Endodontics of dogs and cats: an alternative to extraction

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Introduction

A thorough clinical examination includes a detailed inspection of the oral cavity. Common conditions that a practitioner is presented with often include endodontically compromised teeth. Every week, patients will be seen with a fractured tooth, dental attrition, pulpal haemorrhage or some other cause of pulpal necrosis. Many of these conditions are a source of pain to the animal, and are often ignored by the owner or veterinarian. If ignored, these teeth will form an abscess, leading, in turn, to generalised systemic disease (Glick 1974). Extraction, usually, is not the only solution, because the teeth of small animals respond very well to endodontic treatment.

Endodontics is the branch of dentistry that deals with the prevention, diagnosis and treatment of conditions and injuries of the dental pulp and surrounding periapical tissues (Jensen and Serene 1984). The pulp, the internal core of the tooth, contains nerves, blood vessels, lymphatics and connective tissues (Emily and Tholen 1990). Endodontics, when compared with extraction, may be the quickest, easiest and least traumatic method of treating a tooth with pulpal disease. It enables the patient to maintain a full, healthy dentition, is more personally satisfying for the veterinarian and increases the number of services a practice may offer.

Many veterinarians have avoided performing advanced dental techniques, such as orthodontics, periodontics, and endodontics, but endodontics is a procedure that can be performed by most veterinarians in small animal practice (Holmstrom and Thomsen (1986). During the 1990s many clients will begin to request more sophisticated dental services for their pets.

This paper discusses the indications in dogs and cats for endodontic treatment, the equipment and materials required to perform endodontic procedures, the treatment of vital and non-vital teeth, surgical root canal therapy and complications of endodontic treatment.

Indications

Endodontic treatment may be required when the pulp is undergoing irreversible inflammation or is necrotic. Veterinary endodontics is concerned mainly with the treatment of infectious injuries due to fractured teeth (Holmstrom *et al* 1992). The pulp may be infected via trauma (Figure 1), attrition (Figure 2), caries, canine or feline odontoclastic resorptive lesions (cervical neck lesions) (Figure 3), periodontal disease (Figure 4), or anachoresis (localisation of bacteria from the bloodstream into the inflamed pulp) (Grossman 1988). The dental pulp may easily be injured by a concussive shock, such as a cricket bat or ball, or from continuous bone chewing or stick carrying (Goldstein and Anthony 1990). When the pulp is injured, it becomes inflamed (pulpitis) and swells (pulpal oedema) or haemorrhages (pulpal haemorrhage) (Goldstein and Anthony 1990). If a fracture has occurred, the pulp is bathed in saliva containing bacteria and becomes infected. This leads to an inflammatory pulpitis and oedema.

The innervation of a tooth is all sensory and all dental sensations are perceived as pain (Walton and Torebinejad 1989). Thus inflammation, oedema and haemorrhage resulting in pulpitis may result in pain. During acute pulpitis, the animal may show some or all of the following signs (Goldstein and Anthony 1990):

- Fever of unknown origin
- Pain on chewing
- Irritability/diminished appetite
- Selective rejection of hard food in the diet
- Picking up food, then dropping it
- Chewing on only one side of the mouth
- Sensitivity to hot/cold stimuli

Acute pulpitis is followed by a hyperplastic stage where the pulp swells and granulation tissue may form at the fracture site (Goldstein and Anthony 1990). If the trauma is severe and no treatment is given for the inflammation, pulpal strangulation (compartment syndrome) and death of the dental pulp will ensue. The result is liquefaction of the necrotic pulp, and escape of liquid through the apex. Bacteria penetrating the delta foramen may lead to a periapical granuloma and abscess formation. During these stages the signs may be more obvious and could be (Goldstein and Anthony 1990):

- coronal fracture with granulation tissue exposure
- pawing at the mouth
- rubbing the head/chin along the ground
- reluctance to be patted on the head
- excessive salivation
- pulpal discolouration
- maxillary/mandibular swelling
- draining tracts/sinuses

Thermal injuries to the pulp may occur when an animal undergoes an incorrectly performed dental procedure. Ultrasonic scalers vibrate at 25 000 - 40 000 Hertz, and will cause a rise in pulpal temperature of 2°C within ten seconds, if the scaling tip is not adequately cooled, not continuously moved over the tooth surface or left on the one tooth too long (Eisner 1992c). A polishing cup may cause thermal pulpitis if pressed too hard against the tooth or used with too little pumice. If sectioning a tooth or removing carious dentine, a dull bur or lack of cooling water may lead to acute pulpitis, especially if the bur is used within 1 mm of the pulp (Eisner 1992c).

Dogs that are chronic chewers of rock or bone or dogs that continuously chew their skin because of skin irritation may wear down their teeth, and due to stimulation or irritation of the odontoblasts that line the pulp cavity, a secondary dentine layer may be formed to protect the pulp. The secondary dentine is black or brown in colour, and if an explorer is drawn across the tooth, it should not enter the pulp. These teeth do not require root canal treatment, but the owners should be counselled on future dietary habits and the increased chance of tooth fracture. However, if the tooth is worn down at a faster rate than the secondary dentine is being produced, then the pulp may become exposed. These teeth will require either endodontics or extraction. With severe periodontal disease, bacteria may gain access to the pulp via the apical delta, infected cementum or lateral canals (RB Wiggs personal communication).

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Goals of Treatment

The goal of endodontic therapy is to recognise the conditions where the tooth may be injured or compromised, to stop the progression of disease and prevent further damage, and to enable the animal to maintain a healthy intact oral cavity.

An injured tooth generally has three phases, which can be seen by the colour of the tooth (Goldstein and Anthony 1990). An injured tooth first becomes pink because of haemorrhagic pulpitis when, as the dental tubules act as capillaries, the red blood cells travel into the tubules. The second colour phase is purple, the sign of a dying tooth. The blood cells break down into the individual components, changing the whole tooth colour. The third colour phase is grey, which indicates a dead tooth.

