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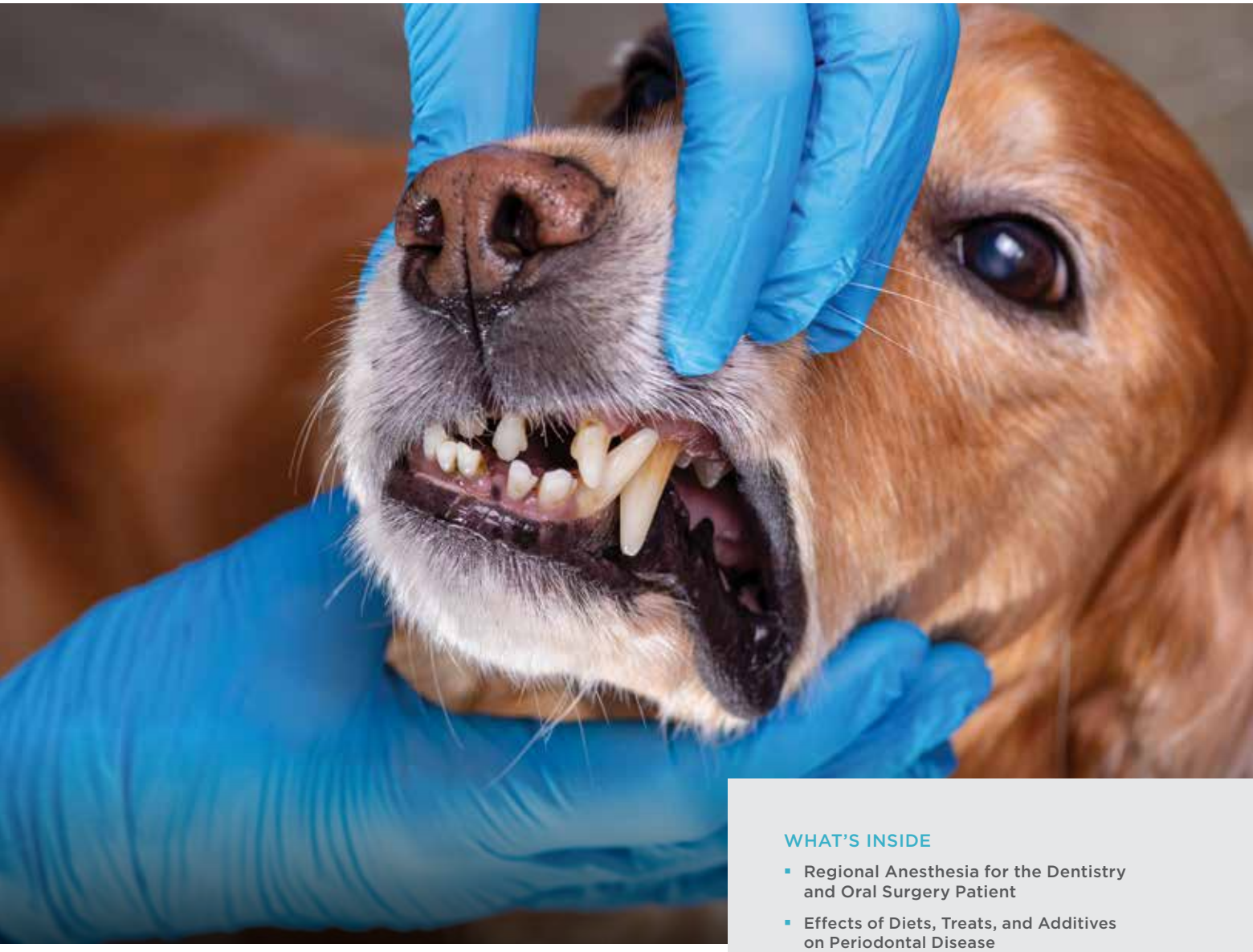
Issues in Dentistry



WHAT'S INSIDE

- Regional Anesthesia for the Dentistry and Oral Surgery Patient
- Effects of Diets, Treats, and Additives on Periodontal Disease
- Tooth Extraction Complications in Dogs and Cats
- Current Concepts in Periodontal Disease
- Treating Periodontal Disease in General Practice

A SUPPLEMENT TO

TVP
TODAY'S VETERINARY PRACTICE

Regional Anesthesia for the Dentistry and Oral Surgery Patient

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For most canine and feline patients, dental cleanings and thorough evaluation of the oral cavity is recommended at least annually.[1] For these patients, general anesthesia is required for an accurate assessment of the health of the oral cavity and for a thorough performance of dental cleaning.[1,2] According to the 2013 American Animal Hospital Association Dental Care Guidelines for Dogs and Cats, general anesthesia with a secured airway is necessary for proper assessment and treatment of canine and feline patients.[1]

However, general anesthesia in veterinary patients is not to be taken lightly. Clients have significant concerns and anxiety when thinking about their pets being placed under general anesthesia.

As practitioners, to help reduce the incidence of anesthetic-related complications, we should perform an accurate presurgical/preanesthetic assessment of each patient. A thorough physical examination, baseline screenings, and appropriate diagnostic testing to identify any underlying conditions will help us optimize the condition of the patient before the procedure.

In addition, we should consider adding regional anesthesia to the anesthetic protocol. Regional anesthesia decreases the patient's dependence on general anesthesia, which benefits both the patient and the practitioner. This article emphasizes the benefits and describes the drugs and techniques involved in proper administration of regional anesthesia.

ASSESSING PAIN

As veterinarians, we do not have the luxury of asking our patients if they are experiencing pain. However, the International Association for the Study of Pain states that the inability to communicate pain does not necessarily negate the possibility that pain is being experienced.[3] Dogs and cats with dental disease experience

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When a regional anesthetic drug is injected into canine and feline patients, it is imperative that the administrator first aspirate the syringe to avoid inadvertent intravenous injection.

discomfort that the client and general practitioner may not appreciate. According to the 2015 American Animal Hospital Association/American Association of Feline Practitioner Pain Management Guidelines for Dogs and Cats, an animal's inability to self-report pain and discomfort leaves the assessment and recognition of pain with the veterinary professional.[4] According to a 2014 survey of veterinary surgeons in the United Kingdom, among the top 3 perceived common causes of chronic pain in their patients was dental disease.[5] This pain may not be appreciated by the practitioner or client until after the disease has been treated and the patient has resumed its prepain normal behavioral activities.[4]

WHAT IS PAIN?

As described by the International Association for the Study of Pain, pain is a sensory or emotional stimulus associated with actual or apparent tissue trauma that is perceived as unpleasant.[6] The purpose of pain is to elicit a reaction from the body to prevent additional damage to the affected area. Response to a painful stimulus can range from hyperalgesia, an exaggerated response to a stimulus normally perceived as painful,[7] to allodynia, a painful response to a stimulus that is not normally perceived as painful.[7] When pain is incurred for an extended duration, central sensitization (windup) can occur. This response occurs when the associated neurons repeatedly fire at a lower than normal threshold[8] and is commonly seen in patients suffering from chronic oral pain (e.g., severe periodontal disease).[9]

When tissue is injured, the painful response is recognized by the central nervous system through a process called **nociception**. Recognition and processing of the painful stimulus occur in 4 steps: transduction, transmission, modulation and perception.[10]

1. **Transduction** is the transformation of energy from a painful stimulus into nerve impulses by pain receptors.[10] Transduction can be inhibited by multimodal pain-relieving methods (e.g., use of local anesthetics, nonsteroidal anti-inflammatory drugs, and opioids).[11]
2. **Transmission** is the movement of nerve impulses to the spinal cord and then to the brain.[10] This process can be inhibited by use of local anesthetics, opioids, and alpha-2 agonists.
3. **Modulation** is the transmission of the painful stimulus at the spinal cord to be transmitted to the brain as pain or to inhibit further transmission to the brain.[10]
4. **Perception** is the method by which impulses are recognized as pain.[10] Perception can be inhibited by administering opioids, alpha-2 agonists, anesthetics, and inhalants.[11]

Ideally, multimodal pain management techniques should be used to try to lessen the amount of general anesthesia that is needed for a given procedure. For dentistry and oral surgery, one of the most effective ways to help block a painful stimulus is to use regional anesthesia.

REGIONAL ANESTHESIA

For the dentistry and oral surgery patient, regional anesthesia can eliminate transduction and transmission, thereby decreasing pain perception and central sensitization.[11] A study conducted in 2013 found that

TABLE 1. Drugs Used for Regional Anesthesia

DRUG	CONCENTRATIONS	ONSET	DURATION OF ACTION	PREFERRED DOSE, DOGS	PREFERRED DOSE, CATS
Lidocaine	2%	Within 5 minutes	60-120 minutes	2 mg/kg	1 mg/kg
Bupivacaine	0.25%, 0.5%, 0.75%	8-30 minutes	4-10 hours	2 mg/kg	2 mg (4 quadrant block at 0.5 mg/quadrant)

use of regional anesthesia reduced the minimum alveolar concentration of isoflurane needed without causing any adverse effects on the hemodynamic state of the patients.[12] Keeping patients in a lighter plane of anesthesia increases client satisfaction because the patients recover quickly from the effects of anesthesia and are therefore less likely to be discharged with a drug "hangover." Regional anesthesia helps create a painless transition from general anesthesia to consciousness and continues to work after the procedure to reduce patient discomfort and allow oral pain medication to begin working.

COMMONLY USED MEDICATIONS

Lidocaine

A short-acting medication that is commonly used for regional anesthesia is lidocaine. This medication is usually supplied as a 2% solution (20 mg/mL). It has a rapid onset of action (within 5 minutes)[13] and a relatively short duration of action (60 to 120 minutes).[14] If you want intraoperative pain relief only and would like to have the local anesthetic metabolized by the time the patient is awake, this drug would be the most appropriate choice for regional anesthesia. Cats are significantly more sensitive than dogs to this medication. Reported doses are 6 mg/kg for dogs and 3 mg/kg for cats.[15] However, we prefer to use a maximum dose of 2 mg/kg in the dog and 1 mg/kg in the cat (**TABLE 1**). Note that the total dosage of this medication is additive. If lidocaine is being used as part of an induction agent or maintenance pain medication (e.g., constant rate infusion), the total dosage must not exceed 5 mg/kg in dogs.[16] Our preference is to keep the dosage below 2 mg/kg in both canine and feline patients. A potential side effect of lidocaine administration is central nervous system excitation, which could result in convulsions.[17]

Bupivacaine

A longer-acting medication used for regional anesthesia is bupivacaine. This medication comes in different concentrations: 0.25% (2.5 mg/mL), 0.5% (5 mg/mL), and 0.75% (7.5 mg/mL). The onset of effect has been reported to be as short as 8 minutes and as long as 30 minutes, and the effect has been reported to last from 4 to 10 hours, depending on where it is placed. For cats, the toxic dose of this medication is greater than 2 mg/kg total dose.[15] As with lidocaine, cats are also extremely sensitive to bupivacaine. The maximum dosage of this medication should never be exceeded. For dogs and cats, the recommended total dosage of bupivacaine is less than 2 mg/kg (**TABLE 1**).[15] Unlike lidocaine, bupivacaine is not used in constant rate infusions because it is highly cardiotoxic. However, in dogs and cats, the total dosage for local blocks is additive. Complications include neurotoxic and cardiotoxic complications (e.g., tremors, seizures, coma, respiratory depression, profound cardiac depression, ventricular fibrillation, and asystole).[18]

When a regional anesthetic drug is injected into canine and feline patients, it is imperative that the administrator first aspirate the syringe to avoid inadvertent intravenous injection. We have never experienced any adverse side effects or complications when careful technique is used and recommended dosages are followed.

ADDITION OF AN OPIOID

An adjunctive medication that can be added to bupivacaine to extend the action of the regional block is buprenorphine. We recommend that buprenorphine be added to the regional block at a dose of 15 mcg per patient. Studies have shown that when bupivacaine was combined with an opioid such as buprenorphine, it increased the duration of action of the local anesthetic agent by threefold.[19,20] In a study evaluating the effect of adding buprenorphine to bupivacaine in an infraorbital nerve block and its effects on the minimum alveolar concentration of isoflurane, the anesthetic requirement for patients that received the combination was less than that for patients that received bupivacaine alone.[21] The same study also provided support for prolonged regional anesthetic effects.[21] The authors speculated that the addition of buprenorphine to a regional anesthetic block may extend the duration of the block to 48 to 96 hours after administration instead of 4 to 10 hours without buprenorphine.[21]

REGIONAL ANESTHESIA TECHNIQUE

Regional anesthesia is safe for the patient as long as the administrator has a grasp of the anatomy surrounding the region to be injected and uses safe technique. Because regional anesthesia is administered when the patient is under general anesthesia, it can be invasive if careful technique is not used. Another consideration is whether regional anesthesia should be used when biopsy samples are being collected or a resection is

being performed in an area that may contain neoplastic cells. Placement of regional anesthesia in an area containing neoplastic cells could push those cells away from the original tumor margins; therefore, caution should be exercised when performing regional blocks in an area that may be neoplastic.

Anatomy Considerations

Anatomic landmarks for the most commonly used regional anesthesia techniques are the infraorbital foramen, mandibular foramen, angular process, and the facial vascular notch (**FIGURE 1**). Innervation to the maxilla, and hence the nerve(s) that innervate the dental structures and surrounding soft tissues, is supplied by the infraorbital nerve, which is a branch of

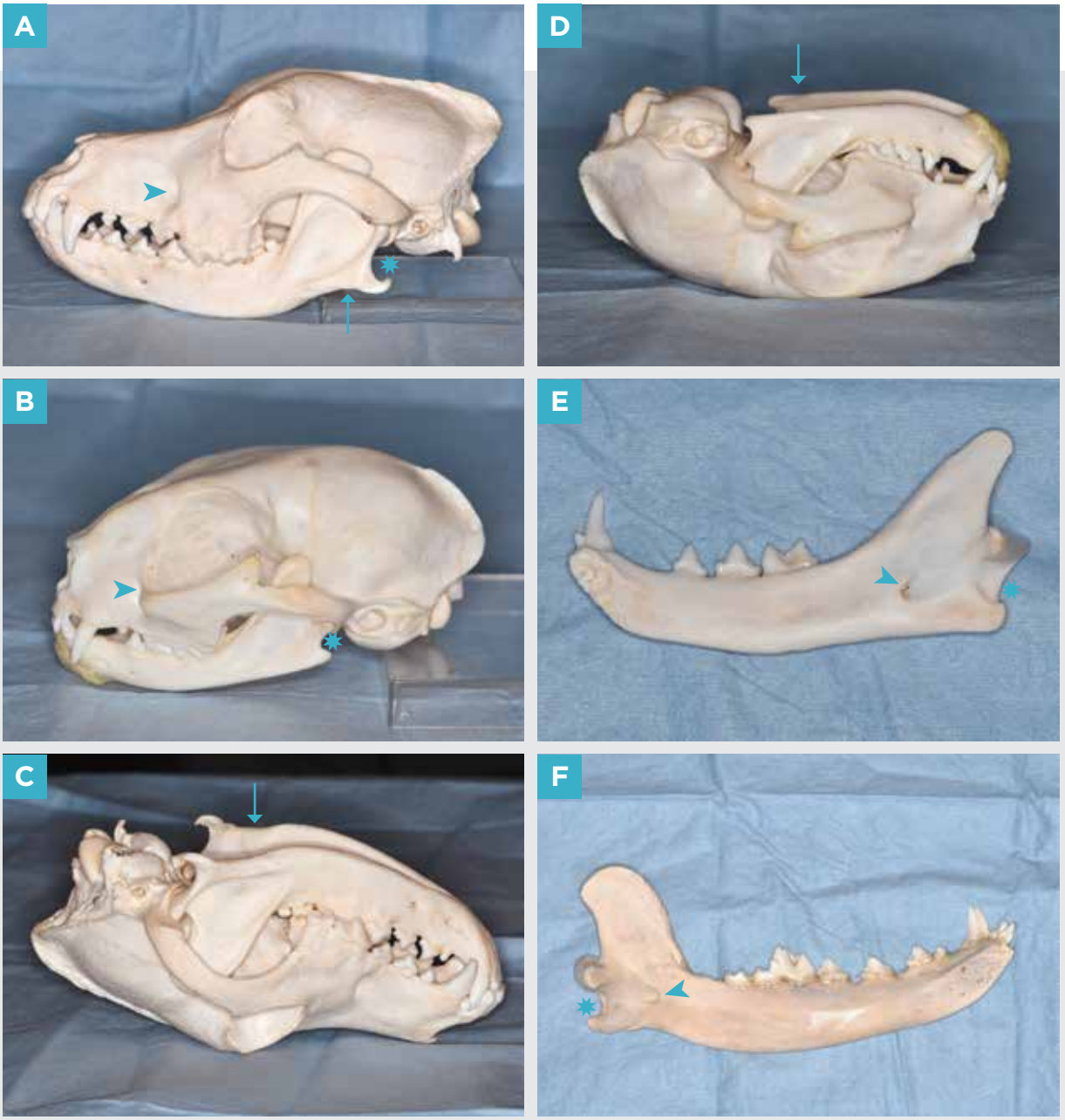

FIGURE 1. (A) Canine skull showing infraorbital foramen (arrowhead), angular process (star), facial vascular notch (arrow). **(B)** Feline skull showing infraorbital foramen (arrowhead) and angular process (star). **(C)** Canine skull showing facial vascular notch (arrow). **(D)** Feline skull showing facial vascular notch (arrow). **(E)** Feline mandible, lingual aspect, showing mandibular foramen (arrowhead) and angular process (star). **(F)** Canine mandible, lingual aspect, showing mandibular foramen (arrowhead) and angular process (star); note that the specimen is missing a mandibular third molar.

the maxillary nerve and its associated branches. Innervation to the mandible is supplied by the inferior alveolar branch of the mandibular nerve.

