TOTAL PACKAGE Accurate diagnosis and treatment of oral diseases require a complete intraoral examination under anesthesia, including periodontal probing and charting and full mouth radiographs.

INSIGHTS IN DENTISTRY

Intraoral Radiographs: Identifying Common Pathology

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In the May/June issue of *Today's Veterinary Practice,* "Intraoral Radiographs: Identifying Normal Anatomy" reviewed the first step in learning how to interpret intraoral radiographs. This article describes the steps involved in making clinical decisions regarding dentistry cases and recognizing radiographic findings associated with common oral diseases.

CLINICAL DECISION-MAKING

Making treatment decisions during dentistry procedures should include evaluation of intraoral radiographic findings as well as clinical oral examination findings. A clinical oral examination under general anesthesia is essential for evaluating soft tissue changes, including inflammation, gingival recession, furcation exposure, and periodontal pocket formation. Also included in the clinical examination is evaluation of the tooth itself, checking for tooth resorption, fractured teeth, worn teeth, pulp exposure, caries, and missing teeth. All abnormal clinical findings should be noted on an oral examination chart. Intraoral radiograph interpretation should be recorded in the patient's medical record.

Making treatment decisions during dentistry procedures should include evaluation of intraoral radiographic findings as well as clinical oral examination findings.

To determine the appropriate treatment for each tooth in each patient, consider the following questions:

- What do I see clinically during the intraoral examination? (Gingival recession? Furcation exposure? Periodontal pockets? Mobility? Tooth resorption? Fractured teeth? Abrasion/attrition? Caries? Missing teeth? Oral mass?)
- What are the intraoral radiographic findings? (Horizontal or vertical bone loss? Periapical lucency? Pulp cavity that is not consistent with the age of the patient? Changes in bone structure? Tooth resorption?)
- What tooth is involved? (Is it a strategic tooth for this patient?)
- Who is the patient? (Age? Breed? Medical history?)
- What is the client's commitment to the pet's oral health care? (Annual dentistry procedures? Home care? Desire to save teeth?)

COMMON PATHOLOGY

Periodontal Disease

Periodontitis is a disease of the supporting structures of the teeth (the periodontium). The periodontium includes the gingiva, periodontal ligament, cementum, and alveolar bone. The word *periodontitis* literally means inflammation around the tooth (perio = around, dontitis = inflammation of the tooth).

Evaluating loss of periodontal tissue support in patients with periodontitis involves radiographically assessing bone levels in combination with clinical attachment levels.[1] The alveolar bone margin, the most coronal portion of the alveolar bone, is normally parallel to the plane of occlusion and 1 to 2 mm apical to the cementoenamel junction. Alveolar bone loss is a common sequela of periodontitis and may be radiographically evident as vertical or horizontal bone loss or both (**BOX 1**).[2] Studies show that horizontal bone loss is the most common radiographic pattern of periodontal bone loss in cats.[2]

A clinical examination (probing and charting) in combination with intraoral radiographs is necessary to properly diagnose periodontal disease. Subtle changes

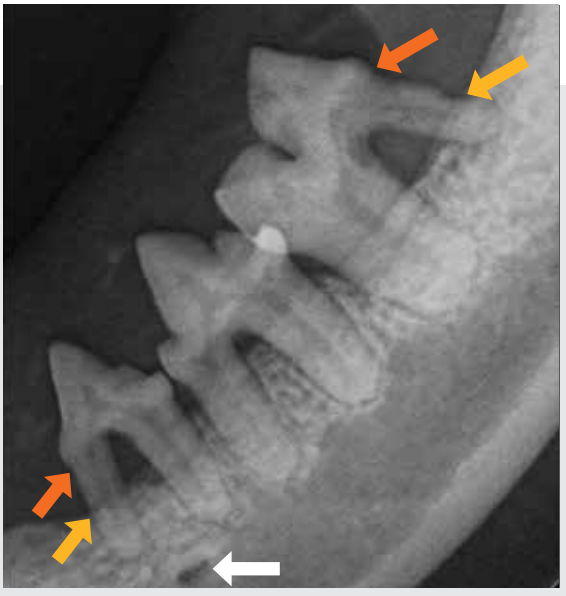


FIGURE 1. Horizontal bone loss in a cat. Radiograph of the left mandibular third and fourth premolars and first molar (307, 308, 309), showing reduced alveolar bone height involving all 3 teeth **(yellow arrows)**. Normally, the alveolar bone margin is within 1 mm of the cementoenamel junction **(orange arrows)**. Note the tooth resorption lesion on the distal root of 309 and the caudal mental foramen **(white arrow)**.

BOX 1 Radiographic Signs of Periodontal Disease

Horizontal bone loss (FIGURE 1)
- Reduced alveolar crest height
- Parallel to cementoenamel junction
- 2 or more teeth typically involved

Vertical bone loss (FIGURE 2)
- Apical direction along the tooth root
- Perpendicular to the cementoenamel junction
- Base of the defect apical to the surrounding bone
- Associated with an infrabony pocket

