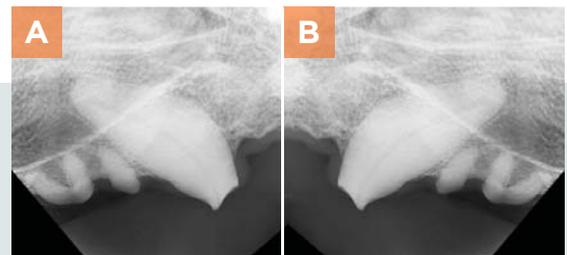


FIGURE 2. Lateral intraoral radiograph (A) of the right maxillary canine tooth in an 8-year-old dog; the radiograph is oriented properly based on dental radiographic viewing standards. Mirror image (B) of the same tooth that would be confused as the left maxillary canine tooth based on its orientation.

The total number of radiographs may range from 10 to 20, depending on size of the animal, but the images are always displayed based on labial mounting (**Figure 3**). Labial mounting consists of organizing images with the:

- Maxillary radiographs shown on the upper half of the study
- Mandibular radiographs on the lower half
- Radiographs of the patient's right side on the left
- Radiographs of the patient's left side on the right.

The first step when mounting is to determine whether the radiographs correspond to maxillary or mandibular dentition and rotate them as needed, with the maxillary teeth pointed downward and mandibular teeth pointed upward. Identifying structures unique to the maxilla or mandible assists the process:

- The presence of the palatine fissures and/or nasal turbinates, or the characteristic shapes, size, and number of roots of the maxillary fourth premolar and molar teeth, identify radiographs of maxillary teeth.
- In contrast, presence of the mandibular symphysis, mandibular canal, mental foramina, or ventral mandibular cortex, or the characteristic shapes, size, and number of roots of the mandibular first, second, and third molar teeth, indicates mandibular dentition.

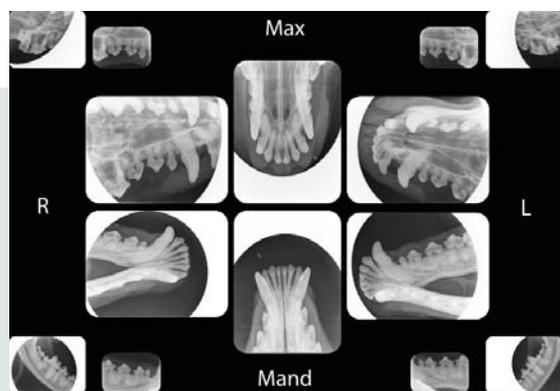


FIGURE 3. Labially mounted full-mouth radiographic study from a 5-year-old dog. The maxillary (**Max**) teeth are displayed on the upper half, and the mandibular (**Mand**) teeth are displayed on the lower half. The letters **R** and **L** indicate the right and left sides, respectively.

The next step is to assign radiographs to the left, center, or right of the study. Initially, the two occlusal radiographs (ie, one maxillary, one mandibular) are placed in the center. For all other radiographs, the dentition present is identified in order to place the film/plate on the side in which the mesial teeth are located closer, and the distal teeth farther, to the occlusal radiograph.

RECOMMENDED WORKFLOW

Once the full-mouth study is mounted properly, the radiographs are ready for review. Radiographs usually are reviewed twice.

The first review occurs during the treatment planning stage, usually while the patient is under general anesthesia (**Figure 4**). The ideal time for review is after dental charting has been completed and the animal is receiving complete periodontal treatment (ie, supra- and subgingival ultrasonic scaling with or without hand scaling) prior to any surgical intervention as indicated by clinical and radiographic findings (eg, extractions, biopsy, periodontal surgery, endodontic therapy).

This initial radiograph review should be performed in the context of the oral examination findings that were recorded in the patient's chart. This allows the clinician to establish a tooth-by-tooth diagnosis and decide whether disease is present and, if so, which treatment is indicated.