Cranial Infraorbital Nerve Block

The cranial infraorbital nerve block inhibits stimulation to the following nerves: infraorbital, incisivomaxillary, rostral superior alveolar dental, external nasal, internal nasal, and superior labial.[14] This block desensitizes the maxillary first, second, and third premolars, canine, and incisor teeth on the same side on which the block is administered. It also desensitizes the associated soft tissues, skin of the muzzle, and the upper lip on the ipsilateral side of block administration.[14]

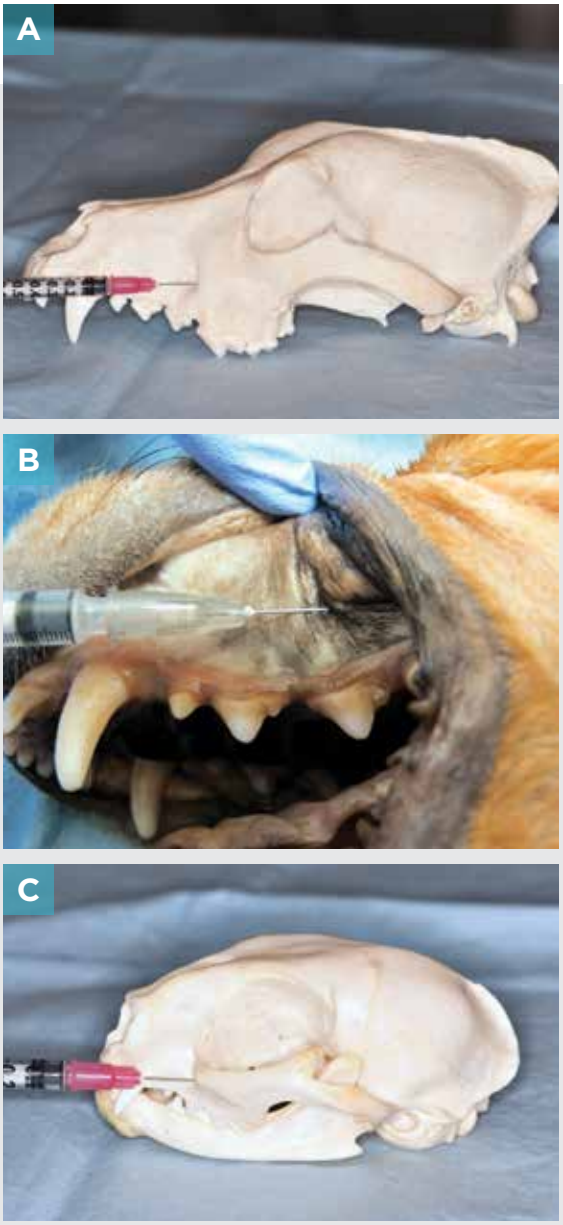

FIGURE 2. Location of the infraorbital canal opening and appropriate penetration into the canal for the cranial infraorbital (cranial maxillary) nerve block. **(A)** Canine skull. **(B)** Canine cadaver. **(C)** Feline skull.

To perform the cranial infraorbital block in the dog, palpate the infraorbital foramen as a depression in the alveolar mucosa apical (dorsal) to the distal root of the maxillary third premolar or the mesial root of the maxillary fourth premolar. In the cat, the infraorbital foramen is located at the mesial aspect of the third premolar. The needle should be inserted just into the canal (**FIGURE 2**), parallel with the canal or directed slightly ventral to it. If you insert the needle apically (dorsally), it could penetrate the retrobulbar space or the globe of the eye. If you insert the needle too far ventrally, it could contact the floor of the infraorbital canal, preventing insertion deeper into the canal. The chosen drug, after appropriate dose calculation, should then be slowly injected into the canal. The drug should be infused into the canal rather than infiltrated directly into the nerve. To prevent intravascular infusion, after inserting the needle into the canal, rotate the syringe 360 degrees, aspirating at each quarter turn. After injection into the canal, remove the syringe and apply digital pressure to the opening of the infraorbital canal for 1 minute.

Caudal Infraorbital (Maxillary) Nerve Block

The caudal infraorbital nerve block inhibits stimulation to the following nerves: maxillary; infraorbital; caudal, middle, and superior alveolar dental; incisivomaxillary; and rostral superior alveolar dental.[14] This block desensitizes the maxillary 1st and 2nd molars and all premolars, canine, and incisors of the ipsilateral quadrant.[14] Also blocked are the bone and soft tissues of the maxilla on the ipsilateral side of block administration, along with the skin of the nose, cheek, and upper lip on the ipsilateral side.[14]

The technique for the caudal infraorbital nerve block is identical to that for the cranial infraorbital nerve block. The needle should be inserted into the canal and directed approximately half the length of the zygomatic arch (**FIGURE 3**). The direction of the needle should be parallel with the canal. If the needle is inserted apically (dorsally) or ventrally, the problems described above can occur. The same injection procedure described for the cranial infraorbital block should be followed,

ending with digital pressure to the rostral opening of the canal for 1 minute.

Other approaches to the caudal infraorbital block include the subzygomatic approach and a technique using the maxillary tuberosity. However, because of variations in skull type and breed, we prefer the approach described above.

The technique for the caudal infraorbital nerve block is identical to that for the cranial infraorbital nerve block.

Caudal Inferior Alveolar Nerve Block

The caudal inferior alveolar nerve block inhibits innervation to the inferior alveolar branch of the mandibular nerve before it dives into the mandible; to the caudal, middle, and rostral mental nerves; and to the incisive nerve.[14] Anesthesia to this region desensitizes all teeth (incisors, canine, premolars, molars), associated labial tissues, the rostral lower lip, and the rostral intermandibular tissues on the side in which it is placed.[14] There are 2 approaches to the caudal inferior nerve block: intraoral and extraoral.

Intraoral Approach: To perform this block, palpate the angular process of the mandible on the external surface of the patient. This is a palpable prominence located at

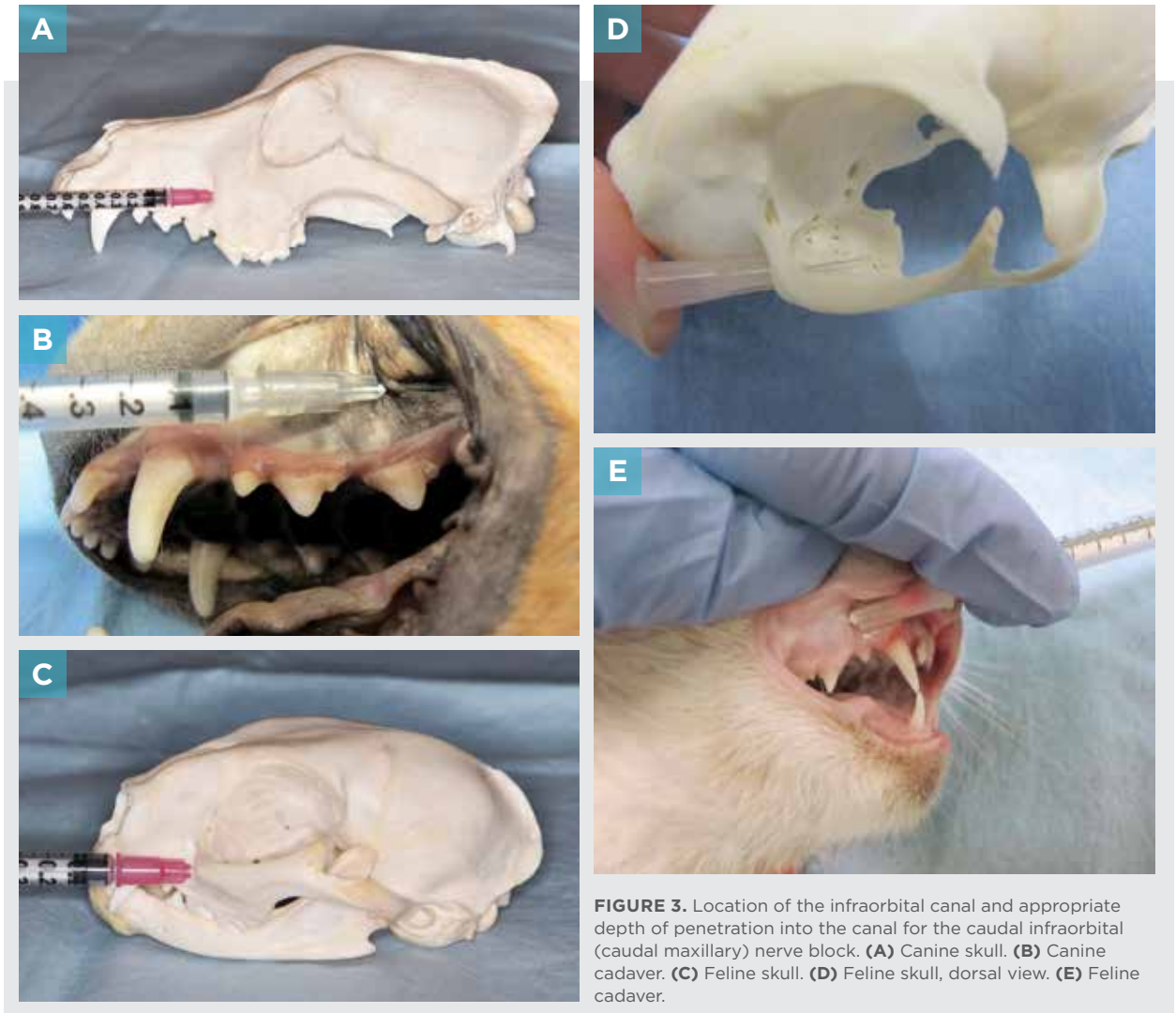

FIGURE 3. Location of the infraorbital canal and appropriate depth of penetration into the canal for the caudal infraorbital (caudal maxillary) nerve block. **(A)** Canine skull. **(B)** Canine cadaver. **(C)** Feline skull. **(D)** Feline skull, dorsal view. **(E)** Feline cadaver.

the caudal-most aspect of the mandibular body (**FIGURE 1, A, B, E, F**). Insert the needle intraorally through the gingiva at the location of the distal aspect of the mandibular third molar in the dog or the mandibular first molar in the cat (**FIGURE 4**). Then insert the needle on the lingual aspect of the mandible, as opposed to the buccal surface, directed toward the angular process, attempting to palpate and deposit the block at the opening of the mandibular foramen (**FIGURE 5**). The opening of the mandibular foramen is located half the distance between the alveolar crest distal to the last molar and the angular process of the mandible. After the needle is inserted into the region of the mandibular foramen, the syringe should be rotated 360 degrees, aspirating at each quarter turn. Because this foramen and nerve may be difficult to palpate, you can place the local anesthetic along periosteum of the body of the mandible in the location of the mandibular foramen, which should cause the local anesthetic to spread over a large surface area. After withdrawing the syringe, apply digital pressure to the area of the foramen for 1 minute to allow the block to diffuse within the tissues.

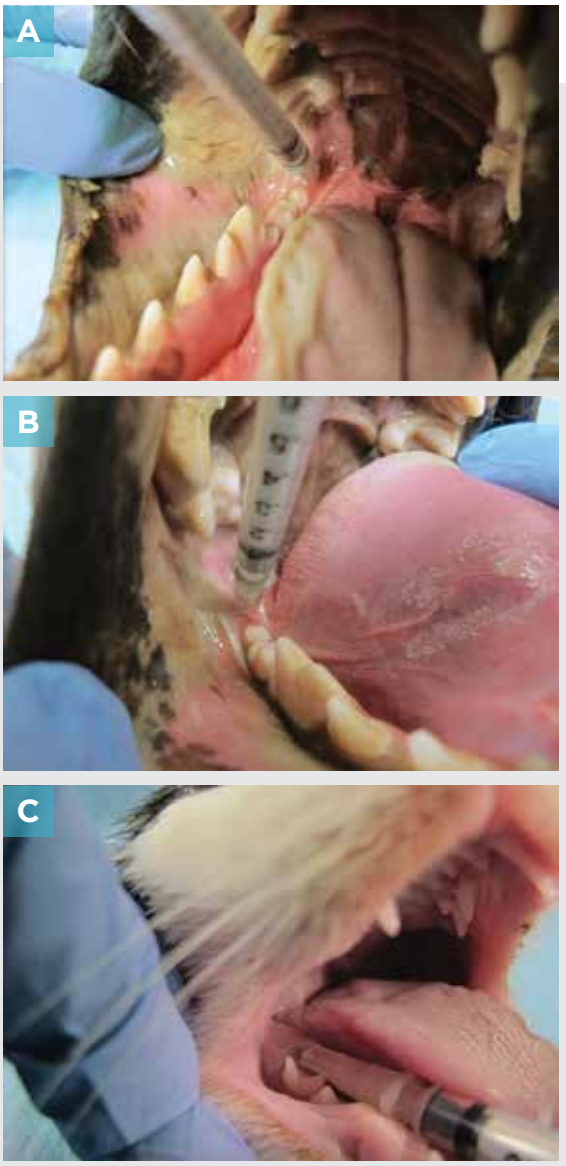

FIGURE 4. Appropriate placement of the needle for the intraoral approach to the caudal inferior alveolar (caudal mandibular) nerve block. **(A, B)** Canine cadaver. Note that the gloved hand is on the external surface of the patient and is palpating the angular process. **(C)** Feline cadaver.

Extraoral Approach: To perform this block, palpate the facial vascular notch (**FIGURE 1, A, C, D**). This structure is located on the ventral aspect of the caudal mandible. The needle should be inserted directly through the skin in the middle of this structure

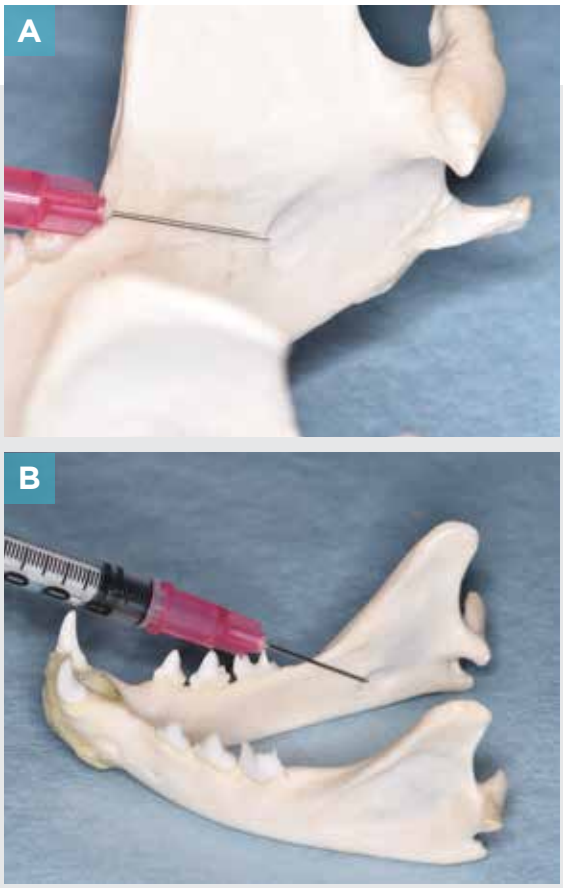

FIGURE 5. Intended location of the caudal inferior alveolar (caudal mandibular) nerve block. The block should be administered at the opening of the mandibular foramen. This structure is located half the distance between the location of the alveolar crest distal to the last molar and the angular process. **(A)** Canine mandible, lingual aspect. **(B)** Feline mandible.

(**FIGURE 6**), directed parallel with the lingual aspect of the mandible and continued dorsally to half the width of the mandible (**FIGURE 7**). This is the location of the mandibular foramen, similar to the intraoral approach. As described for the intraoral approach because this foramen and nerve may be difficult to palpate, you can place the local anesthetic alongside periosteum of the body of the mandible in the region of the mandibular foramen, which should cause the local anesthetic to spread over a large surface area. Injection technique is the same as above.

DISCUSSION

Multimodal pain-relieving efforts should be pursued for canine and feline patients. Just because our patients cannot communicate their pain to us does not negate the fact that they are experiencing pain. Regional anesthesia, especially when combined with an opioid, can provide a more comfortable procedure for our patients and a more satisfying experience for our clients. When safe technique is used, regional anesthesia not only helps the dentistry and oral surgery patient but also increases client satisfaction. Regional anesthesia reduces the general anesthetic requirement, provides intraoperative and postoperative pain relief, and contributes to a smoother postoperative recovery. These benefits increase client satisfaction by making the patient's postoperative recovery more comfortable and allowing the patient to be discharged with less drug hangover. Clients expect the same services for their pets as they do for themselves. We can reduce their concerns about use of general anesthesia for dental cleaning patients if at the time of discharge, our patients are awake, pain-free, and able to ambulate as well as when they came in that morning. TVP

FIGURE 6. Location of the facial vascular notch on an anesthetized dog. For the caudal mandibular nerve block, the needle is inserted through the skin and directed on the lingual aspect of the mandible for half the width of the mandible in the location of the mandibular foramen.

References

1. Holmstrom SE, Bellows J, Juriga S, et al. 2013 AAHA dental care guidelines for dogs and cats. *JAAHA* 2013;49:75-82.
2. American Veterinary Dental College. Companion animal dental scaling without anesthesia. http://avdc.org/Dental_Scaling_Without_Anesthesia.pdf Accessed September 2018.
3. International Association for the Study of Pain. Terminology. iasp-pain.org/Education/Content.aspx?ItemNumber=1698 Accessed August 2018.
4. Epstein M, Rodan I, Griffenhagen G, et al. 2015 AAHA/AAFP pain management guidelines for dogs and cats. *JAAHA* 2015;51:67-84.
5. Bell A, Helm J, Reid J. Veterinarians' attitudes to chronic pain in dogs. *Vet Record* 2014;175(17)426-427.
6. Merskey H, Albe-Fessard D, Bonica J, et al. Pain terms: a list with definitions and notes on usage. *Pain* 1979;6(3):294-252.
7. Dubin A, Patapoutian A. Nociceptors: the sensors of the pain pathway. *J Clin Invest* 2010;120(11):3760-3772.
8. Li J, Simone DA, Larson AA. Windup leads to characteristics of central sensitization. *Pain* 1999;79(1):75-82.
9. Beckman B. Pain management and periodontal disease. *NAVC Clinician's Brief, Consultant on Call* 2008:17-20.
10. Osterweis M, Kleinman A, Mechanic D. Chapter 7: The anatomy and physiology of pain. In: *Pain and Disability: Clinical, Behavioral, and Public*

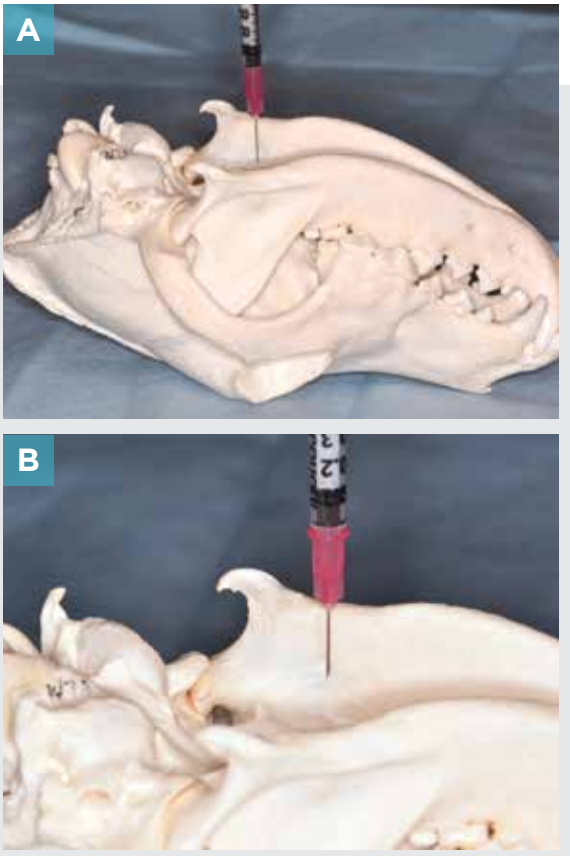

FIGURE 7. (A, B) Canine skull showing the location of the mandibular foramen identified by using the facial vascular notch.