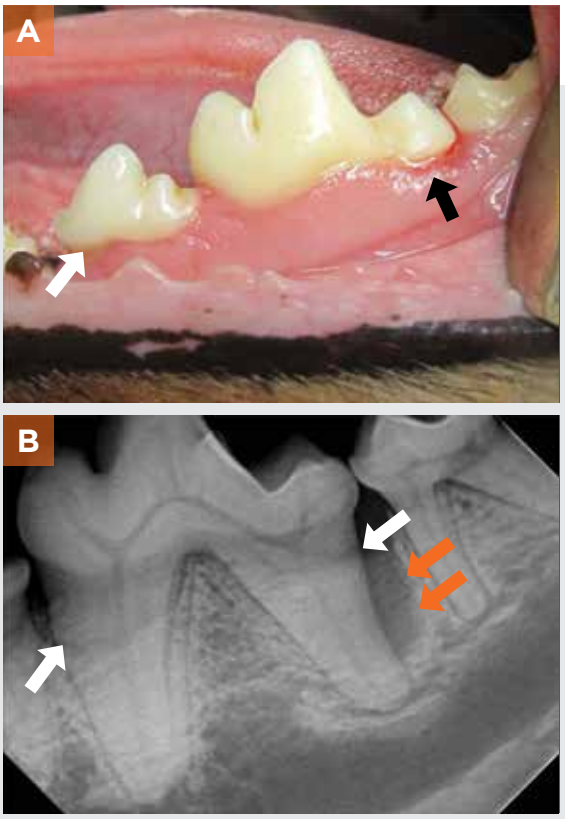


FIGURE 2. Vertical and horizontal bone loss in a dog. **(A)** Left mandibular fourth premolar and first and second molars (308, 309, 310) in a dog with clinical evidence of periodontal disease. There is gingivitis and gingival recession of the mesial root of the left mandibular fourth premolar (308) **(white arrow)** and distal root of the left mandibular first molar (309) **(black arrow)**. Periodontal probing indicated a pocket greater than 6 mm associated with the distal root of 309. **(B)** Intraoral radiograph of 309, showing horizontal bone loss **(white arrows)** and vertical bone loss **(orange arrows)**. This is a nondiagnostic radiograph for the mesial root of 309 because the periapical bone is not visible.

in the angle of the x-ray beam can obscure mild bone loss and stage 1 furcation exposure. Bone loss confined to the buccal or palatal side of maxillary teeth may be difficult to detect radiographically due to superimposition of other bony structures on the tooth roots (**FIGURE 3**).

Oronasal Fistula

An oronasal fistula is a direct communication between the oral and nasal cavities and occurs secondary to advanced periodontal disease affecting any of the maxillary teeth. Diagnosis requires a clinical examination and periodontal probing (**FIGURE 4**). The palatal surface of maxillary canine teeth in dogs cannot be evaluated with a lateral and occlusal radiograph alone due to a radiographic artifact created by the ridge in the interalveolar margin between the maxillary canine teeth and third incisors.[3]

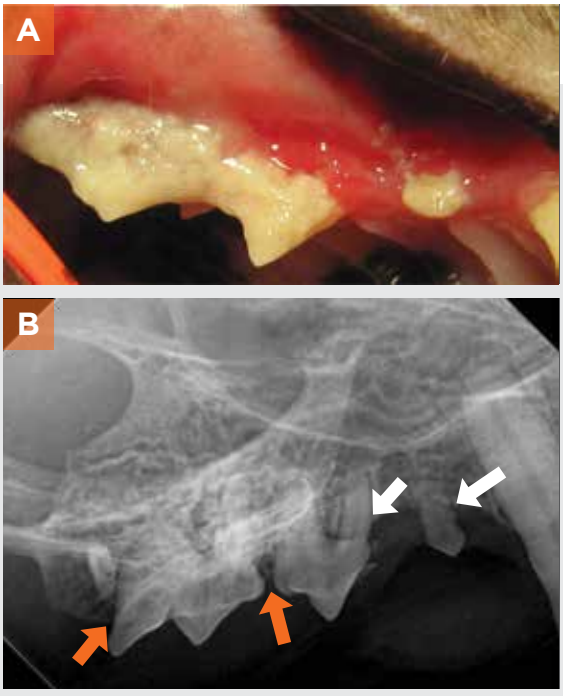
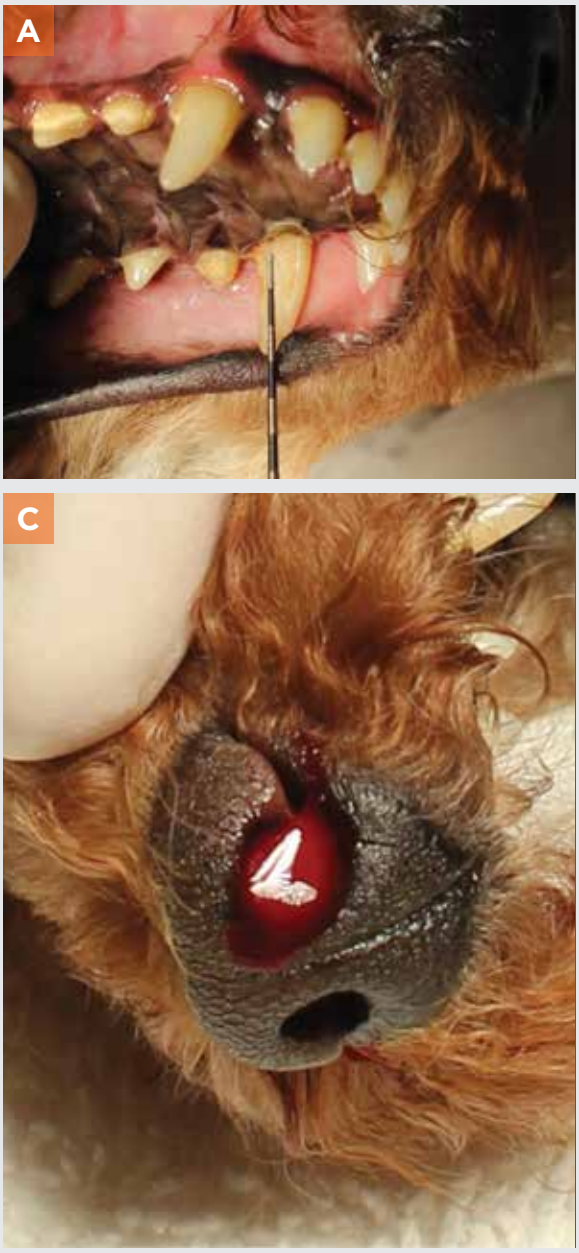


