ON THE LOOKOUT
Recognizing clinical signs of a fractured tooth during wellness visits can prevent future emergencies and/or unnecessary pain for patients down the line.

INSIGHTS IN DENTISTRY

Diagnosis and Treatment of Fractured Teeth

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Dentoalveolar trauma affects as many as 26.2% of dogs and cats[1] and may be categorized as discolored, luxated, avulsed, or fractured teeth. The trauma type encountered most often is fracture.[1] Although numerous classification systems have been developed for further describing fractured teeth,[2] it is well accepted that teeth with pulp exposure are referred to as complicated fractures and those without pulp exposure are referred to as uncomplicated fractures. These descriptions can be further defined by denoting whether the fracture is limited to the crown, affects the root, or involves both (**FIGURE 1**). An uncomplicated crown fracture, by virtue of sparing the pulp, may also be referred to as an enamel–dentin fracture, and a fracture that involves the pulp may similarly be labeled an enamel–dentin–pulp fracture.

CLINICAL SIGNS

Clinical signs associated with the pain of a fractured tooth may include a preference for soft or softened food, lip licking, pawing the face or mouth, difficulty apprehending food, or decreased interest in play.[3] In a survey of humans with limited or no access to dental care, the experience of pulpitis was described as "intense, throbbing, piercing, miserable, and unbearable."[4] However, despite oral discomfort, many patients with fractured teeth appear to be asymptomatic. Veterinarians are in a position to be the patient's advocate and present treatment options for achieving a comfortable, disease-free mouth. Making this timely observation may prevent a future emergency and unnecessary pain for the patient. Insisting on a healthy mouth facilitates management of comorbidities[5] and potential behavior challenges[6] and improves the patient's quality of life.

EVALUATION AND DIAGNOSIS

A wellness visit is a good opportunity to identify a fractured tooth and convey the need for further assessment to the client. Showing clients their own pet's fractured tooth during a visit may be helpful if it can be done so without causing pain or fear for the patient. Showing them photographs and/or radiographs of similar tooth fractures in other patients is often helpful when explaining the pathology and treatment options.

For some patients, whether a fractured tooth requires intervention is determined by further diagnostics while under a light plane of anesthesia; but for many, an oral examination while conscious provides enough information to enable the practitioner to recommend further evaluation and treatment as needed. With the patient anesthetized, a full evaluation of the mouth is indicated as multiple teeth may be fractured and

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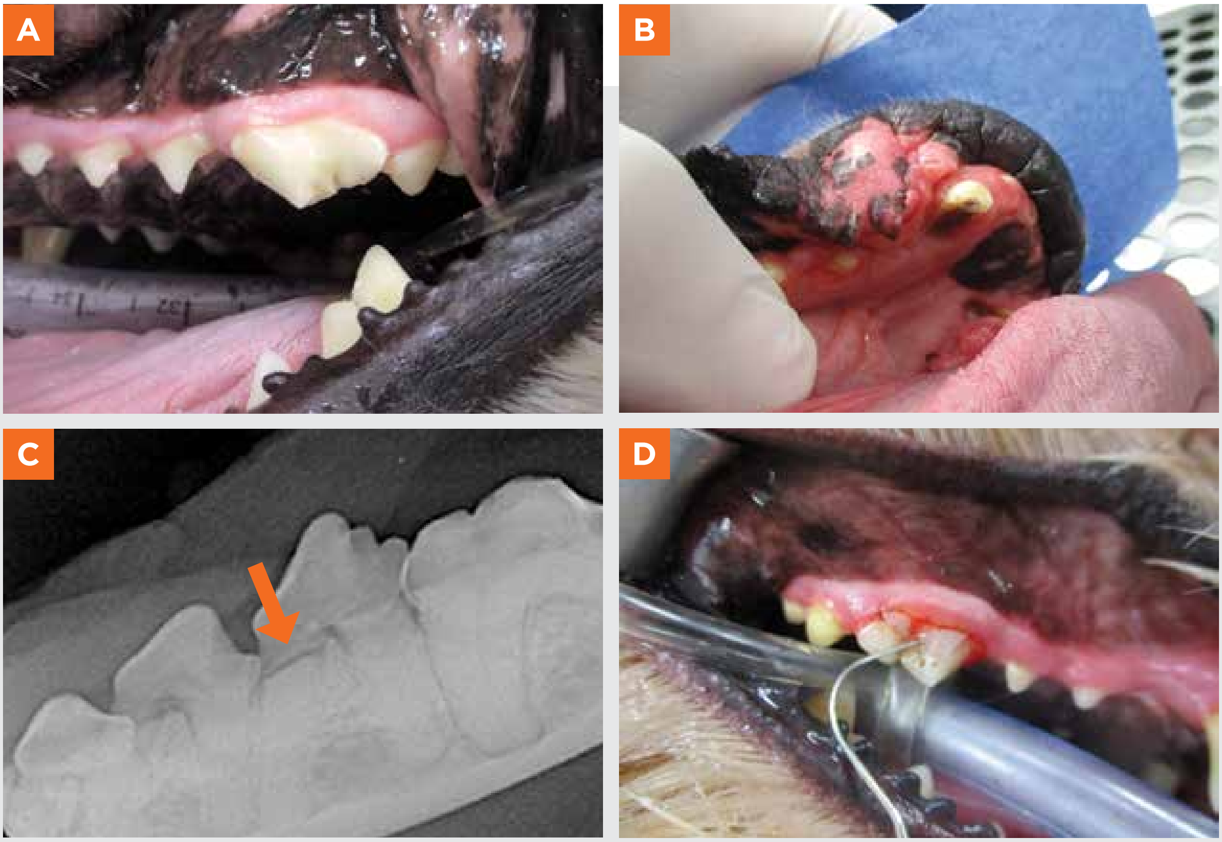

