Root Canal Therapy for Fracture-Induced Endodontic Disease in the Dog

K.E. Queck, DVM*
C.L. Runyon, DVM, MS**

Introduction

Endodontics is a division of veterinary dentistry that deals with pathologic conditions of the tooth pulp. Endodontic disease occurs whenever viable pump tissue is exposed and becomes infected. It is a common sequela to tooth fractures, and occurs less frequently following dental decay and severe periodontal disease. It is the second most common disease in the oral cavity of companion animals.[5]

Endodontic therapy is undertaken to salvage the undamaged portion of an infected tooth. Procedures used include root canal debridement and pulpotomies. In the past, endodontic therapy was performed only on an experimental basis in valuable zoo animals and guard dogs, since few veterinarians possessed either the training or equipment to routinely perform the procedures. However, as more veterinarians gain expertise in this field, endodontic therapy will become a viable option to tooth extraction for the average household pet.

The most frequent endodontic problem presented to the veterinary practitioner is a fractured tooth with subsequent pulpal damage. This article will review the pathogenesis, diagnosis, and treatment of this common problem in the dog.

Dental Anatomy

The mature canine tooth is divided into two parts: the crown, which projects above the gumline and is used for mastication, and the root, which lies within the alveolar bone of the jaw and anchors the tooth in place. On cross section, each tooth is also made up of three layers: an inner layer of pulp tissue, an intermediate dentinal layer, and an outer layer of enamel or cementum (Figure 1). The inner pulp tissue consists of nerves, vessels, and arteries which provide sensory and metabolic function to the interior of the teeth. Connective tissue is also present to support the root's functional cells, the odontoblasts. The odontoblasts line the pulp chamber walls, and produce a substance known as dentin. Dentin acts to separate, buffer, and protect the tooth from harmful external stimuli.[1]

External to the dentin lies enamel (on the crown) or cementum (covering the tooth). Enamel, composed of 96% inorganic material, is the hardest substance in the body. It functions to completely cover and protect the dentin from external exposure. In contrast, cementum, a softer substance of only 50% inorganic material, functions as a bony lattice to which fibers of the periodontal ligament attach, firmly suspending the tooth in the alveolar socket.[2,3]

At the root apex, the pulp tissue narrows and divides into numerous small branches. This region is known as the apical delta, and may contain between five and fifty branches of the pulpal nerve.[4] This area is especially important to evaluate prior to endodontic therapy, since apical abscesses nearly always develop following pulpal death.[5]

Disease

Endodontic disease is caused primarily by trauma-induced fractures of the teeth, which expose vital pulp tissue and allow bacterial invasion. Less often, caries and/or severe peridontal disease with exposure of the root apex may also lead to decay.[6,7,8,9]

The pathogenesis of endodontic disease is shown in the Figure 2. Whenever the pulp tissue is exposed, a pulpitis develops, followed by periapical abscess formation. Ninety-percent of the cases lead to periodontal ligament and alveolar bone destruction, and eventually tooth avulsion. Only ten perdent of the cases develop into oral-nasal fistulas which chronically drain.

*Dr. Queck is a 1986 graduate of the College of Veterinary Medicine at Iowa State University.
**Dr. Runyon is an assistant professor at the Atlantic Veterinary College, University of PEI, Charlottetown, Prince Edward Island, Canada.

