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World Small Animal Veterinary Association Global Dental Guidelines

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Abstract

Dental, oral, and maxillofacial diseases are some of the most common problems in small animal veterinary practice. These conditions create significant pain as well as localized and potentially systemic infection. As such, the World Small Animal Veterinary Association (WSAVA) believes that un- and under treated oral and dental diseases pose a significant animal welfare concern. Dentistry is an area of veterinary medicine which is still widely ignored and is subject to many myths and misconceptions. Effective teaching of veterinary dentistry in the veterinary school is the key to progression in this field of veterinary medicine, and to the improvement of welfare for all our patients globally.

These guidelines were developed to provide veterinarians with the information required to understand best practices for dental therapy and create realistic minimum standards of care. Using the three-tiered continuing education system of WSAVA, the guidelines make global equipment and therapeutic recommendations and highlight the anaesthetic and welfare requirements for small animal patients.

This document contains information on common oral and dental pathologies, diagnostic procedures (an easily implementable and repeatable scoring system for dental health, dental radiography and radiology) and treatments (periodontal therapy, extractions). Further, there are sections on anaesthesia and pain management for dental procedures, home dental care, nutritional information, and recommendations on the role of the universities in improving veterinary dentistry. A discussion of the deleterious effects of anaesthesia free dentistry (AFD) is included, as this procedure is ineffective at best and damaging at worst. Throughout the document the negative effects of undiagnosed and/or treated dental disease on the health and well-being of our patients, and how this equates to an animal welfare issue, is discussed.

INTRODUCTION

The World Small Animal Veterinary Association (WSAVA) is an 'association of associations' with over 200,000 small animal veterinarians globally represented by over 101 member associations. Utilizing guidelines assists the entire healthcare team to understand, embrace, and enact practice standards to improve quality of care for all patients.

Like those before it, the Global Dental Guidelines committee was established to develop a universally relevant document that would take into consideration the world-wide differences in educational background, access to equipment and drugs, as well as treatment modalities of its members. The guidelines committee encompasses members from diverse veterinary specialties, emphasizing the multimodal approach necessary to provide proper dental health services. Authors representing advanced training in dentistry, nutrition, anaesthesia, analgesia, and animal welfare have come together to each highlight the importance of oral and dental diseases treatment and prevention for our patients from various areas of veterinary care.

The WSAVA sincerely hopes these guidelines will empower members of the global healthcare team to recognize and treat oral and dental diseases, further promote and guide inclusion of dentistry in the veterinary university curriculum, and increase the level of confidence in the need for proper veterinary dental care for patients worldwide.

USE OF THIS DOCUMENT

Oral and dental diseases know no geographical boundaries, and as such the guidelines were developed to assist practitioners from around the world. The only limiting factors to proper dental therapy are awareness of its prevalence or impact on patient health and welfare, education on the subject, and a commitment to include oral and dental assessment in every physical examination. These guidelines were created with easy to implement fundamentals at their core. Their purpose is to guide the general practitioner towards successful detection, diagnosis and therapy of the most common oral and dental conditions. While continued research is required in all areas represented in these guidelines, a distinct effort has been made to provide peer reviewed, evidence-based, recommendations in all areas. Where veterinary dental research is unavailable or lacking, additional human dental literature may be cited. Each section contains an extensive reference list should the practitioner require additional information. There is additional reference material available on the WSAVA website (www.wsava.org).

Throughout this document, the WSAVA's continuing education three-tiered system has been utilized to make recommendations for the various member associations. It is understood that even within countries, there is great variability in standards of care, and this document should be viewed as it was intended, as guidelines to improve dental care. Tiering where appropriate should be used to guide the practitioner to minimum acceptable practices in their represented countries, but is by no means meant to recommend an interested practitioner stop there in their provision of service, or pursuit of educational goals. Tier 3 could also be considered best practice internationally, Tier 2 minimal standard in a less economically developed country, and falling below the Tier 1 standard unacceptable anywhere in the world. Acknowledgement of the vast differences in the availability of analgesic and anaesthetic drugs is made, and practitioners are guided to the Global Pain Council's guidelines (2013) available in JSAP and on the WSAVA website.

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SECTION 1: ORAL ANATOMY AND COMMON PATHOLOGY

ORAL AND DENTAL ANATOMY AND PHYSIOLOGY

Bones of the maxilla and mandible

The upper jaw consists of paired maxillae and incisive bones. Their alveolar processes contain alveoli for the incisor (incisive bone), canine, premolar and molar teeth (maxillary bone). (**Figure 1)** The lower jaw is formed by the two mandibles which are joined at the symphysis. Each mandible has a body with the alveoli for incisor, canine, premolar and molar teeth, and a ramus consisting of the angular, coronoid and condylar processes. The condylar process of the mandibular ramus articulates with the temporal bone at the temporomandibular joint (Lewis & Reiter 2010, Evans & de Lahunta 2013). **(Figure 2)**.

There are six clinically important foramina in the jaws:

- maxillary foramen: directly dorsal to the caudal aspect of the maxillary fourth premolar tooth, this is the entrance for the infraorbital nerve and blood vessels into the infraorbital canal
- infraorbital foramen: dorsal to the interdental space of the third and fourth maxillary premolar tooth, this is where the infraorbital nerve and blood vessels exit the infraorbital canal
- mandibular foramen: on the medial surface of the mandibular ramus, this is the caudal opening of the mandibular canal and serves as the entrance for the inferior alveolar nerve and blood vessels into the mandibular canal
- caudal, middle and rostral mental foramina: these are the rostral openings of the mandibular canal. The caudal foramen is located at the level of the mesial root of the mandibular third premolar, the middle at the mesial root of the second premolar, and the rostral at the second incisor tooth. The caudal and middle foramina may coalesce into one

Innervation, blood supply and muscles of mastication

Innervation of the maxillofacial region, oral cavity and tongue is provided by the trigeminal nerve (V), facial nerve (VII), glossopharyngeal nerve (IX), vagus (X) and hypoglossal nerve (XII). Blood supply comes through the maxillary artery. The branches of the maxillary artery which are most commonly encountered during oral and maxillofacial surgery are the minor palatine artery, infraorbital artery, descending palatine artery (this later gives rise to the major palatine and sphenopalatine arteries) and inferior alveolar artery (Lewis & Reiter 2010, Evans & de Lahunta 2013). **(Figure 3)**.

There are four groups of muscles of mastication – masseter, temporal, lateral and medial pterygoid, and digastric. Apart from the digastricus, which opens the mouth, the other three muscle groups close the mouth (Lewis & Reiter 2010, Evans & de Lahunta 2013). **(Figure 4)**.

Saliva

Oral fluid (mixed saliva) is formed by secretions of the major salivary glands (parotid gland, mandibular gland, monostomatic sublingual and polystomatic sublingual gland and zygomatic gland in the dog, plus a molar salivary gland in the cat), minor glands, desquamated oral epithelial cells, microorganisms and their byproducts, food debris, and serum components and inflammatory cells from the gingival crevice. Normal production of saliva is of extreme importance for oral health (Nanci 2013a, Lewis & Reiter 2010)

Lymph drainage

There are three lymph centers draining the oral cavity, head and neck. These are the parotid, mandibular (with buccal lymph nodes) and retropharyngeal lymph centers. Pathways of lymphatic drainage are unpredictable, but the main lymph draining center for the head is the retropharyngeal lymph center, In certain head and neck tumours, lymph draining can occur via the superficial and deep cervical lymph nodes. (Randall *et al*. 2020) which consists of a medial and sometimes a lateral lymph node (Lewis & Reiter 2010, Evans & de Lahunta 2013, Skinner *et al*. 2016).

Oral cavity proper and dentition

The limits of the oral cavity proper are the hard and soft palate dorsally, the dental arches and teeth rostrally and laterally, and the floor of the oral cavity consisting of the tongue and ventral oral mucosa. The teeth are located in the upper and lower dental arches, each consisting of two quadrants.

When using the modified Triadan system to describe the dentition in an adult animal, the right maxilla is quadrant one, left maxilla is quadrant two, left mandible is quadrant three, and right mandible is quadrant four. The dental formula of a dog is 2x I 3/3: C 1/1 : P 4/4 : M 2/3 = 42. In puppies, the dental formula is 2x i 3/3: c 1/1: p 3/3 = 28, in adult cats 2x I 3/3: C 1/1: P 3/2: M 1/1 = 30, and kittens 2x 3/3: c 1/1: p 3/2 = 26. **(Figure 5)**

The occlusion describes how the teeth meet and six points should be evaluated – incisor, canine, premolar, and caudal premolar/molar teeth occlusion, as well as head symmetry, and the presence/position of the individual teeth (Lewis & Reiter 2010, Verstraete 2011, AVDC Nomenclature Committee 2019).

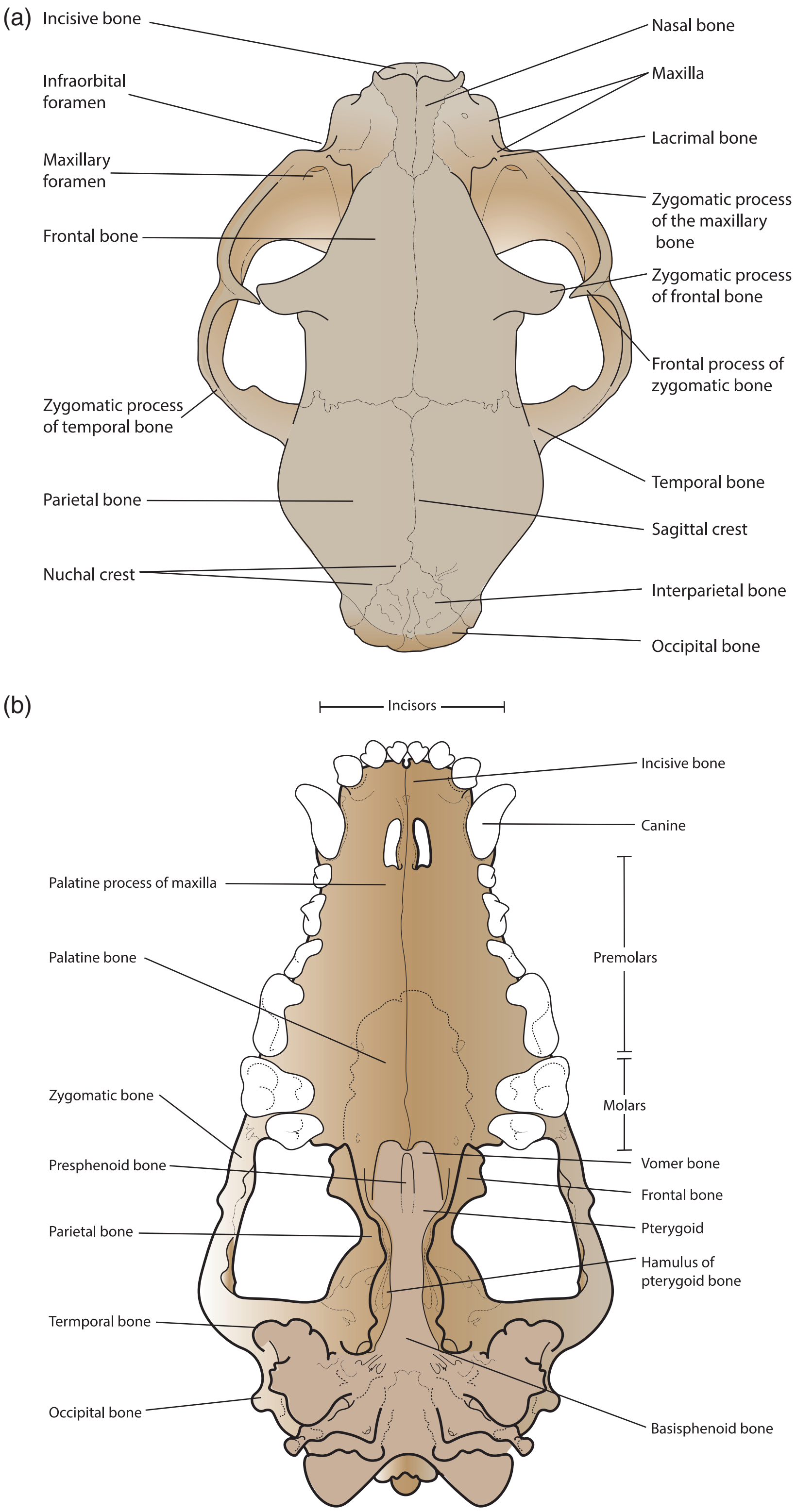

Figure 1. a) Anatomy of the feline skull (dorsal aspect), b) Anatomy of the canine skull (ventral aspect)

Dogs and cats have diphyodont (two generations of teeth), anelodont (teeth do not grow continuously), brachydont (roots are longer than crowns and crowns are fully covered by enamel) dentition. Permanent incisor teeth are small single-rooted teeth. Canine teeth are the largest single-rooted teeth. The apex (end of the root) of the mandibular canine tooth lies lingual to the middle mental foramen and occupies a large portion of the mandible. There is only a thin plate of bone between the root of the maxillary canine tooth and the nasal cavity, therefore this is a common location for oronasal fistulation.