FIGURE 3. Buccal bone loss in the right maxilla of a cat. **(A)** Clinical examination shows heavy calculus and plaque, severe gingivitis, and alveolar mucositis. Gingival recession and bone loss are visible. **(B)** Radiograph of right maxillary second, third, and fourth premolars and first molar (106, 107, 108, 109) in the same cat, showing severe horizontal bone loss at 106 and moderate horizontal bone loss affecting the mesial root of 107 **(white arrows)**. Buccal bone loss is not appreciated on the distal root of 107, 108, or 109 **(orange arrows)** because other bony structures are superimposed.

Alveolar Bone Expansion in Cats

Alveolar bone expansion describes the thickening or widening of the alveolar bone commonly associated with 1 or more canine teeth in cats.[4] Bone expansion results in firm swelling on the buccal surface of the canine teeth. Periodontal disease, extrusion, or tooth resorption may be associated with alveolar bone expansion. A study suggests that buccal bone width of the canine teeth up to 2 mm may be considered normal.[2] On the other hand, a buccal bone width greater than 2 mm may reflect a pathologic process as 10 of 11 cats in the study with moderate or severe



buccal bone expansion at 1 or more canine teeth also had severe vertical bone loss. Radiographically, alveolar bone expansion appears as a thickening of the bone affecting 1 or more canine teeth in the cat. Alveolar bone expansion may be associated with severe vertical bone loss and present as a spherical appearance to the alveolar bone (**FIGURE 5**).[2]

Endodontic Disease

The term *endodontic* comes from the Greek words *endo*, meaning inside, and *dontic*, meaning pertaining to teeth. Endodontic disease refers to disease affecting the pulp cavity (inside part of the tooth). Tooth trauma, the most common cause of endodontic disease, results in pulp inflammation and leads to pulp necrosis and apical periodontitis (inflammation of the tissue around the apex of the tooth).

To evaluate a tooth for endodontic disease, radiographs are needed because the endodontic system of the tooth is completely hidden from view. Radiographs must include the apex of the tooth and the surrounding bone. In patients with endodontic disease, radiographic changes may be observed in the tissues around the tooth root or associated with the tooth itself (**BOX 2**).[5]

BOX 2 Radiographic Signs of Endodontic Disease

Changes around the tooth root (FIGURE 6)
- Periapical lucency
- Increased width of the periodontal ligament space
- Loss of the lamina dura
- Diffuse or well-defined periapical lucency

Changes in the tooth itself (FIGURE 7)
- Arrested tooth maturation (nonvital tooth)
- Pulp cavity size not consistent with age of the animal or contralateral tooth
- External inflammatory root resorption affecting the tooth apex
- Internal resorption

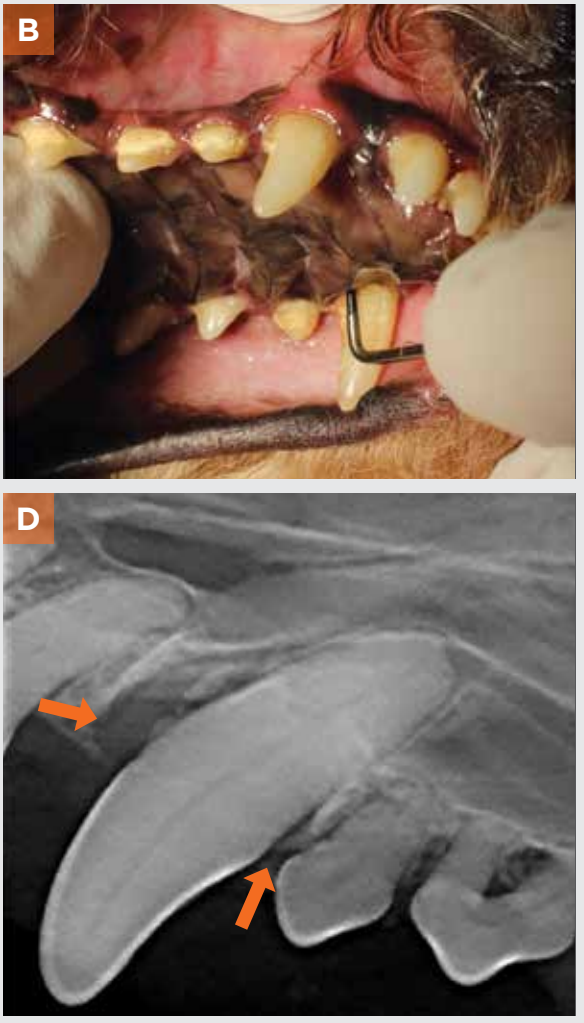


FIGURE 4. Oronasal fistula in a dog. **(A)** Photograph of periodontal probe before its insertion on the palatal side of the left maxillary canine tooth (204). **(B)** Photograph of 16-mm periodontal pocket on the palatal surface of 204. **(C)** Bleeding from the left side of the nose, noted with periodontal probing. **(D)** Radiograph of 204 showing vertical bone loss visible on the mesial and distal side **(orange arrows)**. Bone loss on the palatal side is not visible because overlying structures are superimposed.