When the pulp dies, the tooth has not lost its whole blood supply; the periodontal tissues, alveolar bone, periodontal ligament and cementum retain their blood supply and continue to support the tooth in the alveolus (Williams 1986). For a tooth with pulpal death, the alternatives are endodontic therapy or extraction. Failure to treat or extract may lead to chronic pain and infection, or worse, a constant bacteraemia and major organ infection. If the tooth remains untreated, it will eventually abscess. This may be rapid, occurring within a month, or prolonged, taking several years (HB Lobprise personal communication).

Equipment and Materials

The proper endodontic instruments will allow decreased procedure time, less stress on the veterinarian and a better standard of therapy (Eisner 1992c).

Many fractures result in an open pulp canal, and access may be achieved through this opening. In cases of slab fracture involving the carnassial tooth, accidental iatrogenic pulp exposure or pulpal haemorrhage, there may be an indication where drills are needed to gain access to the pulp chamber (Anthony 1991a; Holmstrom *et al* 1992).

Electric handpieces operate between 25 000 and 120 000 rpm, require no air compressor, produce more torque for cutting than air-driven systems, but produce more heat, which may damage the pulp (Eisner 1992c).

The air-driven drills are run by either compressed air, carbon dioxide or nitrogen gas. They are usually supplied as a dental cart comprising ultrasonic and subsonic scalers, high speed and low speed hand pieces and a water/air triplex. It is also possible to obtain a light curing hand piece to attach to the cart. The air-driven units operate high speed hand pieces at 300 000 to 400 000 rpm but also run slow speed handpieces at 25 000 rpm (Eisner 1992c). The high speed drill requires a cooling water jet to cool the bur and rinse away the debris. It is possible to adapt fibre-optics to these handpieces.

Radiographic machines are an essential part of competent veterinary dentistry (Wiggs 1992). Treatment planning is made easier with radiographs and comparisons may be made if follow-up radiographs are taken. It is useful to acquire both periapical and occlusal intra-oral radiographic films for use with cats and dogs. It is generally easier to position these smaller films within the mouth.

The following instruments are necessary for diagnosis and access to the pulp: a sharp metal explorer, a good light source and carbide cutting burs (Eisner 1992c; Wiggs 1991a). Burs are used if the tooth is intact and an opening for access needs to be drilled. They can also be used when the tooth has been fractured, as the aim is to achieve a straight line from the access opening to the apex. This, of course, is not always possible. So a direct line, where the instruments pass through the root canal without touching the walls until the first curve of the canal, is attempted (Walton and Torebinejad 1989).

A barbed broach is a piece of straight wire with barbs designed for removing intact pulp (Krell 1989; Buchanan 1991; Wiggs 1991b). It may be inserted into the apical area of the root, rotated allowing the barbs to engage the pulp, and withdrawn, bringing the pulp with it (Wiggs 1991b). Broaches may bind to the dentine wall if forced; they are fragile and thus easily broken.

Endodontic files and reamers may also be used to remove pulp, but are mainly used to clean and debride the pulp canal walls, removing necrotic tissue and debris, thus shaping the dentine walls for the filling materials (Buchanan 1991; Wiggs 1991a). Reamers, K-files and H-files are pieces of metal manufactured to provide cutting edges (Krell 1989; Holmstrom *et al* 1992).

Files are available in 21-30 mm lengths (human) or 55-60 mm lengths (veterinary). It is necessary to have both lengths. Files are assigned a number from 0 to 140. Manufacturers have endeavoured to standardise endodontic instruments and root filling (obturation) materials so that there will be uniformity of size, taper and length (Anon 1976, 1982a, b). The diameter of the instrument in tenths of a millimetre at the tip, determines its number in the standardised system, that is, a 100 file is 1 mm in diameter at the tip. The colour code on the handle allows easy identification (Krell 1989).

The smaller files are used first, and should precede the larger ones in strict numerical order. The H-files are weaker than K-files or reamers, thus they can only be used in a push-pull, in-out manner (Wiggs 1991b). As well as the push-pull motion, K-files and reamers can also be used by being rotated clockwise and pulled upwards, thus enhancing their cutting action (Holmstrom *et al* 1992).

Gates-Glidden burs are long shank, slow speed cutting burs in sizes 1-6 starting at 0.5 mm at the tip and increasing in size 0.2 mm. Thus a number 1 is equivalent to a size 50 file, whereas a number 2 would be equivalent to size 70 file. The Gates-Glidden bur has a blunt end so it travels along the length of the root canal and decreases the chances of perforation through the wall. They are used to debride the coronal access canal walls (Krell 1989).

Irrigation is used between files to remove debris and disinfect the pulp canal during treatment. Many products have been used, including sodium hypochlorite, hydrogen peroxide and saline. The solutions used depend on personal preference. Hypochlorite is the most universally accepted irrigant (P Emily personal communication). It aids in dissolution of organic debris and in the destruction of bacteria (Abou-Ross and Piccinino 1982). Ethylenediamine tetraacetic acid (EDTA) can be used to chelate and soften inorganic debris by demineralising the dentine wall (Stewart *et al* 1969; Buchanan 1991). It may be placed on the files or injected into the canal.

Absorbent paper points are used to dry the canal after filing and flushing is complete. They are available in various lengths and either fine, medium or course sizes. They are used once and discarded.

Root canal sealers can be placed into a number of categories: the eugenol-based, calcium hydroxide, glass ionomers and the resins. The eugenol-based sealer is prepared by mixing eugenol, an essential oil and zinc oxide, a white powder, into a sticky liquid. It can be mixed on a glass mixing slab and either injected via needle and syringe, or spun via a spiral filler, into the canal. Zinc oxide/eugenol (ZnOE) is the most commonly used sealer in veterinary endodontics (Eisner 1992b). It provides a long working time, is non-irritating, anti-bacterial, and lasts five to eight years in a root canal (Tholen 1983). Calcium hydroxide may also be used as a sealer within the canal (CA Williams personal communication). It can also be used to stimulate apical closure and as a liner for pulp protection under permanent restorations. In a vital tooth, it irritates and stimulates the odontoblasts to produce secondary dentine (Tronstad *et al* 1981; Rossman *et al* 1985). Calcium hydroxide is alkaline and is anti-bacterial. Resin sealers can be used with gutta percha to provide rapid setting, usually within minutes, and a very good apical seal, but they are very difficult to remove if re-obturation is necessary (Eisner 1992c). Glass ionomer is very new as a sealer and there are few data on its success at present. Glass ionomers bond very well to dentine, thus providing an excellent apical seal, but would be almost impossible to remove if re-obturation is needed.