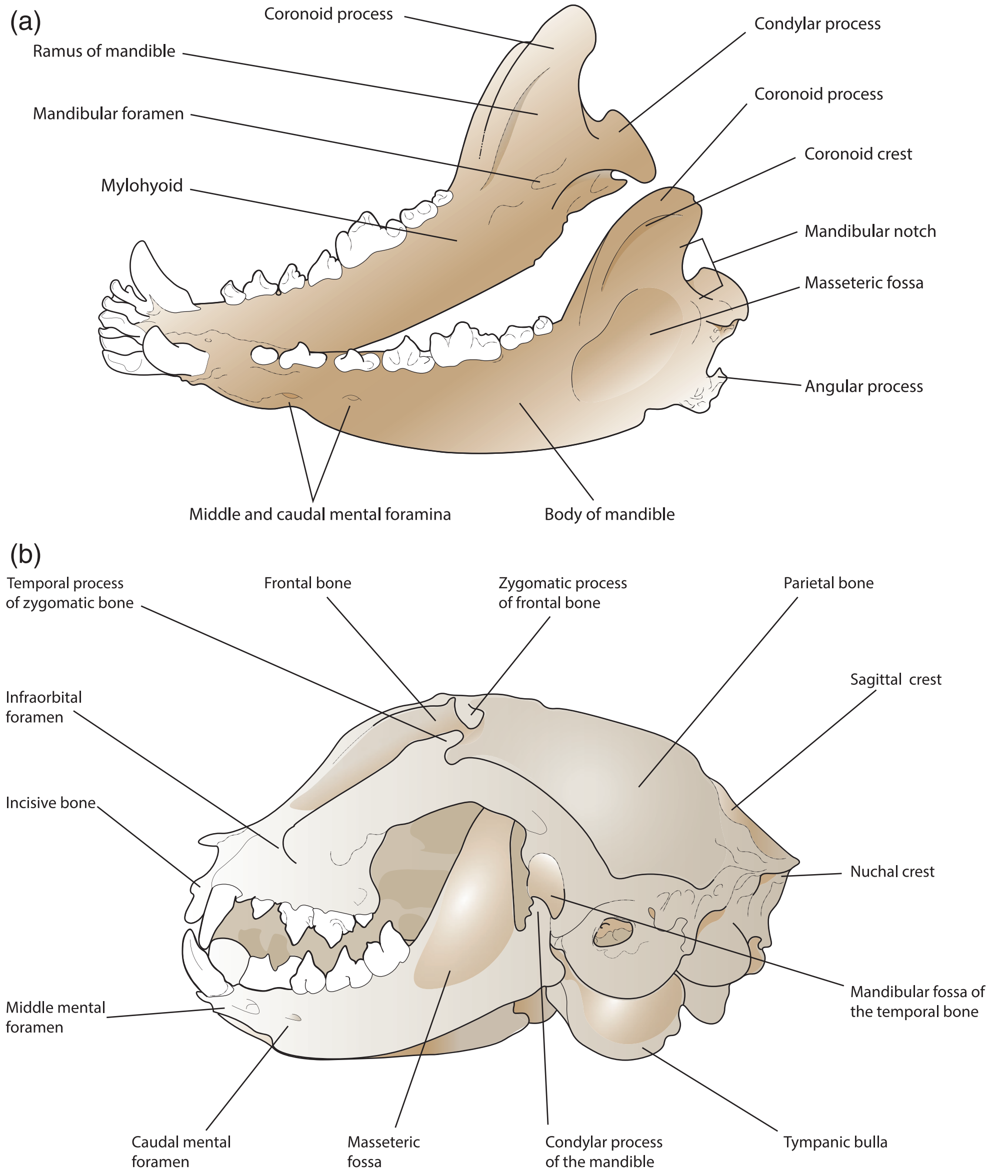

Figure 2. a) Anatomy of the canine mandibles, b) Anatomy of the feline skull

In dogs, the premolar teeth vary in size and number of roots. First premolar teeth (maxillary and mandibular) are small, single-rooted teeth, the maxillary fourth premolar tooth is a large three-rooted tooth, and the rest of the premolar teeth are two-rooted. Roots of individual maxillary premolar and molar teeth are close to the infraorbital canal, nasal cavity and orbit. Maxillary molar teeth in the dog are three rooted with a flat occlusal surface palatally. The mandibular first molar is a large two rooted tooth with roots close to the mandibular canal (Lewis & Reiter 2010, Verstraete 2011, AVDC Nomenclature Committee 2019). In small dogs, the mandibular first molar tooth is proportionally larger relative to the mandibular height compared to larger dogs (Gioso 2003). The mandibular second and third molar teeth are similar, with the second having two roots and the third one root.

In cats, the maxillary second premolar tooth is a small, single-rooted tooth (rarely two-rooted). The maxillary third premolar tooth is a two-rooted (possibly three-rooted) tooth, and there is a larger three-rooted maxillary fourth premolar tooth. The mandible bears only two (third and fourth) premolar teeth with two roots each, which lie close to the mandibular canal.

There is a small single-rooted or two-rooted maxillary molar tooth and a large two-rooted mandibular molar tooth in the cat. For the most part, the two-rooted teeth are symmetrical with roots being relatively the same size. A notable exception to this is the mandibular first molar, which has a large mesial and very small distal root. (Niemiec 2014)

Deciduous teeth are smaller, slimmer and sharper compared to the permanent teeth however they have proportionally longer roots. (Lewis & Reiter 2010, Verstraete 2011)

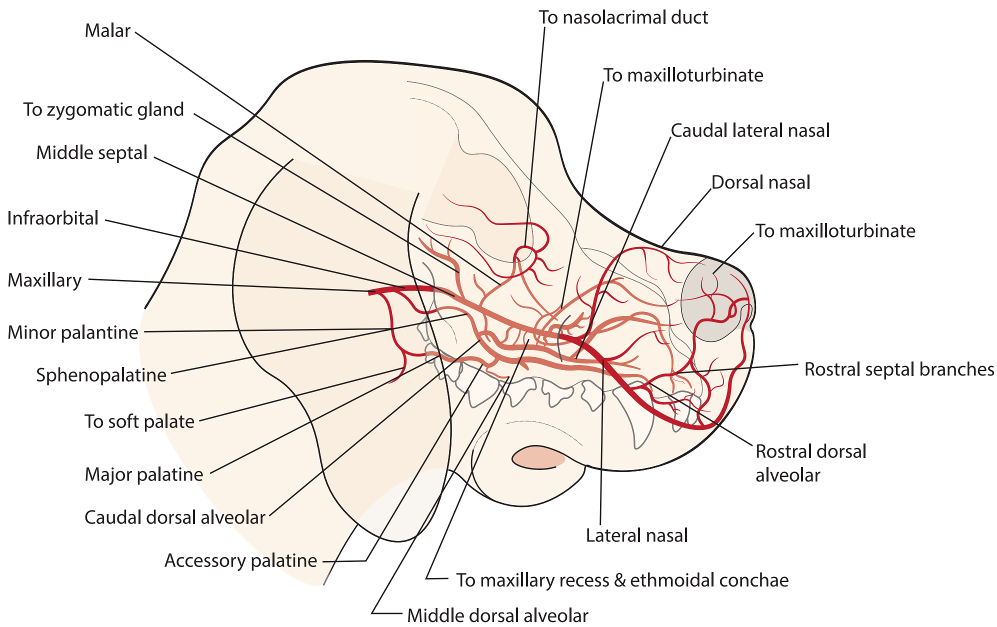

Figure 3. Blood supply to the head and face

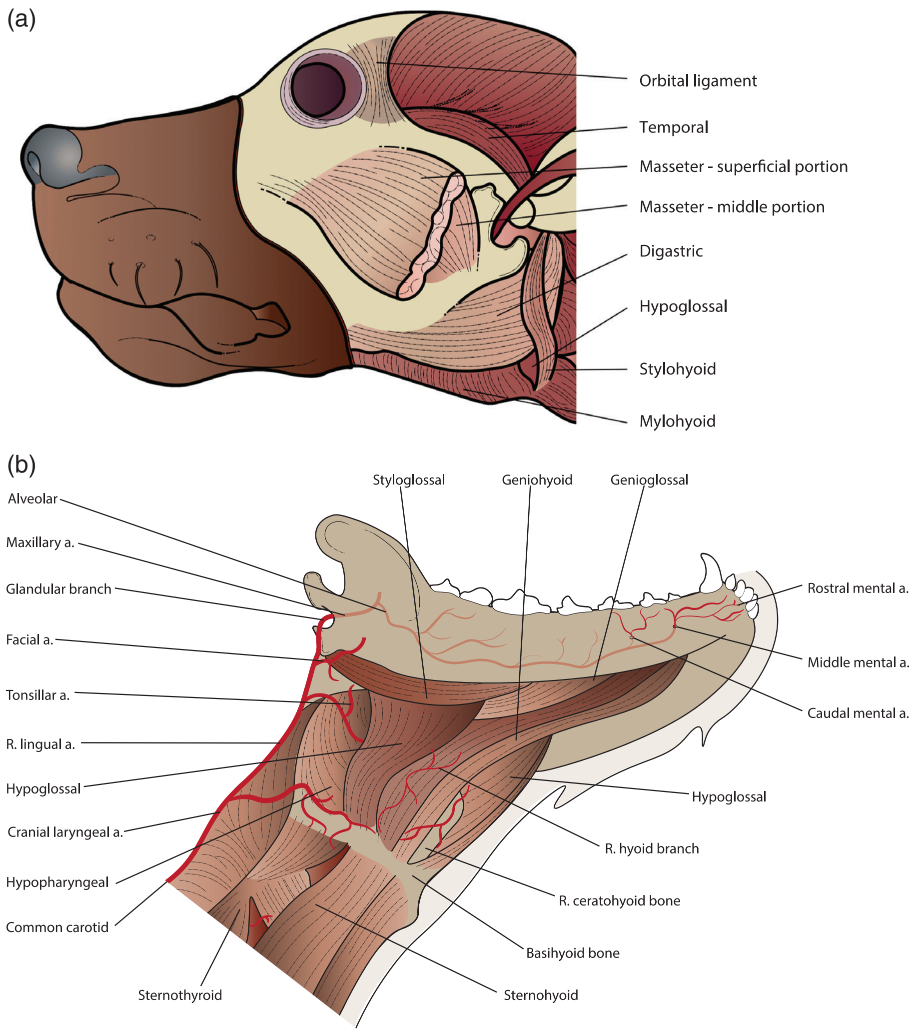

Figure 4. a) Muscles of the head, b) Muscles and vasculature of the neck.

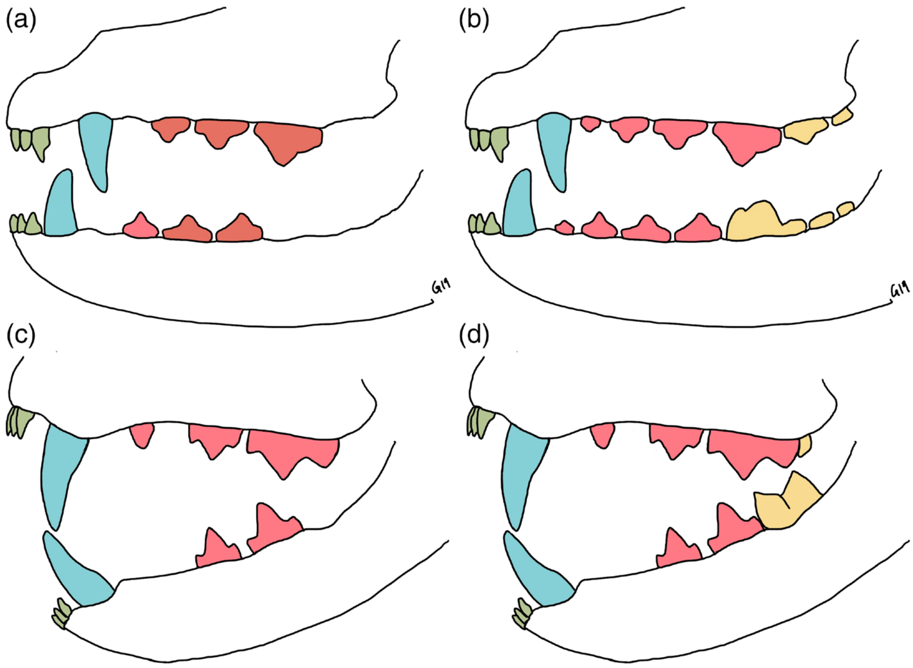

Figure 5. Nomenclature of the teeth: incisors (green), canines (blue), premolars (red), molars (orange) a) Canine primary dentition; b) Canine permanent dentition; c) Feline primary dentition; d) Feline permanent dentition

Structure of the teeth and tooth supporting apparatus

The majority of the (adult) tooth is comprised of dentin, which is formed by odontoblasts at the periphery of the pulp. Primary dentin is formed during tooth development, while secondary dentin is laid down after root formation is complete and signifies normal aging of the tooth. Tertiary dentin is formed as an attempt at repair. The central portion of the tooth (pulp cavity) is occupied by dental pulp. Dental pulp contains nerves, blood and lymphatic vessels, connective tissue and odontoblasts. Dental pulp communicates in dogs and cats with the periodontal ligament at the apical delta and lateral canals in adult animals. In young animals, the apical opening is large and it closes into an apical delta in the process of apexogenesis. The coronal portion of the tooth is covered by enamel, which is the hardest and most mineralized tissue in the body. Enamel is formed by ameloblasts only prior to the tooth eruption (Pashley & Liewehr 2006, Nanci 2013b, Lewis & Reiter 2010, Verstraete 2011). Enamel thickness varies from 0.1mm-1mm in cats and dogs (Crossley 1995). The root of the tooth is covered by cementum, which is mineralized connective tissue similar to bone, formed by cementoblasts (Pashley & Liewehr 2006, Nanci 2013b, Lewis & Reiter 2010, Verstraete 2011). **(Figure 6)**.

