Several of the endodontic conditions discussed in this article may be well known to readers, but since veterinary dental education is quite variable, even these common conditions will be presented. Some of the pathologies presented are more subtle and warrant careful consideration, as they are no less painful or damaging than more obvious conditions, and should be afforded the same level of respect as classic endodontic disease. The consequences and treatments of many of these diseases are largely misunderstood by the general veterinary profession.

Beyond the information presented on diagnosis and care, this article will convey the deeper impact of specific dental pathologies in a way that allows you to communicate the significance of the conditions to your clients. This communication should help you increase the number of patients receiving dental prophylaxis and treatment per your recommendations, presenting an opportunity to improve the patient’s health as well as the practice’s financial health.

TOOTH ANATOMY
The crown of the tooth is made up of 3 layers (Figure 1):1,2

- **Pulp Chamber**: The innermost layer is the pulp chamber (or root canal), which is comprised of blood vessels, nerves, and connective tissue.
- **Enamel**: The outermost layer is the enamel, which is 96% inorganic material. Enamel has no sensory ability and no ability to regenerate if damaged or lost.

*Figure 1. Anatomy of a single-root tooth*
**Dentin**: The middle layer, between the pulp chamber and enamel, is called dentin. Dentin makes up the majority of the tooth structure in mature animals and has a similar mineral density to bone.

- Dentin contains millions of dentinal tubules that radiate from the root canal to the periphery of the dentin, which is covered with enamel (Figure 2).
- Each one of these dentinal tubules contains an odontoblastic process with nervous innervations, resulting in a dynamic living structure with sensory ability and the capability to respond to stresses.³
- Canine dentin has 50,000 to 100,000 tubules/mm², which is twice the number of tubules in human teeth.⁴ Therefore, dogs’ teeth are twice as sensitive as ours.

### RESPONSE TO INFLAMMATION

Teeth are subject to many sources of inflammation; in veterinary medicine, the result is generally traumatic.⁵

Once the tooth undergoes trauma, it reacts with inflammation. This reaction is termed **pulpitis**, which can be reversible or irreversible:

- **Reversible pulpitis** indicates that the tooth will respond favorably to therapy and remain vital.
- **Irreversible pulpitis** eventually results in pulp death and necrosis.

**Direct pulp exposure will invariably result in pulp death, necrosis, and subsequent infection, unless treated immediately with vital pulp therapy.** This therapy protects the pulp with a medicant; then 2 layers of restorative material. The goal is to maintain long-term tooth vitality and in order to have a chance at success, this therapy must be performed properly and immediately.⁶ Even under ideal conditions, vital pulp therapy has a poorer prognosis than standard root canal therapy.⁷⁻¹⁰

Traumas, such as uncomplicated crown fractures, attrition, and abrasion, will result in inflammation that is reversible or irreversible depending on the degree of inflammation and treatment (if any). Over time, the tooth may respond to inflammation by increasing the distance between the injury and the pulp (tertiary dentin) or

**HYDRODYNAMIC THEORY OF DENTIN SENSITIVITY**

The intimate association of **nerve fibers** with **odontoblasts** (cells that produce tooth dentin) is an area of active speculation. It is still unclear how odontoblasts and nerve endings interact. One theory regarding this interaction is the **Hydrodynamic Theory of Dentin Sensitivity**.

It states that the movement of fluid in dentinal tubules is the basic event that elicits dentinal pain (Figure 3). The direct exposure of the dentin allows for more rapid movement of fluid. Heat, cold, dessication, and dental probing can all displace fluid and therefore elicit pain. In this theory, it is **A fibers** (nerve fibers that have the fastest rate of transmission of nervous impulses) that are activated by fluid movement.
decreasing dentin permeability (dentinal sclerosis). This may be sufficient to protect the pulp; however, it is impossible to measure.

**BROKEN TEETH**

Broken teeth are a very common problem in veterinary patients. In fact, *1 out of 10 dogs has a broken tooth in their mouth with direct root canal (nerve) exposure* which is called a complicated crown fracture (Figure 4). This number does not include the numerous pets with uncomplicated crown fractures (Figure 5) or fractured teeth that do not directly involve the root canal system. Both types of tooth fractures require therapy, but the treatments are often different.

---

**Figure 4.** (A) Slab fracture of the maxillary left fourth premolar (208); (B) Slab fracture of the maxillary left fourth premolar (208) with direct pulp exposure (yellow arrow); (C) Complicated crown fracture of the mandibular left canine (304) with direct pulp exposure; (D) Severely comminuted, complicated crown fracture of the mandibular left first molar (309).