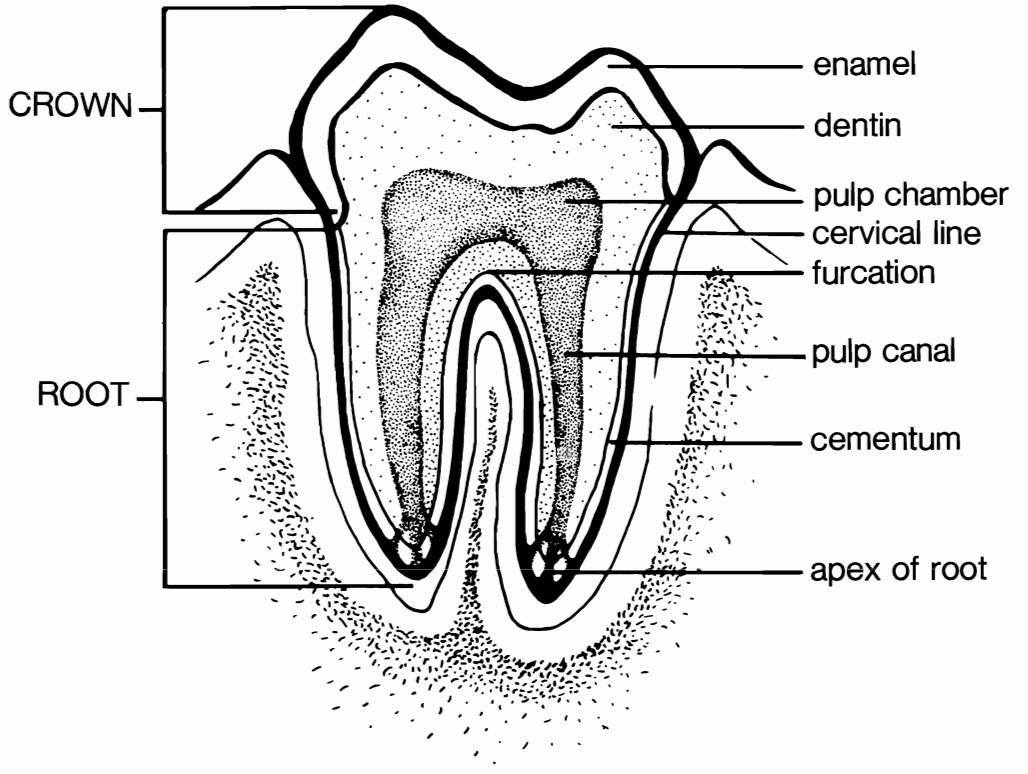

FIGURE 1: Normal anatomy of a multi-rooted tooth in the dog.[2]

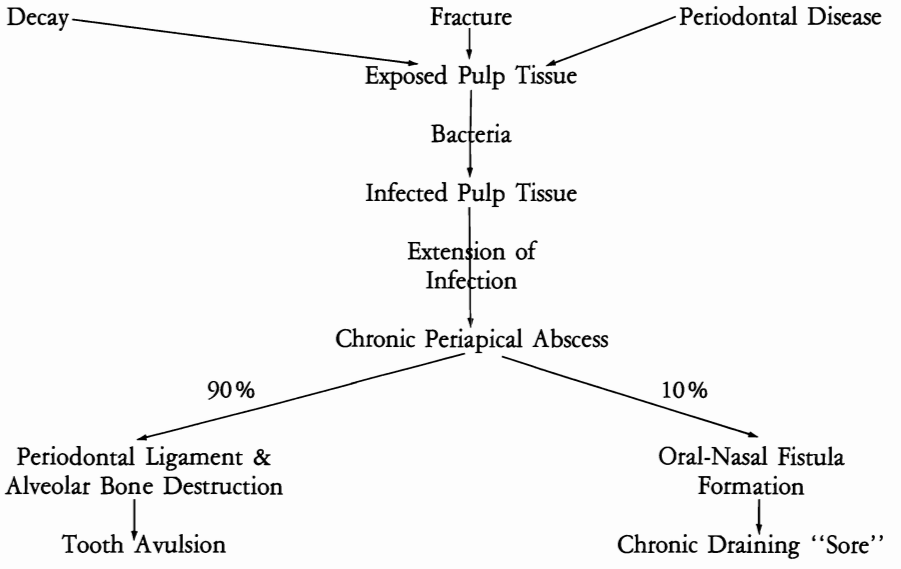

FIGURE 2: Pathogenesis of endodontic disease in the dog.

Diagnosis

Diagnosis of endodontic disease is difficult since animals rarely will show signs associated with exposed nerve endings and subsequent pulpal infection.[10] Signs seen are associated with pulpal pain, and include favoring one side of the mouth when chewing, rubbing the mouth with the paws, lethargy, and fever. A reluctance to retrieve objects by obedience-trained dogs may also be noticed. However, these subjective signs of endodontic disease disappear as the pulpal nerve tissues become more devitalized and unable to respond, and the pain diminishes.[7,9]

Cross changes from endodontic disease may also be present. Externally, swelling, abscesses, and oral-nasal fistulas may be evident. On oral exam, pulp tissue vitality can be evaluated by the color of the dentin over the end of the pulp chamber or the translucent characteristics of the tooth.[1] If the pulp tissue is black, it has been exposed for a long period of time and is necrotic. If the pulp tissue is red or pink, exposure has occurred more recently and pulpal death will follow within the next six to eighteen months. If the end of the pulp chamber is tan or brown in color, the tooth has successfully protected the pulp tissue by secondary dentin deposition, and will remain vital. A pinkish transluscent hue to the enamel is indicative of pulpal hemorrhage, while pulpal devitalization will give the tooth a dull gray color.