The tooth supporting apparatus is the periodontium, which consists of the gingiva, periodontal ligament, cementum and alveolar bone. Gingiva is divided into attached and free parts. The gingival sulcus is the area between the tooth and the free gingiva and its normal depth is 0 – 1 mm in cats and 0 – 3 mm in dogs. The floor of the gingival sulcus is formed by junctional epithelium. Below it lies the major connective tissue attachment of the tooth – the periodontal ligament. The periodontal ligament is anchored into the cementum on one side and the alveolar bone on the other and thus holds the tooth in the alveolus. (Wolf *et al.* 2005, Lewis & Reiter 2010, Verstraete 2011).

Key Points

- Knowledge and understanding of oral and dental anatomy, physiology, and basic embryology is the key to understanding disease processes and other abnormalities of the maxillofacial region, oral cavity and teeth.
- Optimal diagnostic techniques and treatments are impossible to achieve without excellent knowledge of basic anatomy and physiology.
- Basic anatomy and physiology familiarity includes awareness of the structure and function of the maxillofacial bones, muscles of mastication, innervation and vascularization, lymph drainage, salivary glands, oral cavity proper and dentition (including structure of the teeth and tooth supporting apparatus).

PERIODONTAL DISEASES

Introduction

Periodontal diseases are one of the most common health problems in small animal patients (Lund *et al.* 1999). A study from the 1980's reported that by two years of age, 70% of cats and 80% of dogs have some form of periodontal disease (Marshall 2014). More

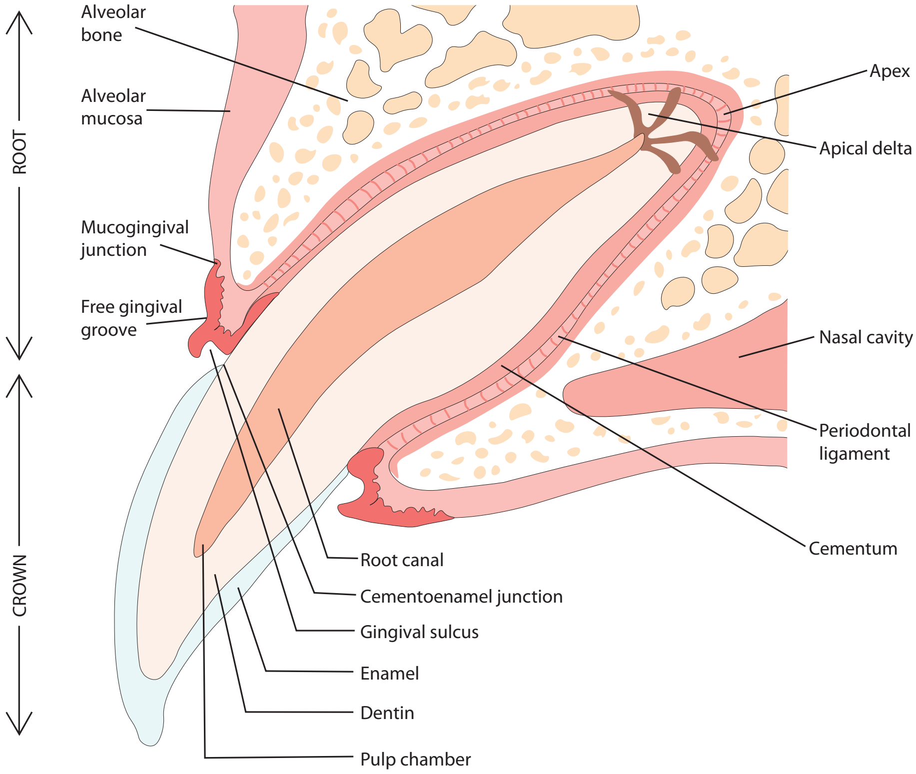

Figure 6. Cross-sectional structure of the tooth and its supporting apparatus

recent studies have reported the incidence of closer to 90% of all patients (Fernandes 2012, Queck *et al.* 2018, Stella et al. 2018). Small and toy breed dogs are particularly susceptible (Hoffmann & Gaengler 1996), and its incidence increases with age (Stella *et al.* 2018). Despite the prevalence, periodontal diseases are underdiagnosed, partially due to lack of education, but mostly from the lack of outward clinical signs. For these reasons, therapy typically comes very late in the course of disease. This lack of diagnosis and prompt therapy may lead to progressive periodontal disease, with numerous local and systemic consequences.

Pathogenesis

Periodontal diseases are generally described as gingivitis and periodontitis. Gingivitis is the initial, reversible stage in which the inflammation is confined to the gingiva. Gingival inflammation is created by microorganisms in the dental plaque and may be reversed with a thorough dental prophylaxis and consistent homecare (Silness & Low 1964, Loe *et al.* 1965, DeBowes 2010). Periodontitis is the later stage and is defined as an inflammatory disease of the deeper supporting structures of the tooth (periodontal ligament, cementum and alveolar bone) caused by microorganisms (Armitage 1999, Novak, 2006, DeBowes 2010). The inflammation results in the progressive destruction of the periodontal tissues, leading to attachment loss (Wiggs & Lobprise 1997). This can be clinically observed as gingival recession, periodontal pocket formation, or both. A periodontal pocket is diagnosed, when there is a pocket at the tooth greater than 3-mm in dogs and 0.5 mm in cats. Periodontal bone loss is irreversible without advanced reparative surgery (Shoukry *et al.* 2007, DeBowes 2010). While bone loss is irreversible, proper therapy may arrest its progression, keeping in mind it may be difficult to maintain periodontally diseased teeth. It is important to note that periodontal attachment loss may be present with or without active inflammation.

Periodontal diseases are initiated by oral bacteria which adhere to the teeth in a substance called plaque (Lindhe *et al.* 1975, Boyce *et al.* 1995, Quirynen *et al.* 2006). Plaque is a biofilm which is made up almost entirely of oral bacteria, contained in a matrix composed of salivary glycoproteins and extracellular polysaccharides (DuPont 1997, Socransky 2002, Quirynen *et al.* 2006). Plaque will attach to clean teeth within 24 hours if not disturbed. (Boyce *et al.* 1995, Holcombe *et al.*, 2014) If a plaque control regimen is established, the oral microbiome will return to normal within a few days resulting in the resolution of gingivitis (Silness & Low 1964, Loe *et al.* 1965). Plaque and calculus may contain up to 100,000,000,000 (10^{12}) bacteria per gram (Socransky et al. 2002, Quirynen *et al.* 2006). More importantly, bacteria within a biofilm are 1,000 to 1,500 times more resistant to antibiotics and concentrations of antiseptics up to 500,000 times that which would kill singular bacteria (Elder *et al.* 1995, Socransky *et al.* 2002, Quirynen *et al.* 2006).

Periodontal diseases are initiated not by increasing numbers of bacteria, but by a change in population of the oral microbiome. Plaque in healthy sites is almost all aerobic species, with anaerobic species constituting the majority of the population in periodontal diseases. (Davis *et al.* 2013a, Holcombe *et al.* 2014) Further, the Davis study (2013a) showed the percentage of anaerobes appears to increase with worsening disease. It is this change in bacterial species that results in the initiation of gingivitis (Quirynen *et al*. 2006). Although the disease process is histologically similar between humans and dogs, differences between human and canine dental plaque formation and composition have recently been described (Holcombe *et al*. 2014). Dewhirst *et al*. (2012) reported that only 16.4% of taxa are shared between humans and canines. One difference is that the composition of plaque in healthy humans is mostly gram-positive aerobes, whereas in canines it is predominantly gram-negative aerobes (Davis *et al*. 2013a). Further, the initial colonizers of canine plaque are Neisseria and Bergeyella (Holcombe *et al*. 2014). A theory for the discrepancy in species between human and canine is the relative alkalinity of canine saliva (Lavy et al. 2012, Bardow & Vissink 2015).

Plaque on the visible tooth surface is known as supragingival plaque (Teughels *et al*. 2015, Niemiec 2013a, Wiggs & Lobprise 1997). Once it extends under the free gingival margin and into the gingival sulcus (space between the gingiva and the teeth or alveolar bone), it becomes subgingival plaque (Quirynen *et al*. 2006, Niemiec 2008b). Supragingival plaque likely affects the pathogenicity of the subgingival plaque in the early stages of periodontal disease. However, once the periodontal pocket forms, the effect of the supragingival plaque is minimal (Quirynen *et al*. 2006). Therefore, control of supragingival plaque alone is ineffective in controlling the progression of periodontal diseases (Westfelt et al. 1998, Niemiec 2013a, DeBowes 2010).

The bacteria in the subgingival plaque excrete toxins and metabolic products which create inflammation of the gingival and periodontal tissues (Wiggs & Lobprise 1997, Harvey & Emily 1993). This inflammation causes damage to the gingival tissues, or gingivitis, which eventually may lead to periodontitis, i.e. the loss of periodontal tissues. In addition to directly creating tissue damage, the bacterial metabolic byproducts also elicit an inflammatory response from the animal, which further damages the periodontal tissues. (Thoden van Velzen *et al*. 1984, Lang *et al*. 2002, Scannapieco 2004). White blood cells and other inflammatory mediators migrate out of the periodontal soft tissues and into the periodontal pocket due to increased vascular permeability and increased space between the crevicular epithelial cells. When released into the pocket, these enzymes cause further inflammation of the delicate gingival and periodontal tissues. The progression of periodontal diseases is determined by the virulence of the bacteria combined with the host response (Nisengard *et al*. 2006).

The inflammation produced by both subgingival bacteria and host response damages the soft tissue attachment of the tooth, and decreases the bony support via osteoclastic activity. (Nisingard *et al*. 2006). Loss of periodontal attachment progresses in an apical direction (towards the root tip). The end stage of periodontitis is tooth loss; however, the disease will have created significant problems prior to tooth exfoliation.

Calculus (or tartar) is plaque which has become mineralized by salivary interaction. Calculus itself is relatively non-pathogenic, providing mostly an irritant effect and creating a plaque-retentive surface (Wiggs & Lobprise 1997, Hinrichs 2006, Niemiec 2008b).

Clinical Features

Normal gingival tissues are coral pink in color (allowing for normal pigmentation), and have a thin edge, with a smooth and regular texture. **(Figure 7)** There should be no demonstrable plaque or calculus.

The first clinical sign of gingivitis is gingival erythema, followed by edema and halitosis (Fiorellini *et al*. 2006a; DeBowes 2010) **(Figure 8).** Increased gingival bleeding on probing, brushing or chewing may be noted prior to the red color change (Meitner 1979, Fiorellini et al. 2006a, Niemiec 2013a) **(Figure 9)**. A recent study showed that general anaesthesia is required to diagnose most periodontal pathology (Stella JL *et al*. 2018). Gingivitis is typically associated with calculus, but is primarily elicited by plaque and thus can be seen in the absence of calculus **(Figure 10).** Alternatively, widespread supragingival calculus may be present with little to no gingivitis **(Figure 11).** It is critical to remember that calculus itself is essentially non-pathogenic (Wiggs & Lobprise 1997, Sherman *et*

Figure 7. Normal gingival tissues: Coral pink in color, no erythema or edema. No visible deposits on the dentition.

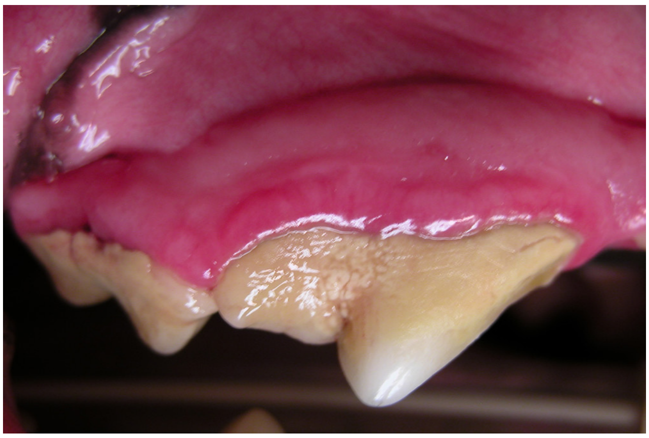

Figure 8. Gingivitis on the right maxillary fourth premolar (108) of a dog. Inflammation is demonstrated by significant erythema and edema of the free and attached gingiva. There is also significant dental calculus on the tooth.