11. Kumar S, Gupta R, Kaleem AM, Pandey AK. Mitigation of pain and anesthetic drugs. *OA Anaesthetics* 2014;2(1):2.
12. Snyder CJ, Snyder LB. Effect of mepivacaine in an infraorbital nerve block on minimum alveolar concentration of isoflurane in clinically normal anesthetized dogs undergoing a modified form of dental dolorimetry. *JAVMA* 2013;242(2):199-204.
13. Pascoe PJ. The effects of lidocaine or a lidocaine-bupivacaine mixture administered into the infraorbital canal in dogs. *Am J Vet Res* 2016;77(7):682-687.
14. Gracis M. The oral cavity. In: Campoy L, Read M, eds. *Small Animal Regional Anesthesia and Analgesia*. Ames, IA: John Wiley and Sons, Inc.; 2013:119-140.
15. Carpenter RE, Marretta SM. Dental patients. In: Tranquilli WJ, Thurmon JC, Grimm KA, eds. *Lumb and Jones Veterinary Anesthesia and Analgesia*. 4th ed. Ames, IA: Blackwell Publishing;2007:993-995.
16. Liu PL, Feldman HS, Giasi R, et al. Comparative CNS toxicity of lidocaine, etidocaine, bupivacaine and tetracaine in awake dogs following rapid intravenous administration. *Anesth Analg* 1983;62(4):375-379.
17. Grimm K. Regional anesthesia: dental nerve blocks. In: Greene SA, ed. *Veterinary Anesthesia and Pain Management Secrets.* Philadelphia, PA: Hanley & Belfus;2002:311-314.
18. Beckman BW, Legendre L. Regional nerve blocks for oral surgery in companion animals. *Comp Cont Ed Pract Vet* 2002;24:439-444.
19. Candido KD, Franco CD, Khan MA, et al. Buprenorphine added to the local anesthetic for brachial plexus block to provide postoperative analgesia in outpatients. *Reg Anesth Pain Med* 2002;27(2):162-167.
20. Modi M, Rastogi S, Kumar A. Buprenorphine with bupivacaine for intraoral nerve blocks to provide postoperative analgesia in outpatients after minor oral surgery. *J Oral Maxillofac Surg* 2009;67(12):2571-2576.
21. Snyder LB, Snyder CJ, Hetzel S. Effect of buprenorphine added to bupivacaine infraorbital nerve blocks on isoflurane minimum alveolar concentration using a model for acute dental/oral surgical pain in dogs. *J Vet Dent* 2016;33(2):90-96.

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Effects of Diets, Treats, and Additives on Periodontal Disease

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Teeth help increase the surface area of food by making individual pieces of food smaller, thus allowing for better mixing of food with the lubricating saliva before the bolus of food is swallowed. The teeth are held in position by the periodontium, which is made up of the gingiva, periodontal ligament, alveolar bone, and cementum. When the periodontium becomes infected or inflamed because of plaque bacteria and the host's response to the bacterial insult, periodontal disease (gingivitis and periodontitis) is the result.[1]

PERIODONTAL DISEASE

Gingivitis (inflammation of the gingiva) is the less severe form of periodontal disease and can be treated with proper oral hygiene.

Periodontitis affects the gingival and nongingival components of the periodontium, resulting in tooth attachment loss, gingival recession, root exposure, furcation exposure, pocket formation, and bone loss. Clinical signs vary widely (**BOX 1**). Treatment depends on the severity of periodontal disease and may range from professional dental cleaning, closed periodontal therapy (root planing, gingival curettage), administration of antiseptic and anti-inflammatory medications, open periodontal therapy (improved access to diseased tissues after creation of a flap), and complex flap and bone grafting procedures to extraction of nonsalvageable teeth.

In an otherwise healthy patient, periodontal disease can lead to bacteremia, but it is rapidly cleared by the reticuloendothelial system.[2] Thus, routine use of systemic antibiotics is discouraged and required only for selected patients with conditions that could worsen during or after a dental or oral surgery procedure (e.g., established organ disease, immunosuppression). In addition to bacteremia, periodontal disease can lead to the chronic release of inflammatory mediators, immune complexes, and byproducts of bacterial and cellular degradation into the blood and lymph vessels, which could produce direct or immune-mediated organ pathology (e.g., liver, kidney, and myocardium in dogs).[1]

PREVENTING OR MANAGING PERIODONTAL DISEASE

To be able to make appropriate recommendations, the veterinary professional should always ask clients about any home oral hygiene that they may perform for their pet; their pet's chewing habits and diet; and which, if any, chewing objects they offer their pet.[3] As

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BOX 1 Signs of Oral and Dental Diseases in Dog and Cats

- Decreased appetite, weight loss
- Bad breath (malodor, halitosis)
- Dental deposits (plaque, calculus [tartar]), particularly when asymmetrical
- Preferential chewing on one side
- Mobile, malpositioned, and/or fractured teeth
- Inability or reluctance to open or close the mouth
- Dropping food from the mouth
- Oral inflammation (individual ulcers, widespread stomatitis)
- Oral discharge (e.g., drooling saliva, bleeding, pus)
- Sneezing, nasal discharge, decreased airflow from one nostril
- Ocular discharge, exophthalmos/enophthalmos
- Facial/head asymmetry, oral and/or maxillofacial swellings
- Extraoral and/or intraoral sinus tracts
- Regional lymphadenomegaly
- Vocalizing, pawing at the face, repetitive lower jaw motions
- Uncooperative behavior during examination, pain on touch

mentioned, there are many professional treatment options for periodontal disease; this article focuses on products available to help clients prevent or manage periodontal disease at home.

Home Oral Hygiene

No discussion of oral health would be complete without mentioning home oral hygiene, a critical component of oral health maintenance. Plaque is soft enough to be brushed or wiped off; however, if allowed to accumulate for 2 to 3 days, plaque becomes mineralized to form calculus (tartar), which resists removal by tooth brushing or mastication (although some dental diets and chews may remove some calculus via the process of chewing). Thus, to remove plaque before it mineralizes, toothbrushing needs to be done daily or at least every other day.[4] Pet-specific toothbrushes are available; some are angled to assist in brushing the caudal teeth. Cats and small dogs often prefer finger brushes. Regardless of what type of brush is used, the bristles of the brush must be soft. Other products that can be used to remove plaque from the tooth surfaces include medicated wipes, gauze, and cotton-tipped applicators. Pet dentifrices (pastes or powders) are also available and come in many flavors; some are more abrasive for working on calculus and others contain enzymes to reduce plaque.[5]

Oral health also improved significantly in cats and dogs fed a commercial dry diet compared with those fed a home-prepared diet.[9]

Products for Improving Oral Health

Products that reduce plaque and calculus buildup include dental diets; chews, treats, and toys; and drinking water or food additives.[6] Oral rinses, gels, and toothpastes are also effective but fall outside the scope of this article. The Veterinary Oral Health Council (VOHC; vohc.org) is an entity of the American Veterinary Dental College and awards a seal of acceptance to products that meet pre-set criteria for mechanically and/or chemically controlling plaque and/or calculus deposition in dogs and cats. Clients often educate themselves through the Internet, and they can be confident that the marketing claims are credible for products that have been awarded the VOHC Seal of Acceptance. However, VOHC is not a regulatory agency, and submission of clinical trial results to the VOHC on behalf of a company is voluntary. Furthermore, VOHC does not determine the safety of a product but requires assurance by the company that a product is safe and meets all applicable regulatory requirements.[5]

Dental Diets

A study in Australia compared the oral health of domestic cats eating commercially available canned and dry diets with that of feral cats whose diets consisted of small mammals, birds, reptiles and insects. Researchers found that calculus accumulation was more severe in the domestic cats but prevalence of periodontal disease did not differ significantly between the 2 groups.[7] For

reasons of food safety, pets should generally not be fed raw meat or unpasteurized dairy products.[5]

In terms of food texture, another study found that compared with soft and mixed (dry and soft) food, dry food had a positive influence on the oral health of cats and dogs, decreasing the occurrence of mandibular lymphadenopathy, accumulation of dental deposits, and development of periodontal disease.[8] Oral health also improved significantly in cats and dogs fed a commercial dry diet compared with those fed a home-prepared diet.[9] Cats fed large kibbles had significantly less gingivitis and calculus than did cats fed small kibbles.[10] Specially engineered dry kibble with added polyphosphates or chlorhexidine provides the mechanical and chemical actions, respectively, to prevent or retard plaque and calculus formation. Long fibers within a large kibble oriented in one direction help to keep the kibble from crumbling when a dog or cat bites into it. This design allows the kibble to mechanically scrape the sides of the teeth as they penetrate it.[11,12]

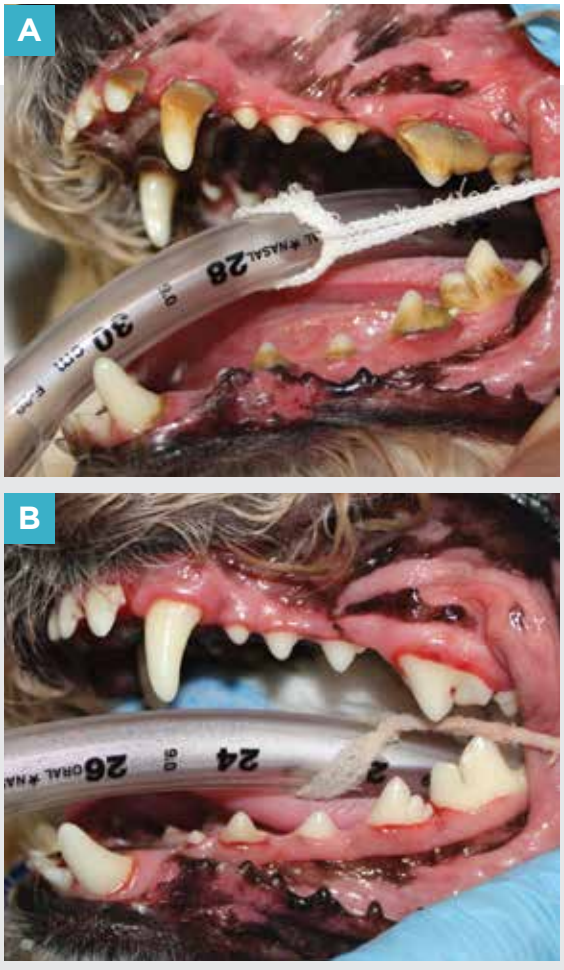

FIGURE 1. Images showing a dog's teeth before **(A)** and after **(B)** professional dental cleaning. Showing such images to clients can inspire them to start daily toothbrushing as part of their pet's home oral hygiene.

Studies in cats demonstrated that the daily addition of a dental treat to the dry diet resulted in significantly less plaque and calculus accumulation on tooth surfaces.[19,20]

Chews, Treats, and Toys

Dental chews and treats given daily have been shown to reduce plaque and calculus accumulation, gingivitis, and bad breath in dogs.[13-15] Rawhides in particular seemed to have a protective effect against periodontal disease; this effect was more obvious in dogs fed dry food only.[16] Note, however, that there have been some reports of potential rawhide contamination with *Salmonella.* The inclusion of polyphosphates or chlorhexidine may further improve the effectiveness of a chew or treat.[17] However, the decisive factor in maintaining oral health in dogs seems to be the abrasiveness of the product rather than the activity of the added chemical.[18] Studies in cats demonstrated that the daily addition of a dental treat to the dry diet resulted in significantly less plaque and calculus accumulation on tooth surfaces.[19,20] The size and shape of any chew, treat, or toy should be matched with the chewing habits of the pet. Chewing objects should not be too hard because very hard materials can fracture teeth.[21] Inappropriate items include plastic bones made of hard nylon, cow hooves, antlers, rocks, large ice cubes, and wooden sticks. Meat bones (cooked and uncooked) are also too hard and carry the risk of esophageal obstruction and gastrointestinal perforation. Tennis balls are very abrasive to teeth because they collect tiny particles of dirt and sand and will wear down the crowns, leading to pulp exposure.[5]

Food and Water Additives

Some plaque or calculus-retarding agents can also be added as a liquid to the drinking water or as a powder to the food.[22] Pet owners generally should avoid products with unsubstantiated or unreasonable claims (e.g., "no more brushing of teeth needed," "replaces general anesthesia for dental cleanings").

Despite the value of the above-mentioned products (diets, chews/treats, water/food additives), none replaces thorough oral examinations (including periodontal probing and dental radiography) and dental cleanings (including root planing and gingival curettage) performed by trained veterinary professionals. The gold standard for the management of periodontal disease is diagnosis and treatment under general anesthesia, followed by home oral hygiene (daily toothbrushing and proper nutrition). Anesthesia-free dental cleaning done by untrained persons may be cosmetically pleasing to some pet owners, but it provides a false sense of accomplishment by making parts of the crowns look good while neglecting the subgingival areas of the teeth where periodontal disease is active.[5] A painful mouth will make for a noncompliant pet and may cause the client to give up completely on toothbrushing and other home oral hygiene measures. Thus, it is often best to start with professionally cleaned teeth and healthy gums, which will be hugely motivating to the client and far more beneficial to the pet (**FIGURE 1**).[5] TVP

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References

1. Reiter AM. Commonly encountered dental and oral pathologies. In: Reiter AM, Gracis M, eds. *BSAVA Manual of Canine and Feline Dentistry and Oral Surgery*. 4th ed. Gloucester, UK: BSAVA; 2018:89-118.
2. Silver JG, Martin L, McBride BC. Recovery and clearance of oral micro-organisms following experimental bacteremia in dogs. *Arch Oral Biol* 1975;20(10):675-679.
3. Kirby S, Miller B. Dental and oral examination and recording. In: Reiter AM, Gracis M, eds. *BSAVA Manual of Canine and Feline Dentistry and Oral Surgery*. 4th ed. Gloucester, UK: BSAVA; 2018:33-48.
4. Harvey C, Serfilippi L, Barnvos D. Effect of frequency of brushing teeth on plaque and calculus accumulation, and gingivitis in dogs. *J Vet Dent* 2015;32(1):16-21.
5. Reiter AM, Castejon-Gonzalez A. Perioperative considerations in dentistry and oral surgery. In: Reiter AM, Gracis M, eds. *BSAVA Manual of Canine and Feline Dentistry and Oral Surgery*. 4th ed. Gloucester, UK: BSAVA; 2018:338-370.
6. Roudebush P, Logan E, Hale FA. Evidence-based veterinary dentistry: a systematic review of homecare for prevention of periodontal disease in dogs and cats. *J Vet Dent* 2005;22(1):6-15.
7. Clarke DE, Cameron A. Relationship between diet, dental calculus and periodontal disease in domestic and feral cats in Australia. *Aust Vet J* 1998;76(10):690-693.
8. Gawor JP, Reiter AM, Jodkowska K, et al. Influence of diet on oral health in cats and dogs. *J Nutr* 2006;136(7 Suppl):2021S-2023S.
9. Buckley C, Colyer A, Skrzywanek M, et al. The impact of home-prepared diets and home oral hygiene on oral health in cats and dogs. *Br J Nutr* 2011;106(Suppl 1):S124-S127.
10. Vrieling HE, Theyse LRF, Winkelhoff van AJ, et al. Effectiveness of feeding large kibbles with mechanical cleaning properties in cats with gingivitis [in Dutch]. *TijdschrDiergeneeskd* 2005;130(5):136-140.
11. Clarke DE, Kelman M, Perkins N. Effectiveness of a vegetable dental chew on periodontal disease parameters in toy breed dogs. *J Vet Dent* 2011;28(4):230-235.
12. Logan EI. Dietary influences on periodontal health in dogs and cats. *Vet Clin North Am Small Anim Pract* 2006;36(6):1385-1401.
13. Clarke DE, Servet E, Hendriks W, et al. Effect of kibble size, shape, and additives on plaque in cats. *J Vet Dent* 2010;27(2):84-89.
14. Hennet P, Servet E, Venet C. Effectiveness of an oral hygiene chew to reduce dental deposits in small breed dogs. *J Vet Dent* 2006;23(1):6-12.
15. Quest BW. Oral health benefits of a daily dental chew in dogs. *J Vet Dent* 2013;30(2):84-87.
16. Harvey CE, Shofer FS, Laster L. Correlation of diet, other chewing activities and periodontal disease in North American client-owned dogs. *J Vet Dent* 1996;13(3):101-105.
17. Rawlings JM, Gorrel C, Markwell PJ. Effect on canine oral health of adding chlorhexidine to a dental hygiene chew. *J Vet Dent* 1998;15(3):129-134.
18. Brown WY, McGenity P. Effective periodontal disease control using dental hygiene chews. *J Vet Dent* 2005;22(1):16-19.
19. Gorrel C, Inskeep G, Inskeep T. Benefits of a 'dental hygiene chew' on the periodontal health of cats. *J Vet Dent* 1998;15(3):135-138.
20. Ingham KE, Gorrel C, Bierer TL. Effect of a dental chew on dental substrates and gingivitis in cats. *J Vet Dent* 2002;19(4):201-204.
21. Soltero-Rivera M, Elliott MI, Hast MW, et al. Fracture limits of maxillary fourth premolar teeth in domestic dogs under applied forces. *Front Vet Sci* 2019;5:339.
22. Clarke DE. Drinking water additive decreases plaque and calculus accumulation in cats. *J Vet Dent* 2006;23(2):79-82.

Tooth Extraction Complications in Dogs and Cats

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One of the most commonly performed oral surgery procedures in general practice is exodontia, or tooth extraction. Indications for extraction, grouped by patient age, are shown in **BOX 1**. Your objective with extraction is to remove the entire tooth and root without unnecessary damage to the surrounding soft tissue or bone. The easiest way to avoid surgical complications is through adequate preparation. Completing extractions in a consistent, orderly manner will decrease the incidence of complications.

EXTRACTION BASICS

When oral surgery is performed to remove teeth, controlled forces and proper technique—including use of a short finger stop (**FIGURE 1**)—are essential. Before attempting to elevate the tooth roots, section all multirooted teeth, and for open extractions, remove adequate buccal bone to visualize the tooth root. Visualization is

BOX 1 Indications for Extraction

Mature patients
- Periodontal disease
- Malocclusions
- Crowded teeth
- Impacted or unerupted teeth
- Supernumerary teeth that predispose adjacent teeth to periodontal disease
- Advanced caries
- Tooth resorption
- Inflammatory conditions (stomatitis)
- Nonvital teeth if endodontic treatment is not an option

Immature patients
- Persistent deciduous teeth
- Fractured deciduous teeth
- Interceptive orthodontics for treatment of deciduous malocclusions

XiXinXing/shutterstock.com

FIGURE 1. Short finger stop.

crucial for successful surgical extractions. The tooth is held in the alveolus by the periodontal ligament. The key to tooth removal is stretching and breaking down the periodontal ligament by placing the dental elevator into the periodontal ligament space and using slow rotational pressure to fatigue the periodontal ligament.