Gutta percha is the most popular core material for obturation (filling) (Eisner 1992b). Gutta percha is a rubber-based material and is available in varying sizes and lengths. When used with a sealer, such as ZnOE or calcium hydroxide, gutta percha provides excellent obturation, removing voids in the canal and provides an apical seal

that prevents bacteria from entering the pulp canal. When gutta percha is used, hand instruments called spreaders and pluggers are needed. A plugger is used for vertical compaction, whereas a spreader is used to compress the gutta percha laterally. Thermoplasticised gutta percha is also available. A canula of gutta percha is heated and then, with the use of a handgun, the liquid gutta percha is injected into the root canal (Golden 1993). The canulas come in lengths that for most veterinary endodontics are too short, making the procedure very frustrating and time-consuming.

After the root canal has been obturated, intermediate restorative materials can be used between the root canal sealer and final restoration. These provide a firm base and added support for the final restoration. They also add a sandwich layer between two materials, such as ZnOE and composite, because composite will not harden in the presence of eugenol. There are many types of intermediate restoratives: zinc phosphate, IRM, glass ionomer and calcium hydroxide. Zinc phosphate is used with composite and may be used in non-vital teeth. IRM is a ZnOE preparation; it would be contraindicated when composite is used, but works well under amalgam. Glass ionomers are obtainable as a powder/liquid mix, are more expensive than zinc phosphate and IRM, but are recommended because they bond to the exposed dentine, providing a very good hermetic seal against bacteria entering the tooth. They can be acid-etched, which gives the composite a better hold on the tooth. Calcium hydroxide may be used as a base if the pulp is exposed or when only a thin layer of dentine overlies the pulp.

Final (surface) restoratives are those that can be used to restore the endodontic access site and restore the tooth both aesthetically and functionally. Amalgam is a metal alloy, is exceptionally strong, needs mechanical retention using an undercut, and requires equipment and hand instruments to be used efficiently (Bradford 1992). Composite materials are available as both self-cure and light-cure. The self-cure composites are inexpensive, easy to use but have a finite working time. The light-cure composites require a curing light, which is expensive, but give the operator an infinite working time. The newer composites are also able to bond to the dentine and enamel (Bradford 1992).

A temporary filling may be used if the access site needs to be covered for a period of two to four weeks. It sets on contact with saliva and can be easily removed on subsequent treatments.

Endodontic Procedures

There are a number of different endodontic procedures; which one is selected depends on the individual circumstances. Selection depends on the duration or severity of the injury, the stage of the tooth's development, the type of tooth, the owner's desires and the veterinarian's ability.

In a tooth with recent pulp exposure, the purpose of endodontic treatment is to preserve the vital pulp. The procedures available include:

- apexogenesis
- vital pulpotomy
- direct pulp capping

In a tooth with a lesion that has not exposed the pulp but is very close, the one procedure available is indirect pulp capping.

If the pulp is severely infected or necrotic, the aim is to remove the entire pulp, clean the canal and seal a sterile and functional tooth. The procedures available include:

- apexification
- standard root canal therapy (pulpectomy)
- apicoectomy (surgical root canal therapy)

The affected tooth should be radiographed (Wiggs 1992). The use of the bisecting angle technique (Klippert 1993) (Figure 5) and intra-oral film will aid the veterinarian in diagnosis (Gorrel 1993), detection of complications and in obtaining the working length for standard root canal therapy (Holmstrom and Thomsen 1986) (Figure 6).

Deciduous Teeth

The deciduous teeth of dogs and cats are replaced early in life, thus the only procedure that, generally, can be recommended is extraction (Clarke and Lobprise (1994).

Apexification

Immature adult teeth have wide pulp canals, thin-shelled dentine walls and open apices (Figure 7). The procedure on these teeth depends on whether or not the pulp is still vital. In non-vital immature adult teeth, the purpose is to stimulate apical closure, and fill and seal a clean and functional tooth. Apexification does this (Chawla 1986; Eisner 1992a) (Figure 8). Apexification requires removal of the entire necrotic pulp, followed by cleaning, irrigating, drying and filling the canal with calcium hydroxide paste. Initially, the working length needs to be determined by radiography. The length of the root canal is measured from the initial radiograph (Figure 6)

In the case of a fractured tooth, access to the pulp may be via the fracture site (Holmstrom *et al* 1992). In the cases of avulsion, acute pulpitis, pulpal haemorrhage, combined periodontic-endodontic disease or trauma without fracture, a high speed handpiece and round diamond or tungsten carbide bur can be used to gain access (Anthony 1991a; Holmstrom *et al* 1992) (Figure 9). Preparation for access depends on the tooth involved, but is generally over the pulp floor (Manfra Marretta *et al* 1993). The aim is to obtain a direct line between the site of access and the root apex (Walton and Torebinajad 1989). The site of access on the canine tooth is 3 mm coronal to the gingival margin on the mesial surface of the tooth.