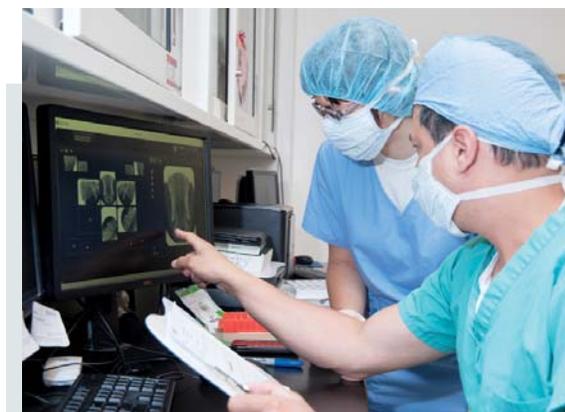


FIGURE 4. The initial dental radiographic review usually occurs in a clinical setting. The clinical findings (dental chart) are compared with the radiographic findings, and a treatment plan is established, usually while the patient is still under general anesthesia.

A second and more meticulous review is recommended to allow a detailed radiographic report to be written and incorporated into the patient's medical record. This can be done after the procedure has ended to avoid unnecessarily prolonging the anesthetic event.

REVIEWING DENTAL RADIOGRAPHS

To minimize oversight when reviewing radiographs, establish a routine based on both the order in which the radiographs are examined and certain predetermined categories.

A logical sequence is to examine quadrants in the following order:

- Right maxillary
- Left maxillary
- Left mandibular
- Right mandibular.

For each quadrant, review the most *mesial* tooth first and the most *distal* tooth last. Assess each quadrant separately based on the following predetermined clinically and radiographically relevant categories.

Anatomic & Developmental Findings

Assess the presence, number, and relative size, shape, and direction of the teeth and corresponding roots and identify dental tissues, anatomic areas of interest, and surrounding structures. All findings should be interpreted with consideration of the age, size, and breed of the patient.

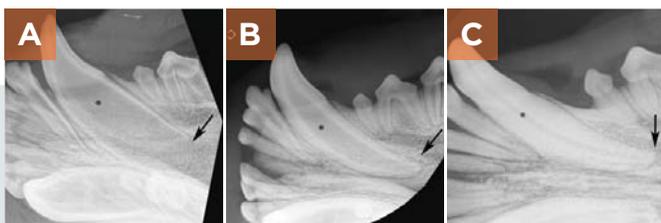


FIGURE 5. Lateral intraoral radiograph (A) of the left canine tooth in a 6-month-old dog showing a relatively wide pulp cavity (**asterisk**), relatively thin dentinal walls, and an incompletely formed apex (**black arrow**). Radiographs (B and C) corresponding to the same projection and tooth in an 11-month-old dog and a 9-year-old dog, respectively. Compare the differences in apex, pulp width, and dentinal wall thickness, as would be expected based on the animals' ages.

Two normal developmental processes are relevant when evaluating radiographs: dentin deposition and apex formation.

Dentin deposition begins prior to tooth eruption and, under physiologic conditions, continues throughout the life of each permanent tooth. Any dentin secreted prior to eruption is called *primary dentin*. Once the tooth erupts, usually with still very thin dentinal walls, all further dentin secretion that occurs under physiologic conditions is called *secondary dentin* (**Figure 5**). As the animal ages, more dentin is secreted and the pulp cavity diameter gradually narrows (see **Endodontic Findings**).

Apex formation (**Figure 5**) describes eruption of the permanent tooth prior to full formation of the apex. An incompletely formed apex is often referred to as an *open apex*. Apex formation lasts a few weeks after eruption and is usually complete by the age of 9 months in both cats and dogs.

Finally, distinguish radiographically deciduous from permanent teeth. Deciduous teeth are relatively smaller and less *radiodense* than permanent teeth. Under normal circumstances based on average eruption times, the term *mixed dentition* is applied when permanent and deciduous teeth are present simultaneously in the oral cavity (**Figure 6**).