After tooth removal, *always* inspect the extracted root to be sure the apex is smooth and round. A rough or jagged root edge indicates the probability of a root remnant remaining in the alveolus. *Always* take postoperative radiographs to document complete extraction of the entire tooth root without unnecessary damage to the surrounding bone. The following list provides tips and guidelines to help you avoid complications when extracting teeth. See also **BOX 2**.

- **Always consider your skill and knowledge.** If a procedure is beyond your capability based on your knowledge, skill, and/or the pathology that is present, it is best to refer the patient to a board-certified veterinary dentist.
- **Understand basic anatomy**, including tooth anatomy, location of neurovascular bundles, the mandibular canal, nasal cavity, and the orbit. This knowledge is critical for avoiding key structures during extractions.
- **Always take preoperative intraoral radiographs.** Preoperative radiographs enable you to carefully evaluate the entire tooth, the periapical area, and the surrounding bone (**FIGURE 2**), as well as to formulate a treatment plan.
- **Consider all information.** Combine what you see clinically, what you see radiographically, and clients' commitment to their pet's oral healthcare to make an appropriate treatment decision about each tooth.
- **Use preemptive multimodal pain management** to provide oral surgery patients with a more comfortable intraoperative and postoperative period. Use of intraoral regional nerve blocks decreases minimum alveolar concentration of isoflurane needed by the patient without affecting cardiovascular parameters or causing observable adverse effects.[2] Nerve blocks provide analgesia in the postoperative period, improving patient comfort and decreasing the need for additional analgesics.[2]
- **Use controlled forces and proper technique**, including appropriately sized, sharp instruments and the use of a short finger stop. If the elevator slips during extraction, using a short finger stop prevents inadvertent penetration of the sublingual space, mandibular canal, nasal cavity, and orbit.

COMPLICATIONS

Fractured Tooth Roots

Use of excessive force or use of extraction forceps before

BOX 2 Guidelines for Surgical Extraction[1]

- Be able to clearly visualize the area
- Have adequate light and magnification
- Adequately expose the tooth to be removed
- Section multirooted teeth
- Use controlled force
- Use a short finger stop
- Handle tissue atraumatically
- Achieve hemostasis
- Release periosteum to allow for tension-free closure
- Debride the gingival margin before closure

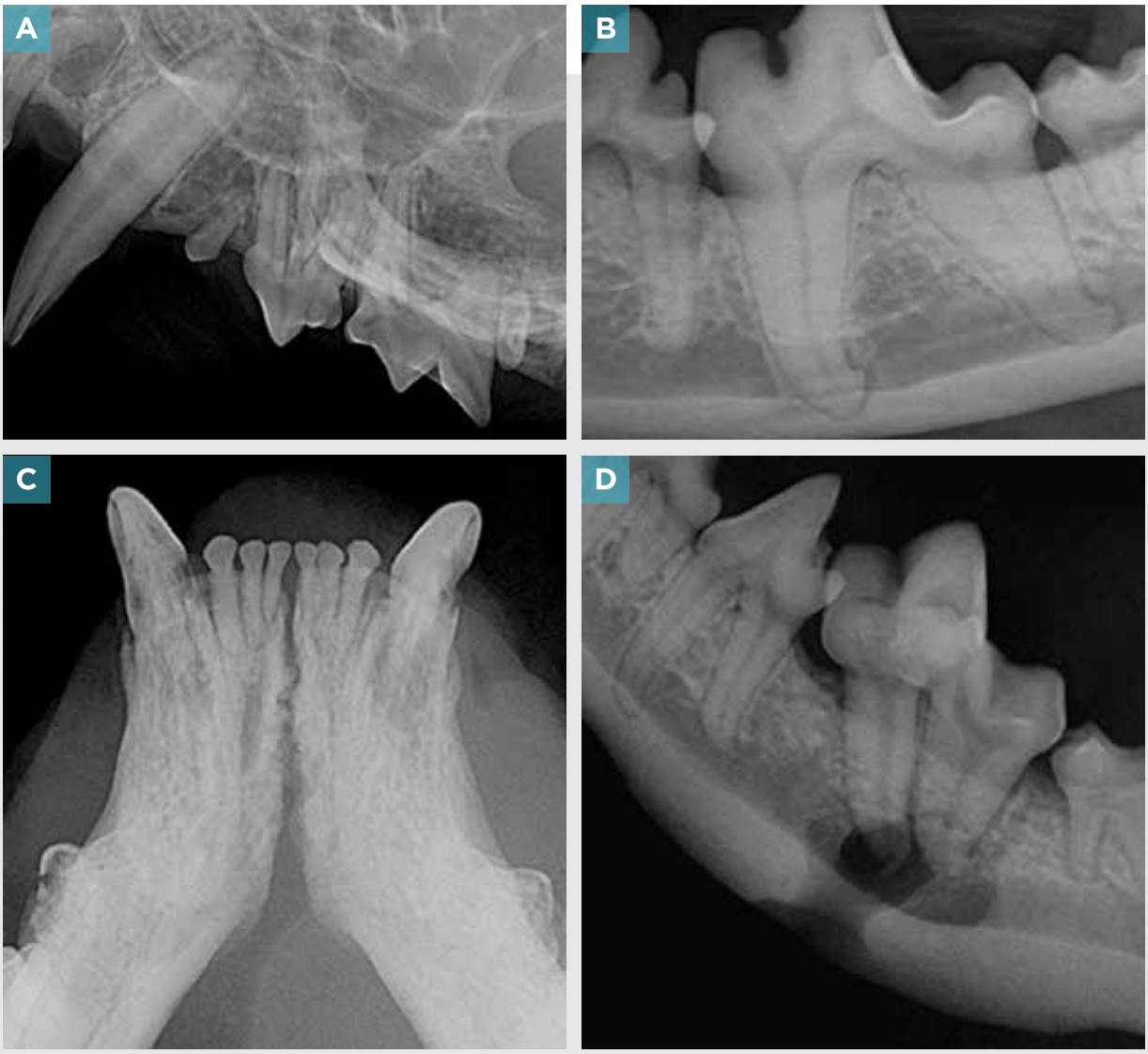

FIGURE 2. Radiographic abnormalities that may alter the approach to extraction. **(A)** Supernumerary root of tooth 207. **(B)** Curved roots of tooth 309. **(C)** Type 2 tooth resorption of teeth 304 and 404. **(D)** Dens invaginatus, periodontal and endodontic disease of tooth 309.

the tooth is adequately elevated can lead to root fracture. Anatomic variations in root structure (e.g., hooked, curved, or bulbous roots) can predispose the root to fracture during extraction (**FIGURE 3**). In addition, the mesial root of the mandibular first molar in the dog has a groove along the distal aspect of the root in an apical coronal axis, which makes extraction of this tooth root more difficult.[3]

Sometimes, however, despite our best attempts, tooth roots fracture during oral surgery and additional surgery is needed to extract the root tip. The first step in root tip retrieval is to take a deep breath! Then follow these subsequent steps:

1. **Take intraoperative radiographs.** The radiographs will confirm the anatomy of the remaining root, the adjacent structures, and the pathology associated with the surrounding bone. Keep in mind the anatomy of the area, particularly the location of the neurovascular bundles, the mandibular canal (**FIGURE 4**), the nasal cavity, and the orbit.
2. **Visualize the root tip.** Creating an open exposure to retrieve a fractured root tip makes the procedure quicker and less traumatic for the patient.[4] Your objective is to visualize the root tip *before* attempting to remove it. Visualization can be improved by removal of additional buccal bone, magnification, and adequate lighting. *Never dig blindly for root tips.*

FIGURE 3. Radiograph of tooth 309, showing curved roots and the mesial root in the ventral cortex of the mandible.

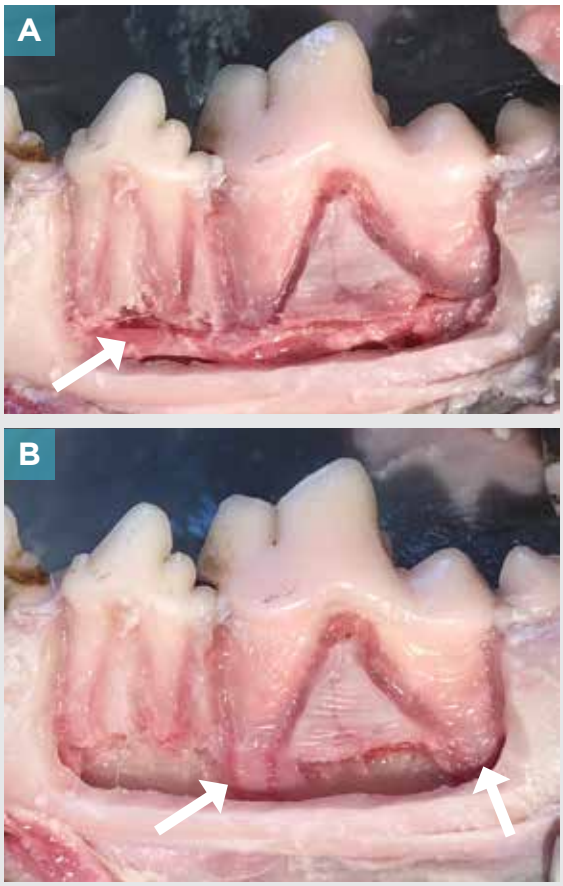

FIGURE 4. Dog cadaver **(A)** with bone overlying the neurovascular bundle (arrow) and tooth roots removed showing the proximity of the roots of teeth 308 and 309 to the mandibular canal; **(B)** with the neurovascular bundle removed showing the root tips of 309 (arrows) lingual to the neurovascular bundle and closely adjacent to the ventral cortex of the mandible.

3. **Remove alveolar bone.** To expose the remaining root structure and identify the periodontal ligament space, use a small bur to remove additional buccal alveolar bone. Perform this procedure with care because tooth roots can be located on the lingual or vestibular aspect of the mandibular canal.[5] You can use a smaller round bur to create a groove in the mesial and distal periodontal ligament spaces to allow insertion of the dental elevator in these locations (**FIGURE 5**). If needed, a small bur can be introduced into the alveolus to create a circumferential "moat" around the root to allow introduction of a root tip elevator into this expanded periodontal ligament space.[3] Do not remove excessive bone, and always consider the location of the neurovascular bundles, nasal cavity, mandibular canal, and orbit.
4. **Mobilize the root.** After bone removal, place a small dental elevator into the periodontal ligament space of the root tip on the mesial and distal sides. Gently rotate the elevator to stretch the periodontal ligament. *Do not use apical pressure* because excessive apical pressure can displace the root tip into the mandibular canal, nasal cavity, or maxillary sinus. After the tooth root is mobile, it can be removed through the newly created buccal bone window. Root tip extraction forceps with fine tips may be used to assist in the removal of the mobile tooth root from the alveolus.

Do not blindly pulverize a fractured or resorbing root by using a bur on a high-speed handpiece. Potential complications of root pulverization include air embolism,[6] subcutaneous emphysema, inadvertent penetration of the nasal cavity, damage to the neurovascular bundle in the mandibular or infraorbital canals, and displacement of the root apex into the nasal cavity or mandibular canal.

Very seldom is it appropriate to leave a root tip in place. Do so *only* if the risks of surgery to remove the root tip outweigh the benefits of removing the root tip. The surgical risks include: a patient who is not stable under anesthesia; the possibility that continued attempts at root tip removal may affect vital structures

FIGURE 5. Dog cadaver, showing fractured mesial root of tooth 206 with buccal bone removed.

(nerves and blood vessels within the mandibular canal, the nasal cavity, or orbit); and the potential for significant destruction of surrounding bone or soft tissues or displacement of the root tip into the mandibular canal, nasal cavity, or retrobulbar space.[4]

Do not leave a root tip in place if you see any clinical or radiographic evidence of periodontal or endodontic disease associated with the tooth. *Do not* leave root tips in cats and dogs with stomatitis. For a fractured root tip to be left in place, the root tip must be small and deep within the alveolus.

If you decide that the benefit of fractured root removal does not outweigh the risks and the root tip will remain in place, take intraoral radiographs to document the remaining root structure. Referral to a veterinary dentist is recommended. Inform the client of the decision, the reason for the decision, and the possible clinical sequelae. Document the decision in the patient's medical record. For follow-up, take radiographs of the retained root tip each year to look for any pathology associated with the remaining root fragment. If pathology is found, root tip retrieval is necessary.

In summary, fractured root tips are frustrating and sometimes difficult to remove. Intraoral radiographs must be obtained before extraction to evaluate the tooth structure and surrounding alveolar bone. Proper extraction technique minimizes the chances for fracturing root tips. Removal of buccal alveolar bone and proper sectioning of teeth facilitates extraction. Use of proper, sharp instruments and slow, controlled forces are recommended. Above all, be patient!

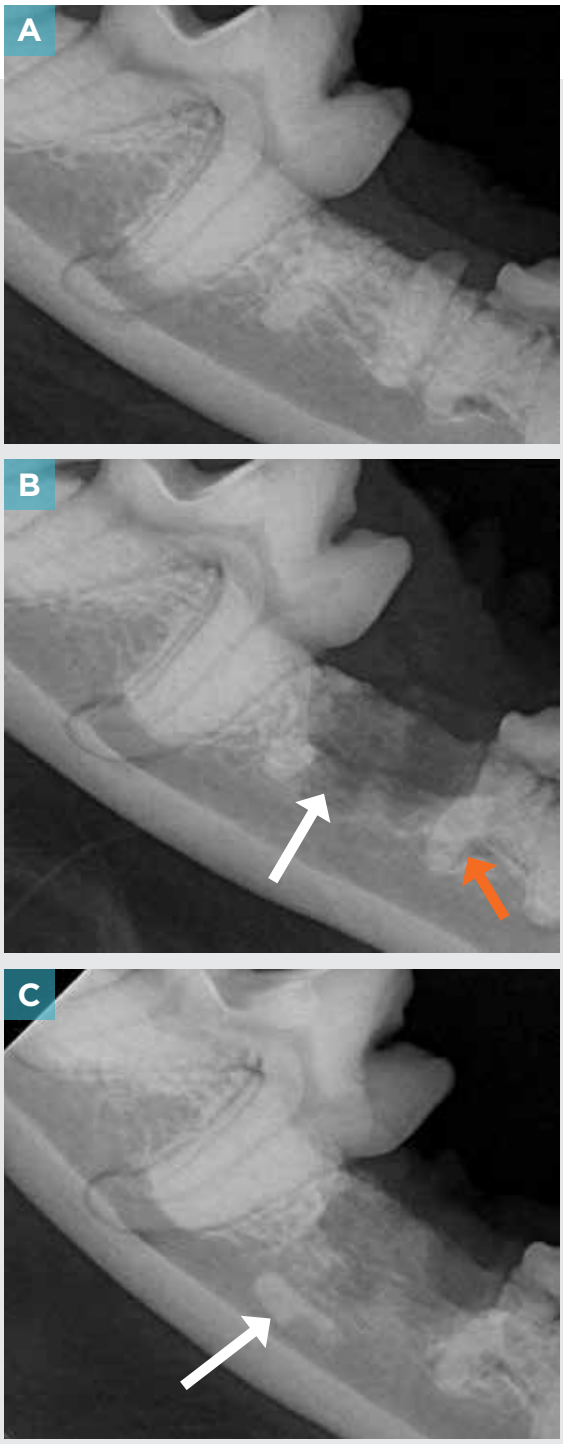

FIGURE 6. (A) Preoperative radiograph of retained tooth roots resulting from fractured tooth 408 at cementoenamel junction. **(B)** Mesial root of tooth 408 displaced during attempted removal, now overlying the distal root of tooth 407 (orange arrow). The distal root fractured during extraction because the buccal bone removal was mesial to the tooth root (white arrow) and the root was not clearly visualized before removal. **(C)** The distal root of tooth 408 and periodontal ligament were not identified before removal of the distal root, and apical pressure applied while attempting elevation displaced the distal root into the mandibular canal (arrow).

Displacement of Root Tips

While attempting to retrieve fractured root tips, you might displace a tooth root into the mandibular canal, nasal cavity, or maxillary sinus.[7] Root displacement can be avoided by removing alveolar bone to enable visualization of the root tip and carefully elevating fractured root tips with minimal apical force. If displacement occurs, it is desirable to remove the root tip or tooth fragment. Removal is usually facilitated by removal of additional bone and careful evaluation to identify the displaced root tip. When removing root tips from the mandibular canal, avoid the mandibular neurovascular bundle. Root retrieval from the nasal cavity can be difficult because of the large space and potential for tooth fragment migration. These procedures are often beyond the ability of the general practitioner, and referral to a veterinary dentist for evaluation is recommended (**FIGURE 6**).

Hemorrhage

Excessive bleeding may originate from the extraction site or from trauma to vascular structures or soft tissue during the extraction. If hemorrhage originates from the mandibular canal or nasal cavity, direct ligation of the vessels is usually not possible. In most instances, hemorrhage can be controlled by direct pressure with a moist gauze sponge. If the bleeding originates from the alveolus, closing the oral surgery site over the alveolus will mechanically put pressure on the area of bleeding and should lead to clot formation. Other techniques to control intraoperative bleeding include ligation of the lacerated vessel, use of electrocautery, or application of a hemostatic agent.

FIGURE 7. Cadaver, showing incomplete fracture of alveolar bone that occurred during extraction of tooth 104.

Trauma to the Flap

Tearing of the mucoperiosteal flap may result from penetration of the flap by the periosteal elevator during flap preparation, damage to the flap by the high-speed bur, an inadequately-sized flap, or excess tension on the flap during the extraction procedure. If the tear is very small, it may be possible to suture it, depending on its location. In most cases, suturing the tear will result in adequate but delayed healing.[1] If the perforation is large, trimming the tissue at the area of the perforation and redesigning the flap may be required to ensure tension-free closure.

Trauma to Adjacent Teeth

Teeth adjacent to the tooth being removed can be damaged during sectioning, removal of buccal bone, or elevation of the diseased tooth. The formerly healthy, now damaged, tooth should be evaluated visually and radiographically. Appropriate treatment will be determined by the extent of the damage.