FIGURE 1. Types of tooth fractures. **(A)** Uncomplicated crown fracture (enamel–dentin fracture); **(B)** complicated crown fracture (enamel–dentin-pulp fracture); **(C)** root fracture **(arrow)**; **(D)** complicated crown-root fracture.

FIGURE 2. Left mandibular canine tooth fracture. The fracture angle of the tooth suggests that the trauma was incurred from the distal aspect of the tooth (e.g., from biting cage bars).

additional oral pathology may be present. Included in the assessment is a complete tooth-by-tooth visual assessment with special attention to crown fractures, wear, enamel abnormalities, and gingival color or prominence as well as assessment of periodontal pocket depth. During the oral examination, assess pulp exposure by determining whether the explorer tip can fall into the pulp exposure site.

Depending on the chronicity of the crown fracture, the site may need to be ultrasonically scaled to remove calculus blocking the site of pulp exposure. If the clients are interested in preventing future fractures, the fracture angle may be assessed to determine the cause of the fracture. For example, a fractured canine tooth with the fractured surface visible from the mesial aspect was probably caused by pressure on the distal aspect of the tooth[7] (**FIGURE 2**), such as pulling on cage bars. A fracture surface facing distally probably resulted from force received on the mesial aspect of the crown; these types of fractures occur when large dogs collide with an object (e.g., car, baseball bat) and in small dogs and cats when they fall from a height (**FIGURE 3**).

Worn teeth may be missing a large portion of the crown but have no exposed pulp if the rate of tertiary dentin was able to keep up with the rate of wear. White, organized dentin may represent repair at a slower rate of wear (reactionary dentin), and a brown, haphazard pattern of repair may represent a faster rate of wear (reparative dentin); both responses are protective of the pulp.[8] Despite the presence of reparative or reactionary dentin, some teeth affected by wear become nonvital and diagnostic imaging is still necessary to assess their vitality.

Diagnostic imaging, which may include dental radiographs and/or cone beam computed tomography (CBCT), is imperative for assessing tooth vitality and for treatment planning. Dental radiography is useful for assessing the periapical region and the size of the pulp cavity. CBCT may be especially advantageous[9] when the affected tooth is maxillary[10] or when teeth are crowded, as in brachycephalic patients (**FIGURE 4**). The time before development of periapical disease in a nonvital tooth varies, and the absence of periapical disease does not necessarily indicate an acute fracture. Radiographically, periapical disease and a wide or irregular pulp cavity indicate a nonvital tooth that requires treatment. Some periapical lesions may not be evident on dental radiographs alone and require CBCT for detection.[11]