A file is placed into the canal to the pre-measured working length and the tooth radiographed again to ensure the file has not penetrated the apex. If the file is at the apex, a rubber stopper is placed on the file to measure this depth. The stopper can then be placed at this length on subsequent files to avoid over-instrumentation of the canal (Bramante and Berbert 1974). This length is called the working length. Canal preparation is begun using this file, which should be worked in and out of the the canal with gentle finger pressure against the canal wall. This action removes necrotic dentine from the canal wall. The entire circumference of the root canal should be debrided. The canal is flushed with sterile saline between files (Figure 10). Saline is preferred to sodium hypochlorite, because apical extrusion of hypochlorite can cause severe pain (Becker *et al* 1974; Wiggs 1991b). The next size file is selected based on increasing file size, and the procedure repeated until the dentine walls are clean. The canal is then dried with sterile paper points (Figure 11), and filled with calcium hydroxide paste. The calcium hydroxide encourages apical closure (Tronstad *et al* 1981; Rossman *et al* 1985). Usually, within 3 to 6 months of apexification, radiographs should be taken to confirm apical closure. If necessary, a standard root canal procedure may now be performed (Eisner 1992a), but generally, a single procedure using calcium hydroxide is satisfactory (Chawla 1986).

Vital Pulpotomy Procedures

Immature adult teeth with vital pulps, very recent fractures of mature adult teeth, and accidental iatrogenic exposure of the pulp may require a vital pulpotomy procedure (Figure 12). In immature adult teeth, the procedure is called apexogenesis, where the preservation of vital pulp allows the tooth to obtain normal length and root apex closure (Torneck 1986; Grossman 1988). The pulp at the site of exposure should appear healthy and bleed on sterile probing. If the exposure is iatrogenic, the procedure is termed direct pulp capping (Eisner 1992a), and the tooth should be washed with copious amounts of sterile saline and bleeding stopped with gentle pressure with a sterile cotton pledget or a blunt-ended absorbent paper point.

Once the bleeding has stopped, a dressing of calcium hydroxide is placed and then a surface restorative used over this. Direct pulp capping is the procedure of choice for disarming dogs when all four canine teeth are reduced in height to the level of the adjacent incisors. It may also be used for base narrow canine conditions, in which the permanent canine teeth are lingually displaced and, if left untreated, damage soft or hard tissue resulting in a traumatic ulcer on the hard palate or oro-nasal fistula.

Recent Pulp Exposure — Mature Teeth

When the pulp has been recently exposed in mature adult teeth, then a vital pulpotomy can be performed (Bellows 1992). Pulpotomy is the removal of the coronal portion of the pulp, and offers a quicker alternative to pulpectomy and leaves the tooth with a vital, healthy pulp. The coronal portion of the pulp is removed using a sterile bur or curette. Access may be gained via the fracture site. The pulp is removed down to healthy pulp with space for medications, the pulp canal is irrigated with copious amounts of sterile saline and allowed to dry.

Haemostasis is difficult to achieve in healthy pulps, but can be obtained with gentle pressure using a sterile cotton pledget or blunt-ended absorbent paper point for a few minutes. If the bleeding persists once the paper point is removed, then more pulp should be removed and pressure re-applied. If bleeding continues for longer than 5 to 6 min, then the pulp may be irreversibly inflamed and a complete pulpectomy is needed. Once the bleeding has stopped, a thin 1 mm layer of calcium hydroxide powder is placed over the pulp to encourage formation of a secondary dentinal bridge. Hard-setting calcium hydroxide paste is gently applied over the powder to a thickness of 2 mm. ZnOE or glass ionomer may then be used as a sandwich layer before placement of the final restorative. The tooth then needs six-monthly radiographs to check for apical abcessation or root resorption.

Indirect Pulp Capping

Indirect pulp capping (Eisner 1992a) is a procedure performed when a fracture, carious lesion, or canine or feline resorptive neck lesion has not penetrated the pulp but is very close (Emily 1986; Eisner 1992a) (Figure 13). The lesion must be debrided, flushed with sterile water and allowed to dry. A thin layer of calcium hydroxide is then placed in the cavity to act as an antiseptic as well as stimulating and irritating the pulp to produce secondary dentine. This provides a thicker protection for the underlying pulp. However, calcium hydroxide alone has insufficient strength and a sandwich layer must be used under the final restorative.

If the defect being restored is a carious molar then either composite or amalgam may be used to restore the tooth. If the defect is a canine or feline odontoclastic resorptive lesion then glass ionomer may be used to restore the tooth. Glass ionomer releases fluoride into the area to strengthen the tooth, to reduce sensitivity and is antibacterial. Radiographs must be taken before a resorptive lesion is restored to rule out internal resorption and check the condition of the tooth roots and supporting bone. Internal resorption, tooth root damage or lack of tooth support are contra-indications for restoration.

Antibiotics

Endodontic procedures are usually performed on teeth compromised by infection or potential infection. Therefore the protocol should be to use broad spectrum antibiotics, achieve a therapeutic blood concentration at the time of surgery, and continue the medication for 7 to 10 days post-operatively (Eisner 1992c). Amoxycillin/clavulanic acid combination or clindamycin would be good choices of antibiotic (Harvey 1993).

Standard Root Canal Therapy

Standard root canal therapy is indicated for mature adult teeth with long-standing infections, and teeth that are discoloured or dead or have periapical abcessation. Standard root canal therapy involves

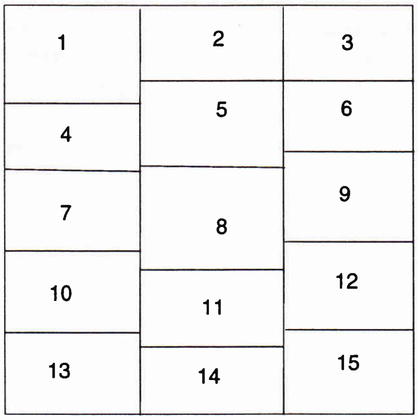


Figure 1. Coronal fracture (arrow) of the upper lateral incisor tooth has exposed the pulp canal with resultant pulpal exposure and granulation tissue formation at the fracture site.

Figure 2. Attrition of the lower fourth pre-molar tooth has exposed the pulp canal, as shown by the black necrotic pulp tissue and access of the explorer into the pulp canal.

Figure 3. Odontoclastic resorptive lesions in a cat. Upper third pre-molar tooth on the buccal surface shows enamel defect at the gingival margin (arrow).