Radiographically, endodontic disease can be diagnosed by examining the region of the pulp apex. Radiolucency around one or more of the root tips indicates an abscess or a cystic process is occurring secondary to pulp exposure and infection.[11] One author feels that pulpal death always results in apical abscess formation, so that radiography is a reliable means for endodontic disease diagnosis.[5] However, in the early stages of abscess formation bony changes are not radiographically evident, so a diagnosis of endodontic disease cannot be eliminated on the basis of negative radiographic findings.[12]

Treatment

The goal of endodontic therapy is to preserve a dead, but functional tooth that will last throughout the animal's lifetime.[13] This is achieved by removing all infected pulp tissue, disinfecting the pulp canal, and filling the pulp chamber so that both the apex and crown are effectively sealed. If traumatic exposure of the pulp has just occurred and the animal is immediately presented for treatment, a pulpotomy (partial endodontic therapy) can be considered. If the pulp tissue has been chronically exposed and is infected, full endodontic therapy in the form of a root canal, with or without an apicoectomy, is indicated. Endodontic therapy is contraindicated if complete fracture lines are present in the tooth root, or in recently erupted teeth with wide apical ends. In these types of teeth it is difficult to obtain a complete filling seal, and tooth extraction is indicated.[4]

Materials & Methods

For endodontic therapy, canine patients are placed in a surgical plane of anesthesia using inhalant anesthetics. A cuffed endotracheal tube is used to prevent aspiration pneumonia, and a rolled towel is placed under the animal's neck to ventrally position the muzzle and facilitate drainage. Prophylactic bacteriocidal antibiotics are recommended for use if the tooth is infected or if ultrasonic cleaning will accompany the treatment.[12]

Instruments and materials needed for endodontic therapy include: (1) dental drill with a low-speed handpiece; (2) suction apparatus; (3) endodontic files, 55mm in length, sizes #10 through #140; (4) dental burs: round, inverted cone, fissure, and bone; (5) retrograde amalgam carrier and amalgam plugger; (6) silver alloy pellets, mercury, and amalgamator; (7) zinc oxide and eugenol paste; (8) solutions of calcium hydroxide, 2.5% sodium hypochlorite, 3% hydrogen peroxide, and sterile saline; (9) scalpel and blade; (10) paper, cotton, or gutta percha points; and (11) 1:50,000 epinephrine /saline solution.

Prior to endodontic therapy, the affected tooth should be cleaned of excessive calculus and plaque. Many veterinarians ultrasonically clean all of the teeth and rinse the mouth with a dilute antiseptic solution, before proceeding. The environment can never be made surgically sterile due to the resident bacterial population, but it can be cleaned up considerably by following this procedure.

Full Endodontic Treatment

All endodontic treatment procedures require adequate access to the pulp canal. In incisor teeth, the fracture site provides ready access to the pulp tissue, and all endodontic procedures are carried out through this site. An additional access site is needed in canine teeth, since the extremely long, curved roots make complete filing difficult. The extra access site is made near the gingiva on the affected tooth's rostal margin. In multi-rooted teeth, an additional hole is made near the buccal gingiva. This allows access to the pulp canal of each individual

root. The veterinarian can then completely file, disinfect, and fill each root without having to remove a large portion of the tooth crown.

Access holes are created with a low-speed handpiece and dental drill. The handpiece operates at 0-30,000 rpm, is powered on compressed air or electricity, and is cooled by a continuous stream of water. These handpieces are preferred over the high-speed handpieces (which operate at speeds in excess of 250,000 rpm) because they are easier to control and create fewer complications.[14]

The burs used to create access holes are made of either carbide or steel. Carbide burs are recommended because they are stiffer and stronger than steel burs, and do not dull or rust as rapidly as steel.[14] A round bur is generally used for making endodontic access holes, while an inverted cone bur is useful for sealing amalgam fillings. Bone and fissure burs are used for penetrating bone and removing pieces of tissue (Figure 3).

