Tooth Anatomy:
Teeth are roughly broken up into three layers: enamel, dentin, and pulp. The innermost layer is the endodontic system (root canal or pulp). It contains the nerves, blood vessels, and connective tissue which supply and nourish the tooth during life. The blood and nervous supply enters the tooth through the very bottom or apex of the root.
The outer layer of the tooth crown is enamel, which is an inorganic substance. It is virtually all (97%) calcium and phosphorus and is the hardest substance in the body. Enamel has no nervous or circulatory system. It is applied in a very thin layer (less than 1 mm thick in veterinary patients) over the tooth surface during development by a cell layer called amelioblasts. Once eruption has occurred, enamel cannot be replaced or repaired.
The central layer, which is the vast majority of the tooth structure in mature patients, is dentin. Dentin has roughly the same mineral content as bone. Dentin is a somewhat living structure which has a nervous supply and can occur can respond to stresses. Running at right angles to the root canal all the way around the tooth from the root canal out to the enamel are dentinal tubules. Each one of these dentinal tubules contains an odontoblastic process, which is basically a nervous supply; however they are only sensory and can only report changes as pain. There are approximately 50,000 dentinal tubules per mm$^2$ coronal dentin. Therefore, a 1 cm area of enamel loss will expose 3-4 million odontoblasts!

Response to Damage:
Exposure of the dentinal tubules will lead to much quicker dentinal fluid flow out through these dentinal tubules via the capillary effect. This increase in fluid flow deforms the A-delta C-delta fibers and thus will be perceived by the patient as pain. Anything that will change the flow rate will cause the nerves to fire and result in pain (sensitivity). This includes heat, cold, and desiccation. The sensitivity is actually a sign of low grade pulp inflammation known as pulpitis. These fractures are exceedingly common in large breed dogs. However, they rarely show clinical signs and therefore are only diagnosed with a careful oral exam, often under general anesthesia. Therefore, this commonly goes undiagnosed and therefore untreated.
In addition to the sensitivity produced by the exposure of the dentinal tubules, there is a possibility of ingress of bacteria into the root canal system. In some cases this can result in endodontic infection and subsequent abscessation. This occasionally can be seen clinically as a
swelling or draining tract, but is generally subclinical and therefore undiagnosed. The only way to diagnose this infection is via dental radiographs.

**Uncomplicated Crown Fractures**

These are very common in large breed dogs. They occur when a piece of the crown is broken off, which exposes the dentin but not the pulp. Occasionally, these teeth can become infected through the dentinal tubules. Again, this infection will go undiagnosed without dental radiology. However, teeth with no to small pulpal exposures tend to be the ones with clinical abscession.

**Diagnosis**

First, perform a thorough visual exam to determine pulp exposure or other extensive damage. Next, use a dental explorer or small endodontic file to definitively rule out pulp exposure (any soft spot should be a suspect). Finally, expose a dental radiograph to rule out endodontic disease.

**Treatment**

If the dental radiographs are within normal limits, perform a bonded sealant (see below) and recheck radiographs in 9-12 months to ensure continued vitality.

If there is radiographic evidence of endodontic disease root canal therapy or extraction is indicated.

**Complicated crown fractures:**

Broken teeth are a very common problem in animal patients. As a matter of 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. 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 amongst clients and general practice veterinarians that this doesn’t hurt by the fact that the pet is eating just fine. In fact, many clients are told by their veterinarians to “watch it” or “it doesn’t bother him, wait until it abscesses”. The fact is, once the nerve is exposed, the tooth cannot heal itself and therefore requires therapy.

*Direct pulp exposure is initially excruciatingly painful for the pet. If it is not treated, the exposure will invariably result in pulp death, necrosis, and subsequent infection.*

Fractured and/or infected teeth do 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. However, most owners see a notable or even dramatic improvement in their pet’s attitude and energy level after therapy is provided. Because animal patients are typically much more stoic than humans, a lack of obvious signs of oral pain should not be misinterpreted as a benign state. It is typical for animals to continue to eat normally despite intense oral pain. Furthermore, after a broken tooth eventually dies and much of the associated pain subsides, the root canal system acts as a bacterial pathway, creating not only a local infection, but also allowing bacteria to spread systemically into the bloodstream. Bacteria
in the bloodstream 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; ignoring these teeth is NOT an option.*

**Treatment:**  
The treatment options for these teeth are vital pulp therapy, root canal therapy, or extraction. When properly performed, root canal or extraction should result in complete and lifelong resolution of pain and/or infection. There are advantages and disadvantages to each treatment option, and recommendations vary depending on which tooth is involved and the level of disease. We will discuss these treatment options and where indicated.