Combined Periodontal and Endodontic Lesion

A lesion is considered combined when periodontal disease and endodontic disease affect the same tooth (**FIGURE 8**). A periodontal/endodontic lesion develops when bone loss resulting from periodontal disease allows bacteria to enter the pulp cavity through a lateral canal or the apex of the tooth, resulting in apical periodontitis. An endodontic/periodontal lesion occurs when a periapical lesion dissects coronally along the side of the root to exit in the sulcus.[5]

Missing Teeth

All teeth that appear to be missing clinically need to be radiographed. Teeth may appear to be missing for

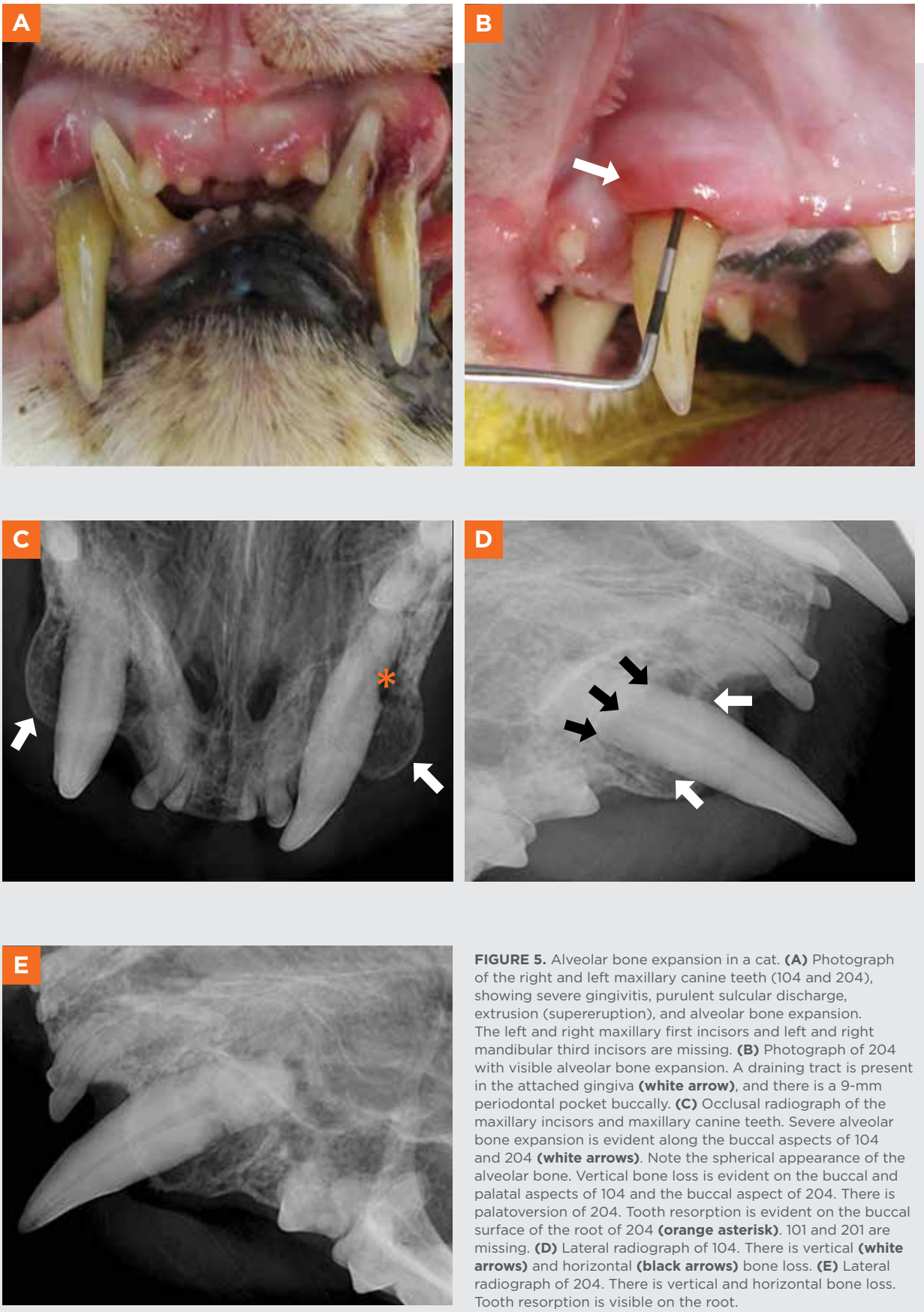


FIGURE 5. Alveolar bone expansion in a cat. **(A)** Photograph of the right and left maxillary canine teeth (104 and 204), showing severe gingivitis, purulent sulcular discharge, extrusion (supereruption), and alveolar bone expansion. The left and right maxillary first incisors and left and right mandibular third incisors are missing. **(B)** Photograph of 204 with visible alveolar bone expansion. A draining tract is present in the attached gingiva **(white arrow)**, and there is a 9-mm periodontal pocket buccally. **(C)** Occlusal radiograph of the maxillary incisors and maxillary canine teeth. Severe alveolar bone expansion is evident along the buccal aspects of 104 and 204 **(white arrows)**. Note the spherical appearance of the alveolar bone. Vertical bone loss is evident on the buccal and palatal aspects of 104 and the buccal aspect of 204. There is palatoversion of 204. Tooth resorption is evident on the buccal surface of the root of 204 **(orange asterisk)**. 101 and 201 are missing. **(D)** Lateral radiograph of 104. There is vertical **(white arrows)** and horizontal **(black arrows)** bone loss. **(E)** Lateral radiograph of 204. There is vertical and horizontal bone loss. Tooth resorption is visible on the root.