Fractured Alveolar Bone

Occasionally, if too much force is used or if extraction forceps are used before the tooth has been adequately elevated, a piece of buccal alveolar bone may be removed with the extracted tooth. If this occurs,

FIGURE 8. Radiograph showing fractured mandible after removal of tooth 304.

smooth the remaining bone and close the oral surgery site. Alternatively, you may see a small fissure line in the buccal alveolar bone (**FIGURE 7**) or a fractured segment of buccal bone after tooth extraction. If the fracture is incomplete and there are no loose bone fragments, you can smooth the rough edges of the fracture with a diamond bur. Always remove any loose bone fragments before closing the oral surgery site.

Iatrogenic Jaw Fractures

The mandible is most commonly inadvertently fractured during extraction of the mandibular canine tooth in dogs and cats or the mandibular first molar in small-breed dogs[8,9] (**FIGURE 8**). The large contribution of the first molar and canine roots at their respective locations in the mandible indicates the need for careful planning when performing extractions and raises awareness of a potential cause of iatrogenic fractures.[10] Iatrogenic jaw fractures may result from preexisting periodontal or endodontic disease (**FIGURE 9**), excessive force used by the operator, or a combination of both.

In small-breed dogs, the ratio of first molar height to mandibular height is higher than that in large-breed dogs, which increases their risk for pathogenic or iatrogenic fracture.[11] In this anatomic circumstance, the periodontal ligament space extends from the alveolar bone margin to near the ventral cortex of the mandible. In dogs, presence of periodontal or endodontic disease at the level of the mandibular first molar can lead to bone loss in the area, increasing the susceptibility of the mandible to fracture.[12]

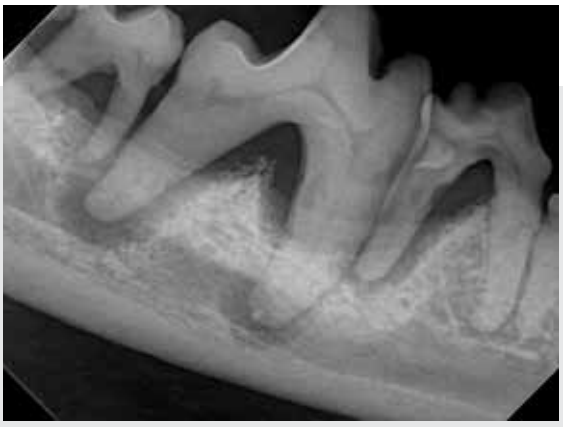

FIGURE 9. Radiograph showing advanced periodontal disease affecting teeth 408, 409, and 410.

If a mandibular canine tooth is diseased, evaluate the stability of the mandibular symphysis before removing the tooth. Some cats and dogs have symphyseal laxity, which should be noted before starting oral surgery.

If an iatrogenic fracture occurs secondary to extraction, contact your local veterinary dentist for treatment recommendations.

Dehiscence

Dehiscence at the oral surgery site usually results from lack of a tension-free closure. Other causes for flap dehiscence include poor flap design, sutures not supported by bone, occlusal interference from the teeth opposing the oral surgery site, and inappropriate postoperative care of the extraction site (e.g., patient chewing on hard objects or pawing at the mouth). The keys to a tension-free closure are creation of a well-designed, wide-based mucoperiosteal flap and release of the periosteum.

Treatment for dehiscence depends on its location and the state of the alveolus before closure. When the alveolus is intact and no necrotic bone is present, the site can be allowed to granulate by second intention (**FIGURE 10**). However, in the presence of an oronasal

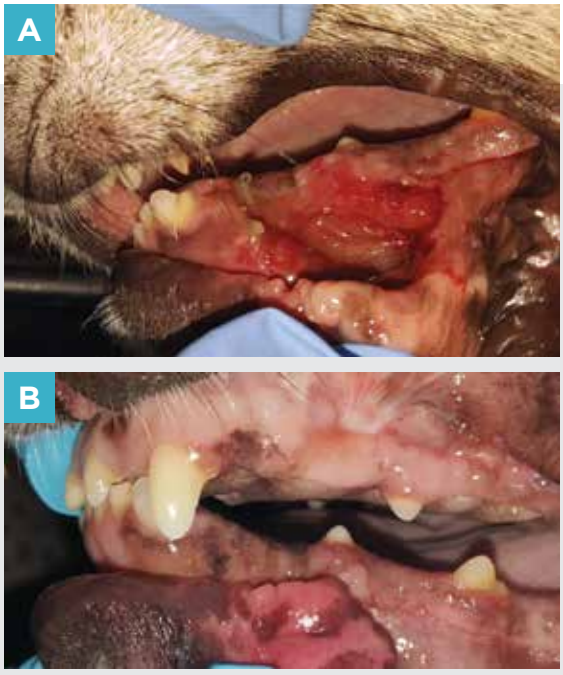

FIGURE 10. Extraction site at tooth 304 **(A)** 7 days postoperatively; **(B)** after healing by second intention.

fistula, it is never appropriate to try to allow a defect to heal by second intention. If after 2 weeks the oral surgery site shows no evidence of healing, an examination under general anesthesia is indicated to rule out neoplasia as a potential cause.

Oronasal Fistulas

Oronasal fistulas may be preexisting and associated with any maxillary tooth that is affected by severe periodontal disease. Most commonly, oronasal fistulas develop in small-breed dolichocephalic dogs, secondary to advanced periodontal disease associated with the palatal aspect of the maxillary canine teeth. An oronasal fistula may be visible in the area of a previously extracted maxillary canine tooth when a mucoperiosteal flap was not used to close the extraction site (**FIGURE 11**). In addition, an oronasal fistula may be iatrogenic, created during extraction by removal of a piece of bone on the palatal aspect of the root with the tooth root itself.

In each instance, closure of the resulting oronasal defect with a tension-free flap is indicated. Debride the margins of the defect, create a well-designed mucoperiosteal flap, and release the periosteum to allow for tension-free closure. Most of the time, an oronasal fistula can be repaired with a single mucoperiosteal flap.[13] Occasionally, to repair a large or nonhealing oronasal fistula, use of a double-layer mucoperiosteal flap, an allograft membrane, or auricular cartilage may be needed.[14,15]

If at the postoperative recheck examination you find a defect in the area of the previously repaired oronasal fistula, a new mucosal flap must be created to close the defect. A defect that overlies the nasal cavity will not "granulate in" or heal by second intention.

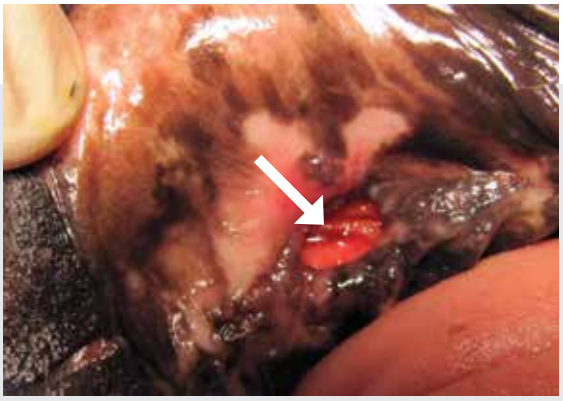

FIGURE 11. Oronasal fistula (arrow) in area of previously extracted tooth 204.

Ophthalmic Damage

Extraction of teeth in the caudal maxilla of dogs and cats may be associated with damage to the surrounding tissues, including the orbit and globe, especially if the patient has concurrent periodontal disease.[16] The apices of the maxillary fourth premolar and first and second molars in the dog and the maxillary fourth premolar and first molar in the cat lie in close proximity to the ventral floor of the orbit, and only a thin shelf of alveolar bone surrounds these tooth roots (**FIGURE 12**). The bony orbit of the dog and cat is incomplete; the floor of the orbit is composed of soft tissues, including the zygomatic salivary gland, orbital fat, and medial pterygoid muscle.[17] Inadvertent penetration of the orbital floor during caudal maxillary tooth extraction is often multifactorial and may be associated with the regional anatomy, periodontal pathology, and improper or aggressive extraction techniques.[16] If the tooth is affected by periodontitis and if a short finger stop is not used during extraction, the orbit can easily be penetrated with a dental elevator. Penetration of the globe may result in panophthalmitis and may ultimately require enucleation.

FIGURE 12. Caudal view of the orbit in a dog.

You can help prevent this complication by being familiar with the regional anatomy, understanding the extent of periodontal disease, using controlled forces, and using a short finger stop.[18] Traumatic brain injury has been reported as an iatrogenic complication of extractions, resulting from the dental elevator slipping during removal of the maxillary molars in the dog and penetrating the retrobulbar space into the brain.[18,19] Use of a short finger stop and controlled forces in the caudal maxilla during tooth extraction cannot be overemphasized.

Lip Entrapment

Lip entrapment is a potential complication of maxillary canine tooth extraction and is most commonly seen in cats. The mandibular canine tooth contacts the upper lip or rests on the outside of the upper lip and may result in an ulcer (**FIGURE 13**). Lip entrapment can be avoided by paying close attention to flap positioning and by not removing excess bone during extraction of the maxillary canine tooth. If this condition doesn't self-correct, then treatment is indicated. To eliminate the contact, treatment may be coronal reduction and endodontic treatment or extraction of the mandibular canine tooth.

SUMMARY

During every procedure, have a silent conversation with yourself about what you are doing and how you are doing it. Create your own checklist or use the one in **BOX 3**. Atul Gawande and his research team have developed checklists (written guides that walk them through the key steps in any procedure) that have been successfully used in hospitals and operating rooms around the world to decrease patient morbidity and mortality.[20] Mental conversations and written checklists can help create muscle memory and consistency in your approach to oral surgery, which will help you avoid complications.

FIGURE 13. Lip entrapment in a cat.

Your goal with all extractions is to extract the entire tooth and root without damage to surrounding structures. Unfortunately, we all encounter complications during tooth extraction at some point in our career. Recognition of potential complications and their causes and knowledge of appropriate treatment methods for those complications help minimize pain and discomfort for our patients. The easiest way to avoid surgical complications is through adequate preparation and use of a checklist. Finally, if a particular case or circumstance is beyond your ability, referral to a veterinary dentist is in the best interest of the patient. TVP

BOX 3 Checklist to Help Minimize Extraction Complications

- ☐ Assess your skill and knowledge
- ☐ Understand local anatomy
- ☐ Always obtain preoperative radiographs
- ☐ Consider all information
- ☐ Preemptively manage pain
- ☐ Use appropriate instruments for the procedure
- ☐ When completing an open extraction
  - ☐ Visualize the tooth roots
  - ☐ Create an appropriately designed mucoperiosteal flap for adequate exposure and to allow tension-free closure
  - ☐ Remove an adequate amount of buccal bone
- ☐ Always section multirooted teeth into single root segments to facilitate extraction
- ☐ Use controlled forces and proper technique
- ☐ Recontour the alveolar bone (alveoplasty)
- ☐ Lavage the alveolus
- ☐ Take a postoperative radiograph
- ☐ Release the periosteum
- ☐ Debride the marginal gingival tissue
- ☐ Suture the mucoperiosteal flap to the lingual or palatal mucosal tissue with no tension

References

1. Hupp JR. Prevention and management of extraction complications. In: Hupp JR, Ellis E, Tucker MR, eds. *Contemporary Oral and Maxillofacial Surgery*. 6th ed. St. Louis, MO: Elsevier Mosby; 2014:174-187.
2. Snyder LB, Snyder CJ, Hetzel S. Effects of buprenorphine added to bupivacaine infraorbital nerve blocks on isoflurane minimum alveolar concentration using a model for acute dental/oral surgical pain in dogs. *J Vet Dent* 2016;33(2):90-96.
3. Woodward TM. Extraction of fractured tooth roots. *J Vet Dent* 2006;23(2):126-129.
4. Hupp JR. Principles of more complex exodontia. In: Hupp JR, Ellis E, Tucker MR, eds. *Contemporary Oral and Maxillofacial Surgery*. 6th ed. St. Louis, MO: Elsevier Mosby; 2014:119-142.
5. Martinez LA, Gioso MA, Lobos CM, Pinto AC. Localization of the mandibular canal in brachycephalic dogs using computed tomography. *J Vet Dent* 2009;26(3):156-163.
6. Gunew M, Marshall R, Lui M, Astley C. Fatal venous air embolism in a cat undergoing dental extractions. *J Small Anim Pract* 2008;49(11):601-604.
7. Taylor TN, Smith MM, Snyder L. Nasal displacement of a tooth root in a dog. *J Vet Dent* 2004;21(4):222-225.
8. Smith MM. Surgical extraction of the mandibular canine tooth in the dog. *J Vet Dent* 2001;18(1):48-49.
9. Marretta SM. Surgical extraction of the mandibular first molar in the dog. *J Vet Dent* 2002;19(1):46-50.
10. Scherer E, Snyder CJ, Malberg J, et al. A volumetric assessment using computed tomography of canine and first molar roots in dogs of varying weight. *J Vet Dent* 2018;35(2):131-137.
11. Gioso MA, Shofer F, Barros PS, Harvey CE. Mandible and mandibular first molar tooth measurements in dogs: relationship of radiographic height to body weight. *J Vet Dent* 2001;18(2):65-68.
12. Scherer E, Hetzel S, Snyder CJ. Assessment of the role of the mandibular first molar tooth in mandibular fracture patterns in dogs. *J Vet Dent* 2019;36(1):32-39.
13. Marretta SM, Smith MM. Single mucoperiosteal flap for oronasal fistula repair. *J Vet Dent* 2005;22(3):200-205.
14. van de Wetering A. Repair of an oronasal fistula using a double flap technique. *J Vet Dent* 2005;22(4):243-245.
15. Soukup JW, Snyder CJ, Gengler WR. Free auricular cartilage autograft for repair of an oronasal fistula in a dog. *J Vet Dent* 2009;26(2):86-95.
16. Ramsey DT, Marretta SM, Hamor RE, et al. Ophthalmic manifestations and complications of dental disease in dogs and cats. *JAAHA* 1996;32(3):215-224.
17. Murphy CJ, Pollock RVS. The eye. In: Evans HE, ed. *Miller's Anatomy of the Dog*. 3rd ed. Philadelphia, PA: WB Saunders; 1993:1030.
18. Smith MM, Smith EM, La Croix N, Mould J. Orbital penetration associated with tooth extraction. *J Vet Dent* 2003;20(1):8-17.
19. Troxel M. Iatrogenic traumatic brain injury during tooth extraction. *JAAHA* 2015;51(2):114-118.
20. Gawande A. *The Checklist Manifesto: How to Get Things Right.* New York, NY: Metropolitan Books; 2010.

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Current Concepts in Periodontal Disease

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Of the most common health problems of companion animals throughout their life, dental disease stands out as the number 1 concern. While studies from previous decades list the prevalence of periodontal disease in the 60% to 70% range,[1-4] a 2018 study found that almost 90% of all canine patients had some degree of periodontal disease.[5] Another 2018 study using more accurate diagnostics found evidence of periodontal disease in 100% of canine subjects and concluded that periodontal disease is underdiagnosed based on visual examination alone.[6] In cats, the incidence is reported to be as high as 70% by 2 years old.[7] Based on its chronicity, prevalence, and impact on overall health, dental disease was considered the number 1 health-related welfare concern in dogs in the United Kingdom in 2019.[8]

While studies from previous decades list the prevalence of periodontal disease in the 60% to 70% range,[1-4] a 2018 study found that almost 90% of all canine patients had some degree of periodontal disease.[5]

Sadly, many owners and veterinarians still misunderstand the significant effects of periodontal disease, believing them to be limited to bad breath and tooth loss. This lack of understanding, combined with improper or outdated diagnostic methods, can lead to delayed therapy at best and misdiagnosis at worst. Both of these situations are concerning, as significant pain and infection from unchecked periodontal disease have several local and potentially systemic consequences (**BOX 1**). Intervention by veterinarians and educated owners is the only solution to improving health and alleviating distress in these patients.

PATHOGENESIS

There are two recognized stages to periodontal disease—gingivitis and periodontitis—but they often present concurrently. In the initial stage, gingivitis, the inflammation is confined to the gingiva. This is a reversible process. When gingivitis progresses due to lack of or inappropriate treatment, periodontitis typically ensues. Periodontitis is defined as an inflammatory disease of the deeper supporting structures of the tooth (the periodontal ligament and

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alveolar bone) that is caused by bacteria and their byproducts. Progressive destruction of the periodontal tissues leads to attachment loss. Periodontitis is considered an irreversible process, unless the patient is treated with advanced periodontal surgery techniques including guided tissue regeneration.

Periodontal disease begins with the formation of plaque.[11] Plaque, one of many biofilms that naturally occur, is made up almost entirely of oral bacteria that adhere to the teeth and are held together by a matrix of extracellular polysaccharides and salivary glycoproteins. Plaque can be found on tooth surfaces within 24 hours of dental cleaning.

When plaque is visible on the surface of the tooth, it is known as *supragingival* plaque. Once it extends below the gumline, it is called *subgingival* plaque. While supragingival plaque is easier to see, the damaging effects of periodontal disease come from the presence of subgingival plaque within the gingival sulcus or periodontal pocket.[12] Calculus, or tartar, is also relatively nonpathogenic. Therefore, control of supragingival plaque or tartar alone, as is found with non-anesthesia dentistry, is ineffective in controlling the progression of periodontal disease.[5,13]

When subgingival bacteria are able to proliferate, the combination of the inflammation produced by the bacteria themselves and the host's own immune response begins the irreversible damage of periodontitis. Inflammation of the soft tissue weakens attachment, while osteoclastic activity decreases the bony support. Current studies suggest that there is a strong genetic component to periodontal disease, potentially related to the amount of damage attributed to the host response.[2,13,14] Periodontal disease culminates in tooth loss; however, significant problems can precede tooth exfoliation.

BOX 1 Potential Consequences of Periodontal Disease

Local[9]
- Oronasal fistulas
- Class II periodontic-endodontic lesions
- Pathologic fractures
- Ocular problems
- Osteomyelitis
- Oral cancer

Systemic[10]
- Renal, hepatic, and cardiac disease
- Increased inflammatory markers
- Anemia of chronic disease
- Arthritis
- Diabetes mellitus

CLINICAL FEATURES

Healthy gingiva should look coral pink and have a thin edge. When gingivitis starts, the first clinically notable sign is erythema of the gums, followed by halitosis and gingival edema (**FIGURE 1**). While color change is a

FIGURE 1. Left maxilla of a dog with early to moderate gingivitis. Note the red and slightly swollen gingiva.

FIGURE 2. Mandibular right canine (404) of a dog with normal-appearing gingiva, but bleeding on probing. This is the first sign of gingivitis.