Figure 9. Bleeding on probing is grade II gingivitis. a) No visible gingival inflammation or significant dental deposits on these teeth. b) When gently probed, note the significant haemorrhage. This demonstrates these teeth have gingivitis despite the lack of visible gingival inflammation.

Figure 10. Photograph of a feline patient with significant gingivitis despite visibly clean teeth. This picture (along with figure 9 above), demonstrates why the level of calculus should not be used to determine the need for professional care.

Figure 11. A feline patient with significant calculus deposits, but no obvious evidence of gingivitis. This patient does require therapy (a professional dental cleaning). After removal of the calculus pathology may be found.

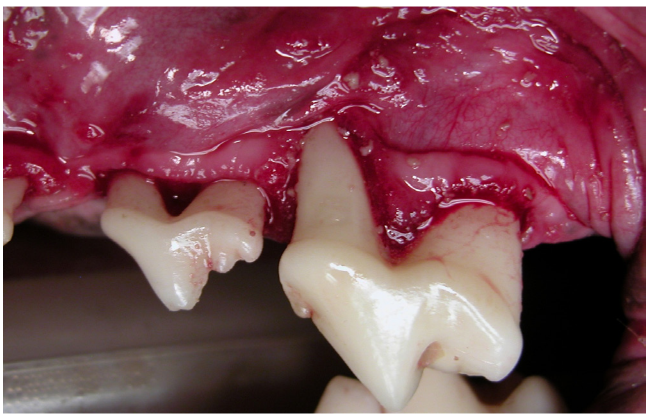

Figure 12. Advanced gingival recession on the left maxillary third and fourth premolars (207, 208). A significant amout of the root surface is exposed. Both these teeth require extraction.

Figure 13. Deep (9-mm) periodontal pocket on the mesio-palatal aspect of the right maxillary canine (104) in a dog. Note there is minimal gingivitis and no evidence of dental deposits. This image demonstrates the importance of an anaesthetised dental examination for maintaining oral health. This tooth requires periodontal flap surgery or extraction.

al. 1990, Niemiec 2013a). Therefore, the degree of gingival inflammation should be used to judge the need for professional therapy, not the level of calculus (Niemiec 2013a).

As gingivitis progresses to periodontitis, the oral inflammatory changes intensify. The hallmark feature of established periodontitis is apically progressive attachment loss. There are two common presentations of attachment loss: gingival recession with possibly normal probing depth, and normal gingival height with periodontal pocket formation. When recession occurs while the probing depth remains the same, tooth roots become exposed and may be identified on conscious examination **(Figure 12).** However, with periodontal pocket **(Figure 13)** formation, diagnosis commonly requires general anaesthesia to allow for thorough periodontal probing. It is important to note that both presentations of attachment loss can occur in the same patient, as well as the same tooth. Generally, attachment loss progresses to tooth exfoliation. After tooth exfoliation occurs, the area generally returns to an uninfected state, but the bone loss is permanent.

Significant Local Consequences

The most common severe local consequence of periodontal disease is an oronasal fistula (ONF). ONFs are typically seen in older, small and chondrodystrophic breed dogs (especially Dachshunds); however, they can occur in any canine or feline breed (Holmstrom *et al.* 1998, Marretta 1998, Smith 2000). ONFs are created by the progression of periodontal tissue loss up the palatal surface of any maxillary tooth, most commonly the canine tooth (Smith 2000, Marretta & Smith 2005, Niemiec 2010a). The result is a communication between the oral and nasal cavities, creating chronic nasal inflammation (rhinitis). **(Figure 14)** Clinical signs include chronic nasal discharge, sneezing, and occasionally anorexia and halitosis. Definitive diagnosis of an oronasal fistula often requires general anaesthesia. The diagnosis is made by introducing a periodontal probe into the periodontal space on the affected surface of the tooth. **(Figure 15)** Interestingly, this condition can occur even when the remainder of the patient's periodontal tissues is relatively healthy (including other surfaces of the affected tooth) (Niemiec 2008a, Niemiec 2013b). Appropriate treatment of an ONF requires extraction of the tooth and closure of the defect with a mucogingival flap following proper debridement of the tissues (Smith 2000, Marretta & Smith 2005, Marretta 1988).

In multirooted teeth, class II perio-endo lesions may occur (Niemiec 2001). Periodontal loss progresses apically allowing bacteria to gain access to the endodontic system, and the endodontic infection spreads via the common pulp chamber causing periapical lesions on the other root(s). (Sunitha *et al.* 2008, Varughese *et al.* 2015) **(Figure 16)** In contrast, class I lesions are defined as periodontal infection extending from the root canal system and class III lesions are true combined lesions (Wiggs & Lobprise 1997). Type 1 lesions are not a consequence of periodontitis, and type III lesions are exceedingly rare in veterinary patients. Class II lesions can be treated by extraction, or if only one root is periodontally affected by tooth/root resection and endodontic therapy of the other root (Niemiec 2001a, Varughese *et al.* 2015)

Pathologic fractures secondary to chronic periodontitis are most commonly seen around the mandibular teeth (especially the canines and first molars) due to weakened bone (Mulligan *et al.* 1998, DeBowes 2010) **(Figure 17)**. More commonly seen in small breed dogs, it is proposed that this may be due to their proportionally larger teeth (especially the mandibular first molar) as compared to their jaw size **(Figure 18).** (Gioso 2003, Snyder *et al.* 2016a) Pathologic fractures occur most commonly as a result of mild trauma (tooth extraction, play behaviours, eating, etc.). Pathologic fractures carry a guarded prognosis, especially due to the lack of remain-

Figure 14. A canine patient suffering from an oronasal fistula following right maxillary canine (104) extraction. 2 sutures are still in place.

Figure 15. A periodontal probe inserted along the palatal surface of the left maxillary canine (204) in a dog. The probe enters the nasal cavity, confirming the presence of an oronasal fistula.

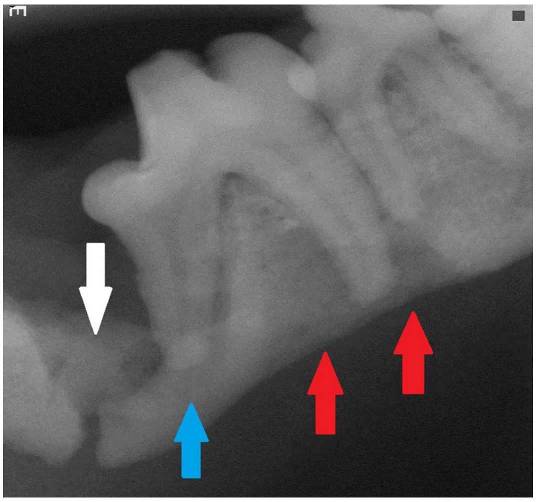

Figure 16. Intraoral dental radiograph of the right mandibular first molar (409) in a small breed (4 kg) dog with advanced periodontal disease and a class II perio-endo lesion. Periodontal disease has destroyed the bone all the way to the apex of the distal root (blue arrow). Bacteria gained access to the endodonic system through the apical blood supply and caused tooth death. Resultant inflammation via the common pulp chamber caused a large periapical lesion on the mesial root (red arrows). There is a fibrous union holding the mandible together just caudal to the distal root (white arrow). Extraction of this tooth must be performed VERY carefully in order not to fracture the jaw. Alternatively, the distal root can be resected and a root canal performed on the mesial root.

Figure 17. Intraoral dental radiograph of a small breed (3.5 kg) dog demonstrating a pathologic mandibular fracture associated with the left mandibular fourth premolar (308) (yellow arrow). The weakened bone fractured due to a minor trauma (dog fight).

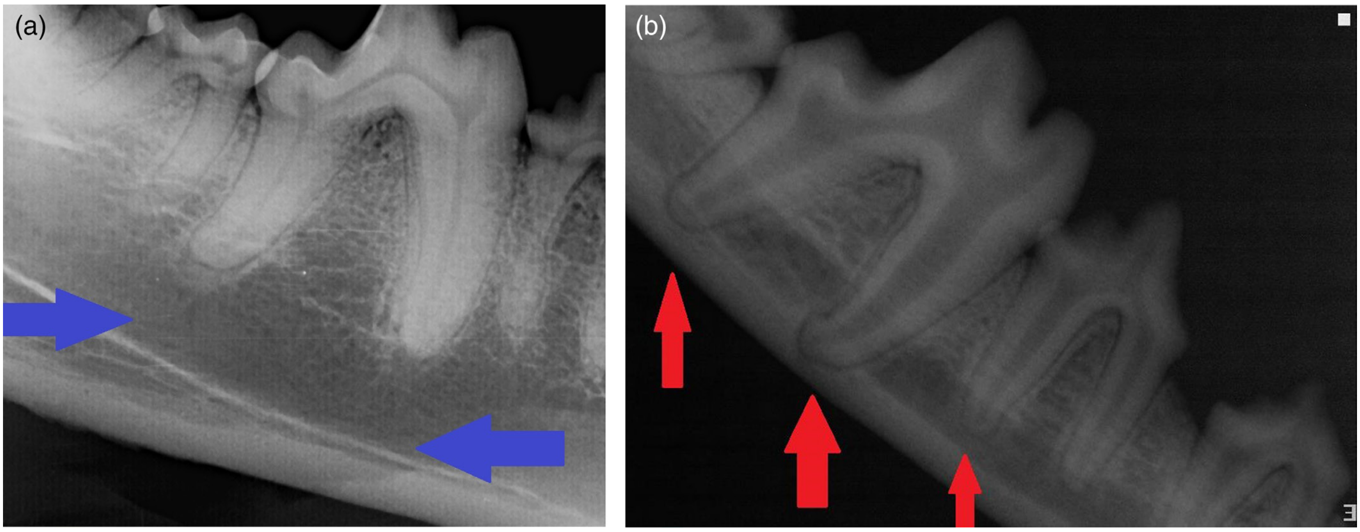

Figure 18. Intraoral dental radiographs comparing the mandibular height of a large breed (40 kg) (a) and small breed (3 kg) (b) dog. Note that in (a) there is a significant amount of bone ventral to the tooth apicies (blue arrows), thus making a fracture highly unliekly even if all the periodontal attachment was lost. In (b), however, there is minimal (approximately 1 mm) bone ventral to the apex of the mesial root (large red arrow). This significantly predisposes this area to fracture either secondary to periodontal disease or during extraction.

ing bone and infection. There are numerous options for fixation, but regardless of the method, the diseased tooth root(s) must be extracted for healing to occur (Niemiec 2008b, Taney & Smith, 2010) **(Figure 19)**. Awareness of the risk of pathologic fractures can help the practitioner to avoid problems in at risk patients during dental procedures.

Severe periodontitis can lead to inflammation close to the orbit, and potentially blindness due to global rupture (Ramsey *et al.* 1996, Anthony *et al.* 2010). The proximity of the tooth root apices of the maxillary molars and fourth premolars places these delicate optic tissues in jeopardy. **(Figures 20 & 21)**

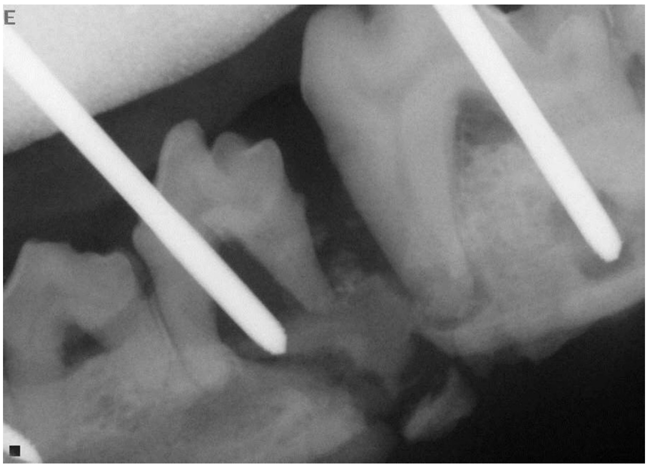

Figure 19. Intraoral dental radiograph of the left mandible in a patient with a pathologic mandibular fracture that has been incorrectly fixated with an external fixator. Note, the infected teeth have not been extracted, which will delay bony healing. This complication could have been avoided if dental radiographs were exposed. Further, the pins are impinging on the teeth, creating pain and possible inflammation. This is one reason that external fixators are not generally recommended for oral fractures.

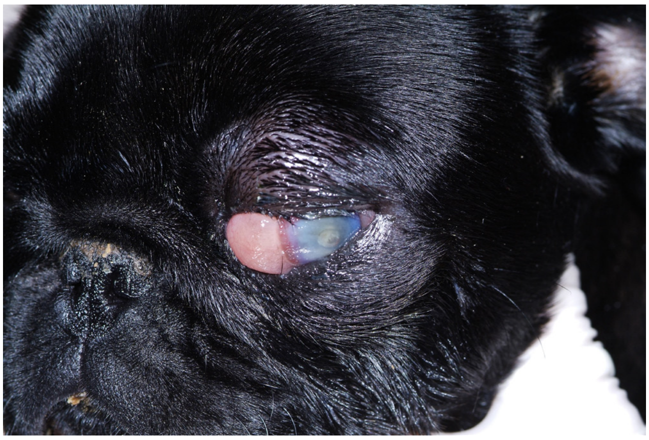

Figure 20. The left eye of this pug has been chronically infected despite numerous rounds of local and systemic antibiotics. This eventually resulted in the need for enucleation.