FIGURE 6. Radiograph of the left mandibular first molar (309) with an uncomplicated crown fracture in a dog. There is loss of the lamina dura and periapical lucency associated with both roots of 309 **(arrows)** consistent with apical periodontitis.

several reasons:

- Missing since birth
- Previously extracted
- Lost as a result of trauma
- Fractured below the gingival margin
- Impacted or embedded teeth

Retained Tooth Roots

Retained tooth root fragments in dogs and cats are a common radiographic finding.[6,7] Tooth roots may be retained as a result of poor extraction technique or may be fractured as a result of trauma or tooth resorption. Retained tooth roots can act as a nidus of inflammation and infection and may cause draining tracts, gingival inflammation, osteomyelitis, infection, and chronic pain.[6] A recent study found that most retained tooth root fragments were associated with inflammation and supported the current recommendation for extraction of retained root fragments whenever feasible.[8] For all extraction cases, postoperative radiographs are required to confirm complete extraction of all tooth root fragments (**FIGURE 9**).

Dentigerous Cyst

A dentigerous cyst is a benign, non-neoplastic, well-circumscribed, cystic lesion associated with an impacted tooth. The fluid-filled cyst forms around the tooth crown and is attached to the neck of the unerupted tooth. The resulting expansile lesion can cause significant bone loss and may require extensive surgery or result in a pathologic fracture (**FIGURE 10 A–D**). Brachycephalic breeds are most affected. Studies show that a dentigerous cyst was associated with 29.1% to 44.4% of unerupted teeth and that the most commonly unerupted tooth was the mandibular first premolar.[9,10] Early detection is critical. In young patients, it is important to count teeth after eruption to confirm the presence of all permanent teeth. Early radiographic evaluation of missing teeth can enable prevention of large dentigerous cyst formation in unerupted teeth (**FIGURE 10 E AND F**).

Tooth Resorption

In Cats

Tooth resorption is a common dental condition in cats, although the exact cause is undetermined. The lesions are characterized by odontoclastic resorption of enamel, dentin, and cementum.

Intraoral radiographs may show a focal or multifocal radiolucency on the crown of the tooth and/or roots that are being replaced by alveolar bone. A clinically visible defect in the tooth that may or may not be covered with inflamed gingival tissue usually

BOX 3 Types of Tooth Resorption in Cats[12]

Type 1

- Tooth roots are of normal density and easily distinguished from surrounding bone
- Periodontal ligament space and lamina dura are well defined
- Associated horizontal or vertical bone loss may be present

Type 2

- Root structure is replaced by alveolar bone; radiodensity is similar to surrounding bone
- Periodontal ligament space or lamina dura are not visible
- Periodontal disease is not a common finding

Type 3

- Multirooted tooth has type 1 resorption in 1 root and type 2 resorption in a different root

BOX 4 Characteristics of Tooth Resorption in Dogs[13]

- Frequency of tooth resorption in dogs is 53.6%
- External replacement resorption and external inflammatory resorption are most common
- Incidence of external replacement resorption increases with age and body weight
- External inflammatory resorption is associated with periodontal disease, endodontic disease, or both, and increases with age

corresponds to the radiolucency on the crown. Pulp involvement associated with odontoclastic resorption lesions does not seem to be associated with radiographically detectable periapical lucencies.[11] Cats with tooth resorption are more likely than cats without tooth resorption to have severe focal vertical bone loss.[2] The radiographic characteristics of the 3 types of tooth resorption in cats are described in **BOX 3** and shown in **FIGURE 11**.

In Dogs

Although tooth resorption is often thought of as a feline disease, it also occurs in dogs. A comprehensive review of tooth resorption in dogs is beyond the scope

FIGURE 7. Two-year-old cat with right nasal and ocular discharge. The client obtained the cat when it was 6 months of age and reported no history of trauma. **(A)** Photograph showing right nasal discharge. The right maxillary canine tooth (104) has a blunt crown tip and appears shorter than the left maxillary canine tooth (204). **(B)** Radiograph of 204. Pulp cavity size is consistent with the age of the cat (2 years). **(C)** Radiograph of 104. The pulp cavity size is large and is not consistent with the age of the cat or with the contralateral tooth. The apex is open and there is a diffuse area of periapical lucency consistent with apical periodontitis. There is an irregular, slightly more radiopaque structure within the lucency. **(D)** 104 after extraction. Note the granulation tissue present at the apex of the tooth, consistent with the irregular opacity within the periapical lucency on the radiograph.

FIGURE 8. A combined periodontal/endodontic lesion. Radiograph of the left mandibular third and fourth premolars and first molar (307, 308, 309) showing horizontal bone loss at 307, 308, and 309 and vertical bone loss affecting the distal root of 307 and both roots of 308. There is a periapical lucency associated with the distal root of 308. The roots of 307 and 308 are irregularly shaped, consistent with external inflammatory resorption.

of this article. In dogs, some types of tooth resorption are believed to be incidental findings (external replacement resorption), and others are associated with common dental conditions (external inflammatory resorption) (**FIGURE 12**). The characteristics of tooth resorption in dogs are described in **BOX 4**.