Figure 4. Periodontal disease. Upper right fourth pre-molar and first molar are covered in plaque and calculus (short thick arrow). The cranial root of the molar tooth shows pus formation (long thin arrow), gingival oedema (long thick arrow), gingival recession and epithelial attachment loss (short thicker arrow), allowing apical extension of plaque to occur with resultant abscess formation and possibly pulpal involvement.

Figure 5. Bisecting angle radiograph technique.

Figure 6. Measuring the root canal from the initial radiograph to determine the working length. In this case, the working length would be 23 mm.

Figure 7. Immature adult teeth in a 15-month-old cat. Note the wide root canal, the thin dentine walls and the wide open apex.

Figure 8. Apexification.

Figure 9. Access preparation. In most teeth, the access point is over the pulp floor. For the canine tooth, the access in on the mesial surface, about 3 mm coronal to the gingival margin.

Figure 10. Irrigating the root canal between files using a 20 mL syringe and 27 g needle.

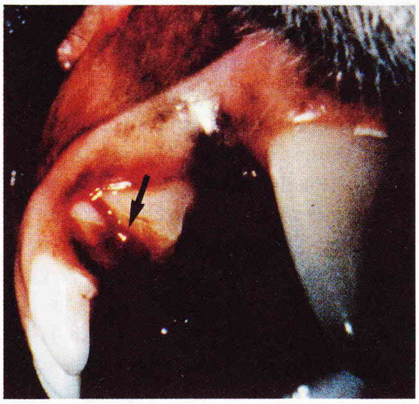
Figure 11. Drying the canal using a sterile absorbent paper point and endodontic forceps.

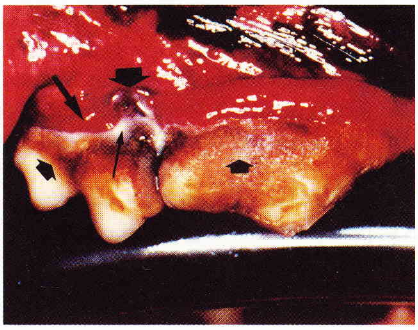
Figure 12. Vital pulpotomy procedure. Calcium hydroxide is firstly placed against the exposed pulp tissue, followed by an intermediate layer, usually a glass ionomer, and final restoration, using composite or amalgam.

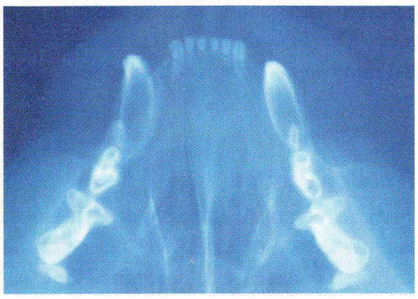
Figure 13. Indirect pulp capping procedure. When the pulp is close to being exposed, it is protected by using a calcium hydroxide liner, onto which a hard restorative, such as composite or amalgam, is placed.

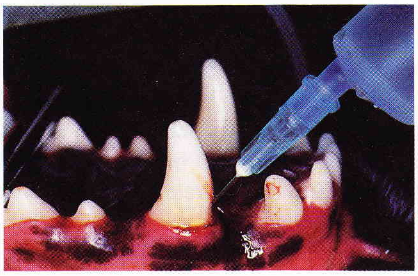
Figure 14. When obturation is finished, there are many gutta points protruding from the access opening or fracture site.

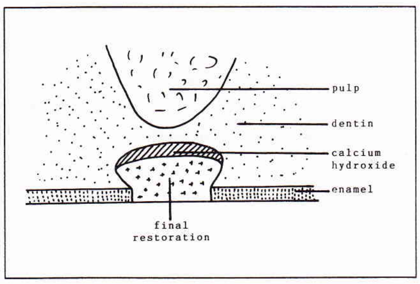
Figure 15. The radiograph of this canine tooth shows the apical root canal filled completely using a mixture of zinc oxide and eugenol. Note there are no air bubbles or voids present.







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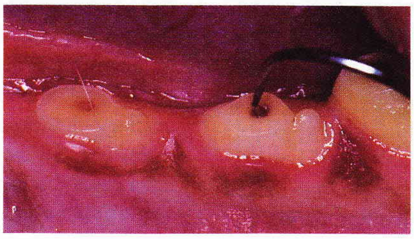