Once access to the pulp canal is gained, the pulp tissue is mechanically removed from the tooth by hand. Endodontic files 55mm in length are inserted into the access sites, rotated clockwise until they are seated snugly within the canal, and then removed using gentle traction and no rotation (Figure 4). The smallest diameter file, a #10, is used to start the preparation. Successively larger files are used until only white dentinal shavings are drawn out of the pulp canal. During the filing procedure, the canal is flushed with 3% hydrogen peroxide, sterile saline, and 2.5% sodium hypochlorite solutions. The hydrogen peroxide and saline flushes mechanically remove debris from within the pulp chamber and lubricate the chamber walls, making it easier to file the canal. The sodium hypochlorite dissolves organic tissue and is used as a final rinse to neutralize the peroxide flushes, preventing oxygen liberation in the periapical tissues and a resultant emphysema.[13] The canal is dried with sterile paper or cotton points, and is ready to be filled and sealed.

There are two primary methods used for filling and sealing a root canal. No longterm follow-up studies have been done comparing the two procedures in the dog; however, both are used frequently and with high degrees of success.[13]

The first technique involves insertion of gutta percha cones into the root canal to obturate dead space. The cones are dipped in root canal sealer or cement, then compressed into the canal using a root canal spreader. The gutta percha filling is covered with dental cement, and the crown is restored using amalgam or composite material (Figure 5). This procedure is preferred by some veterinary dentists because the filling can be removed easily if any corrections or retreatments are required.[13] Also, the gutta percha filling does not dissolve in oral fluids, and is well tolerated by adjacent tissues. However, the quality and durability of the apical seal using gutta percha cones has been questioned.[18]

The second method of filling the pulp canal utilizes root canal cement only. A mixture of zinc oxide and eugenol paste (Tubli-seal[b]) is injected

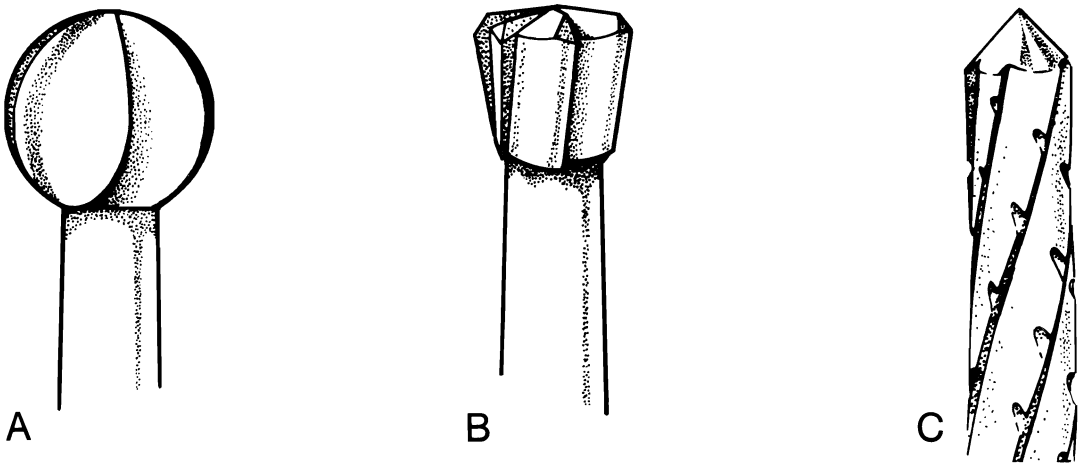

FIGURE 3: Endodontic burs. A, Rosehead (Round) Bur; B, Inverted Cone Bur; and C, Fissure Bur.[17]