**Vital pulp therapy**
Vital pulp therapy (or pulp capping) is designed to keep the tooth alive by medicating and protecting it from the oral environment. This procedure involves steriley removing a small part of the coronal root canal (about 5-7 mm). After haemorrhage is controlled; a protective product called mineral trioxide aggregate is placed directly on the pulp. On top of this, a layer of glass ionomer restorative is placed on top of the MTA and light cured. This product bonds chemically to the dentin and gives an excellent bacterial seal. However, this is not a super strong restorative, and therefore, the final restoration is composite resin.

When performed within 48 hours this has an OK prognosis, but is still far less than standard root canal therapy. After 48 hours the prognosis becomes poor. For this reason, we do not use this procedure on mature teeth. However, for immature teeth it will keep the patient comfortable and the tooth alive long enough to accept root canal therapy. (See below) Note, this must be performed properly and immediately to have a chance of success. Even under ideal conditions, vital pulp therapy carries a lower prognosis than standard root canal therapy.

**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. When properly performed, this has an EXCELLNT long term prognosis and maintains the structure and function of the tooth. Further, this procedure is far less painful and has fewer complications than extraction, especially in regards to major (canine and carnassial) teeth. The lower canine teeth are specifically associated with jaw strength, which makes it optimal to avoid extraction of these teeth if possible. Although almost any tooth may be treated with root canal therapy, it is especially recommended for treating larger, strategic teeth.
**Extraction**

This involves complete removal of the tooth and its root(s). This is an important point, as only **complete** extraction will resolve the infection and retained roots are a very common complication with extractions. This is a good choice for small teeth, but large teeth should be saved. The advantages of extraction include decreased surgical time and expense (for smaller teeth), and this treatment option requires no long term follow-up.

**Conclusions:**

Fractured teeth are a very common condition in small animal veterinary patients. Therefore, a complete (as possible) conscious oral exam should be performed on **every** patient and a thorough oral exam and radiographs completed during every dental procedure. Finally, all fractured teeth with direct pulp exposure must be treated. Ideally, this would be root canal therapy (especially with strategic/large teeth), but complete extraction is also an acceptable means of therapy. In immature pets, vital pulp therapy can be performed to allow the tooth to mature for future root canal therapy.
Treatment recommendation flow chart

Uncomplicated crown fracture
  • Radiographic signs of infection
    o Root canal therapy
    o Extraction
  • No radiographic signs of infection
    o Bonded Sealant
    o Recheck radiograph 9-12 months

Recent CCF in mature tooth (over approximately 13 mo. of age)
  • Pain medication
    o No need for antibiotics
  • Root canal or extraction
    o Soon but not an emergency

Recent CCF in immature tooth (under 13 mo of age)
  • If client is committed to saving tooth
    o Vital pulp therapy (ASAP)
      ▪ Will likely require root canal in future
    o Pain Management
    o Antibiotics
  • If client is not committed to saving tooth
    o Extraction

Old CCF of a mature tooth (non-vital)
  • Root canal therapy or extraction
  • Not an emergency
  • No medications needed

Old fracture of an immature tooth (non-vital) tooth
  • Extraction is best option
  • If client is VERY committed to saving tooth, apexification can be attempted
  • No medications needed

Abscessed tooth
  • Antibiotics and pain medication
  • Root canal or extraction ASAP

Suggested readings:
Restorative dentistry for the general practitioner. (Niemiec BA Editor) Practical Veterinary Publishing, San Diego CA
Veterinary Endodontics: (Niemiec BA Editor) Practical Veterinary Publishing, San Diego CA
Dental Applications in Emergency Medicine and critical or compromised patients, (Niemiec BA Editor) Practical Veterinary Publishing, Tustin CA
Niemiec, BA: Dental Extractions made Easier, (Niemiec BA Editor) Practical Veterinary Publishing, San Diego CA

For educational videos of these pathologies please visit [www.dogbeachdentistry.com](http://www.dogbeachdentistry.com)
For hands on training in extractions and bonded sealants please visit [www.vetdentaltraining.com](http://www.vetdentaltraining.com).