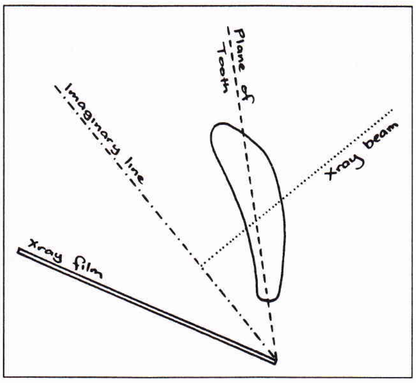
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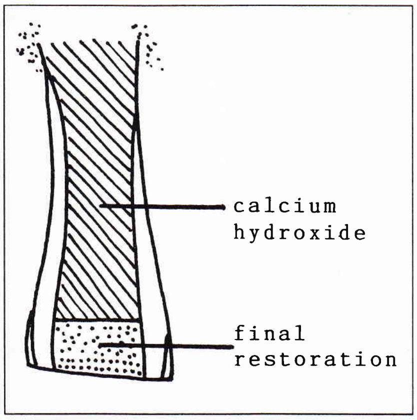
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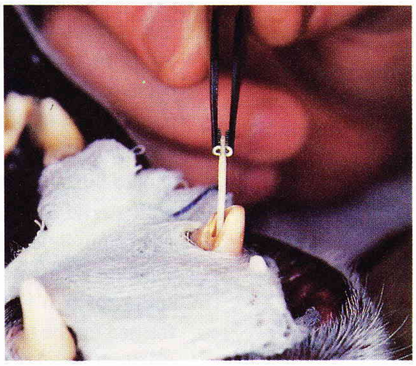
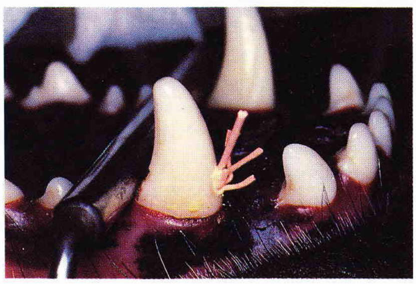
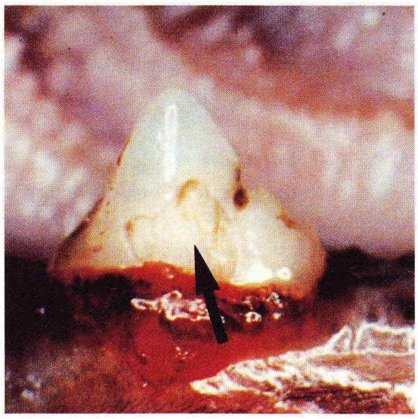
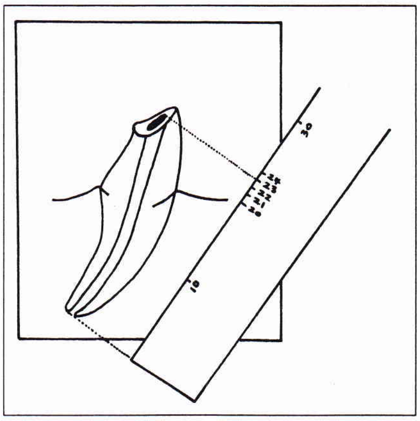
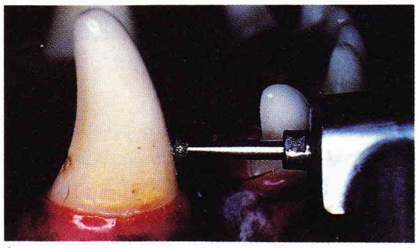
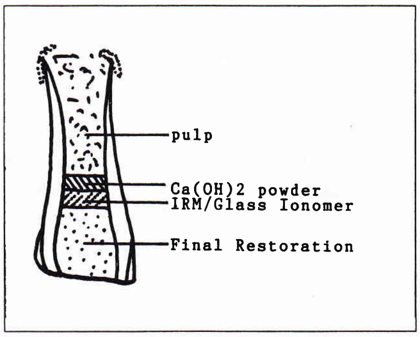


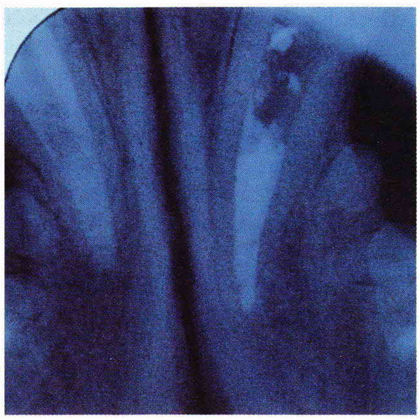









pulp
Ca(OH)2 powder
IRM/Glass Ionomer
Final Restoration



gaining access to the pulp canal, removal of all the pulp tissue, debridement and shaping of the root canal. It is then sterilised, dried and filled with a canal sealer and core material and a final restorative placed (Wiggs 1991a).

Access Preparation

Access to the pulp may be obtained by either using a high speed handpiece and round diamond or tungsten carbide bur, or via the fracture site, as has been described for apexification.

Debridement

Debriding the canal begins by obtaining the working length of the canal by radiography and the working length of files as has been described for apexification.The end of the file needs to be within 1 mm of the apex to clean the canal thoroughly (Taintor *et al* 1979). Having established the working length, barbed broaches may be used to remove most of the pulp (Walton and Torabinejad 1989). The broach is advanced, rotated to engage the pulp and then withdrawn (Wiggs 1991b).

Canal debridement is begun by selecting a file of appropriate size and, via the access site, working the file in and out with pressure against the dentine walls, shaving infected dentine with each stroke (Buchanan 1991). The file is held between forefinger and thumb. If, from the initial radiograph, the root canal is curved, it may be necessary to bend a file before use to negotiate the curved canal (Buchanan 1991). This is done to prevent ledging and gouging during filing. The selected file is used to debride the entire circumference of the canal walls. Once this has been completed and the file no longer binds in the apical portion of the canal, it is removed. The dentine shavings are usually brown, grey or black at the beginning of the procedure. Between files, the pulp canal is flushed using hydrogen peroxide, sodium hypochorite or saline (Figure 10). The next file is selected, based on increasing file size, and the procedure repeated. Files and reamers are used in strict increasing numerical order.

The process of introducing progressively larger files and flushing the canal continues until clean, white dentine shavings are removed on two successive sized files (Wiggs 1991a). Recapitulation with a smaller file at the end is necessary. This involves using a small size file that can access the apical area and is used to clean the apex of any debris or dentine shavings and chips (Anthony 1991a; Buchanan 1991).

Drying

After debridement, the canal must be dried to accept the filling material. This is achieved be using a syringe and needle to aspirate any remaining irrigation fluid followed by absorbent paper points until the canal is dry (Holmstrom *et al* 1992) (Figure 11). Air should not be directed straight down the canal, as this may force air emboli through the apex (Rickles and Joshi 1963).

Obturation

Once dry, the canal can be obturated using a root canal sealer and a filling material. The easiest material to begin using is a creamy mixture of zinc oxide and eugenol without any core material. This can be injected into the canal using a syringe and needle or spun down the canal with a spiral filler. Injecting the mixture into the canal requires a wide canal and it is sometimes difficult to avoid air bubbles getting trapped at the apex. After obturation, the tooth is checked radiographically to ensure that the apex is sealed and the canal is filled.