Carnassial Tooth Malformations

A developmental abnormality that affects mandibular first molar teeth in dogs has previously been referred to as dens invaginatus or dens in dente. A recent study found that this developmental abnormality was not consistent with the findings of dens invaginatus in humans, and the authors recommended that malformations in the mandibular and maxillary carnassial teeth be referred to as carnassial tooth malformations until further information is available.[14]

The malformed teeth have abnormal mineralized tissue surrounded by disorganized dentin within the teeth. Malformed crowns have defects in the enamel and dentin that can open communication between the pulp and oral cavity. The communication may not be clinically obvious, and the tooth may appear grossly normal. The fissures or defects in the tooth allow bacteria to travel to the pulp, resulting in endodontic disease. Common features of carnassial tooth malformations are described in **BOX 5**.

Box 5 Common Features of Carnassial Tooth Malformation[14] (FIGURE 13)

- Frequently bilateral
- Furcation abnormalities
- Abnormalities in coronal enamel
- Abnormal radiopacity within the crown
- Root convergence
- Periapical lucencies and periodontal disease

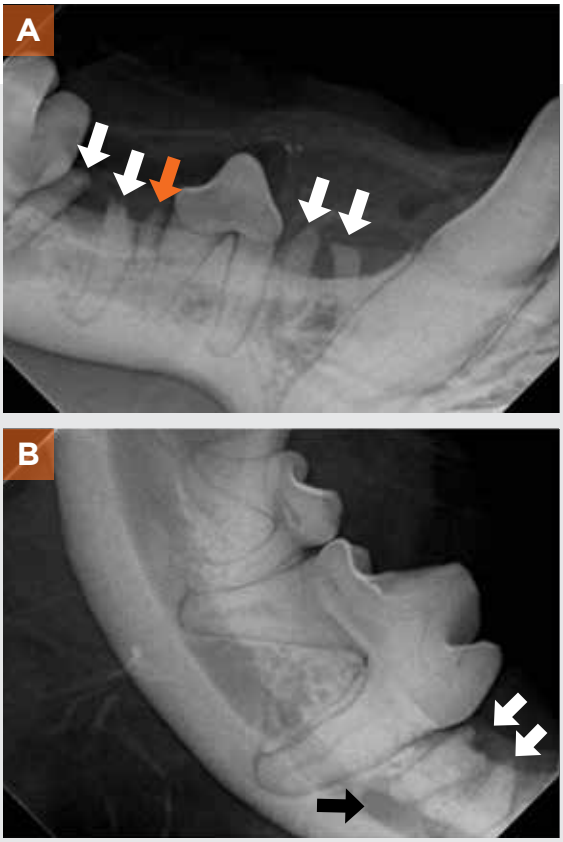


FIGURE 9. Retained tooth roots in a dog. **(A)** Radiograph of the right mandibular premolars in a dog. The right mandibular first premolar (405) is missing. There are retained roots of the right mandibular second and fourth premolars (406 and 408) **(white arrows)**. There is a small root fragment **(orange arrow)** that is probably the retained root of a deciduous tooth. **(B)** Radiograph of the right caudal mandible in the same dog. There are retained roots of 408 **(white arrows)** and a periapical lucency, consistent with apical periodontitis, associated with the distal root of 408 **(black arrow)**. The right mandibular first molar (409) has an area of radiopacity obscuring the pulp chamber in the crown of the tooth and a wide pulp cavity in the distal root. These findings are consistent with a malformed mandibular first molar (dens invaginatus) in dogs.