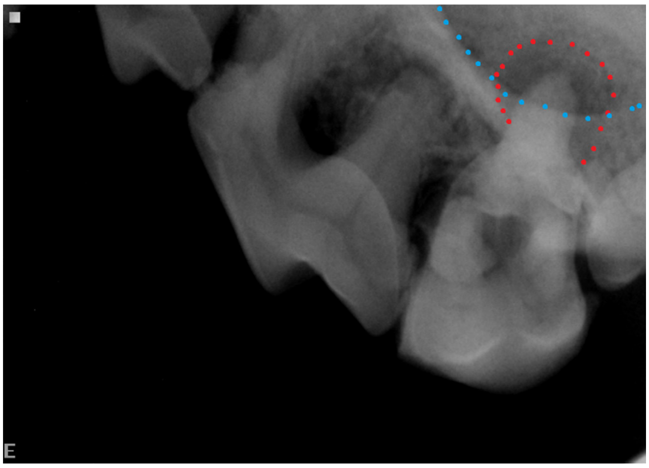

Figure 21. Intraoral dental radiograph of the maxillary left dentition of the patient in Figure 20. The radiographs confirm that the chronic inflammation in the area was most likely caused by the infected first molar (209). The tooth has significant periapical well define periapical lesion (dashed red line) which may be fueling the inflammation around the globe (dashed blue line). An examination under anaesthesia and dental radiographs would have helped diagnose the condition, potentially saving the eye.

Periodontitis is the most common cause of oral osteomyelitis, which is an area of non-vital infected bone **(Figure 23)**. Once an area of bone is necrotic, it can no longer respond to antibiotic therapy; therefore, definitive therapy generally requires aggressive surgical debridement (Wiggs & Lobprise 1997, Niemiec 2008b, Marretta 1998). Osteonecrosis is another possible sequalae of dental disease in dogs (Peralta *et al.* 2015)

While there are currently no studies in the veterinary literature to address this, numerous human studies show an increased incidence of oral cancer in patients with chronic periodontal disease (Graham *et al.* 1977, Zheng *et al.* 1990, Maier *et al.* 1993, Bendgaard *et al.* 1995, Talamini *et al.* 2000, Rosenquist *et al.* 2005, Guha *et al.* 2007, Rezende *et al.* 2008, Wen *et al.* 2014) (Figure 22). The association in this case is likely due to the chronic inflammatory state that exists with periodontitis (Trosko 2001). It is unknown at this time whether the significant difference in length of life between animals and humans allows for extrapolation.

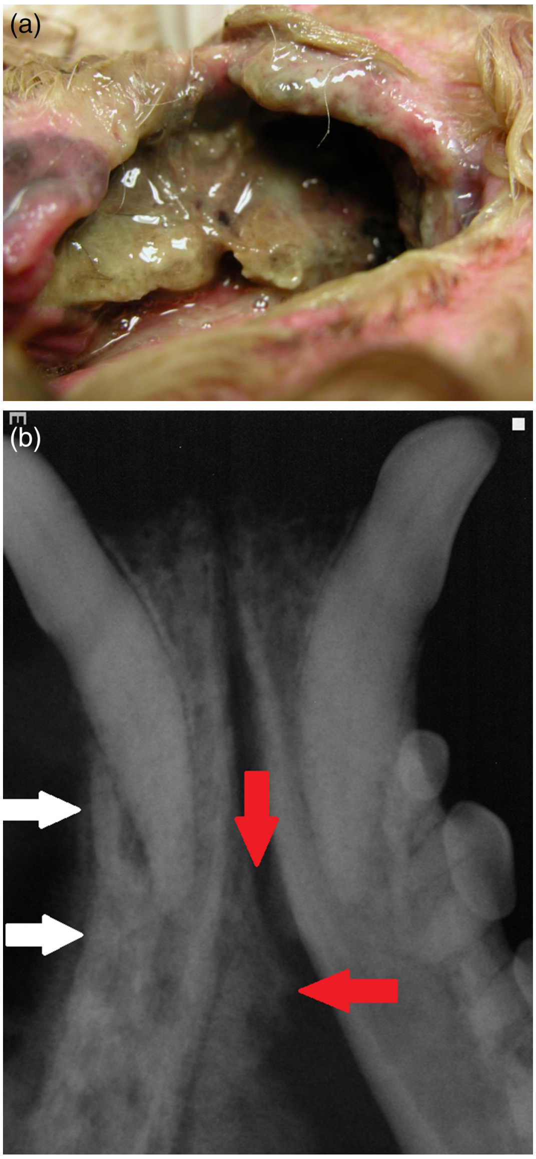

Figure 22. Osteomyelitis/osteonecrosis affecting the right mandible of a dog. a) Severe necrosis affecting the mandible as well as gingival inflammation. b) Intraoral dental radiograph of the area demonstraing that the entre mandible is affected. The osteomyeltis is evidenced by the periosteal reaction (red arrows) and moth-eaten appearence of the bone (white arrows).

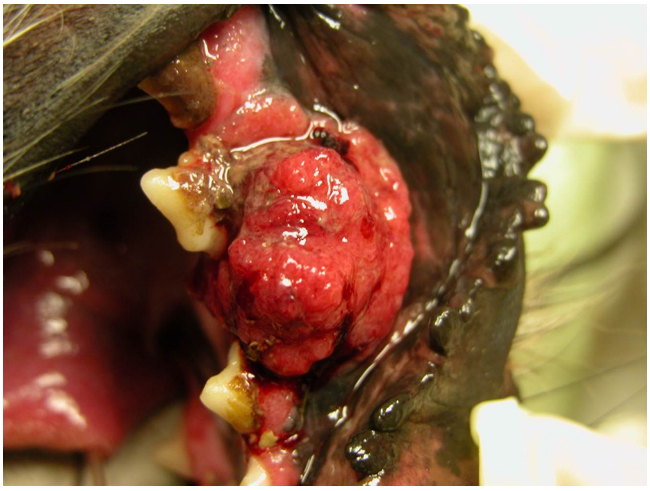

Figure 23. Periodontal disease and an oral mass involving left mandibular fourth premolar (308).

Systemic consequences of periodontal diseases

Systemic ramifications of periodontal diseases have also been extensively reported in the human literature. While generally comprised of correlation (not causation) studies, there is mounting evidence in the veterinary literature as to the negative consequences of periodontal diseases on systemic health (Niemiec 2012b).

Pathogenesis is thought to begin when inflammation of the gingiva and periodontal tissues occurs. This inflammatory response allows the body's defenses to attack the bacteria, but also may lead to bacteria and their associated inflammatory mediators (Takai 2005) breaching the body's natural defenses (Debowes *et al.* 1998, Scannapieco 2004, Mealey & Klokkevold, 2006, Niemiec 2013f). Distant effects can also occur secondary to the activation of the patient's own inflammatory mediators (e.g. IL-1 and 6, PGE2, CRP and TNF) (Lah et al. 1993, Renvert *et al.* 1996, Scannapieco 2004, Pavlica *et al.* 2008, Rawlinson *et al.* 2011). These mediators have been linked to numerous systemic problems such as cardiovascular, hepatic, and renal insults.

In the liver, oral bacterial invasion has been shown to increase parenchymal inflammation and portal fibrosis (DeBowes *et al.* 1996). Pavlica *et al.* (2008) showed a significant relationship between the periodontal disease burden and increased inflammation in the hepatic parenchyma. Furthermore, generalized bacteremias (some of which plausibly oral in origin) have been shown to cause cholestasis in dogs (Taboada & Meyer 1989, Center 1990).

Periodontal diseases have also been proposed as a risk factor for the development of chronic kidney disease in dogs and cats (O'Neill *et al*. 2013, Finch *et al*. 2016). A large retrospective study (Trevejo *et al*. 2018) showed increased risk of both chronic kidney disease and cystitis incidence with increased periodontal scores. These changes are proposed to be due to chronic inflammation and secondary scarring of the organ resulting in decreased function over time (DeBowes *et al*. 1996, Pavlica *et al*. 2008).

In the heart, increases in the incidence of atrio-ventricular valve changes have been noted with periodontal disease (Pavlica *et al*. 2008), showing a 6-fold higher risk for endocarditis for dogs with stage 3 or greater periodontal disease, compared with unaffected dogs (Glickman *et al*. 2009). A recent study has revealed that a common pathogen in canine infective endocarditis (Enterococcus spp.) is identical to the one found in the oral cavity of the patients with periodontal disease (Semedo-Lemsaddek *et al*. 2016). Pigs and mice also seem to exhibit similar increases (Lalla *et al*. 2003, Brodala *et al*. 2005).

Anecdotally, a correlation between glycemic control and periodontal health is commonly accepted in the veterinary world. Improvements in periodontal health appear to assist in control of diabetes in both dogs and cats, and are frequently recommended in the approach to proper diabetic care. Increased systemic inflammatory markers, such as C reactive protein, have been noted to be increased with severe periodontal infection (De Bowes 2008, Kouki *et al*. 2013, McFadden & Marretta 2013).

Further support for the role that periodontal diseases play in systemic diseases is provided by studies that show improvement in health markers following periodontal therapy. Rawlinson *et al*. (2011) noted significant decreases in both C reactive protein and creatinine post periodontal disease therapy. Nemec *et al*. (2013) noted a transitory increase in nitric oxide following appropriate periodontal therapy.

Conclusion

Periodontal diseases are multifactorial conditions leading to multiple, negative local and systemic effects. The main etiologic agent is bacterial plaque, which initiates the inflammatory cascade, resulting in periodontal tissues destruction in susceptible individuals. Bacterial plaque forms quickly, even after effective therapy, and leads to chronic inflammation and infection of the oral structures. Calculus in itself is not pathogenic.

Proper diagnosis of periodontal diseases requires general anaesthesia, however, early symptoms include erythema, oedema, and increased gingival bleeding which may be noted clinically in conscious patients. An accurate diagnosis of the stage of periodontal disease include a thorough examination and probing, and radiological examination. Because subgingival plaque is the most pathogenic, effective therapy needs to extend under the gumline which also cannot be effectively performed without anesthesia. While more research is needed, the correlations between periodontal disease and systemic pathology are mounting, and include negative effects on the heart, kidneys, liver. In addition, there exist numerous papers showing that periodontal diseases have a significant negative effect on systemic inflammatory markers.

Key Points:

- Periodontal diseases are the most common medical conditions in small animal veterinary patients.
- Plaque forms within 24 hours, calculus within 3 days and gingivitis begins as early as 2 weeks.
- Periodontal inflammation is caused by subgingival plaque; therefore, control of plaque needs to address both supra- and more importantly subgingival plaque to be effective at controlling disease.
- Calculus (or tartar) is essentially non-pathogenic.
- The first sign of periodontal disease is bleeding on probing or brushing which occurs prior to a color change.
- Periodontal infections have been linked to numerous systemic maladies including: heart, liver, and kidney disease as well as deleterious changes in systemic inflammatory markers.

  Periodontal disease has been associated with numerous severe local effects including:
  - Oronasal fistulas
  - Oral cancer
  - Mandibular fractures
  - Ocular infection and blindness
  - Osteomyelitis and osteonecrosis
  - Class II perio-endo lesions

COMMON DISORDERS OF THE TEETH

Enamel Hypoplasia

Trauma, heredity, poor nutritional status, or inflammatory conditions (such as viral distemper) during development may cause irregularities in enamel formation (Dupont 2010; Gandolfi *et al.* 2013; Bittegeko *et al.* 1995; Mannerfelt *et al.* 2009; Lukacs *et al* 2001). Trauma and localized infection tend to damage a single tooth or teeth in the same area. However, systemic disease and genetic

Figure 24. Enamel hypoplasia affecting the left mandibuar third incisor and canine (303 and 304) of a dog, most likely as a result of inappropriate technique used to extract the deciduous canine tooth.

Figure 25. Enamel hypomineralisation creating enamel pitting, flakiness and discolouration of the maxillary left incisors (201–203) of a dog.

conditions generally affect most or all the teeth. These episodes may manifest with microscopic changes that produce a tooth with thin enamel that is easy damaged, termed enamel hypoplasia **(Figure 24)**. Also, commonly noted, enamel hypomineralisation causes enamel pitting, flakiness and discolouration **(Figure 25)**. Enamel or dentine may appear absent on examination, or enamel may be thinner and weaker and separate during chewing or examination. The terms hypoplasia and hypomineralisation are often used incorrectly in the veterinary literature.