PATHOLOGY

The enamel of cats and dogs is thin, about 10 times thinner than that of a human tooth; enamel is less than or equal to 0.3 mm in cats and 0.6 mm in dogs.[12] Although enamel is almost completely hydroxyapatite, enamel fractures are rare and more often practitioners diagnose fractures that surpass the enamel and compromise the dentin (i.e., enamel–dentin fractures). In contrast to enamel, dentin is porous, having tens of thousands of tubules per mm^2 within the

FIGURE 3. Right maxillary canine tooth fracture. The fracture angle suggests that the trauma was incurred from the mesial aspect of the tooth.

FIGURE 4. Right maxillary fourth premolar (108) with complicated crown–root fracture. **(A)** Photograph, **(B)** radiograph, and **(C)** cone beam computed tomography (CBCT) images of both maxillary fourth premolars. The periapical pathology associated with this fractured tooth is more evident on the CBCT image; however, evidence of pulp exposure **(arrows)** on oral examination directs the practitioner to address the tooth.

hydroxyapatite.[8] The number of tubules increases as they near the pulp chamber. A popular theory to explain the pain associated with a fractured tooth suggests that when dentinal tubules are exposed, changes in the fluid dynamics within the tubules stimulate the nerve ending within the tubules to send sharp pain messages to the brain.[13] A dog chewing an antler that fractures the maxillary fourth premolar tooth undoubtedly feels pain. Odontoblasts place tertiary (reparative) dentin and mineral crystals into the tubules, attempting to block pulp exposure to the outside world via the tubules. Teeth with acute pulp exposure will die (i.e., develop irreversible pulpitis and pulp necrosis) before the odontoblasts can repair the fracture site, and at this point the pulp is vulnerable to the bacteria of the oral microbiome.

After a tooth has become nonvital, there may be a time during which the pulp, including the nerve supply, is

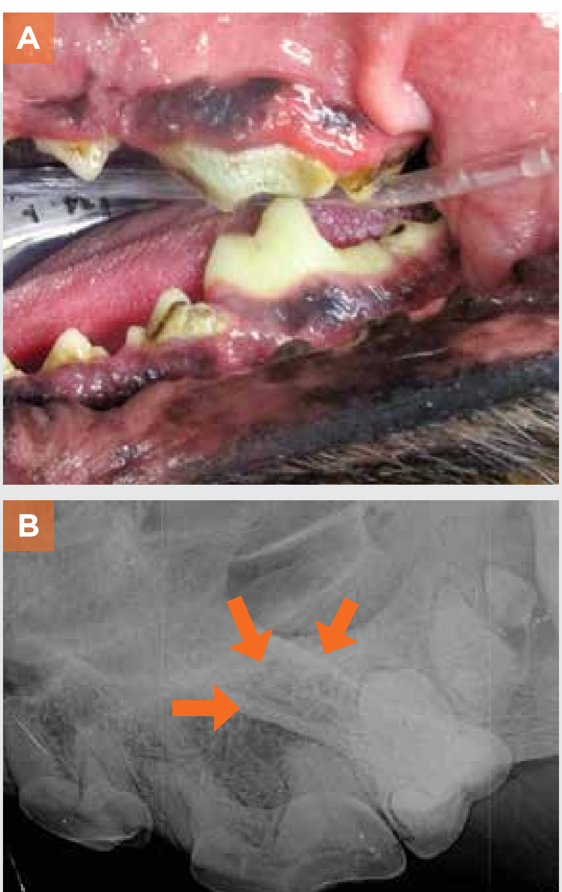

FIGURE 5. (A) Uncomplicated crown fracture of the left maxillary fourth premolar. **(B)** Radiographic evidence of periapical lysis **(arrows)**, indicating that the tooth is nonvital despite the absence of pulp exposure.