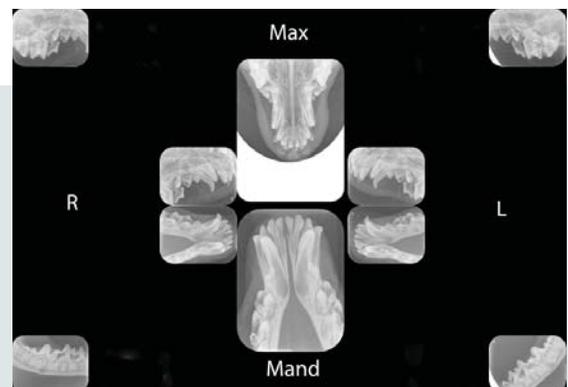


FIGURE 6. Mixed dentition in a 6-month-old dog. The full-mouth study shows the simultaneous presence of erupted deciduous and permanent teeth. L = left; Mand = mandibular teeth; Max = maxillary teeth; R = right.

What You Need to Know

To decide whether radiographic findings are normal, the clinician should be familiar with normal:

- Tooth and root anatomy
- Tooth and root development stages
- Deciduous and permanent dentition formulas
- Normal deciduous tooth exfoliation times
- Normal dental and maxillofacial anatomy
- Any pertinent variations among specific breeds.

Periodontal Findings

The attachment apparatus of teeth (periodontium) consists of the gingiva, periodontal ligament (PDL), cementum, and alveolar bone (**Figure 7**).

Alveolar bone is mineralized and large enough to be seen directly on radiographs. Normal alveolar bone should provide coverage to the entire root(s), and its margin should be located immediately apical to the cemento-enamel junction (CEJ) of the tooth. In multirooted teeth, the area between roots (ie, furcation) should be occupied evenly by cancellous bone.

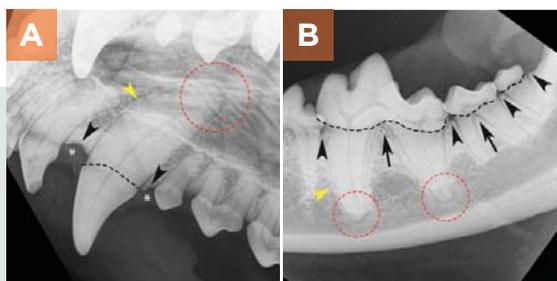


FIGURE 7. Normal periodontal and endodontic findings. Lateral intraoral radiograph (**A**) of the left maxillary tooth in an 8-year-old showing the alveolar margin (**black arrowheads**) in close proximity to the cemento-enamel junction (CEJ; **dotted line**). The gingiva is visible as a soft tissue opacity (**asterisks**) along the alveolar margin. The periodontal ligament (PDL) space can be traced around the entire root as a regular and relatively narrow lucent line surrounded by the lamina dura, seen as a thin, opaque line (**yellow arrowhead**). The apex and periapical structures (**dotted red circle**) show a normal PDL space. Intraoral parallel view (**B**) of the caudal mandible in an 8-year-old dog showing the same normal structures as shown in **A**; note the presence of cancellous bone occupying the entire furcation areas of the first and second molar teeth (**black arrows**).

The **PDL** cannot be seen because it is composed mostly of nonmineralized collagen fibers. Under normal circumstances, however, the space occupied by the PDL can be seen as a relatively narrow, regular, lucent area located between the root(s) and surrounding alveolar bone.

On the osseous side of PDL space, a dense opaque line, referred to as *lamina dura*, can be traced around all roots. Anatomically, the lamina dura corresponds to the compact bone that normally lines the alveolus.

While **cementum** is partially mineralized, it is too thin to be discernible on radiographs. Conversely, while **gingiva** is not usually mineralized, it is thick enough to be visible sometimes on radiographs. If visible, normal gingiva should appear as a subtle soft tissue opacity immediately coronal to the alveolar margin that extends just beyond the CEJ without covering larger areas of the crown.

Endodontic Findings

The structures of interest when evaluating the endodontic status of teeth are the pulp cavity, apex, and periapical tissues (**Figures 7–10**). The integrity of each crown and root is also assessed.

Determining What Constitutes Normal

Because radiographs are two-dimensional images often representing complex anatomic structures, care must be taken not to under- or overestimate what may constitute normal findings.