**Figure 5.** (A and B) Uncomplicated crown fractures with dentin (blue arrows) but no direct pulp exposure of the maxillary left fourth premolars (208); (C) Uncomplicated crown fracture with dentin (yellow arrow) but no direct pulp exposure of the mandibular right first molar (409).
Complicated Crown Fractures

Complicated crown fractures are the most easily diagnosed form of endodontic disease, requiring only an oral examination for diagnosis.

Avoid “Wait & See”

While it may seem obvious that an exposed nerve hurts or a diseased tooth would be a source of infection, this knowledge is not universal. It is a common misconception among clients and even some veterinarians that these fractures don’t hurt because the pet is eating normally. Many clients are told “Just keep an eye on it” or “Since it doesn’t bother him, wait until it abscesses.” The fact is, once the nerve is exposed, the tooth cannot heal itself and requires therapy.

Subtle Clinical Signs

Fractured and/or infected teeth affect animals by creating pain, infection, and even fatigue, but often these signs are subtle or hidden. In addition, signs of infection generally present gradually and are, therefore, less noticeable. Because animals are typically more stoic than humans, lack of obvious signs of oral pain should not be misinterpreted as a benign state.

Veterinary dentists often see animals that continue to eat normally despite the presence of lesions that should be causing intense oral pain.

Bacterial Pathway

After a broken tooth eventually dies and much of the associated pain subsides, the root canal system acts as a bacterial pathway, allowing both local infection and systemic bacterial spread through the bloodstream. Spreading bacteria can negatively affect numerous vital organs, including the heart, liver, kidney, lungs, and brain, leading to serious systemic disorders.

All teeth with direct pulp/nerve exposure must be treated with either root canal therapy or extraction. 14-17 Ignoring these teeth is not an option, as prior to tooth death, the living nerve is excruciatingly painful, and subsequent infection follows. Most owners see a notable or even dramatic improvement in their pets’ attitudes and energy levels after therapy is provided.

Uncomplicated Crown Fractures

Uncomplicated crown fractures are also a very common finding on oral examination, particularly in large-breed dogs. These fractures result in direct den-
tinal exposure, and exposed dentinal tubules likely create significant pain (or sensitivity) for the patient (as discussed earlier). In addition, some of these teeth become nonvital due to the traumatic incident and/or associated inflammation.

Therefore, it is recommended that these teeth be radiographed to ensure vitality (Figure 6, page 43). If teeth are found to be nonvital, they must be treated with root canal therapy or extraction. If teeth appear vital, the application of a bonded sealant is recommended to decrease sensitivity (see More at Todaysveterinarypractice.com).

**ABSCESSED TEETH**

In addition to long-term, low-grade systemic infection, over time an infected tooth may eventually cause swelling or an abscess (Figure 7, page 43). This is also a very painful situation, demanding prompt therapy. Unfortunately, in many cases, abscessed teeth have existed for years prior to the appearance of clinical signs. Furthermore, tooth abscesses typically wax and wane until they are definitively treated.

For example, facial swelling may temporarily resolve (especially if treated with antibiotics), but will eventually recur. The animal’s immune system can often temporarily control the local infection, but ultimately the swelling/abscess cannot be cured until definitive therapy is performed. Definitive therapy is either root canal or extraction.

**DISCOLORED TEETH**

Discoloration is another clinical sign of tooth death and potential secondary infection (Figure 8, page 43). Affected teeth can appear pink, purple, yellow, or grey. A study showed that 92.7% of these teeth are nonvital, despite the lack of clinical or radiographic signs of disease.

Nonvital teeth lose their natural defense ability and are often infected via the bloodstream, which is known as anachorisis. Therefore, most veterinary dentists do not rely on radiographic appearance to determine vitality of stained teeth. All intrinsically stained teeth should be treated the same way as a fractured tooth—with root canal therapy or extraction. Intrinsic staining differs from extrinsic staining (eg, coffee stains in humans) because it is caused by blood product breakdown from pulp hemorrhage.

**NONVITAL TEETH**

Another case of camouflaged endodontic disease is a nonvital tooth that appears completely normal (Figure 9). The vast majority of these cases have some outward sign of disease and will show evidence of nonvitality if transilluminated. However, some cases can only be diagnosed with dental radiology. This highlights the importance of full-mouth dental radiology as part of all patients’ dental prophylaxis.
TREATMENT OPTIONS
As stated previously, all teeth with direct pulp exposure as well as stained and/or nonvital teeth must be treated. The treatment options for these teeth are root canal therapy or extraction. When properly performed, either treatment should result in resolution of pain and/or infection. There are advantages and disadvantages to each treatment, and recommendations vary depending on which tooth is involved and the level of disease.