Figure 5 (A and B): courtesy of Laura Sasser, DVM

Any tooth proven to be nonvital—by discoloration,[15] pulp exposure, periapical lysis, apical lysis, and/or a wide irregular pulp cavity—requires treatment with either extraction or root canal.

dead but inflammation/infection has not yet developed in the periapical tissue. This time span varies, is difficult to predict, and may depend on patient factors such as diameter of the pulp canal, oral microbiome, and immune status. Therefore, it is possible that there is an undetermined period between when a traumatized tooth is acutely painful and when it becomes painful in a deep pain, or a "toothache" kind of way.[14] In most painful teeth, draining tracts will not develop, but a tooth with exposed pulp cannot heal and, in this sense, there is nothing to "wait and see" because the pulp exposure has indicated that treatment is necessary. In other words, monitoring alone for complicated fractures is contraindicated.

TREATMENT

In contrast to human dentists, veterinarians can minimize maintenance of teeth for aesthetic purposes and focus on what will make the patient comfortable and the teeth functional. Any tooth proven to be nonvital—by discoloration,[15] pulp exposure, periapical lysis, apical lysis, and/or a wide irregular pulp cavity—requires treatment with either extraction or root canal. Fractured teeth with pulp exposure, even in the absence of radiographic evidence of periapical disease or a wide or irregular pulp, require intervention 100% of the time; in contrast, about 24% of fractured teeth without pulp exposure require treatment (**FIGURE 5**).[16] Some fractured teeth without pulp exposure have survived the trauma, and whether they suffered reversible pulpitis and/or the tooth developed reparative dentin to address near pulp exposure, the tooth may be proven to be vital by the absence of oral examination findings or radiographic signs of being nonvital. Oral examination findings that indicate that a tooth is nonvital include discoloration and pulp exposure. Imaging may reveal that a tooth is nonvital despite a lack of oral examination findings. Periapical lysis, apical lysis, or a wide or irregular pulp canal indicate that the tooth is nonvital with inflammation affecting the bone surrounding the apex and directly affecting the root of the tooth. A wide pulp canal indicates that the tooth died at a phase of development during which secondary dentin deposition ceased and the tooth failed to continue maturation in contrast to neighboring teeth; the tooth is arrested during development because it is no longer vital. The 2 treatment options for fractured teeth with exposed pulp are root canal or tooth extraction (**FIGURE 6**).

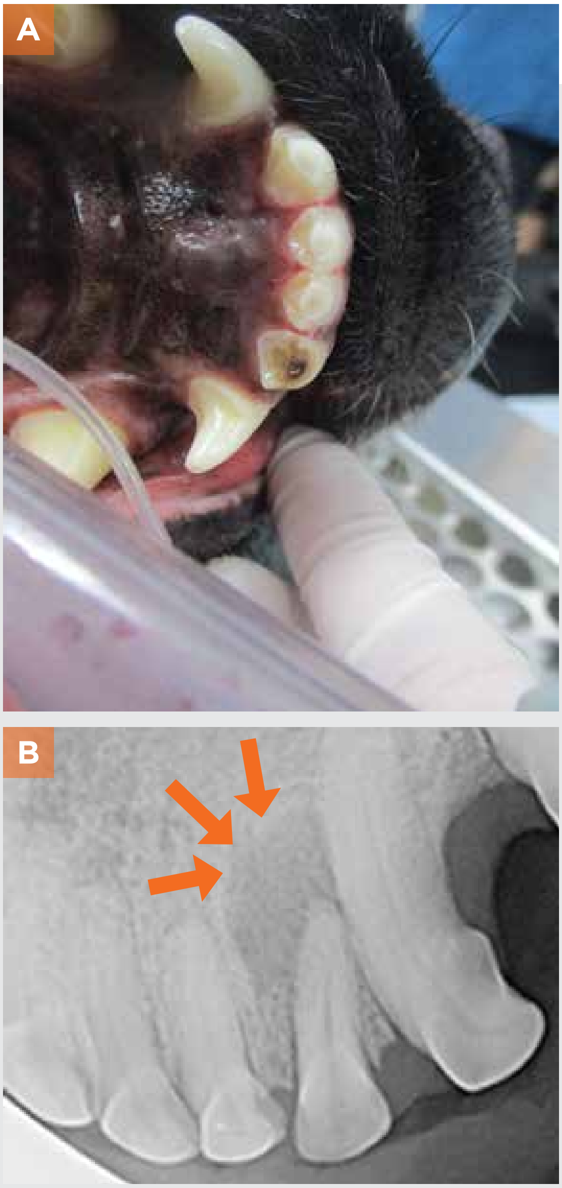

FIGURE 6. Left maxillary second incisor (202). **(A)** Photograph showing pulp exposure. **(B)** Radiograph showing pulp exposure resulting in a large periapical lesion **(arrows)**.