Tooth Wear (abrasion/attrition)

Slow, abrasive loss of enamel and dentine can be classified into the type of wear and the degree of pathology. Physiological wear from mastication, resulting in loss of enamel, dentin, and in advanced cases pulp exposure is termed dental attrition. If attrition is due to malocclusion of teeth, it is termed pathological attrition **(Figure 26)**. Enamel or dentine loss due to an external object, such as metal cages, sticks, balls or bones, is termed dental abrasion (Dupont 2010) **(Figure 27)**. If the process is gradual, odontoblasts can produce tertiary dentine to protect the underlying pulp tissue. However, in cases where attrition or abrasion is rapid, it can result in pulp exposure. Both enamel hypoplasia/hypomineralisation and abrasion/attrition may weaken the tooth structurally leading to a higher chance and prevalence of tooth fracture. This is especially true in cases of chronic cage or fence chewing **(Figure 28)**.

Tooth Fractures

Fractures to the crown and/or root of the tooth are not an uncommon finding in dogs and cats. Fractured teeth have been found in 49.6 % of companion animals (Soukup *et al.* 2015a). Further, 10% of dogs have teeth with direct pulp exposure. (Golden *et al.* 1982). A significant number of dogs and cats have access to bones, sticks, and antlers resulting in injuries caused during chewing. They may also be involved in high impact trauma such as car accidents, sporting injuries, i.e. golf stick/ball, baseball bat; or low impact trauma such as fall resulting in tooth fractures. Trauma to the tooth may be classified based on the amount of tooth structure exposed, i.e. enamel, dentine, or root, as well as whether the pulp tissues are directly exposed **(Figure 29).** It is further classified accordingly as enamel damage or infraction **(Figures 30 & 31),** enamel loss with no exposure of dentine **(Figures 32 & 33),** enamel and dentine exposure without pulp exposure **(Figures 34 & 35),** crown and root involvement without pulp exposure **(Figures 36 & 37),** root fracture without crown damage or pulp exposure **(Figures 38 & 39),** and whether there is pulp exposure, isolated to the crown **(Figures 40 & 41)** or involving both crown and root **(Figure 42 & 43).** An injury that does not expose the pulp is termed uncomplicated, whilst pulp exposure is termed complicated.

A tooth that has suffered trauma without fracture may result in painful pulpitis and eventually pulpal necrosis. Some of these teeth will appear dull or discoloured **(Figure 44)** (termed intrinsic staining) and most require root canal treatment or extraction similar to a tooth with direct pulp exposure (see below) (Hale 2001).

Sequela

All vital teeth with direct pulp exposure are exceedingly painful. (Bender 2000, Hargreaves *et al.* 2004). Over time, these teeth will almost invariably become non-vital.

Figure 26. A canine patient with significant dental attrition due to a mild class III malocclusion (undershot). Note the tertiary (reparative) dentin.

Figure 27. Left side of a canine patient with marked abrasion of the canine and incisor teeth. This was caused by chronic ball chewing.

Figure 28. Marked dental abrasion of the distal aspect of the canine teeth. This was caused by chronic fence biting.

In most cases, a non-vital tooth which is not appropriately treated will become infected. Once this occurs, the bacteria gain access to the local tissues via the apex, creating local inflammation and/or infection. This may be seen on radiographs as periapical rarefaction **(Figure 45).** Patients with non-vital teeth rarely show signs of the pain and/or infection, but deleterious effects are present. Those infected teeth which are not treated by root canal therapy or extraction may result in a draining sinus tract at or near the apex of the root. The most common sites for this are adjacent to the medial canthus of the eye, lateral bridge of the nose (maxillary canine or premolar), or a sinus tract on the lateral or ventral surface of the mandible (mandibular canine tooth, or at the mucogingival junction).

However, even teeth without direct pulp exposure (meaning the dentin is exposed) are also known to be quite painful (Snyder 1976, Brynjulfsen 2002). This is due to a change in the fluid flow in the dentinal tubules, which will deform the A-*delta and* C-*delta* fibers and will be perceived by the patient as pain or sensitivity (Trowbridge 2002). Confirmed uncomplicated crown fractures with

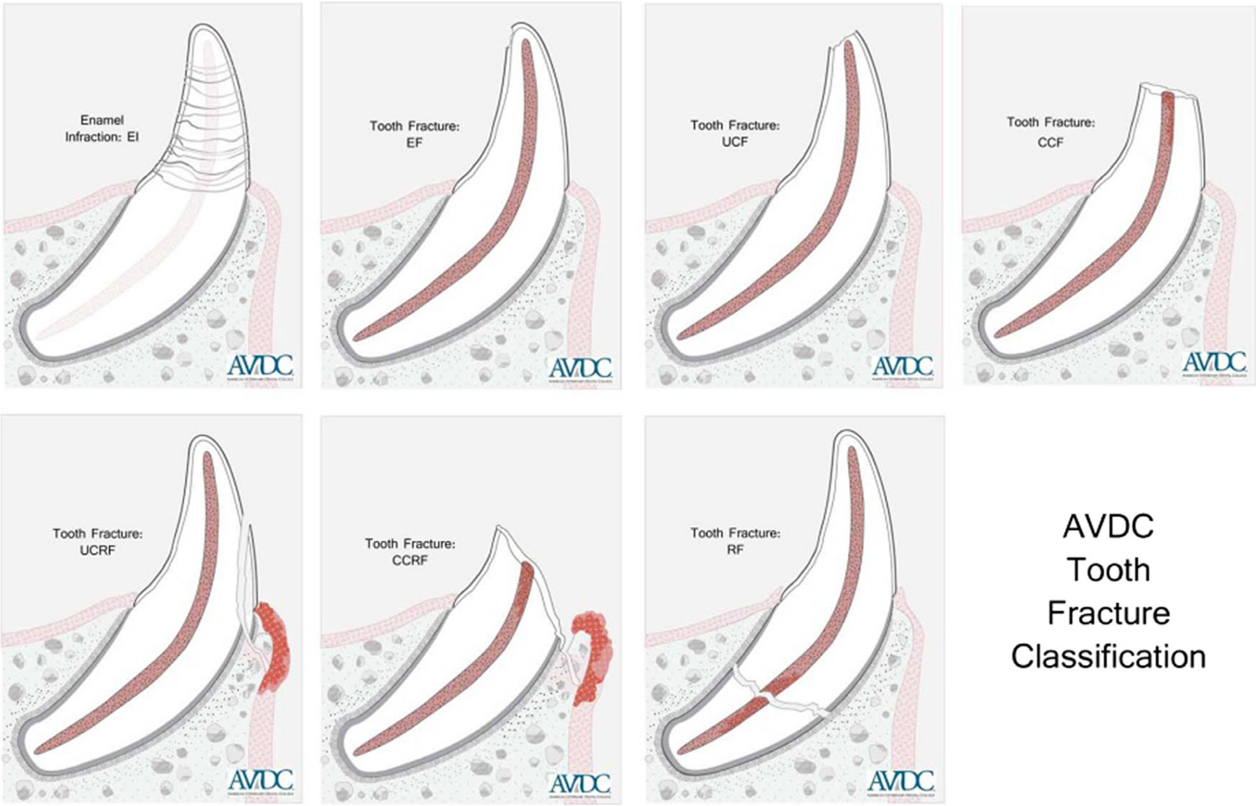

Figure 29. Line drawings of the American Veterinary Dental College Classification of tooth fractures.

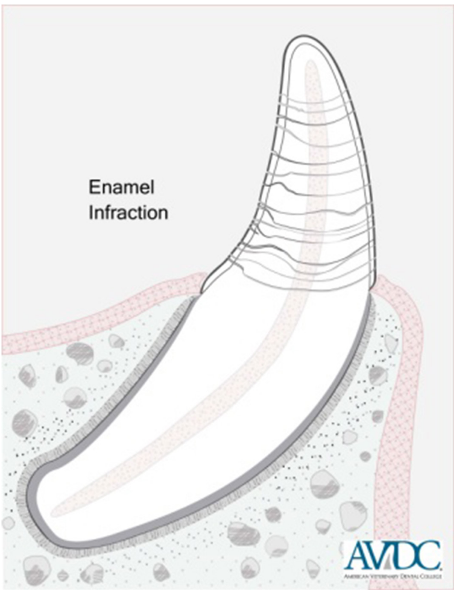

Figure 30. Enamel infraction.

Figure 31. Right mandible of a dog demonstaring enamel infraction of the second-fourth premolars 406–408.

no radiographic evidence of endodontic disease should be treated with a bonded sealant (see below). This will resolve the sensitivity, block off the pathway for infection, improve aesthetics and smooth the tooth to decrease plaque accumulation, thus retarding periodontal disease. (Theuns *et al*. 2011, Woodward 2008a)

Diagnosis

Endodontic examination is incomplete without dental exploration and radiographs to confirm or rule out pulp exposure and to assess the degree of periapical pathology respectively, prior to treatment. If the fracture exposes the pulp chamber, the pulp may appear pink

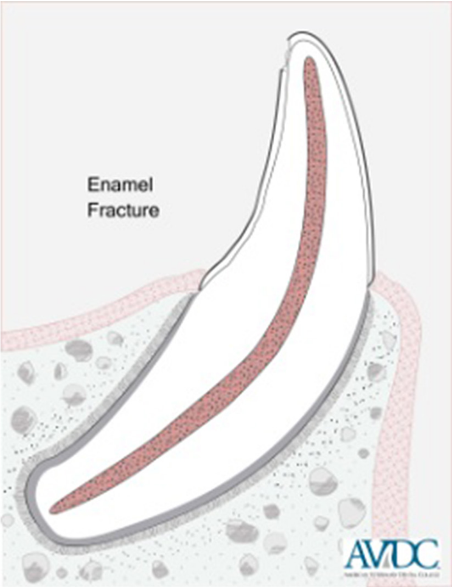

Figure 32. Enamel fracture.

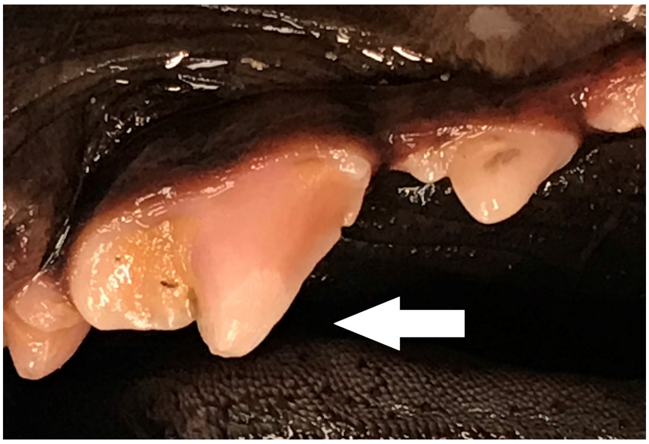

Figure 33. Right maxillary fourth premolar (108) of a dog with an enamel fracture (white arrow). Note that the dentin is not directly exposed. (This is a rare finding in veterinary patients).

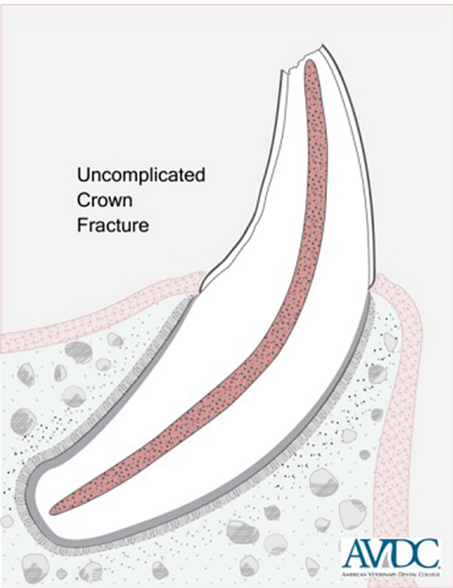

Figure 34. An uncomplicated crown fracture.

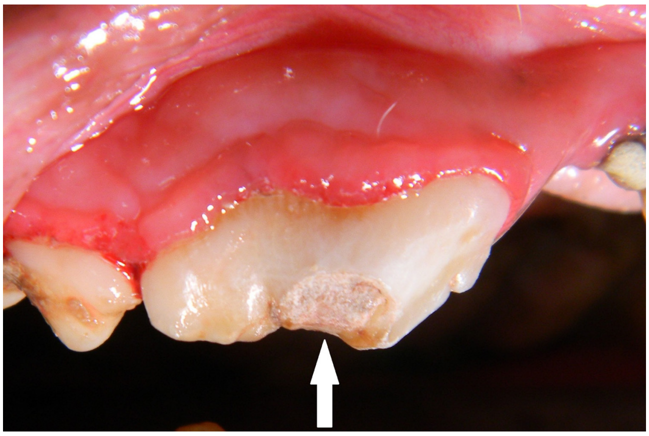

Figure 35. Right maxillary fourth premolar (108) of a dog with an uncomplicated crown fracture (white arrow). Note that the underlying dentin is stained and has a significant amount of dental calculus due to the increased roughness.

if recent, or grey/black if chronic. In recent fractures, the teeth are quite painful and the patient may resist conscious oral examination. Once the pulp is necrotic, there is usually no pain on probing; however, there is long-term low-grade pain and infection.