An oronasal fistula forms when periodontal disease progresses apically from the palatal surface of a maxillary tooth, most commonly a canine.

reliable sign of disease, bleeding on probing, chewing, or brushing is now recognized as the earliest clinical sign of gingivitis (**FIGURE 2**).[15,16]

Dental calculus is often present alongside gingivitis, but plaque bacteria are the true cause of gingivitis and periodontal disease. Therefore, gingivitis can occur in the absence of calculus. By the same logic, widespread supragingival calculus may be notable, with little to no gingivitis accompanying it.[17]

The hallmark clinical feature of periodontitis is attachment loss. This is considered to be periodontal pocket formation and/or gingival recession >3 mm in dogs or >1 mm in cats.[18] Both presentations of attachment loss can occur in the same patient and, occasionally, on the same tooth.

LOCAL CONSEQUENCES

One of the most common of the severe local consequences of periodontal disease is oronasal fistulation (**FIGURE 3**).[9,19] Oronasal fistulas can occur in cats as well as any breed of dog, but they are typically found in older small- and toy-breed dogs. An oronasal fistula forms when periodontal disease progresses apically from the palatal surface of a maxillary tooth, most commonly a canine. While it can be apparent during a conscious oral examination, definitive diagnosis typically requires periodontal probing under general anesthesia. A fistula can exist even when the gingiva looks relatively healthy and the tooth is well attached; therefore, probing every aspect of every tooth in the mouth is a vital part of an oral examination. Appropriate treatment of a fistula entails extraction of the tooth and closure of the defect with a mucogingival flap.[19]

When periodontal disease progresses toward the apex of the tooth and bacteria gain access to the endodontic system through the apical delta, the result is a class II periodontal-endodontic lesion.[18,20,21] In these cases, the affected tooth dies and the infection can then spread via the common pulp chamber to other root(s) (**FIGURE 4**).

In some patients with apical progression of severe periodontal disease, especially brachycephalic patients, the proximity of the tooth root apices of the maxillary molars and distal root of the fourth premolars allow for infection transmission into the area behind the globe. This can lead to infection and abscessation of the

FIGURE 3. Oronasal fistula on the left maxillary canine of a dog. The diagnosis is made by introducing a periodontal probe into the defect.

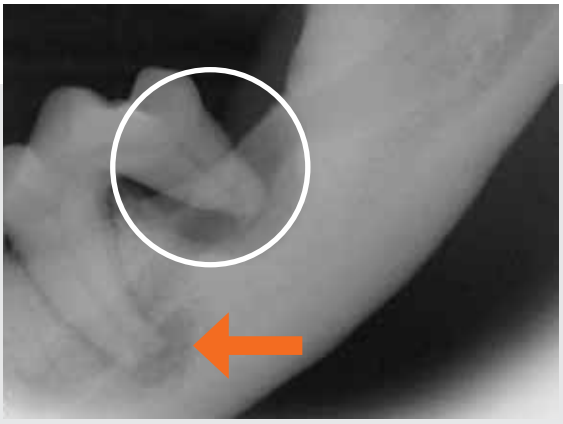

FIGURE 4. Radiograph of the left mandibular first molar (309) of a dog with a class II periodontic-endodontic lesion. The disease has caused loss of the alveolar bone down to the apex of the distal root (white circle). The tooth has become non-vital and the infection has spread through the common pulp chamber to create the endodontic lesion on the mesial root (orange arrow).

TABLE 1 Potential Negative Consequences of Periodontal Disease on Systemic Health[a]

ORGAN/SYSTEM AFFECTED	PROPOSED LINK TO PERIODONTAL DISEASE	ASSOCIATED CLINICAL EFFECTS
Liver	Bacteremia[28]	▪ Parenchymal inflammation (dogs)[28,29] ▪ Portal fibrosis (dogs)[28] ▪ Cholestasis (dogs)[28]
Kidney	Chronic stimulation of the immune system leading to presence of immune complexes in the kidney[30]	▪ Glomerulonephritis[30] ▪ Chronic kidney inflammation and secondary scarring[30] ▪ Decreased kidney function and filtration ability[31] ▪ Chronic kidney disease (dogs and cats)[32,33]
Heart	Bacteria in bloodstream attach to roughened heart valves	▪ Cardiopulmonary changes (dogs)[34] ▪ Increased risk of endocarditis (dogs with stage 3 periodontal disease; 6× that of controls)[35] ▪ Hypertension[36] ▪ Endothelial effects[37]
Metabolic	Increased C-reactive protein and other inflammatory markers that improve with periodontal care[38–41]	▪ Increased inflammatory lipids ▪ Overall lipidemic state (human and animal studies)[29,40,42–45] ▪ Insulin resistance[44,45]

[a]*Unless otherwise noted, studies are in human medicine.*

periorbital tissue of the eye and may result in eye loss or blindness.[22,23]

When chronic periodontal loss weakens the bone, pathologic fracture of the jaw can occur (**FIGURE 5**).[18,24] This condition is seen almost exclusively in small- and toy-breed dogs, in which the teeth are large in proportion to the jaws, and most frequently affects the mandible around the canines and first molars. It occasionally affects the mandibular canine area in cats.

Chronic osteomyelitis or osteonecrosis (**FIGURE 6**) are well-known sequelae of periodontal disease.[25] Once periodontal bacteria gain access to them, deeper bony tissues become infected and die. Necrotic bone no longer has a functioning blood supply, so it can no longer respond to antibiotic therapy. In patients with suspected osteonecrosis, aggressive surgical debridement is necessary and may require partial or complete mandibulectomy. These animals can live long and comfortable lives after surgery, providing disease has been completely addressed.

In people, chronic periodontal disease has also been linked to an increased incidence of oral cancer.[26,27] While the mechanism for this is currently unknown, the chronic inflammatory state that exists with periodontitis is the likely cause. Further studies in veterinary medicine are needed to establish this relationship in dogs and cats.

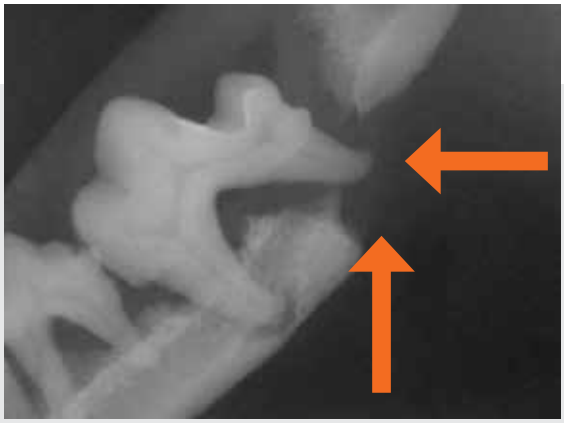

FIGURE 5. Radiograph showing a pathologic mandibular fracture at the distal root of the left mandibular first molar (309) in a small-breed dog (orange arrows). The bone has been weakened to the point of fracture.

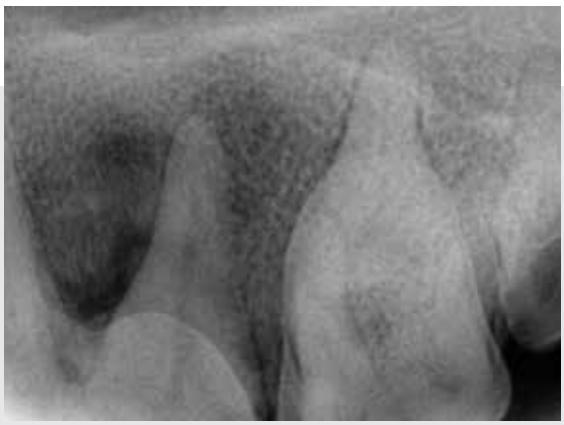

FIGURE 6. Radiograph showing osteomyelitis of the left maxilla of a dog.

Veterinary patients require both doctors and owners to provide frequent, clinically effective dental care to support good health and quality of life.

SYSTEMIC CONSEQUENCES

Systemic health consequences of periodontal disease have seen a strong uptick in research over the last few decades. While no causal relationship has been identified, and much of the research is in human medicine, the evidence that periodontal disease has negative consequences on systemic health is mounting, based on the ability of oral bacteria to gain access to the bloodstream through inflamed periodontal tissue. Once the bacteria have access to the rest of the body, multiple negative sequelae are possible (**TABLE 1**).

While further veterinary studies are needed to fully investigate the deleterious effects periodontal disease can have on companion animals, studies in people have correlated poor periodontal health with increased rates of gastrointestinal, kidney, pancreatic, and hematologic cancers,[46-48] as well as a major contributor to complications of diabetes mellitus.[44,45] Periodontal disease has been shown to be a significant predictor of early mortality in humans,[49-51] with one study reporting that severe periodontal disease is linked to a higher risk factor of early death than smoking.[52]

BOX 2 The Five Animal Welfare Needs[54]

1. **Health:** To be protected from suffering, injury, disease states, and pain, and to be treated if illness or injury occurs
2. **Behavior:** To behave in a normal species-specific manner (e.g., to dig, chew, scratch, play)
3. **Companionship:** To live with, or apart from, other animals as is appropriate to the species and individual animal's preference
4. **Diet:** To be fed a biologically appropriate diet for the age, species, and activity level of the animal that provides adequate nourishment without obesity or poor body condition, and to have access to freely available fresh water
5. **Environment:** To live in a suitable, safe, comfortable environment that contains places to rest, hide, explore, and exercise

HEALTH AND WELFARE BENEFITS OF PERIODONTAL THERAPY

Veterinary patients require both doctors and owners to provide frequent, clinically effective dental care to support good health and quality of life. Owners, therefore, must be educated about the impact of periodontal disease on an animal's health-based welfare. Additionally, while it may seem counterintuitive, patients rarely show obvious behavioral changes in response to oral pain, so waiting for these signs simply lengthens time to appropriate therapy and increases the severity of disease for the patient. Veterinarians are considered leaders in the assessment and improvement of animal welfare globally;[53] however, incorporating animal welfare conversations into daily practice can be challenging, especially when an animal's needs differ from the client's desires.

The Five Animal Welfare Needs (FAWN) framework (**BOX 2**) provides veterinarians with a context in which patient welfare may be more easily evaluated and discussed with clients in language they can understand and embrace.[54] The need to be protected from pain, suffering, injury, and disease is the most obvious FAWN element in the assessment of periodontal disease. Remembering the need for a suitable diet and the need to be able to exhibit normal behavior patterns may also lead to discussions that uncover potential improvements that can be realized through adequate dental care.

For a patient to truly benefit from dental care, both the veterinarian and owner must understand, accept, and incorporate the changes necessary to effectively control periodontal disease. Discussing ways that periodontal disease can negatively affect an animal's daily welfare may help the pet owner understand how dental health affects their pet's quantity and quality of life and increase compliance with treatment instructions.[55]

CONCLUSION

Patients with periodontal disease are exposed to oral bacteria in the systemic bloodstream daily, creating a state of chronic disease. Veterinarians and pet owners must learn to view periodontal disease as not merely a

dental problem, but as an initiator of more severe local and systemic consequences. With this knowledge, both veterinary professionals and clients can feel confident they are making informed, welfare-centric decisions for the pet's oral care.

Drs. Niemiec and Stewart are contributors to the WSAVA Global Dental Guidelines, which contain expanded information on periodontal disease. These guidelines are available at: wsava.org/global-guidelines/global-dental-guidelines. TVP

References

1. Fernandes NA, Batista Borges AP, Carlo Reis EC, et al. Prevalence of periodontal disease in dogs and owners' level of awareness—a prospective clinical trial. *Rev Ceres Viçosa* 2012;59(4):446-451.
2. Marshall MD, Wallis CV, Milella L, et al. A longitudinal assessment of periodontal disease in 52 miniature schnauzers. *BMC Vet Res* 2014;10:166.
3. Lund EM, Armstrong PJ, Kirk CA, et al. Health status and population characteristics of dogs and cats examined at private veterinary practices in the United States. *JAVMA* 1999;214(9):1336-1341.
4. Hoffmann T, Gaengler P. Clinical and pathomorphological investigation of spontaneously occurring periodontal disease in dogs. *J Small Anim Pract* 1996;37(10):471-479.
5. Stella JL, Bauer AE, Croney CC. A cross-sectional study to estimate prevalence of periodontal disease in a population of dogs (*Canis familiaris*) in commercial breeding facilities in Indiana and Illinois. *PLoS One* 2018;13(1):e0191395.
6. Queck KE, Chapman A, Herzog LJ, et al. Oral-fluid thiol-detection test identifies underlying active periodontal disease not detected by the visual awake examination. *JAAHA* 2018;54(3):132-137.
7. National Companion Animal Study. In: University of Minnesota Center for companion animal health. 1996:3.
8. Summers JF, O'Neill DG, Church D, et al. Health-related welfare prioritisation of canine disorders using electronic health records in primary care practice in the UK. *BMC Vet Res* 2019;15(1):163.
9. Niemiec BA. Local and regional consequences of periodontal disease. In: Niemiec BA, ed. *Veterinary Periodontology*. Ames, IA: Wiley Blackwell; 2013:69-80.
10. Niemiec BA. Systemic manifestations of periodontal disease. In: Niemiec BA, ed. *Veterinary Periodontology*. Ames, IA: Wiley Blackwell; 2013:81-90.
11. Lindhe J, Hamp S, Löe H. Plaque induced periodontal disease in beagle dogs: a 4-year clinical, roentgenographical and histometrical study. *J Periodont Res* 1975;10(5):243-255.
12. Quirynen M, Teughels W, Kinder Haake S, et al. Microbiology of periodontal diseases. In: Carranza FA, Numan MG, Takai HH, et al, eds. *Carranza's Clinical Periodontology*. St. Louis, MO: WB Saunders; 2006:134-169.
13. Wallis C, Patel KV, Marshall M, et al. A longitudinal assessment of periodontal health status in 53 Labrador retrievers. *J Small Anim Pract* 2018;59(5):560-569.
14. O'Neill DG, Butcher C, Church DB, et al. Miniature schnauzers under primary veterinary care in the UK in 2013: demography, mortality and disorders. *Canine Genet Epidemiol* 2019;6:1.
15. Meitner SW, Zander HA, Iker HP, et al. Identification of inflamed gingival surfaces. *J Clin Periodontol* 1979;6:93-97.
16. Niemiec BA. Etiology and pathogenesis of periodontal disease. In: Niemiec BA, ed. *Veterinary Periodontology*. Ames, IA: John Wiley and Sons; 2012:18-34.
17. Niemiec BA. Understanding the disease process. In: Niemiec BA, ed. *Veterinary Periodontology*. Ames, IA: Wiley Blackwell; 2013:18-34.
18. Debowes LJ. Problems with the gingiva. In: Niemiec BA, ed. *Small Animal Dental, Oral and Maxillofacial Disease. A Color Handbook.* London: Manson; 2010:159-181.
19. Marretta SM, Smith MM. Single mucoperiosteal flap for oronasal fistula repair. *J Vet Dent* 2005;22(3):200-205.
20. DuPont GG. Problems with the dental hard tissues. In: Niemiec BA, ed. *Small Animal Dental, Oral and Maxillofacial Disease. A Color Handbook.* London: Manson; 2010:127-157.
21. Wang HL, Glickman GN. Endodontic and periodontic interrelationships. In: *Pathways of the Pulp.* St. Louis, MO: Mosby; 2002:651-664.
22. Ramsey DT, Marretta SM, Hamor RE, et al. Ophthalmic manifestations and complications of dental disease in dogs and cats. *JAAHA* 1996;32(3):215-224.
23. Smith MM, Smith EM, La Croix N, Mould J. Orbital penetration associated with tooth extraction. *J Vet Dent* 2003;20(1):8-17.
24. Mulligan TW, Aller S, Williams CE. Trauma. In: *Atlas of Canine and Feline Dental Radiography.* Trenton, NJ: Veterinary Learning Systems; 1998:176-183.
25. Peralta S, Arzi B, Nemec A, et al. Non-radiation-related osteonecrosis of the jaws in dogs: 14 cases (1996-2014). *Front Vet Sci* 2015;2:7.
26. Zheng TZ, Boyle P, Hu HF, et al. Dentition, oral hygiene, and risk of oral cancer: a case-control study in Beijing, People's Republic of China. *Cancer Causes Control* 1990;1:235-1241.
27. Wen BW, Tsai CS, Lin CL, et al. Cancer risk among gingivitis and periodontitis patients: a nationwide cohort study. *QJM* 2014;107(4):283-290.
28. Taboada J, Meyer DJ. Cholestasis in associated with extrahepatic bacterial infection in five dogs. *J Vet Intern Med* 1989;3(4):216-220.
29. Pavlica Z, Petelin M, Juntes P, et al. Periodontal disease burden and pathological changes in organs of dogs. *J Vet Dent* 2008;25(2):97-105.
30. MacDougal DF, Cook T, Steward AP, Cattell V. Canine chronic renal disease: prevalence and types of glomerulonephritis in the dog. *Kidney Int* 1986;29(6):1144-1151.
31. DeBowes LJ, Mosier D, Logan E, et al. Association of periodontal disease and histologic lesions in multiple organs from 45 dogs. *J Vet Dent* 1996;13(2):57-60.

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Treating Periodontal Disease in General Practice

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The keys to treating and controlling periodontal disease in companion animals and humans are the same: removal and prevention of accumulated plaque.[1] Bacterial plaque and its inflammatory byproducts are the instigating agents of periodontal disease in the form of gingivitis; however, the body's individual response determines the progression of disease. (For a brief overview of the stages, clinical signs, and welfare aspects of periodontal disease, please see "Current Concepts in Periodontal Disease" in the January/February 2020 issue of *Today's Veterinary Practice*.)

Depending on the degree of attachment loss (i.e., periodontal pockets and gingival recession) and client wishes and ability, plaque removal is accomplished through a combination of the following measures:[2]

1. Routine professional dental cleaning
2. Periodontal flap surgery
3. Tooth extraction
4. Home plaque control

PROFESSIONAL CARE

The foundation of all periodontal care is a thorough professional dental cleaning. If careful oral examination finds no pathologic periodontal pockets (i.e., >3 mm in dogs, >1 mm in cats), minimal to no gingival recession, mild to no radiographic evidence of bone loss, and no mobile teeth, only a professional dental cleaning and home dental care are required. Unfortunately, most veterinary patients do not receive care until significant periodontal disease is present, and more extensive procedures are usually necessary.