In dogs, teeth commonly treated with root canal therapy instead of extraction include canine and carnassial teeth (maxillary fourth premolars and mandibular first molars). In addition, root canal therapy may be the priority treatment for maxillary third incisors due to their contribution to the canine

FIGURE 7. Right and left mandibular canine teeth and incisors in a dog. The right mandibular canine tooth (304) has been treated with root canal therapy. The left mandibular first incisor is missing.

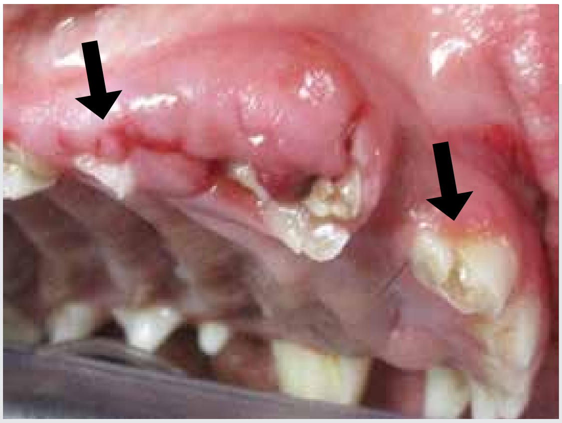

FIGURE 8. Maxillary teeth in a dog with a history of biting cage bars. Crown fractures with exposed pulp affect multiple teeth, including the right maxillary third incisor and right maxillary first premolar **(arrows)**. Right maxillary canine tooth (104) with vertical crown-root fractures make this tooth a poor candidate for root canal therapy.

interlock, especially in working dogs (**FIGURE 7**). Clients with dogs that have a high play drive may elect root canal therapy to avoid the temporary restrictions needed for healing after a surgical extraction. In cats, root canal treatment is commonly limited to the canine teeth.

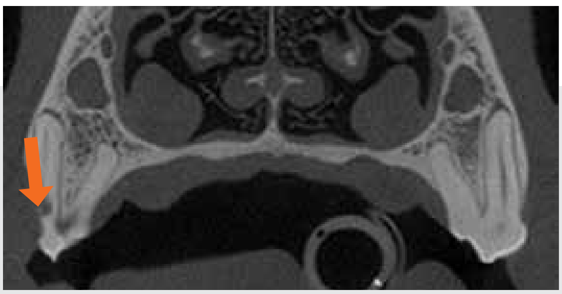

FIGURE 9. Cone beam computed tomography image of the maxillary fourth premolars in a dog. The left maxillary fourth premolar has a defect in the mesiobuccal root **(arrow)**, making this tooth a poor candidate for root canal therapy and a better candidate for extraction.