Therapy

Treatment options are directly related to the type and degree of damage as well as the presence or absence of endodontic infection. All teeth with any type of damage should be radiographically examined for signs of non-vitality or inflammation. There are many radiographic signs of tooth non-vitality, but the two most common are periapical rarefaction and a larger endodontic system compared to surrounding or contralateral teeth (Fiani & Arzi 2010). If there is evidence of this on radiology, root canal therapy or extraction is necessary.

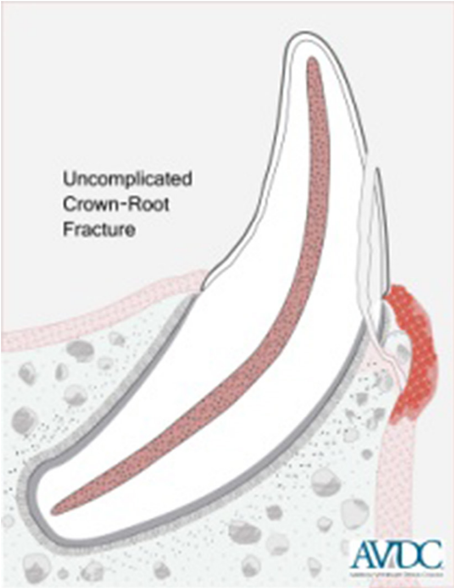

Figure 36. Line drawing of an uncomplicated crown/root fracture.

Figure 37. Right maxillary fourth premolar (108) of a dog with an uncomplicated crown/root fracture. The pulp is not directly exposed, but the fracture extends under the gingival margin. Note that the underlying dentin is rough. The subgingival fracture and roughened tooth surface predispose the tooth to periodontal disease.

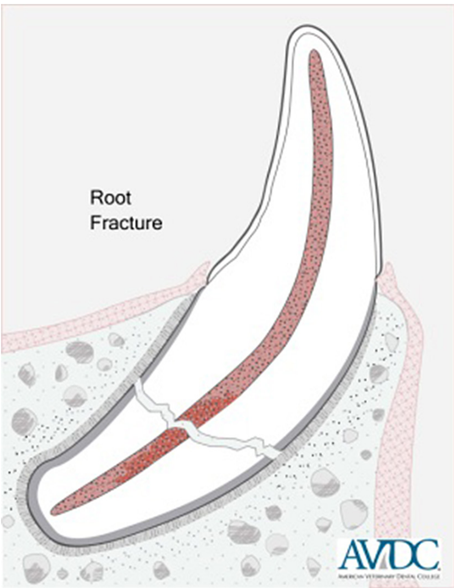

Figure 38. A root fracture.

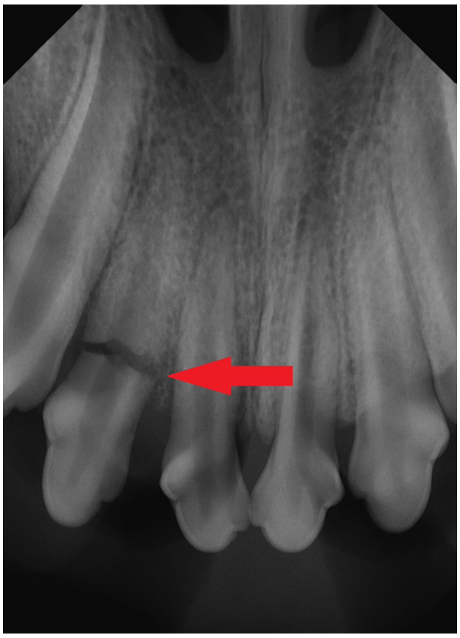

Figure 39. Intraoral dental radiograph of the maxillary incisors of a dog. The right second incisor (102) has a root fracture (red arrow).

- If the defect is confined to the enamel or dentine, without radiographic signs of periapical pathology, smoothing any sharp edges and restoration is all that is required. Treatment of dentin exposure is always recommended to reduce sensitivity, block off the pathway for infection and smooth the tooth, thus decreasing periodontal disease (Woodward 2008a, Theuns *et al.* 2011).
- Chronic wear results in the production of tertiary or reparative dentine so the tooth pulp continues to be protected by a dentinal layer. These teeth require no therapy, as long as they are radiographically healthy.

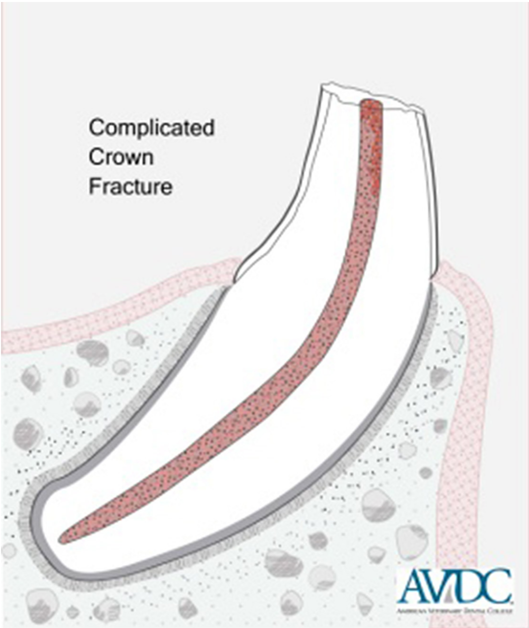

Figure 40. Complicated crown fracture.

Figure 41. Right mandibular canine (404) of a dog with a complicated crown fracture. Note that the endodontic system (pulp) is directly exposed evidenced by bleeding. This is a very painful condition necessitating quick action.

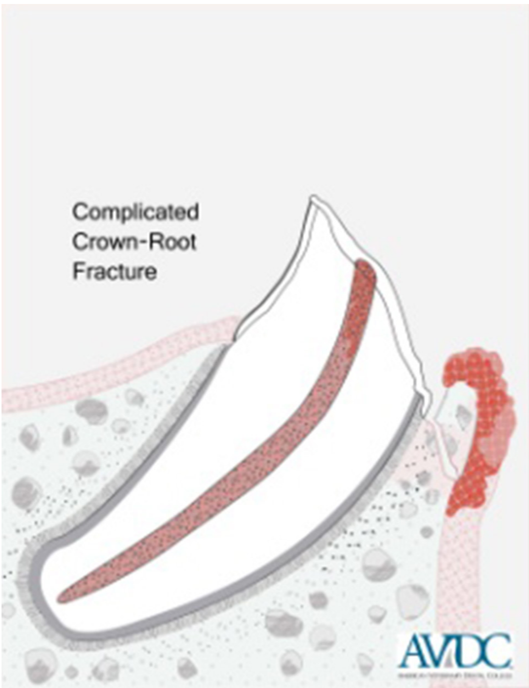

Figure 42. Complicated crown/root fracture.

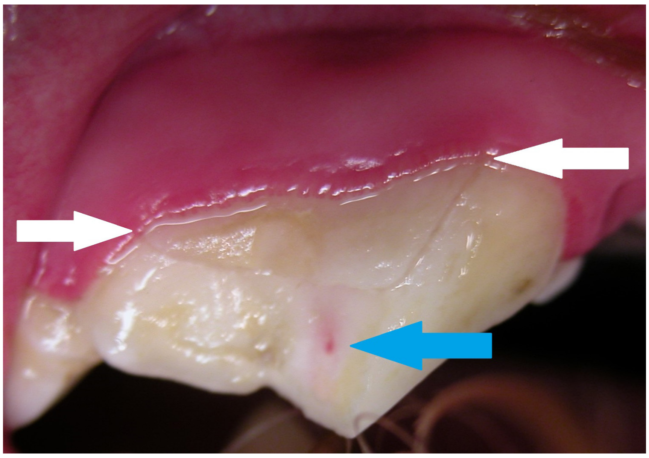

Figure 43. Right maxillary fourth premolar (108) of a dog with a complicated crown/root fracture. Note that the endodontic system (pulp) is directly exposed (blue arrow), and that the fracture extends under the gingival margin (white arrows). Exposed, inflamed pulp is a very painful condition necessitating quick action.

- Any tooth with direct pulp exposure or radiographic signs of tooth death/periapical inflammation requires treatment by extraction or root canal therapy (and rarely vital pulp therapy) to prevent further periapical pathology and subsequent osteomyelitis, which may lead to systemic complications (DuPont 2010, Moore 2011, Clarke 2001a).
- Vital teeth with direct pulp exposure are very painful and should be treated expediently. If a therapeutic delay is necessary, pain management should be provided until surgery. Note, however that antibiotics are not indicated in these cases (Niemiec 2012b, Luotonen *et al*. 2014).

Figure 44. Right maxillary canine (104) of a dog. This tooth is discoloured (intrinsically stained). 92% of stained teeth are non-vital and treatment via extraction or root canal therapy is necessary.

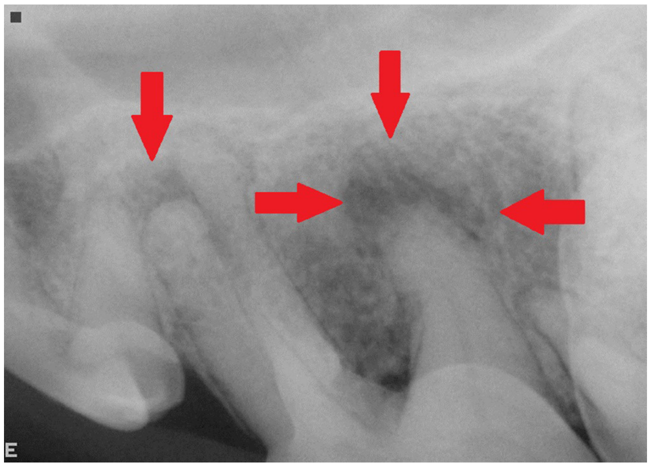

Figure 45. Left maxillary fourth premolar of a dog with periapical radiolucencies (red arrows). This is indicative of pulpal inflammation or necrosis and treatment via extraction or root canal therapy is necessary. The extensive pathology seen here may be associated with a poorer prognosis.

Due to poorer outcome, teeth with advanced periapical lesions or root resorption may benefit from extraction over root canal treatment (Kuntsi-Vaattovaara *et al.* 2002, Niemiec 2005a) especially in cats (Strøm *et al. 2018*).

Key Points:

- Fractures to the crown and complicated crown root fractures are relatively common findings in dogs and cats.
- A complete endodontic examination requires dental exploration and radiographs to confirm or rule out pulp exposure and to assess the degree of periapical pathology respectively, prior to treatment.
- If the defect is confined to the enamel or dentine, without radiographic signs of periapical inflammation, smoothing any sharp edges and restoration is all that is required.
- Any tooth with direct pulp exposure or radiographic signs of tooth death/periapical inflammation requires treatment by extraction or root canal therapy (Theuns & Niemiec, 2013).

The following terms and abbreviations from the American Veterinary Dental College are used:

Abbreviation	Pathology
T/FX/EI	Enamel Infraction - Incomplete fracture (crack) of the enamel without loss of tooth substance
T/FX/EF	Enamel fracture - fracture in which crown substance is lost, limited to enamel
T/FX/UCF	A fracture of the enamel and dentine not involving the pulp. In veterinary species, the types of dental tissue involved in a crown fracture can vary with the species and can include enamel, cementum, and dentine
T/FX/CCF	A fracture involving enamel and dentine and exposing the pulp
T/FX/UCRF	A fracture involving enamel, dentine, and cementum, but not exposing the pulp
T/FX/CCRF	A fracture involving enamel, dentine, and cementum and exposing the pulp
AB	Tooth wear caused by contact of a tooth with a non-dental object
AT	Tooth wear caused by contact of a tooth with another tooth
EH	Enamel hypoplasia/hypomineralisation

TOOTH RESORPTION

Tooth resorption (TR) is, by definition, the loss of dental hard tissues due to odontoclastic activity. Tooth resorption can be physiological (resorption of the root of primary teeth) or pathological. In these guidelines, only pathologic TR is discussed.

TR has been reported in human dentistry (Heithersay 2004) and various species including the dog (Arnbjerg 1996, Peralta *et al.* 2010a & b), feral cat (Verstraete *et al.* 1996), chinchilla (Crossley *et al.* 1997) and horse (Henry *et al.* 2016). In veterinary dentistry, it is most common in the domestic cat where it occurs quite especially in older cats, and it is increasingly noted in the canine population (Peralta *et al.* 2010a, b). In a study, which investigated the incidence of TR in a clinically healthy population of 228 cats using a combination of clinical examination and radiography, it was found that the mandibular 3rd premolars (307, 407) were the most commonly affected teeth and the pattern of TR development was symmetrical in most cats (Ingham *et al.* 2001).

Aetiology

The resorptive process is quite well understood (Okuda & Harvey 1992, Shigeyana *et al.* 1996), however the aetiology of most TRs is not clear (Gorrel C 2015). Resorption was traditionally considered a disease of modern civilization but it has also been reported in wild cats (Berger *et al.* 1996) and in the late medieval era (Berger *et al.* 2004) which directly contradicts that theory.