Dental Cleaning

Dental cleaning is a medical procedure that must be performed meticulously to provide a measurable benefit for the patient. General anesthesia is an essential aspect of professional cleaning, for both health and welfare reasons (**BOX 1**). Protocols (and terms) for dental cleaning vary,[3] but the authors recommend the following steps:[16]

1. **A thorough preanesthesia examination and workup.** This helps ensure safer anesthesia and creation of a reasonable estimate of time and cost.
2. **Proper anesthesia and monitoring.** Dental procedures are typically lengthy and are often performed on older patients. The level of monitoring must be excellent to avoid mishaps.
3. **Chlorhexidine lavage.** This decreases bacterial load not only for the patient but also for the practitioner, staff, and environment.
4. **Supragingival scaling.** This is generally accomplished with an ultrasonic scaler.
5. **Subgingival scaling.** This is by far the most

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BOX 1
The Case Against Nonanesthesia Dentistry

General anesthesia is required for all professional periodontal treatment.[3-8] While heavy sedation or nonanesthetic options may seem enticing, only when the patient is anesthetized can a complete (and safe) cleaning and oral evaluation be performed.[9] Nonanesthesia dentistry (NAD) provides little to no medical benefit, as cleaning the supragingival surfaces of the teeth (especially if only the visible, buccal side) without subgingival cleaning and radiographic examination is cosmetic at best (**FIGURE A**) and potentially deleterious to patient welfare and health at worst (**FIGURE B**). A recent peer-reviewed study showed that patients that received nonanesthesia procedures had more progressive periodontal disease than a control group that received no professional care.[10] Another study found that pets that received more professional dental cleanings under general anesthesia lived longer than those that received no cleanings.[11] At this time, peer-reviewed published research to support or show positive benefits from NAD is severely lacking, despite the growing popularity of this service and the economic gains made by individuals and companies providing it.

Studies have proven that conscious (awake) oral examinations woefully underestimate the frequency and severity of periodontal disease in dogs and cats.[12,13] Based on these studies, as well as the experiences of veterinarians and veterinary dentists worldwide, numerous veterinary associations, including the American Veterinary Dental College, have position statements against NAD.[14] The World Small Animal Veterinary Association Dental Guidelines Committee considers NAD to be an animal welfare concern.[15] It is against the standard of care of several governing bodies and is illegal in several states when performed outside of a veterinary practice. For a list of governing bodies with a stance against this practice, visit wsava.org/global-guidelines/global-dental-guidelines.

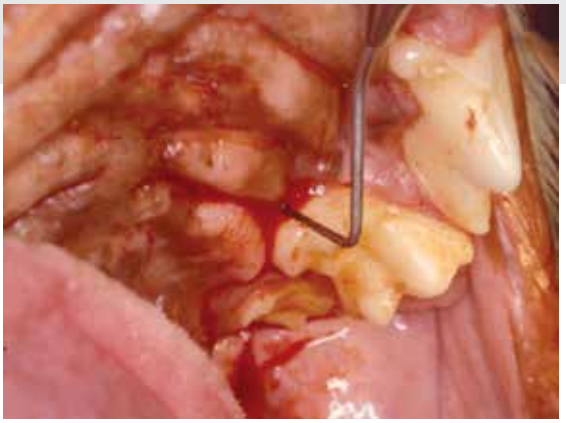

FIGURE A. Deep periodontal pocket on the palatine aspect of the left maxillary right first molar (209) in a dog after anesthesia-free cleaning. The patient presented for a right eye infection a few weeks after the cleaning. Minimal calculus and inflammation were present, but examination under anesthesia revealed this pocket. A class II periodontic-endodontic lesion was confirmed with dental radiology. The tooth was extracted, resolving the infection. Examination and radiography under general anesthesia would have allowed for earlier care of this tooth. This is one example of why veterinary dentists are strongly opposed to anesthesia-free cleaning.

FIGURE B. The palatal surface of the teeth cannot be effectively cleaned without anesthesia. This dog underwent anesthesia-free cleaning 48 hours earlier. The buccal surface looks clean, but the palatal surface is still dirty.

important step. Unless the subgingival plaque is completely removed, minimal to no medical benefit has been achieved. This step can be performed with an ultrasonic scaler if a subgingival tip is used (**FIGURE 1**). However, if there is any attachment loss, hand scaling with a curette is recommended (see **CLOSED ROOT PLANING**).

6. **Polishing.** This smooths the tooth to retard future plaque attachment.
7. **Sulcal lavage with chlorhexidine, saline, or lactated Ringer's solution.** This has been shown to decrease bacterial counts as well as remove debris (e.g., calculus, prophy paste).
8. **Oral examination and charting.** Periodontal probing (**FIGURE 2**) and exploring (**FIGURE 3**) should be performed on all surfaces of all teeth and marked on a high-quality dental chart (a copy of this chart is available for download at dogbeachvet.com). Probing and exploring

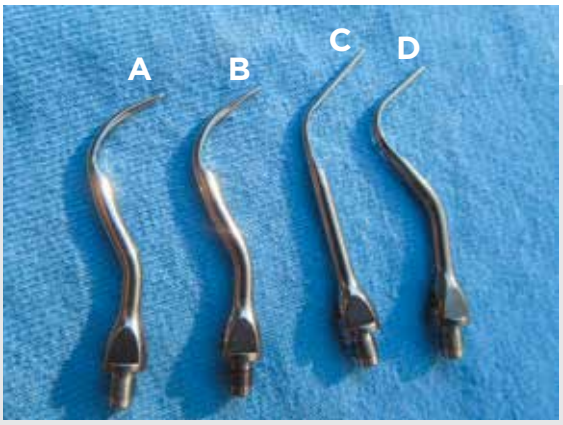

FIGURE 1. Ultrasonic scaler tips. Supragingival tips **(A and B)** are shorter and thicker than subgingival tips **(C and D)**. The subgingival tips are designed to be used on lower power settings because they are used on cementum-covered roots as opposed to more robust enamel-covered crowns. Their design also allows coolant to reach the end of the instrument, thereby avoiding overheating of the teeth and associated soft tissue.

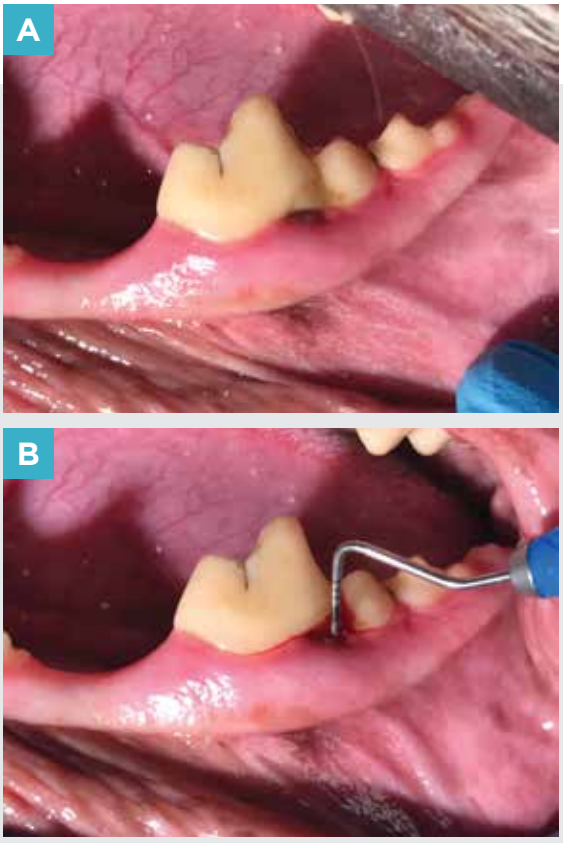

FIGURE 2. Periodontal probing is required for complete periodontal diagnosis. **(A)** The outward appearance of this left mandibular first molar (309) is mild inflammation and gingival recession. **(B)** Probing revealed a 12-mm pocket. This tooth was significantly infected and required extraction. Without probing, this diagnosis would have been missed and the patient left in pain.

are crucial. A simple visual examination will miss significant pathology (**FIGURE 2**).

9. **Dental radiography.** Radiographs are mandatory for proper diagnosis and treatment. Full mouth dental radiographs are always recommended to allow complete assessment of all teeth;[17,18] at a minimum, all pathology, no matter how minor, must be radiographed.
10. **Treatment planning and any additional therapy.** Based on the visual, tactile, and radiographic findings, a treatment plan can be devised and the client contacted for consent. If it is determined that the procedure will be lengthy (i.e., >3 hours), staging the procedure is acceptable.

The handling required for thorough periodontal probing, scaling, and polishing all aspects of the teeth is intense and can cause significant patient pain and anxiety. To avoid compromising patient welfare, gentle, respectful patient handling techniques should be employed from start to finish (**BOX 2**), and analgesia should be used as needed. Minimizing fear and stress not only improves the patient's experience and memory of the event, but also has been shown to decrease the amount of anesthetic needed and improve the postoperative rate of healing.[26-28]

Postoperative analgesia is also an important part of pain management. Reduction of pain and inflammation is harder when analgesia is not used before the inciting incident. Animals experiencing acute, unaddressed postoperative pain have extended healing times and higher physiologic stress levels than animals in which pain is adequately addressed.[29]

FIGURE 3. Exploring along the gingival margin reveals a resorptive lesion in a cat.

BOX 2
Tips for Addressing Patient Fear, Stress, and Anxiety in the Clinic

Multimodal approaches that allow for the sensitivity of individual patients are best and may include:

- Thoughtful patient placement within the hospital, such as placing cats high in the waiting area and in kennels or in cat-only areas away from barking or other loud noises; providing hiding areas or a patient's own carrier for use inside the kennel; and playing species-specific music in kennel areas[19-21]
- Allowing patients to wait with their owner outside the clinic when appropriate
- Use of species-appropriate pheromones at admission (on towels placed over carriers, in kennel areas, or on bandanas)
- Administering anxiety-relieving medications as soon as possible
- Use of carefully selected "treats" (e.g., frozen broth popsicles) during surgical preparation procedures such as IV catheter placement (recent studies have shown that consumption of small amounts of easily digested, liquid-based nutrition does not change regurgitation or anesthetic risk)[22-24]
- Use of treats during nonsurgical oral examinations (**FIGURE A**)
- Anticipating when the patient may experience pain during each step of the professional cleaning and seeking to alleviate conscious perception of this pain though the use of multimodal pain relief (e.g., topical anesthetic applied to IV sites, dental blocks for all extraction sites)[25]

FIGURE A. A feline patient enjoying whipped cream as a distraction and reward during an awake oral examination.

Periodontal Surgery

In teeth without mobility or furcation exposure class 2 or greater (**BOX 3**), periodontal pockets measuring 3 to 6 mm in dogs and 1 to 4 mm in cats can be effectively cleaned with closed root planing. All teeth with deeper pockets (**FIGURE 4**), furcation class 2 or 3 (**FIGURE 5**), or bone loss of >50% (**FIGURE 6**), or that are pathologically mobile require further therapy. It has been shown that it is impossible to effectively clean affected roots without direct visualization.[30-33] Treatment options for these significantly diseased teeth include periodontal flap surgery and extraction.[34] The patient can be referred for surgery, but these procedures can also be learned by general practitioners.

BOX 3 Furcation Exposure Classes

The *furcation* is the area between the roots in a multirooted tooth. In veterinary patients, the furcation is very coronal, meaning minimal attachment loss will result in exposure. There are 3 classes of furcation exposure:

- **F1:** The probe passes up to one-third of the way through the furcation.
- **F2:** The probe passes more than one-third of the way through the furcation, but not all the way through.
- **F3:** The probe passes completely through the furcation.

FIGURE 4. A 10-mm pocket on the palatal surface of the right maxillary canine (104). This tooth requires periodontal flap surgery (ideally with guided tissue regeneration) or extraction.

Top: Courtesy of Dr. Erin Bond, Kawartha Animal Hospital

If periodontal surgery is elected, the owner must be aware that diligent postoperative homecare and regular rechecks are necessary.

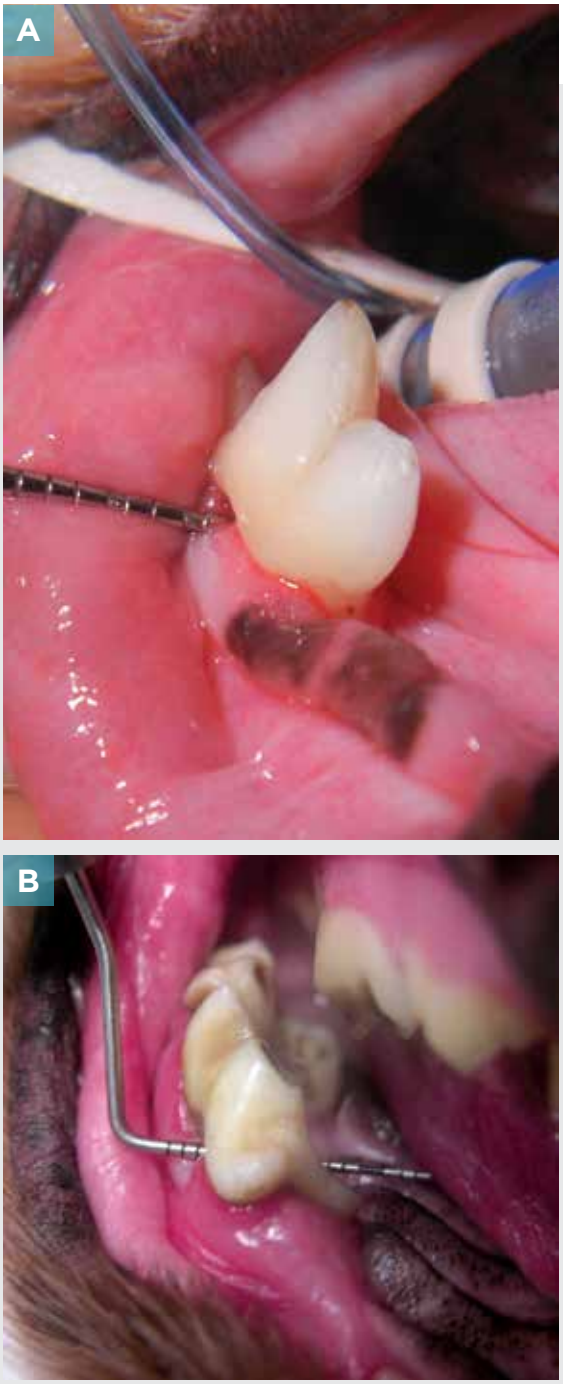

FIGURE 5. (A) Class 2 furcation exposure on the buccal surface of the right mandibular first molar (409). This tooth requires periodontal flap surgery (ideally with guided tissue regeneration) or extraction. **(B)** Class 3 furcation exposure on the left maxillary fourth premolar (208). This tooth requires periodontal flap surgery or, ideally, extraction.

Closed Root Planing

Closed root planing is a challenging technique and must be performed meticulously to effectively clean the teeth and allow reattachment of the gingival tissues. Ideally, it is accomplished using a combination of ultrasonic scaling with a subgingival tip (**FIGURE 1**) and hand scaling with a curette. The roots must be planed until they are clean and smooth. It is strongly recommended that the operator take a hands-on class to sharpen their skills in this critical technique.

After scaling, the authors recommend applying a perioceutic to improve ginigival attachment.[2] While a recent veterinary study refutes the effectiveness of these products,[35] numerous other studies show that they decrease bacterial counts and improve attachment gains.[30,36-38]

Periodontal Flap Surgery

If the client wants to salvage a significantly diseased tooth, periodontal flap surgery can be performed.[34,39] The flap allows visualization and cleaning of the infected areas to remove the infection and allow increased soft tissue attachment. Guided tissue regeneration can be considered in areas where bone may be regrown, such as the palatal surface of the maxillary canine and furcation exposure class 2 (especially for carnassial teeth), but sites should be carefully evaluated for appropriateness.

Extraction

Extraction is typically the best therapy for nonstrategic, severely diseased teeth. While clients may find it extreme, it is the true cure for periodontal disease.

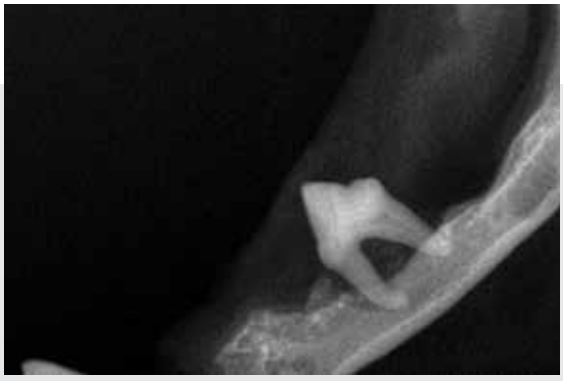

FIGURE 6. Radiograph of the mandibular left 3rd premolar (307) in a dog. This tooth has greater than 50% bone loss and should be extracted.

With all other therapies, the infection will quickly recur, unless the client commits to regular homecare and professional cleanings.

HOMECARE

Homecare is a crucial aspect of lifelong periodontal care. Plaque attaches to clean tooth surfaces within 24 hours of a dental cleaning,[40,41] and in the absence of any other preventive dental care, bacterial counts return to pretreatment levels in just 1 week.[42] Therefore, without homecare, gingival infection and inflammation quickly recur.[43-47]

Active homecare is most effective for the incisor and canine teeth, while passive homecare works best on carnassial (and surrounding) teeth.[48] A combination of active and passive homecare is therefore ideal.[49]

Active Homecare

Products

Active homecare has long been deemed the "gold standard" of home dental care.[50] It consistently decreases periodontal bacterial levels in dogs.[51] The good news for clients is that the only required piece of equipment is a toothbrush. Numerous veterinary brushes are available, and even human soft-bristled (typically child's) brushes can be used. There are also many varieties of veterinary toothpaste. While mechanical removal of plaque by the movement of the brush is the mainstay of plaque control,[50] a recent study has shown that the paste also has beneficial effects.[42]

Available antimicrobial preparations improve plaque and gingivitis control compared with standard pastes when used during brushing (or on their own).[52-54] Chlorhexidine has been shown in several studies to decrease gingivitis if applied consistently over time.[55-57] Another effective oral antiseptic option is soluble zinc salts.[58] A veterinary-labeled oral zinc ascorbate gel has been shown to decrease plaque and gingivitis.[59] The fact that it is tasteless may increase its acceptance by the patient (especially cats).[49]

Performance

While toothbrushing is the simplest, least expensive, most effective way to decrease gingivitis and progression of periodontal disease, it is also the least likely to be performed by clients. Daily homecare is always recommended, as this frequency is necessary to stay ahead of plaque formation.[40,60-62] Three days a week has been shown to be the minimum frequency for patients without active disease.[63] Brushing once a week is insufficient for plaque control, but it is better than nothing.[61]

Best practices to help clients be most successful with toothbrushing revolve around client education, early intervention, and positive training and low-stress handling techniques. The younger the pet is, the more approachable it will be to this type of handling, so clients should be educated from day 1 on the importance of dental homecare and taught how to do it in a gentle and approachable manner, with lots of positive reinforcement training for the pet, as early in the pet's life as possible. For example, at a first healthy puppy visit, showing clients how to gently introduce the pet to facial handling, oral manipulation and examination, and early toothbrushing habits (perhaps with just some toothpaste on a finger) without biting or resistance will help make a lifetime of oral homecare possible.