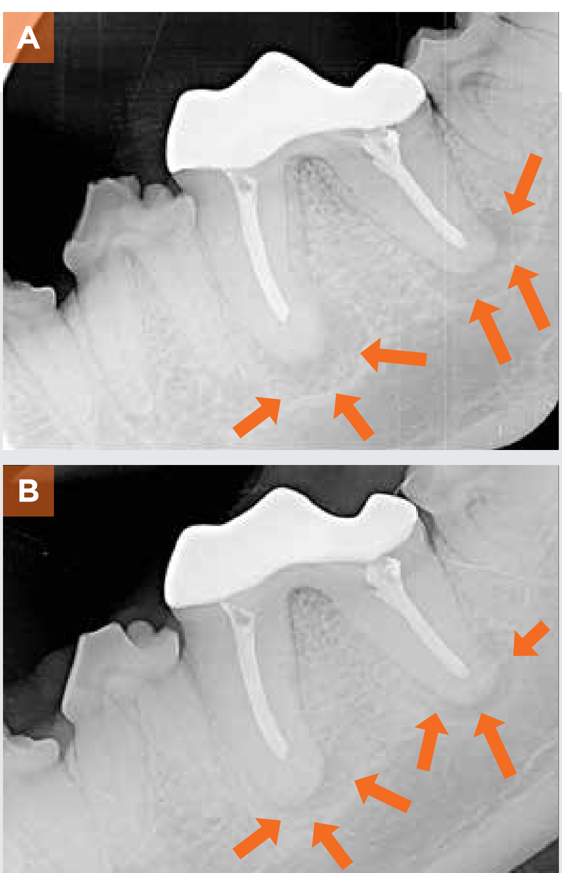

FIGURE 10. Dental radiographs of a left mandibular first molar treated with root canal therapy. **(A)** On the day of treatment, the periapical lesions affect both roots of the first molar **(arrows)**. **(B)** At 18 months after treatment, the amount of periapical lysis is reduced **(arrows)**.

Figure 10 (A and B): courtesy of Stephen Juriga, DVM, DAVDC

Failure rates for root canal therapy are low (4% in dogs and 19% in cats),[17,18] and cases that are likely to have successful outcomes should be selected. A tooth that is a good candidate for root canal therapy is nonvital, may or may not have periapical lysis, and is periodontally healthy. Historically, the presence of periapical lysis has seemed to negatively affect root canal outcome,[19] but a more recent retrospective analysis did not demonstrate a significant effect on root canal outcome.[17] Generally, the presence of periapical lysis is not considered to be a contraindication to root canal therapy. A tooth with advanced periodontal disease is not a good root canal candidate; instead, the recommended treatment is extraction. A tooth that may otherwise be periodontally healthy may be compromised by a crown–root fracture (**FIGURES 8 AND 9**), creating a pseudopocket and predisposing the tooth to further attachment loss. Teeth with periapical lysis that have undergone successful root canal treatment will show reduced periapical lysis on subsequent images (**FIGURE 10**). Teeth treated with root canal therapy may be categorized as stable if the periapical lysis persists without progressing afterward.

To protect teeth that have undergone root canal therapy, custom crown placement is indicated for working dogs, dogs whose teeth will undergo repeated trauma or fatigue, or teeth under daily use (e.g., carnassial teeth) (**FIGURE 11**). Although a root canal does not weaken a tooth, a nonvital tooth is slightly more brittle than a vital tooth,[20] and a crown is likely to protect the tooth for the lifetime of the patient, reducing risk for displacement of the restoration or

FIGURE 11. Left maxillary and mandibular teeth in a dog. The left maxillary fourth premolar was treated with root canal therapy, and a custom titanium-alloy crown now protects the tooth from future fracture and wear. The left maxillary canine tooth was previously treated with root canal therapy for a complicated crown fracture, and wear affecting the left maxillary third premolar and left mandibular third premolar did not result in pulp exposure of these teeth.

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future fracture.[21] Maintaining functionally valuable teeth is a good option for clients to consider, but they should be made aware that most pets also do well after tooth extraction.

PREVENTING FUTURE FRACTURES

After their pet has undergone treatment for a fractured tooth, clients may be motivated to prevent future fractures.

In the author's experience, dogs most often fracture carnassial teeth by chewing hard nylon bones, marrow bones, antlers, and non-toy objects (e.g., ceramic materials, cage bars, and rocks). Cage-chewing may cause or contribute to canine tooth crown fractures (**FIGURE 12**), and some clients may elect to change these risk factors. Chewing on appropriate toys, however, has benefits, including mechanical plaque disruption, energy outlet, and the pet's enjoyment.

FIGURE 12. Mandibular right canine tooth (404) in a dog. Distal abrasive wear in a "cage-chewing" pattern predisposes the tooth to crown fracture.

In contrast, cats are less likely to incur crown fractures from habits that can be modified and are more likely to incur crown fractures as a result of trauma, such as high-rise syndrome.[22]

CONCLUSIONS

Veterinarians are in a unique position to advocate for patients through client education, accurate diagnosis, and timely treatment of teeth affected with crown fractures. Practitioners are likely to encounter opportunities to improve the dental health of patients on a daily basis; and now, more than ever, clients are seeking the best options for promoting the health and quality of life of their canine and feline family members.[23] We can supply our clients with the knowledge they need to best work with us toward creating a comfortable and functional mouth for their pets. TVP

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