Root Canal Therapy
Briefly described, root canal therapy involves removal of the nerve and associated structures, disinfection and filling of the canal, and restoration of the surface of the tooth (Figure 10, page 44).

The advantages of root canal therapy compared to complete extraction include:
• Minimized pain and discomfort
• Retained function of the tooth
• Maintained strength of the jaw
• Decreased surgical complications.

Although almost any tooth can be treated with root canal therapy, it is specifically recommended for treating larger, strategic teeth, such as the canine or carnassial teeth. The lower canine teeth are specifically associated with jaw strength; avoiding extraction of these teeth, if possible, is optimal.

Extraction
Extraction involves complete removal of the tooth and its root(s). This is an important point, as only complete extraction will resolve infection; retained roots are a very common complication with extractions (Figure 11).

The advantages of extraction include:
• Decreased surgical time and expense (for smaller teeth)
• No long-term follow-up.

ARTICLE SUMMARY
Endodontic disease is a very common condition in small animal veterinary patients. Many of these conditions are easily diagnosed, such as complicated crown fractures and discoloration. Other conditions are less obvious (eg, uncomplicated crown fractures) and may require dental radiographs for definitive diagnosis.

Therefore, a complete oral examination should be performed on all patients and a thorough oral examination and radiographs completed during every dental procedure. Finally, teeth affected by endodontic disease should be treated. Root canal therapy (especially with strategic/large teeth) is ideal, but complete extraction is also acceptable.

FIGURE CREDITS

References

Resources
For educational videos of the pathologies discussed in this article, please visit dogbeachdentistry.com.

---

**NEW PRODUCTS**

Taking the Tough Out of Pet Care

January 2012—Virbac Animal Health (virbacvet.com) has introduced two new products that make treating pets or administering preventive care a more pleasant process for all involved.

Virbac’s new C.E.T. HEXTRA Premium Chews for Cats make it easier for clients to clean and protect their cats’ teeth between professional cleanings. Many clients feel it’s too difficult to clean their cats’ teeth at home but don’t realize that this practice prevents plaque and tartar build-up, reducing the risk of disease in their pets. HEXTRA chews are fish-flavored and formulated with an exclusive solution of chlorhexidine.

The other product, EASOTIC Otic Suspension (hydrocortisone acetophenone, miconazole nitrate, gentamicin sulfate) for dogs features a simplified delivery system that includes a flexible nozzle that easily fits into and is gentle on canine ears. One press of the dispenser pump delivers an accurate, premeasured 1-mL dose that provides sufficient coverage of the ear canal, no matter what dog breed is being treated, and only needs to be administered for 5 days. For more information on either product, visit Virbac’s website.

Keeping Radiography Small-Space Friendly

January 12, 2012—ALLPRO Imaging (allproimaging.com) now offers the computed radiography system with the smallest footprint (< 1.9 square feet) for this type of system in the industry—the ScanX Ellipse Cassette-Fed Computed Radiography System for Veterinarians. The ScanX Ellipse is equipped with PACSmart Imaging Software, which includes many features that enable the user to enhance radiographic details, such as sharpen, enlarge, magnify, or invert the images on a computer. The images are stored in a native DICOM format, facilitating interface with practice management software, such as AVImark and ImproMed. To view a demonstration of the system, visit the ALLPRO Imaging website.

**FDA APPROVALS**

Deracoxib Now Approved for Postoperative Dental Pain

December 12, 2011—Deracoxib (DERAMAXX; ah.novartis.us) is now approved by the Food and Drug Administration (FDA) for the control of postoperative pain and inflammation associated with dental surgery in dogs. It is the first nonsteroidal anti-inflammatory drug (NSAID) in the U.S. to be labeled for this use. A recent study1 indicated that perioperative administration of deracoxib to dogs at the low dose of 1 to 2 mg/kg at least 1 H prior to surgery, and again for 2 more days, effectively managed the pain and inflammation association with dental surgery in dogs receiving butorphanol as a preanesthetic. DERAMAXX is also approved for:

- Control of postoperative orthopedic pain and inflammation
- Control of pain and inflammation associated with canine osteoarthritis.


---

Please send any news, press releases, or information relevant to veterinary professionals to KSoldavin@todaysveterinarypractice.com for publication consideration in Today’s Veterinary News.