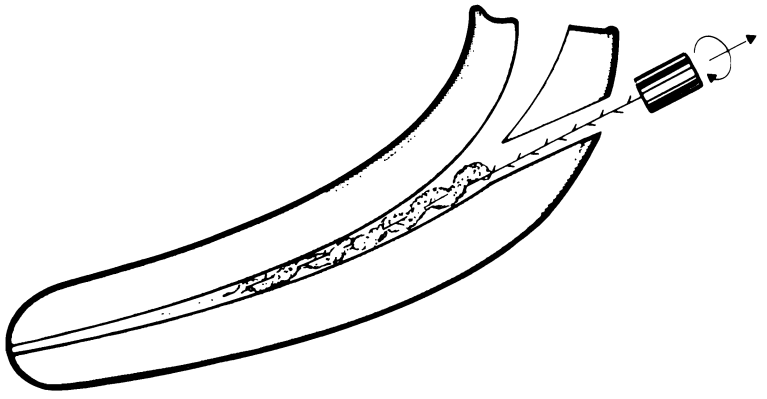

FIGURE 4: Extirpation of pulp tissue using a #10 endodontic file.[17]

slowly into the pulp canal using a 3-ml syringe and a 20-gauge needle. The needle is gradually withdrawn as the pulp canal is filled. Any air bubbles present in the cement are removed by passing cotton points into the canal and forcing the filling material to the pulp apex. Care must be taken not to push medicament past the root apex, as this may cause irritation and require surgical intervention later in the form of an apicoectomy.[8] Once the root canal filling has hardened, an inverted cone bur is used to carve a seat in the access site for an amalgam cap. A lip in the dentin is made to retain the amalgam and to insure a hermetic seal at the apex.[15]

Amalgam is a dental restorative material used for sealing root canals and restoring crowns. Its alloy is composed of silver, tin, copper, and zinc. Mercury is combined with the alloy in an amalgamator, which activates the alloy and converts it into the more familiar silver filling.[16] After the amalgamation process, the silver amalgam is pliable for only three to five minutes, so the veterinarian must work quickly to place the amalgam cap. The soft amalgam mixture is placed in the root canal preparation using an amalgam carrier, then packed tight with an amalgam condenser and firm hand pressure. It is imperative that the filling site be dry during the procedure to prevent filling loss.

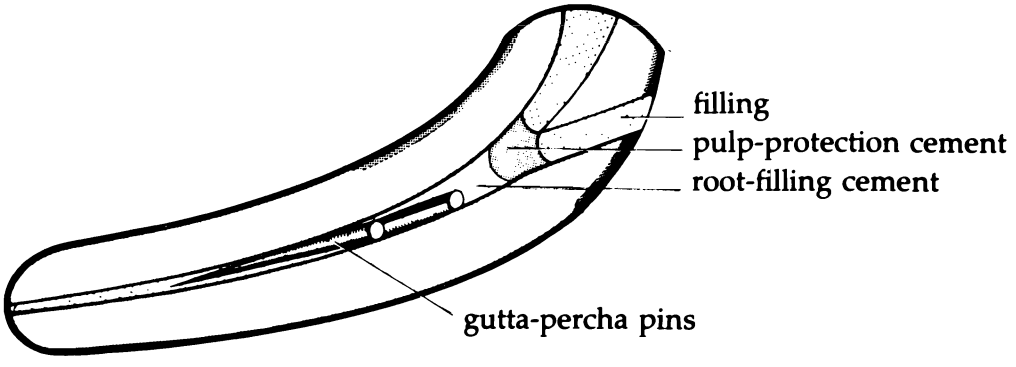

FIGURE 5: Technique using gutta-percha pins to fill a root canal. [17]

Apicoectomy

In fractured canine teeth, an apicoectomy is done in addition to the root canal.[4] An apicoectomy is the surgical exposure and removal of the root apex. This procedure enables the veterinarian to remove all necrotic apical pulp tissue which is inaccessible with endodontic files, due to the excessive length and curvature of the canine pulp canal. It has been suggested that a 20-30% failure rate can be expected three years after canine root canal therapy is done if an apicoectomy is not performed.[4,17] Therefore, most veterinary dentists include this procedure in their standard endodontic therapy for canine teeth.