CEJ and canine alveolar margins: In some cases, additional projections of the same tooth may be necessary. A relevant example is the occlusal view of canine teeth. Because the distance between the CEJ and alveolar margin of canine teeth cannot be established easily on an occlusal projection, a lateral radiograph is necessary to document the periodontal status more accurately (**Figure 7** and **Figure 9**).

CEJ and incisor alveolar margins: In contrast, the periodontal status of the mandibular incisors in dogs does not always correlate with clinical findings and can be overestimated easily. Namely, the radiographs of clinically normal incisors (ie, no mobility, increased probing depth, or gingival recession) often reveal an apparently increased distance between the CEJ and alveolar margin (**Figure 8**).

In all of these cases, always correlate clinical and radiographic findings prior to establishing a diagnosis and/or making any clinical decisions.

The **pulp cavity**—the entire area occupied by the pulp—is divided into three distinct areas: pulp chamber, root canal, and pulp horns in multirooted teeth. As noted, the width of the pulp cavity of permanent teeth decreases with age. Because this process occurs bilaterally at similar rates, no pulp cavity width discrepancies should be noted when comparing endodontically normal teeth with their contralateral counterparts (**Figures 8–10**).

The **apex** refers to the most distal third portion of the root and is the location of the apical delta.

The **periapical tissues**—the PDL space surrounding the apex and the tissues in its immediate vicinity—should be normal. That is, the width of the PDL space in this area should be consistent with the width of the PDL space on the sides of the root, and no evidence of bone lysis affecting the bone periapically should be present.

Finally, root length and appearance of an endodontically normal tooth should be similar to those of its contralateral counterpart.



FIGURE 8. Occlusal mandibular radiograph in a 7-year-old dog showing a normal mandibular symphysis (**arrowheads**). Note the symmetric diameter of the pulp cavity at the left and right canine teeth (**asterisks**). The clinical examination revealed periodontally sound mandibular incisors; despite this, note that the alveolar margin is located apical to the cemento enamel junction at all mandibular incisors.

The clinician should always scrutinize the radiographs of areas in which teeth are missing to rule out the presence of retained roots. However, the clinician must be aware that endodontically diseased teeth sometimes appear radiographically normal.

Other Findings

With regard to teeth, other findings usually include those that do not fit into any of the above categories. Because these findings typically correspond to either normal variations or pathologic findings, however, representative examples will be presented in Part 2.

Several non-dental structures are visible on dental radiographs that could potentially reveal abnormalities or disease. Therefore, the clinician should be familiar with the normal radiographic appearance of these structures.

Nasal Cavity

The nasal cavity is viewed on maxillary occlusal radiographs (**Figure 9**). Under normal circumstances, the following should be present:

- Well-defined turbinate pattern

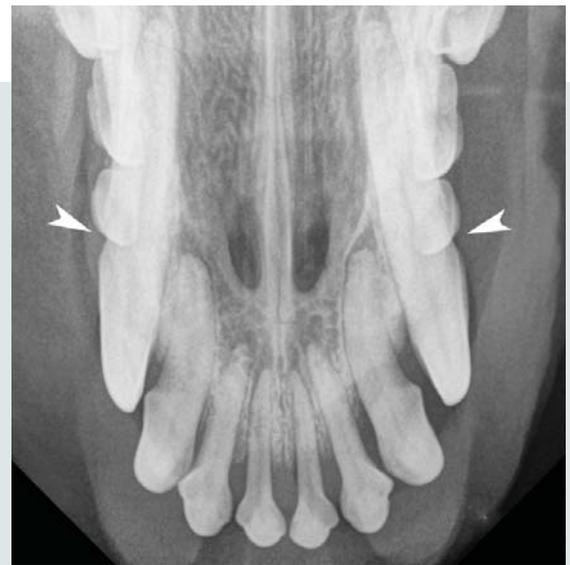


FIGURE 9. Intraoral occlusal maxillary radiograph in a 6-year-old dog illustrating the difficulty in assessing the periodontal status (ie, distance between the alveolar margin and CEJ) at the canine teeth (**white arrowheads**). Note that the pulp cavities of both canine teeth are of similar diameter, which is expected in endodontically healthy teeth, as well as the normal turbinate pattern present in the nasal cavity.