Top Left: courtesy of Bill Krug, DVM, DAVDC

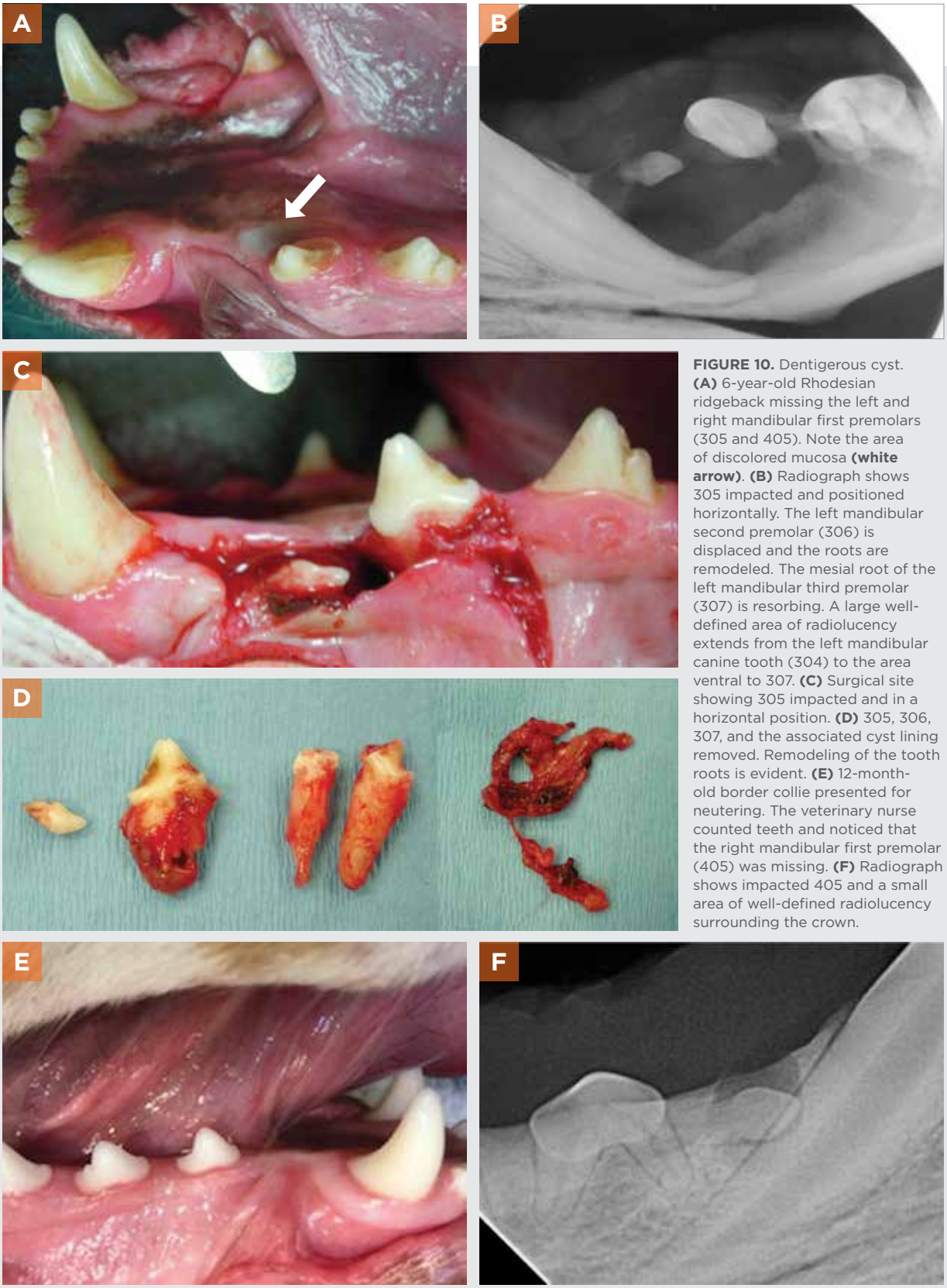


FIGURE 10. Dentigerous cyst. **(A)** 6-year-old Rhodesian ridgeback missing the left and right mandibular first premolars (305 and 405). Note the area of discolored mucosa **(white arrow)**. **(B)** Radiograph shows 305 impacted and positioned horizontally. The left mandibular second premolar (306) is displaced and the roots are remodeled. The mesial root of the left mandibular third premolar (307) is resorbing. A large well-defined area of radiolucency extends from the left mandibular canine tooth (304) to the area ventral to 307. **(C)** Surgical site showing 305 impacted and in a horizontal position. **(D)** 305, 306, 307, and the associated cyst lining removed. Remodeling of the tooth roots is evident. **(E)** 12-month-old border collie presented for neutering. The veterinary nurse counted teeth and noticed that the right mandibular first premolar (405) was missing. **(F)** Radiograph shows impacted 405 and a small area of well-defined radiolucency surrounding the crown.

10E, 10F: courtesy of Kingsbrook Animal Hospital

FIGURE 11. Tooth resorption in cats. **(A)** Type 1 tooth resorption in the right mandibular third premolar (407). Note the focal area of radiolucency at the furcation of the tooth. **(B)** Type 2 tooth resorption in 407. There is no discernible root structure or periodontal ligament space. The root structure blends with the surrounding alveolar bone. **(C)** Type 3 tooth resorption in 407. The mesial root is undergoing type 1 tooth resorption **(black arrow)**, and the distal root is undergoing type 2 tooth resorption **(orange arrow)**. Note the caudal mandibular foramen **(white arrow)**.