The approach for an apicoectomy in the maxilla and mandible varies due to anatomic differences. The apex of the upper canine tooth is found directly above the first premolar and on the convexity caused by the underlying tooth.[11] A lateral approach is used in this tooth. Access to the apex of the lower canine tooth is from a ventral approach, since the middle mental foramen is lateral to the tooth. The apex is usually found around 6mm lateral to the posterior limit of the mandibular symphysis.[11]

For a maxillary canine tooth apicoectomy, an 8mm eliptical incision is made in the gingiva overlying the root apex (Figure 6). Periosteum is elevat-

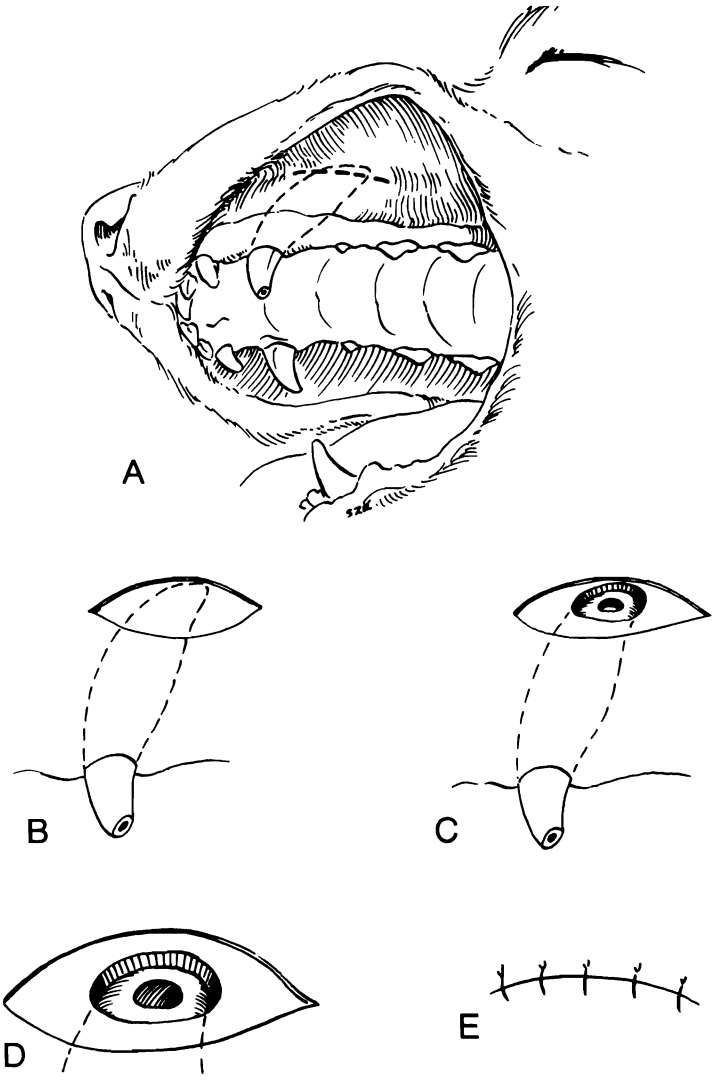

FIGURE 6: Apicoectomy of an upper canine tooth. A & B, A gingival flap is created over the root apex using a scalpel and blade; C, Bone overlying the root and the apex of the root are removed using a fissure bur; D, The apicoectomy site is sealed off from the environment using an amalgam seal.[13]

ed to produce a gingival flap, and hemorrhage is controlled by local infiltration of a 1:50,000 solution of epinephrine to saline. A bone bur and low-speed drill are used to remove maxillary bone. Necrotic apical root tissue is curretted out or removed using a fissure bur. Proper technique requires removal of 3-4mm of root tip.[18] The root canal is disinfected and dried, and the pulp apex access site is sealed with amalgam. After the amalgam has hardened, the gingival flap is sutured closed, and the remainder of the root canal is filled in a retrograde manner using zinc oxide and eugenol paste. Amalgam is also used to seal the crown access site.

The approach to a mandibular canine is a two inch incision along the ventral border of the mandible, with the center of the incision overlying the posterior margin of the mandibular symphysis.[19] Periosteum is elevated laterally and medially, and a bone bur is used to remove mandibular bone. The ideal access point is determined by evaluating a radiograph taken with an endodontic file placed in the root canal.[18] The root apex is removed by using the bone bur or curettage, and filled in a retrograde manner as described previously.

Post-operatively, minimal care is required. The degree of intraoperative hemostasis determines the amount of post-operative swelling, which is usually minimal. Dogs resume normal mastication as soon as the anesthetic has worn off. Antibiotics are usually unnecessary, as infections are rare.[18]

Treatment of Multi-rooted Teeth

Access to the roots of multi-rooted teeth in dogs may require removal of a large part of the crown.[13] Endodontic therapy is made easier by amputating the smaller roots. In maxillary fourth premolars, the short mesial palatal root is amputated. Failure of endodontic therapy in this tooth usually occurs because the veterinarian was unable to get a complete seal on the end of the mesial root.[16] After the root is removed, the defect is sealed with an amalgam restoration, and the remainder of the tooth is filled using zinc oxide and eugenol paste.