Passive Homecare

Passive homecare for periodontal disease is achieved with special diets, chews, and treats. Since it requires no effort by the client other than selecting the product, it is more likely to be regularly used. Compliance is especially important, since long-term consistency is a crucial aspect of home dental care.[64] Sadly, daily toothbrushing with highly motivated pet owners is only around 50% after 6 months,[65] and one study suggested that passive homecare is superior to active homecare simply because it is performed.[66] However, it should not be inferred that passive care is actually more effective. The truth is that the average client is typically noncompliant with toothbrushing.

Some passive homecare methods are effective, but many are not. Practitioners should perform their own research using peer-reviewed published studies and the Veterinary Oral Health Council (VOHC®) website (vohc.com) to form proper client recommendations rather than relying on marketing statements.

Diets for Dental Care

Traditional dry dog foods have been thought to be helpful in controlling gum disease, and one study supports these claims.[67] However, another study found

that dry food does not perform better than moist food in regards to oral health.[68] Therefore, a specific dental diet that has been proven to decrease tartar and plaque accumulation should be selected.[69]

Several diets have received the VOHC seal as effective against both plaque and calculus reduction. A smaller number of diets have received VOHC approval for calculus reduction only. Although these products may decrease plaque and calculus, they are typically only effective on the cusp tips and do not clean along the gingival margin.[70] Of all the available diets, only one has been proven to decrease gingivitis.[71-73]

Plaque and/or Calculus Control Treats

Several edible treats are available for passive homecare; however, their effectiveness varies, and practitioners are again encouraged to consult the VOHC website in their search for effective products. The most common are the rask-type chews (products composed of compressed wheat, cellulose, or rawhide).[74-79] A few products have been shown to decrease gingivitis.[77,80-86] In addition, a few products have received VOHC approval for plaque and/or calculus control. A product containing the brown algae *Ascophyllum nodosum* has been shown to improve oral health status.[87] Plain baked biscuit treats and chew toys (e.g., rope toys) are not effective in the prevention of periodontitis.[74]

Many "dental treats" or chew toys are very hard, which can result in tooth fracture.[88] As a rule of thumb, clients can be advised that if they cannot make an indentation in the product with their fingernail, it is too hard.[50]

CONCLUSION

Lifelong periodontal care benefits the patient, the client, and the practice. Performing regular (and early) professional dental cleanings, training staff in the proper performance of periodontal care, and establishing the value of homecare early in a pet's life through client education allow the maximal benefit of this lifelong effort to be achieved. Also, as proper cleaning can only be performed within the clinic, periodontal therapy makes the dental department a critical area of medical care, as well as a significant financial center. Avoiding periodontal disease must be the goal, for once it is established, damage is typically irreversible and more invasive care, including surgery and, eventually, tooth extraction, will be necessary. TVP

References

1. Niemiec BA. Etiology and pathogenesis of periodontal disease. In: Niemiec BA, ed. *Veterinary Periodontology*. Ames, IA: Wiley-Blackwell; 2012:18-32.
2. Niemiec BA. Advanced non-surgical therapy. In: Niemiec BA, ed. *Veterinary Periodontology*. Ames, IA: Wiley-Blackwell; 2012:154-169.
3. Bellows J, Berg ML, Dennis S, et al. 2019 AAHA dental care guidelines for dogs and cats. *JAAHA* 2019;55(2):49-69.
4. Colmery B. The gold standard of veterinary oral health care. *Vet Clin North Am Small Anim Pract* 2005;35(4):781-787.
5. Niemiec BA. Professional teeth cleaning. *J Vet Dent* 2003;20(3):175-180.
6. Bellows J. Equipping the dental practice. In: Bellows J, ed. *Small Animal Dental Equipment, Materials, and Techniques: A Primer*. Ames, IA: Blackwell; 2004:13-55.
7. Holmstrom SE, Fitch PF, Eisner ER. Dental prophylaxis and periodontal disease stages. *Veterinary Dental Techniques*. 3rd ed. Philadelphia, PA: Saunders; 2002:175-232.
8. Holmstrom SE, Bellows J, Juriga S, et al. 2013 AAHA dental care guidelines for dogs and cats. *JAAHA* 2013;49(2):75-82.
9. Huffman LJ. Oral examination. In: Niemiec BA, ed. *Small Animal Dental, Oral and Maxillofacial Disease: A Color Handbook*. London: Manson; 2010:39-61.
10. Stella JL, Bauer AE, Croney CC. A cross-sectional study to estimate prevalence of periodontal disease in a population of dogs (Canis familiaris) in commercial breeding facilities in Indiana and Illinois. *PLoS One* 2018;13(1):e0191395.
11. Urfer SR, Wang M, Yang M, et al. Risk factors associated with lifespan in pet dogs evaluated in primary care veterinary hospitals. *JAAHA* 2019;55(3):130-137.
12. Bauer AE, Stella J, Lemmons M, Croney CC. Evaluating the validity and reliability of a visual dental scale for detection of periodontal disease (PD) in non-anesthetized dogs (Canis familiaris). *PLoS One* 2018;13(9):e0203930.
13. Wallis C, Patel KV, Marshall M, et al. A longitudinal assessment of periodontal health status in 53 Labrador retrievers. *J Small Anim Pract* 2018;59(9):560-569.
14. Companion animal dental scaling without anesthesia. American College of Veterinary Dentists. avdc.org/about/#pos-stmts. Accessed May 2018.
15. Global dental guidelines. World Small Animal Veterinary Association. wsava.org/Global-Guidelines/Global-Dental-Guidelines. Accessed May 2018.
16. Niemiec BA. The complete dental cleaning. In: Niemiec BA, ed. *Veterinary Periodontology*. Ames, IA: Wiley Blackwell; 2013:129-153.
17. Verstraete FJ, Kass PH, Terpak CH. Diagnostic value of full-mouth radiography in cats. *Am J Vet Res* 1998;59(6):692-695.
18. Verstraete FJ, Kass PH, Terpak CH. Diagnostic value of full-mouth radiography in dogs. *Am J Vet Res* 1998;59(6):686-691.
19. Engler W, Bain M. Effect of different types of classical music played at a veterinary hospital on dog behavior and owner satisfaction. *JAVMA* 2017;251(2):195-200.
20. Gilbert C, Mikaelsson A, Gilbert S. Enhancing dogs' welfare during a veterinary consultation; impact of environmental factors and positive interactions before the consultation. *Proc Eur Cong Behav Med Anim Welf* 2018:254-255.
21. Hekman JP, Karas AZ, Sharp CR. Psychogenic stress in hospitalized dogs: cross species comparisons, implications for health care, and the challenges of evaluation. *Animals* 2014;4(2):331-347.
22. Savvas I, Raptopoulos D, Rallis T. A "light meal" three hours pre-operatively decreases the incidence of gastro-esophageal reflux in dogs. *JAAHA* 2016;52(6):357-363.
23. Savvas I, Rallis T, Raptopoulos D. The effect of pre-anesthetic fasting time and type of food on gastric content volume and acidity in dogs. *Vet Anaesth Analg* 2009;36(6):539-546.
24. Westlund K. To feed or not to feed: counterconditioning in the veterinary clinic. *J Vet Behav* 2015;10:433-437.
25. Beckman B. Patient management for periodontal therapy. In: Niemiec BA, ed. *Veterinary Periodontology*. Ames, IA: Wiley-Blackwell; 2012:305-312.

26. Hughes J. Anaesthesia for the geriatric dog and cat. *Ir Vet J* 2008;61(6):380–387.
27. Lloyd JKF. Minimising stress for patients in the veterinary hospital: why it is important and what can be done about it. *Vet Sci* 2017;4(2):22.
28. Tynes VV. The physiologic effects of fear. Vet Med. veterinarymedicine.dvm360.com/physiologic-effects-fear. Accessed December 2016.
29. Watanabe R, Doodnaught G, Proulx C, et al. A multidisciplinary study of pain in cats undergoing dental extractions: a prospective, blinded, clinical trial. *PLoS One* 2019;14(3):e0213195.
30. Zetner K , Rothmueller G. Treatment of periodontal pockets with doxycycline in beagles. *Vet Ther* 2002;3(4):441–452.
31. Caffesse RG, Sweeney PL, Smith BA. Scaling and root planing with and without periodontal flap surgery. *J Clin Periodontol* 1986;13(3):205-210.
32. Carranza FA, Takei HH. Phase II periodontal therapy. In: Newman MG, Takei H, Klokkevold PR, et al, eds. *Carranza's Clinical Periodontology*. St. Louis, MO: WB Saunders; 2006:881-886.
33. Danser MM, van Winkelhoff AJ, de Graaff J, et al. Short-term effect of full-mouth extraction on periodontal pathogens colonizing the oral mucous membranes. *J Clin Periodontol* 1994;21:484.
34. Niemiec BA. Periodontal flap surgery. In: Niemiec BA, ed. *Veterinary Periodontology*. Ames, IA: John Wiley and Sons; 2012:206-248.
35. Martel DP, Fox PR, Lamb KE, et al. Comparison of closed root planing with versus without concurrent doxycycline hyclate or clindamycin hydrochloride gel application for the treatment of periodontal disease in dogs. *JAMVA* 2019;254(3):373-379.
36. Gulati M, Anand V, Govila V, et al. Host modulation therapy: an indispensable part of perioceutics. *J Indian Soc Periodontol* 2014;18(3):282-288.
37. Mahajania M, Laddha R, Shelke A, et al. Effect of subgingival doxycycline placement on clinical and microbiological parameters in inflammatory periodontal disease: both in vivo and in vitro studies. *J Contemp Dent Pract* 2018;19(10):1228-1234.
38. Jeffcoat MK, Bray KS, Ciancio SG, et al. Adjunctive use of a subgingival controlled-release chlorhexidine chip reduces probing depth and improves attachment level compared with scaling and root planing alone. *J Periodontol* 1998;69(9):989–997.
39. Niemiec BA. Osseous surgery and guided tissue regeneration. In: Niemiec BA, ed. *Veterinary Periodontology*. Ames, IA: Wiley-Blackwell; 2012:254-288.
40. Wiggs RB, Lobprise HB. Periodontology. In: Wiggs RB, Lobprise HB, eds. *Veterinary Dentistry: Principles and Practice*. Philadelphia, PA: Lippincott–Raven; 1997:186-231.
41. Boyce EN, Ching RJ, Logan EI, et al. Occurrence of gram-negative black-pigmented anaerobes in subgingival plaque during the development of canine periodontal disease. *Clin Infect Dis* 1995;20(Suppl 2):S317-S319.
42. Watanabe K, Kijima S, Nonaka C, et al. Inhibitory effect for proliferation of oral bacteria in dogs by tooth brushing and application of toothpaste. *J Vet Med Sci* 2016;78(7):1205-1208.
43. Debowes LJ. Problems with the gingiva. In: Niemiec BA, ed. *Small Animal Dental, Oral and Maxillofacial Disease: A Color Handbook*. London: Manson; 2010:159-181.
44. Fiorellini JP, Ishikawa SO, Kim DM. Clinical features of gingivitis. In: Newman MG, Takei H, Klokkevold PR, et al, eds. *Carranza's Clinical Periodontology*. St. Louis, MO: WB Saunders; 2006:362-372.
45. Rober M. Effect of scaling and root planing without dental homecare on the subgingival microbiota. *Proc Eur Cong Vet Dent* 2007:28-30.
46. Corba NHC, Jansen J, Pilot T. Artificial periodontal defects and frequency of tooth brushing in beagle dogs (II). Clinical findings after a period of healing. *J Clin Periodontol* 1986;13(3):186-189.
47. Payne WA, Page RC, Olgilvie AL, Hall WB. Histopathologic features of the initial and early stages of experimental gingivitis in man. *J Periodont Res* 1975;10(2):51.
48. Capik I. Periodontal health vs. different preventive means in toy breeds—clinical study. *Proc Eur Cong Vet Dent* 2007:31-34.
49. Niemiec BA. Home plaque control. In: Niemiec BA, ed. *Veterinary Periodontology*. Ames, IA: Wiley-Blackwell; 2012:175-185.
50. Hale FA. Home care for the veterinary dental patient. *J Vet Dent* 2003;20(1):52-54.
51. Watanabe K, Hayashi K, Kijima S, et al. Tooth brushing inhibits oral bacteria in dogs. *J Vet Med Sci* 2015;77(10):1323-1325.
52. Stratul SI, Rusu D, Didilescu A, et al. Prospective clinical study evaluating the long-time adjunctive use of chlorhexidine after one-stage full-mouth SRP. *Int J Dent Hyg* 2010;8(1):35-40.
53. Eaton KA, Rimini FM, Zak E, et al. The effects of a 0.12% chlorhexidine-digluconate containing mouthrinse versus a placebo on plaque and gingival inflammation over a 3-month period. A multicentre study carried out in general dental practices. *J Clin Periodontol* 1997;24(3):189-197.
54. Hennet P. Effectiveness of a dental gel to reduce plaque in beagle dogs. *J Vet Dent* 2002;19(1):11-14.
55. Hamp SE, Emilson CG. Some effects of chlorhexidine on the plaque flora of the beagle dog. *J Periodontol Res Suppl* 1973;12:28-35.
56. Hull PS, Davies RM. The effect of a chlorhexidine gel on tooth deposits in beagle dogs. *J Small Anim Pract* 1972;13:207-212.
57. Maruniak J, Clark WB, Walker CB, et al. The effect of 3 mouthrinses on plaque and gingivitis development. *J Clin Periodontol* 1992;19(1):19-23.
58. Wolinsky LE, Cuomo J, Quesada K, et al. A comparative pilot study of the effects of a dentifrice containing green tea bioflavonids, sanguinarine, or triclosan on oral bacterial biofilm formation. *J Clin Dent* 2000;11(2):53-59.
59. Clarke DE. Clinical and microbiological effects of oral zinc ascorbate gel in cats. *J Vet Dent* 2001;18(4):177-183.
60. Niemiec BA. Periodontal disease. *Top Companion Anim Med* 2008;23(2):72-80.
61. Harvey C, Serfilippi L, Barnvos D. Effect of frequency of brushing teeth on plaque and calculus accumulation, and gingivitis in dogs. *J Vet Dent* 2015;32(1):16-21.
62. Gorrel C, Rawlings JM. The role of tooth-brushing and diet in the maintenance of periodontal health in dogs. *J Vet Dent* 1996;13(4):139-143.
63. Tromp JA, Jansen J, Pilot T. Gingival health and frequency of tooth brushing in the beagle dog model. Clinical findings. *J Clin Periodontol* 1986;13(2):164-168.
64. Ingham KE, Gorrel C. Effect of long-term intermittent periodontal care on canine periodontal disease. *J Small Anim Pract* 2001;42(2):67-70.
65. Miller BR, Harvey CE. Compliance with oral hygiene recommendations following periodontal treatment in client-owned dogs. *J Vet Dent* 1994;11(1):18-19.
66. Vrieling HE, Theyse LF, van Winkelhoff AJ, et al. Effectiveness of feeding large kibbles with mechanical cleaning properties in cats with gingivitis. *Tijdschr Diergeneeskd* 2005;130(5):136-140.
67. Gawor JP, Reiter AM, Jodkowska K, et al. Influence of diet on oral health in cats and dogs. *J Nutr* 2006;136(7 suppl):2021S-2023S.
68. Harvey CE, Shofer FS, Laster L. Correlation of diet, other chewing activities, and periodontal disease in North American client-owned dogs. *J Vet Dent* 1996;13(3):101-105.
69. Jensen L, Logan E, Finney O, et al. Reduction in accumulation of plaque, stain, and calculus in dogs by dietary means. *J Vet Dent* 1995;12(4):161-163.
70. Stookey GK, Warrick JM. Calculus prevention in dogs provided diets coated with HMP. *Proc Am Vet Dent Forum* 2005:417-421.
71. Logan EI, Finney O, Hefferren JJ. Effects of a dental food on plaque accumulation and gingival health in dogs. *J Vet Dent* 2002;19(1):15-18.
72. Logan EI, Proctor V, Berg ML, et al. Dietary effect on tooth surface debris and gingival health in cats. *Proc Am Vet Dent Forum* 2001:77.
73. Logan EI, Berg ML, Coffman L, et al. Dietary control of feline gingivitis: results of a six month study. *Proc Vet Dent Forum* 1999:54.
74. Roudebush P, Logan E, Hale FA. Evidence-based veterinary dentistry: a systematic review of homecare for prevention of periodontal disease in dogs and cats. *J Vet Dent* 2005;22(1):6-15.
75. Hennet P, Servet E, Venet C. Effectiveness of an oral hygiene chew to reduce dental deposits in small breed dogs. *J Vet Dent* 2006;23(1):6-12.
76. Lage A, Lausen N, Tracy R, Allred E. Effect of chewing rawhide and cereal biscuit on removal of dental calculus in dogs. *JAVMA* 1990;197(2):213-219.
77. Stookey GK. Soft rawhide reduces calculus formation in dogs. *J Vet Dent* 2009;26:82-85.
78. Hennet P. Effectiveness of an enzymatic rawhide dental chew to reduce plaque in beagle dogs. *J Vet Dent* 2001;18(2):61-64.
79. Beynen AC, Van Altena F, Visser EA. Beneficial effect of a cellulose-containing chew treat on canine periodontal disease in a double-blind,

placebo-controlled trial. *Am J Anim Vet Sci* 2010;5:192-195.

80. Gorrel C, Bierer TL. Long-term effects of a dental hygiene chew on the periodontal health of dogs. *J Vet Dent* 1999;16(3):109-113.
81. Gorrel C, Warrick J, Bierer TL. Effect of a new dental hygiene chew on periodontal health in dogs. *J Vet Dent* 1999;16(2):77-81.
82. Mariani C, Douhain J, Servet E, et al. Effect of toothbrushing and chew distribution on halitosis in dogs. *Proc Cong Vet Dent* 2009:13-15.
83. Warrick JM, Stookey GK, Inskeep GA, et al. Reducing calculus accumulation in dogs using an innovative rawhide treat system coated with hexametaphosphate. *Proc Am Vet Dent Forum* 2001:379-382.
84. Brown WY, McGenity P. Effective periodontal disease control using dental hygiene chews. *J Vet Dent* 2005;22(1):16-19.
85. Quest BW. Oral health benefits of a daily dental chew in dogs. *J Vet Dent* 2013;30(2):84-87.
86. Clarke DE, Kelman M, Perkins N. Effectiveness of a vegetable dental chew on periodontal disease parameters in toy breed dogs. *J Vet Dent* 2011;28(4):230-235.
87. Gawor J, Jank M, Jodkowska K, et al. Effects of edible treats containing *Ascophyllum nodosum* on the oral health of dogs: a double-blind, randomized, placebo-controlled single-center study. *Front Vet Sci* 2018;5:168.
88. Soltero-Rivera M, Elliott MI, Hast MW, et al. Fracture limits of maxillary fourth premolar teeth in domestic dogs under applied forces. *Front Vet Sci* 2019;5:339.

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