Gutta percha is the filling material of choice used by human endodontists (P Emily personal communication). It is relatively easy to work with, is radio-opaque and has a long life within the root canal. It is an excellent canal filler, but must be used in combination with a sealer. A small amount of sealer can be spun into the canal or the gutta percha can be dipped in the sealer and inserted down the canal (Holmstrom *et al* 1992). The first gutta percha point selected should be the same size as the last endodontic file used. This aims to provide a good seal in the apical third of the canal (Hennet 1990). The gutta percha is condensed laterally, using a spreader, which helps push the sealer into any lateral canals (Holmstrom 1991; Nguyen 1991). In most cases the canal is wider coronally and cannot be filled with a single gutta percha point (the master cone). To laterally condense the gutta percha, a spreader is pushed down the canal next to the gutta percha. Once condensed, this leaves space so that another gutta percha point can be inserted. The spreader is inserted again and another gutta percha point placed. This is repeated many times. When finished, there are many points sticking out of the top of the canal (Figure 14).

A radiograph is then taken to ensure good apical seal and canal fill (Figure 15). If deemed successful gutta percha points are cut off with a hot instrument (Holmstrom and Thomsen 1986) and the canal is sealed with a final restorative. It may be best to use a glass ionomer, because it provides a good hermetic seal against bacteria and bonds to the dentine, and then a composite or amalgam. If obturation has been performed with ZnOE, a layer of glass ionomer will be needed under composite as the oil in the eugenol will interfere with the setting of the composite.

It is most important that the tooth is radiographed after twelve months to check for signs of periapical pathology (Anthony 1991b).

Surgical Root Canal Therapy

Apicoectomy (retrograde root canal therapy) may be indicated when standard root canal therapy has failed (Eisner 1992a). When there is facial swelling or fistula formation, an apicoectomy may be necessary. Apicoectomy is used infrequently in small animals, but has a high degree of success. The procedure involves access to the apex via the bone, surgical removal of the apical tip and retrograde filling.

Tooth Avulsion

Tooth avulsion may be partial or complete. If the upper canine tooth is partially avulsed, the animal should be examined under general anaesthetic and if the tooth can be replaced, a suture around the tooth and through the gingiva (inter-dental wiring technique) can help support it until endodontic therapy is instigated. When the tooth has been completely avulsed, the owner should be advised to place it in saliva or milk (Courts *et al* 1983). Tap water should be avoided because the pH and osmolarity devitalises the periodontal ligament (Lindskog and Blomlof 1982). Excessive handling and dehydration are the tooth's worst enemy. On arrival at the surgery, the animal should be anaesthetised, and the tooth and alveolus irrigated gently with sterile saline. The periodontal ligament should be preserved where possible. The tooth should be replaced in the alveolus and secured with inter-dental sutures or a wire-reinforced, acid-etch splint for two to three weeks (Harvey 1985). All procedures performed on the tooth while the tooth is out of the mouth are inappropriate (Chamberlain and Goerig 1980). Avulsed teeth typically undergo pulpal necrosis, therefore an endodontic procedure (usually pulpectomy and obturation using calcium hydroxide) should be performed fourteen days after avulsion (Henry and Jerrell 1987; Trope *et al* 1992). The use of calcium hydroxide reduces periapical inflammation and the incidence of inflammatory resorption and ankylosis (Andreasen 1981). Incisors that have been avulsed may be replaced as described before, followed by stabilisation using a wire-reinforced acid-etch splint for two to three weeks. If the teeth are non-vital then standard root canal treatment using ZnOE and gutta percha will allow the best chance of survival. All animals that undergo dental avulsion require antibiotic prophylaxis.

Complications

Gouging (Torebinejad 1989) – Gouging occurs when the bur within the pulp canal enters the dentine wall during access preparation. Treatment is to redirect the bur and smooth the wall with a file. The canal wall needs to be checked by radiography for perforation. Gouging of the wall may be repaired by restorative material such as composite.

Furcation perforation (Montgomery 1985; Torabinejad 1989) – Furcation perforation occurs when the bur travels through the canal wall of a multi-rooted tooth during canal preparation or when attempting to locate the orifices of canals. The perforation must be sealed or the tooth extracted.

Ledging (Weine *et al* 1975; Torabinejad 1989) – Ledging occurs when the tip of the file scores the side of the pulp canal wall and forms a ledge. Once the ledge is formed it is very difficult to manoeuvre the file past it, thus the apical portion of the root does not get debrided and the root canal may fail. Treatment may then include the use of precurved files, otherwise extraction or apicoectomy will be necessary.

Root perforation (Torabinejad 1989) – Root perforation occurs when the file is pushed through the apex. This may injure the periapical tissues. Subsequent infection or inflammation may be difficult to control. It is easily done if the apex has not closed and radiographs have not been taken. Treatment is to establish a new working length, create an apical stop and obturate the canal to its proper length. The master cone should fit snugly in the apical portion of the canal.

Broken file tips (Torabinejad 1989) – Breaks may occur if files are excessively rotated in the canal, thin files are fatigued or the operator is impatient. Root canal cutting instruments should be examined frequently, and if the cutting edges appear dull or the shaft is bent, the instrument should be discarded. It may be possible to retrieve a broken file with a barbed broach or by using a smaller sized file.

Calcified canals – In old dogs and cats it may be difficult to fully instrument the canal due to a calcified bridge or a pulpal stone (Tamse *et al* 1982). Filing the canal to the level of the ridge or as close to the apex as possible can be done, with some degree of success.

Vertical tooth fracture (Torabinejad 1989) – A vertical fracture allows bacteria to enter the canal. Thus extraction is the only option.

Underfilling of the root canal (Torabinejad 1989) – Underfilling is obturation of the root canal short of the apex. A radiograph may show a canal filled shorter than it was instrumented. Because of debris in the unfilled portion, the procedure may fail. The filling material should be removed and re-obturated.

Overfilling (Torabinejad 1989) – Overfilling usually involves extrusion of filling material beyond the apex. This causes tissue damage and inflammation. The apical delta will usually prevent overfilling. The prognosis depends on the apical seal and the degree of inflammation. Canals filled to the apex or short of the apex have a better prognosis than those that are overfilled (Martin *et al* 1982).