Pulpotomy

If an animal is available for treatment immediately following traumatic exposure of the tooth pulp, a pulpotomy can be considered. In this procedure, the pulp is removed only from the crown portion of the tooth. Calcium hydroxide paste is placed

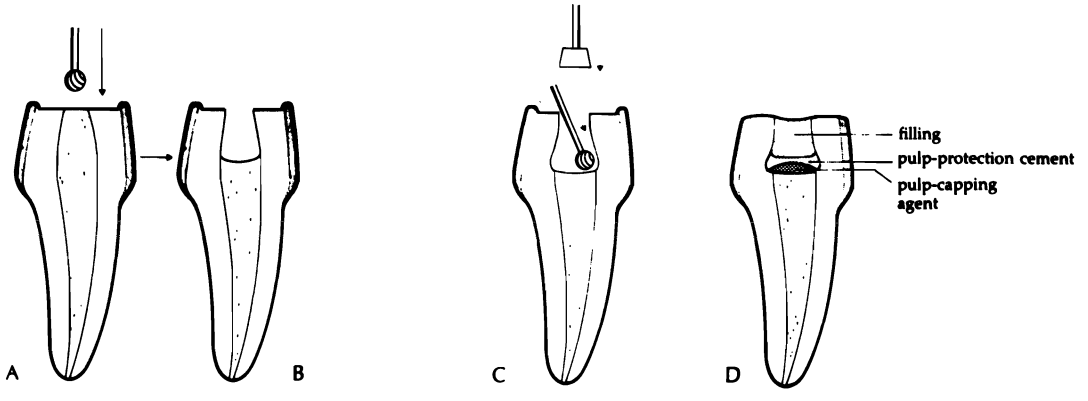

FIGURE 7: Schematic view of a pulpotomy. A, Tooth prior to treatment; B, Removal of superficially injured pulp; C, Enlargement of the preparation using an inverted cone bur and a rosehead bur; and D, Sealing the pulp canal.[17]

over the remaining pulp tissue, followed by a zinc oxide and eugenol dental cement. A seal of dental amalgam is placed in the crown defect (Figure 7). A longterm failure rate of 20% has been reported using this technique in dogs.[13] In contrast, full endodontic therapy takes only a few minutes longer and is less likely to fail. The advantage of a pulpotomy is its potential use in immature animals, since it may permit continued tooth development.[13]

Summary

The importance of maintaining a complete, functional set of teeth in the dog cannot be overemphasized. A dog's teeth are essential not only for food prehension and mastication, but also for protection, personal hygiene, and for grasping and moving objects (i.e. puppies, balls, and unconscious people). Unnecessary extraction or avulsion of portions of the canine dentition serves only to reduce the dog's functional capacity.

The usefulness of working dogs is greatly reduced by tooth loss and infection. Hunting breeds which readily retrieve game are often unwilling to carry the prey in their mouths due to the pain.[9] A loss of teeth in trained guard dogs and common watchdogs renders them ineffective, since they rely on their teeth to be physical and psychological weapons.[18] More commonly, a reduction in overall stamina of the dog is seen, which may nearly incapacitate a herding, tracking, or racing dog.

The health status and longevity of the dogs with endodontic disease is also compromised.[18] A low-grade tooth infection severly stresses the body's immune system by exposing it to bacteria and toxic by-products for prolonged periods of time. This increased stress on the body leads to poor health, lethargy, and fatigue. In addition, a spread of infection to other sites in the body can also occur, causing secondary infections of the organs that may jeopardize the animals's life. Stabilization of fractured or infected teeth is also desirable from a cosmetic and aesthetic viewpoint. Show dogs and breeding animals must appear healthy and well-cared for if they are to bring recognition to their owners. No one is interested in purchasing an animal that has dental disease. In the same way, pet owners want their dogs to look and smell nice so that they are pleasant to be around. If the dogs have signs of dental disease such as halitosis, excessive salivation, and teeth which are discolored, broken, or missing, there is no incentive for the owner to spend time with them.