- Relatively symmetric separation of right and left cavities by vomer and septum
- Palatine fissures clearly visible as two distinct lucent round or oval-shaped structures caudal to the maxillary incisor teeth.

Mandibular Structures

A normal mandibular symphysis appears radiographically as a relatively narrow lucent line that joins the two mandibles at the midline, with the right and left mandibular incisors in symmetric occlusion. The mandibular symphysis can be relatively linear, although in cats it follows more of a zigzag pattern (**Figures 8 and 10**).

The mandibular bodies should also be assessed. Despite some degree of variability among dog breeds with regard to shape and relative size, the mandibular canal should be visible as a relatively lucent linear structure occupying the middle and/or ventral third of the mandibular body (**Figure 11**).

In cats and medium- to large-breed dogs, the roots of the mandibular premolar and molar teeth are located

in the area most dorsal to the canal; in small dogs, the roots of the mandibular fourth premolar and first molar teeth extend into and/or beyond the canal and, in some cases, to the level of the ventral cortex of the mandible.

To avoid misinterpreting them as pathologic findings, note the appearance and typical location of the middle and caudal mental foramina. These structures are usually well defined radiographically and appear as round or oval-shaped lucencies ventral to the first and/or second mandibular premolar teeth and third and/or fourth mandibular premolar teeth, sometimes overlapping with the apex of one of the roots (**Figure 12**).



FIGURE 10. Occlusal mandibular radiograph in a 4-year-old cat showing symmetric diameter in pulp cavity width at both canine teeth (**asterisks**) and the typical zigzag appearance of the mandibular symphysis (**arrowheads**).

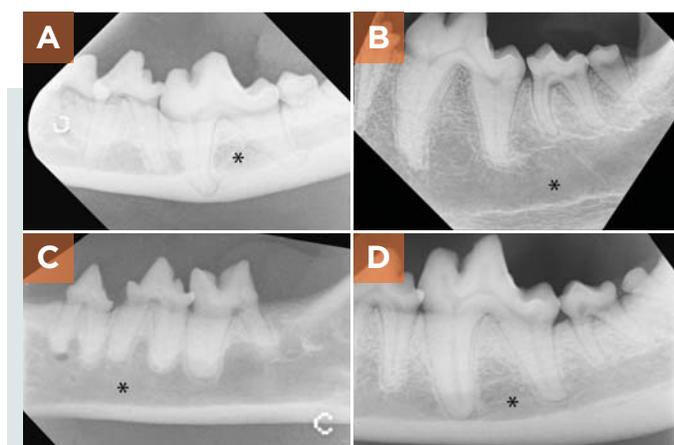


FIGURE 11. Intraoral parallel radiographs showing the normal appearance of the mandibular canal in the caudal mandibular body area. Note the relative position and size of the associated roots in an 8-year-old small dog (**A**), 4-year-old large dog (**B**), 12-year-old cat (**C**), and 7-year-old medium-sized dog (**D**).



FIGURE 12. Intraoral radiograph of the rostral mandibular premolar area showing the middle and distal mental foramina (**arrows**).

The most caudal areas of the mandibular body and the ramus are not visible on dental radiographs. Other imaging modalities should be considered, if medically indicated.

Temporomandibular Joint

The use of dental films for extraoral imaging of the temporomandibular joint has been described;¹⁰ however, examples are not included in this article because the diagnostic yield is poor, especially compared with advanced imaging modalities, and imaging of this structure is beyond what is considered dental radiography. **TVP**

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Glossary

- CEJ** cementoenamel junction
PDL periodontal ligament

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Notes on Images

All radiographic images are representative examples that support the explanations presented in the article. They are displayed based on labial mounting and considered to be of diagnostic quality. Some of the images have been cropped, but the structures of interest have not been altered or enhanced in any way.