Conclusion

Endodontic procedures are the preferred alternative to surgical extraction when the pulp of a tooth is compromised. Root canal therapy is a procedure that may be performed by veterinarians, and owners will begin to ask and expect their veterinarian to be able to complete or otherwise refer their pets for this service. Endodontic therapy is a safe treatment that maintains the dentition of dogs and cats, is personally satisfying for the veterinarian and increases the revenue and services that a good practice may offer.

References

Abou-Ross M and Piccinino MU (1982) *Oral Surg* **54**:323

Andreasen JO (1981) *J Endodont* **7**:245

Anon (1976) *J Am Dent Assoc* **93**:813

Anon (1982a) *J Am Dent Assoc* **104**:506

Anon (1982b) *J Am Dent Assoc* **104**:888

Anthony J (1991a) *Academy Veterinary Dentistry/American Veterinary Dental College Proceedings* p 123

Anthony J (1991b) *J Vet Dent* **8**:24

Becker GL, Cohen S and Borer R (1974) *Oral Surg Oral Med Oral Pathol* **38**:633

Bellows J (1992) *Vet Pract* **4**:1

Bradford P (1992) *Aust Vet Assoc Dent Proc*, p 31

Bramante CL and Berbert A (1974) *Oral Surg* **37**:463

Buchanan LS (1991) In *Pathways to the Pulp*, 5th edn, edited by Cohen S and Burns RC, Mosby Year Book, St Louis, p 166

Chamberlain J and Goerig A (1980) *J Am Dent Assoc* **101**:471

Chawla HS (1986) *J Dent Child* **1**:44

Clarke DE and Lobprise HB (1994) *Aust Vet Pract* **24**:203

Courts F, Mueller W and Tabeling H (1983) *Paediatr Dentistry* **5**:183

Eisner E (1992a) *Vet Med* **5**:418

Eisner E (1992b) *Vet Med* **5**:435

Eisner E (1992c) *Vet Med* **5**:450

Emily P (1986) *Vet Clin North Am* **16**:895

Emily P and Tholen M (1990) In *Small Animal Oral Medicine and Surgery*, edited by Bojrab M M and Tholen M, Lea & Febiger, Philadelphia, p 158

Glick DH (1974) *Dent Clin North Am* **18**:233

Golden AL (1993) *Academy Veterinary Dentistry/American Veterinary Dental College Proceedings*, p 65

Goldstein GS and Anthony J (1990) *Compend Contin Educ Pract Vet* **12**:2

Gorrel C (1993) *Academy Veterinary Dentistry/American Veterinary Dental College Proceedings*, p 69

Grossman LI (1988) *Endodontic Practice*, 11th edn, Lea and Febiger, Philadelphia, p 234

Harvey CE (1985) *Veterinary Dentistry*, Saunders, Philadelphia, p 79

Harvey CE (1993) *Academy Veterinary Dentistry/American Veterinary Dental College Proceedings*, p 175

Hennet P (1990) *Academy Veterinary Dentistry/American Veterinary Dental College Proceedings*, p 145

Henry RJ and Jerrell RG (1987) *Compend Contin Educ Dent* **11**:346

Holstrom SE and Thomsen K (1986) *Calif Vet* **6**:18

Holmstrom (1991) *Eastern States Veterinary Conference Proceedings*

Holmstrom SE, Frost P and Gammon RL (1992) In *Veterinary Dental Techniques*, Saunders, Philadelphia, p 207

Jensen JR and Serene TP (1984) In *Fundamentals of Clinical Endodontics*, 8th edn, edited by Jensen JR and Serene TP, Kendall Hunt Publishing, Dubuque, p 1

Klippert L (1993) *Academy Veterinary Dentistry/American Veterinary Dental College Proceedings*, p 147

Krell KV (1989) In *Principles and Practice of Endodontics*, edited by Walton RE and Torabinejad M, Saunders, Philadelphia p 145

Lindskog S and Blomlof L (1982) *Acta Odontol Scand* **40**:435

Manfra Marretta S, Golab G and Klippert L (1993) *Academy Veterinary Dentistry American Veterinary Dental College Proceedings*, p 106

Martin RL, Gilbert B and Dickersonn AW (1982) *Oral Surg* **54**:668

Montgomery S (1985) *J Endodont* **11**:257

Nguyen NT (1991) In *Pathways to the Pulp*, 5th edn, edited by Cohen S and Burns RC, Mosby Year Book, St Louis, p 183

Rickles NH and Joshi BA (1963) *J Am Dent Assoc* **647**:397

Rossman LR, Garber DA and Harvey CE (1985) In *Veterinary Dentistry*, edited by Harvey CE, Saunders, Philadelphia, p 79

Stewart G, Kapsimalis P and Rappaport H (1969) *J Am Dent Assoc* **78**:335

Taintor J, Biesterfeld R and Valle G (1979) *Dent Surg* **3**:54

Tamse A, Kaffe I, Littner MM and Shani R (1982) *J Endodont* **8**:81

Tholen MA (1983) In *Concepts in Veterinary Dentistry*, Veterinary Medicine Publishing, Lenexa, p 114

Torabinejad M (1989) In *Principles and Practice of Endodontics*, edited by Walton RE and Torabinejad M, Saunders, Philadelphia, p 295

Torneck CD (1986) In *Current Treatment in Dental Practice*, edited by Levine N, Saunders, Philadelphia, p 170

Tronstad L, Anreasen J and Hasselgren G (1981) *J Endodont* **7**:17

Trope M, Yesilsoy C, Koren L, Moshonov J and Fiedman S (1992) *J Endodont* **18**:492

Walton RE and Torabinejad M (1989) In *Principles and Practice of Endodontics*, edited by Walton RE and Torabinejad M, Saunders, Philadelphia

Weine F, Kelly R and Lio P (1975) *J Endodont* **1**:255

Wiggs RB (1991a) *Eastern States Veterinary Conference Proceedings*, p

Wiggs RB (1991b) *J Vet Dent* **8**:4

Wiggs RB (1992) *North Am Vet Conf Proc*, p 106

Williams CA (1986) *Am Anim Hosp Assoc Proc*, p 143

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