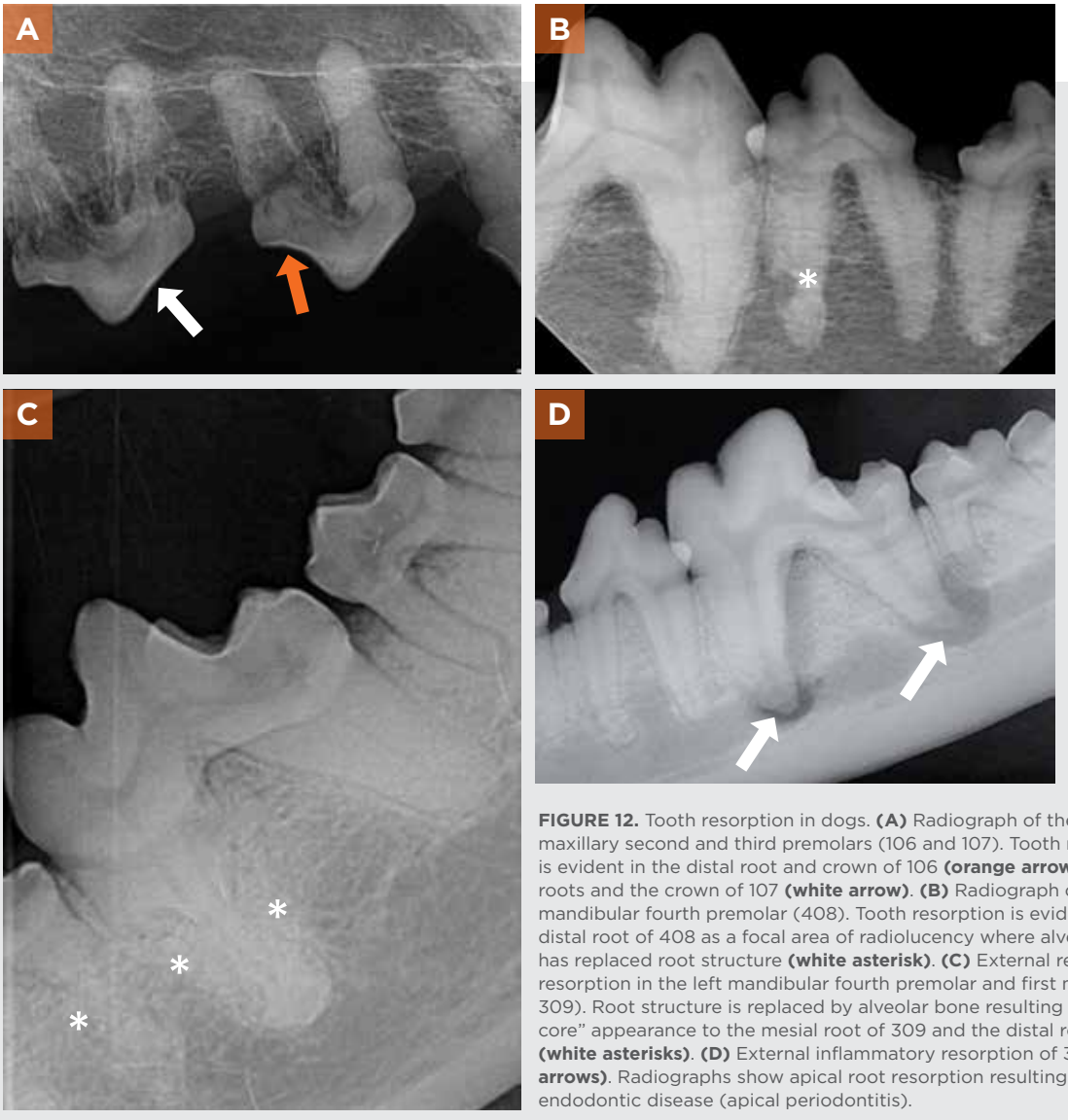


FIGURE 12. Tooth resorption in dogs. **(A)** Radiograph of the right maxillary second and third premolars (106 and 107). Tooth resorption is evident in the distal root and crown of 106 **(orange arrow)** and both roots and the crown of 107 **(white arrow)**. **(B)** Radiograph of the right mandibular fourth premolar (408). Tooth resorption is evident on the distal root of 408 as a focal area of radiolucency where alveolar bone has replaced root structure **(white asterisk)**. **(C)** External replacement resorption in the left mandibular fourth premolar and first molar (308, 309). Root structure is replaced by alveolar bone resulting in an "apple core" appearance to the mesial root of 309 and the distal root of 308 **(white asterisks)**. **(D)** External inflammatory resorption of 309 **(white arrows)**. Radiographs show apical root resorption resulting from endodontic disease (apical periodontitis).

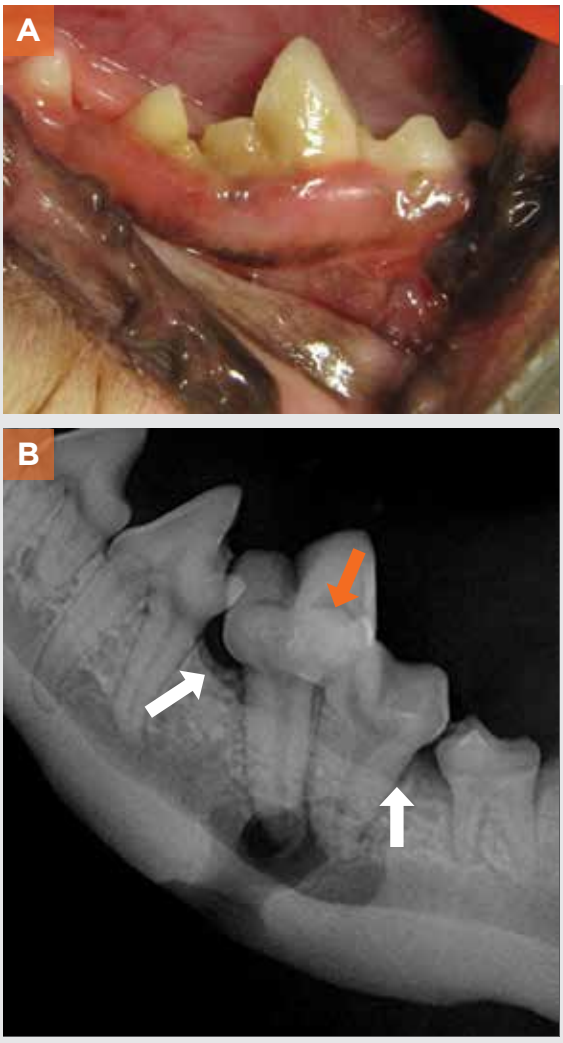


FIGURE 13. Carnassial tooth malformation in a dog. **(A)** Photo of the left mandibular first molar (309). The crown of the tooth appears clinically normal. **(B)** Radiograph of the same tooth. An abnormal radiopaque area within the crown obscures the pulp chamber and pulp horns **(orange arrow)**. Horizontal bone loss **(white arrows)** is evident. The roots are converging, and there is a large periapical lucency associated with both roots that extends into the ventral cortex of the mandible.

CONCLUSIONS

Accurate diagnosis and treatment of oral diseases require a complete intraoral examination under anesthesia, including periodontal probing and charting and full mouth radiographs. Teeth that appear clinically normal may have pathology that is detectable only on intraoral radiographs.

The more you learn about oral pathology, the more oral pathology you will recognize in your patients and the better you will treat them.

Author's Note: Special thanks to the veterinary nurses who obtained these radiographs and are an integral part of the oral healthcare team. TVP

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