Because endodontic therapy for animals is becoming more popular and economical, there is no reason for a dog to suffer for long periods of time from endodontic disease. Root canal procedures are relatively painless for the animal, and easy to perform if the veterinarian has the proper equipment, minimal training, and patience. The success rate of root canal therapy in the dog is high, with authors reporting success rates of 80% to 100%. An increased number of veterinary dental books, articles, and equipment is also available to help the practitioner get into the field of dentistry. In addition, owners are beginning to request endodontic therapy for their dogs.

Client education and prophylactic dental treatment should go hand-in-hand with endodontic therapy. Biannual check-ups and ultrasonic tooth cleaning are very useful in the prevention and early detection of dental disease. Informational pamphlets about periodontal disease and diet help inform the client about potential dental problems. Regular cleaning of the dog's teeth using a toothbrush or cloth and baking soda will also allow the client to get involved in their pet's dental care.

Because of the excellent endodontic procedures available, endodontic therapy in the form of tooth extraction should be used only as a last resort. Preservation of a complete, healthy set of teeth in the dog should always be a primary goal.

REFERENCES

1. Ross DL: The oral cavity. In: Theran P. (ed): Diseases of the gastrointestinal system. *Current Veterinary Therapy VI: Small Animal Practice.* Philadelphia: WB Saunders. pp. 921-924. 1977.
2. Tholen M: Veterinary restorative dentistry — 1: basic principles. *VMSAC.* 78(12):1875-1880. 1983.
3. Dorn AS: Dentistry in the geriatric dog. In: Brace JJ (ed.): *The Veterinary Clinics of North America: Small Animal Practice.* Vol II, No. 4. Philadelphia: WB Saunders. pp. 689-704. 1981.
4. Ross DL. Canine endodontic therapy. *JAVMA* 180:356-357. 1982.
5. Colmery BH: Dentistry. In: Bojrab JM (ed.): Pathophysiology in Small Animal Surgery. Philadelphia: Lea & Febiger. pp. 78-83. 1981.
6. Colmery BH: Dental techniques. In: Frost P, Richards LW. (eds.): General Small Animal Surgery. Philadelphia: JB Lippincott. pp. 1043-1046. 1985.
7. Harvey CE: Diseases of oral cavity and pharynx. In: Slatter DH (ed.): *Textbook of Small Animal Surgery.* Vol I. Philadelphia: WB Saunders. pp. 611-615. 1985.
8. Shagam EV: Step by step endodontic techniques in exotic animal dentistry. In: Fowler ME (ed.): *Proceedings — 1983 Annual Meeting AAZV, Tampa, FL.* pp. 11-13. 1983.
9. Ross DL: Veterinary dentistry. In: Ettinger SJ (ed.): *Textbook of Veterinary Internal Medicine.* Philadelphia: WB Saunders. pp. 1059-1062. 1975.
10. Frost P: Canine dentistry — a compendium. Day Communications. pp. 46-51. 1985.

11. Ramy CT, Sergreto VA: Apicoectomy and root canal therapy for exposed pulp canal in the dog. *JAVMA.* 150:977-983. 1967.
12. Tholen MA: Endodontic therapy. In: *Concepts in veterinary dentistry.* Edwardsville KS: Veterinary Medicine Publishing Co. pp. 114-133. 1983.
13. Rossman LE, Garber DA, Harvey CE: Disorders of teeth. In: *Veterinary dentistry.* Philadelphia: WB Saunders. pp. 86-93. 1985.
14. Tholen MA: Veterinary restorative dentistry — 2: cavity preparation. *VMSAC.* 79(1):73-82. 1984
15. Lawer DR: Root canal with retrograde amalgam filling. *Cal Vet.* 33:11-15. 1979.
16. Tholen MA: Veterinary restorative dentistry — 4: restorative materials. *VMSAC.* 79(3): 351-356. 1984.
17. Eisenmenger E, Zetner K: Tooth fracture and alveolar fracture. In: *Veterinary dentistry.* Philadelphia: Lea & Febiger. pp. 83-103. 1985.
18. Ross DL, Myers JW: Endodontic therapy for canine teeth in the dog. *JAVMA.* 157:1713-1718. 1970.