All images were acquired following standard technique for small animals^{7,11} using a commercially available dental X-ray unit (Heliodent DS, Sirona, Bensheim, Germany) and a computerized radiographic processor using phosphor plates of size 0, 2, or 4 with corresponding software (CS7600, Carestream, Rochester, NY). Due to space limitations, most radiographs shown are from dogs, but radiographs from cats are included if a feline-specific point needs to be made.

In case some readers are unfamiliar with other accepted systems (ie, modified Triadan), anatomic dental nomenclature is used here.¹² For more information, interested readers are encouraged to consult a more specialized source.¹³

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Interpretation of Dental Radiographs in Dogs & Cats

Part 1: Principles & Normal Findings

LEARNING OBJECTIVES

After reading this article, clinicians should:

- Recognize the importance of appropriately mounting and displaying dental radiographic films/plates for review and interpretation purposes
- Understand how to establish a reproducible workflow to review and record pertinent findings systematically
- Be able to describe how normal dental and associated structures appear radiographically.

OVERVIEW

This article, page 55, is the first of two articles that focus on interpretation of dental radiographs in dogs and cats. It includes basic principles of dental radiographic interpretation and describes normal radiographic findings.

This article is RACE-approved for 1 hour of continuing education credit. To receive credit, take the approved test online at vetmedteam.com/tvp.aspx (CE fee of \$5/article).

1. Choose the most appropriate orientation for the radiograph shown below.



- a. Rotate the image 90 degrees clockwise.
b. Rotate the image 180 degrees.
c. Rotate the image 90 degrees counterclockwise.
d. The image should remain as it is.
2. What structure does the radiograph in Question 1 show?
- a. Right maxillary canine tooth
b. Left maxillary canine tooth
c. Left mandibular canine tooth
d. Right mandibular canine tooth

NOTE

Questions online may differ from those here; answers are available once CE test is taken at vetmedteam.com/tvp.aspx. Tests are valid for 2 years from date of approval.

3. Which of the following statements about dental radiography in dogs and cats is TRUE?

- a. Full-mouth radiographic studies are not recommended.
b. Radiographs are not necessary if dental charting was performed.
c. Dental radiographs are by definition always obtained intraorally.
d. Radiographs and dental charting are both necessary to establish a diagnosis and treatment plan.

4. From what type of animal was the following radiograph most likely obtained?

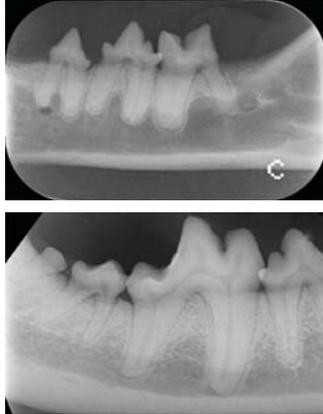


- a. 6-month-old dog
b. 6-year-old dog
c. 12-year-old dog
d. Cannot determine based on the image

5. What type of radiograph is shown in Question 4?

- a. Standard extraoral view of the rostral maxilla
- b. Standard occlusal radiograph of the mandible
- c. Standard occlusal view of the maxilla
- d. Cannot determine based on the image

6. Assuming both are appropriately displayed (ie, based on labial mounting), which of the following images corresponds to the left mandibular molar/premolar teeth?



- a. Top image
- b. Bottom image
- c. Neither
- d. Both

7. What structures are part of the periodontium?

- a. Gingiva, apical delta, cementum, periodontal ligament
- b. Gingiva, pulp, cementum, periodontal ligament
- c. Gingiva, alveolar bone, cementum, periodontal ligament
- d. None of the above

8. What is the area occupied by the dental pulp and surrounded by dentinal walls?

- a. Root canal
- b. Pulp cavity
- c. Pulp canal
- d. Pulp chamber

9. What are the radiographic areas of interest when evaluating the endodontic status of a tooth?

- a. Integrity of the crown and root
- b. Relative pulp cavity width
- c. Periapical structures
- d. All of the above

10. Which of the following cannot be assessed using standard dental radiographic technique?

- a. Mandibular ramus
- b. Alveolar bone height relative to the cemento enamel junction
- c. Mandibular body
- d. Mandibular symphysis