Tooth resorption is due to an active process where odontoclasts become activated. The resorption appears to be a progressive process. It initiates on the root surface, typically at the cemento-enamel junction in type 1 lesions. It then invades the root and spreads within the root dentine up into the coronal dentine, where it may undermine the enamel (Gorrel C 2015). This loss of support may cause the enamel to collapse or break off. Therefore, clinical findings (visual or tactile), even if they are very small, often represent an advanced stage of the disease **(Figure 46).**

There appear to be two distinct types of tooth resorption: idiopathic and inflammatory (Peralta *et al.* 2010b; Eikenberg *et al.* 1998; Reiter *et al.* 2002). The resorption induced by inflammation (periodontal disease or stomatitis) creates type 1 lesions and the idiopathic variety of resorption results in type 2 (see below) (DuPont & DeBowes 2002, Farcas *et al.* 2014a). Any trauma can create resorption of the root surface, however some of these defects heal while others do not. A possible etiopathogenic model for 'idiopathic' feline external root resorption is that an area of tooth trauma which does not properly heal will lead to dentine exposure and eventually ankylosis and replacement resorption (Gorrel C 2015) (**Figure 47**).

In type 2 lesions, below the gum line, resorbed areas are replaced by cementum- or bone-like material. The pulp resists becoming exposed by the resorption by the creation of tertiary dentin until late in the disease course (Gorrel C 2015). Above the gum line, smaller defects are often covered by a highly vascular granulation tissue, which may be attempt by the body to cover the exposed dentinal tubules (**Figure 48**).

Classification

A distinction is made depending on the localization of the lesion and further classified into inflammatory and non-inflammatory resorption. Internal resorption starts within the endodontic system and is mostly due to pulpitis. External resorption has its origin at the root surface and can have several causes, with periodontal inflammation being one of them (Farcas *et al.* 2014a, Gorrel C

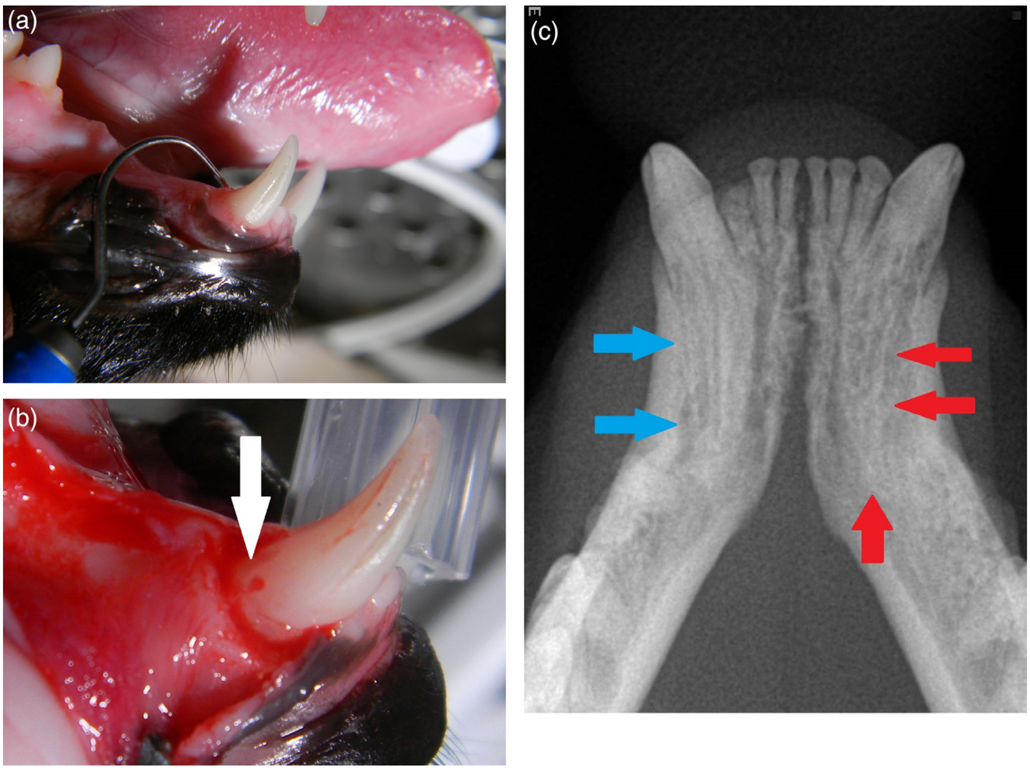

Figure 46. TRs do not generally become clinically evident until they are very advanced. a) Right mandibular canine (404) in a cat. The tooth appears visibly normal, however careful examination with a dental explorer along the gingival margin elucidated the TR. b) Small TR near the gingival margin (white arrow). c) Intraoral dental radiograph of this patient revealing the significant degree of replacement resorption in this tooth (blue arrows). This tooth is a candidate for crown amputation. Note that the contralateral tooth has extensive replacement resorption as well (red arrows). The root of 403 has been resorbed and replaced by bone-like material and the crown is missing.

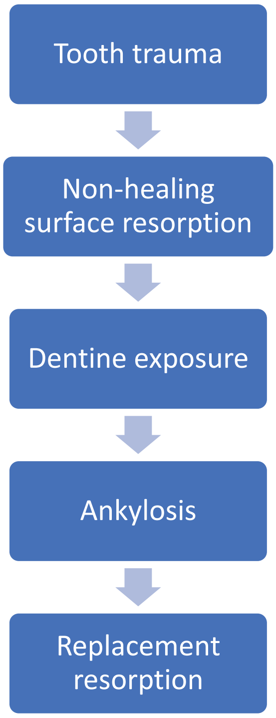

Figure 47. Schematic diagram of one possible etiopathogenic model for 'idiopathic' feline external root resorption.

Figure 48. Left maxilla of a cat. There is a significnat TR affecting the third premolar (207), which is evidenced by the inflammatory granulation tissue filling the defect (white arrow).

2015). In an advanced stage, the two forms can hardly be distinguished. In dogs and cats, external inflammatory resorption is more common.

Tooth resorption in cats is classified based on the severity of the resorption (Stages 1-5) and on the radiographic appearance of the resorption (Types 1-3) (American Veterinary Dental College, 2017). The AVDC classification of tooth resorption assumes that tooth resorption is a progressive condition.

In dogs, tooth resorption is classified based on human classification into 7 different classes (Peralta *et al.* 2010a, b).

Types of Resorption Based on Radiographic Appearance in Cats

Type 1 (T1): On a radiograph of a tooth with type 1 **(T1)** appearance, focal or multifocal radiolucencies are present in the tooth with otherwise normal radiopacity and normal periodontal ligament space and endodontic system. There is tooth destruction but no replacement. **(Figure 49 a)**

Type 2 (T2): On a radiograph of a tooth with type 2 **(T2)** appearance, there is narrowing or obliteration of the periodontal ligament space in at least some areas and decreased radiopacity of at least part of the tooth. There are signs of replacement resorption. **(Figure 49 b)**

Type 3 (T3): On a radiograph of a tooth with type 3 **(T3)** appearance, features of both type 1 and type 2 are present in the same tooth. A tooth with this appearance has areas of normal and narrow or lost periodontal ligament space, and there are focal or multifocal radiolucencies in the tooth and decreased radiopacity in other areas of the tooth. **(Figure 49 c)**

Stage of Resorption Based on Radiographic Appearance in Cats

Feline TR can be further defined by the degree of resorption evident radiographically. One system (AVDC Nomenclature Committee 2019) is currently acknowledged and accepted.

Stage 1 (TR 1): Mild dental hard tissue loss (cementum or cementum and enamel).

Stage 2 (TR 2): Moderate dental hard tissue loss (cementum or cementum and enamel with loss of dentin that does not extend to the pulp cavity).

Stage 3 (TR 3): Deep dental hard tissue loss (cementum or cementum and enamel with loss of dentin that extends to the pulp cavity); most of the tooth retains its integrity.

Stage 4 (TR 4): Extensive dental hard tissue loss (cementum or cementum and enamel with loss of dentin that extends to the pulp cavity); most of the tooth has lost its integrity.

- **TR4a:** *Crown and root are equally affected;*
- **TR4b:** Crown is more severely affected than the root;

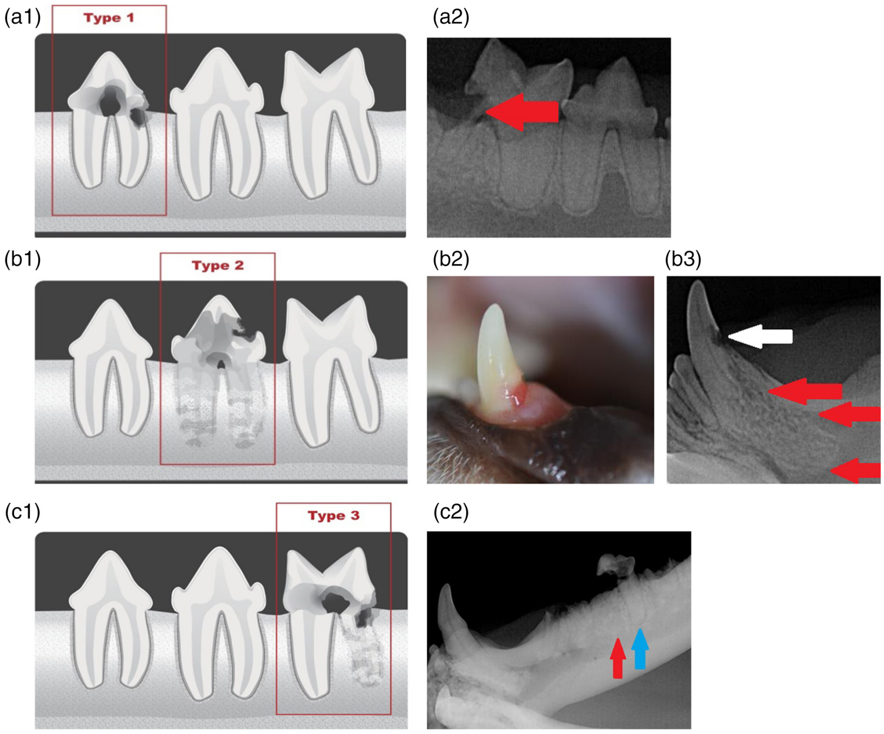

Figure 49. Graphic demonstration of the different types of TRs. a) Type 1 TR (This type does not have replacement resorption). 1. Medical illustration of a type 1 TR. 2. Intraoral dental radiograph of the mandibular right first molar (409) in a cat affected with a type 1 TR (red arrow). b) Type 2 TR. 1. Medical illustration of a type 2 TR. 2. Mandibular left canine (304) affected with a type 2 TR. 3. The tooth in (b-2) showing the clinical defect (white arrow) and the extensive. c) Type 3 TR (This type has replacement in one root and no replacement in another). 1. Medical illustration of a type 3 TR. 2. Intraoral dental radiograph of the mandibular left fourth premolar in a cat which is affected by a type 3 TR. The mesial root is undergoing replacement resorption (red arrow), while the distal root is not (blue arrow).

- **TR4c:** Root is more severely affected than the crown.

Stage 5 (TR 5): Remnants of dental hard tissue are visible only as irregular radiopacities, and gingival covering is complete.

Several types and stages of TR can coexist in the same patient. **(Figure 50)**

Idiopathic and inflammatory tooth resorption is being seen more commonly in canines now too. (Arnbjerg 1996, Dupont 2010; Peralta *et al* 2010 a&b). The etiology for this condition is unknown, but appears similar to type 2 lesions in cats. It begins on the root surface (external) and may (or may not) eventually extend into the oral cavity. Treatment is similar to that in felines, where completely subgingival lesions are generally considered non-painful and may be radiographically and clinically monitored every 12 months

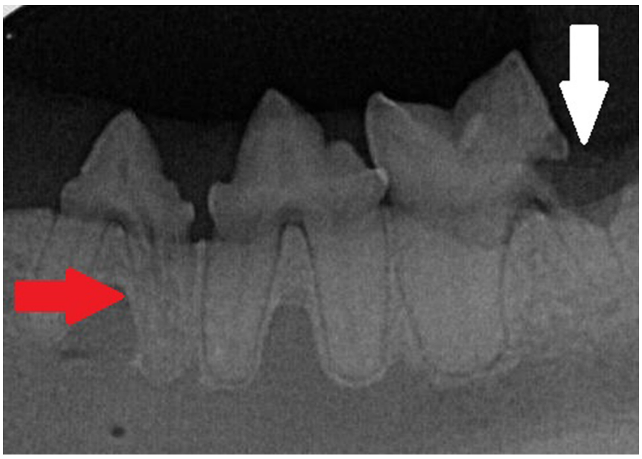

Figure 50. Various types of TR can be present in the same patient. In this intraoral dental radiograph of the left mandible of a cat, the third premolar has a type 2 TR (red arrow), while the first molar has a type 1 TR lesion (white arrow).

(Liang *et al.* 2003, DuPont 2010). Any lesions with oral involvement require extraction, which is often complicated by significant ankylosis. (Dupont 2010). Crown amputation is not currently an accepted treatment for this condition in canines.

Clinical significance

TR is very common in domestic cats and dogs. Studies have shown that 28.5 to 67% of mature cats are clinically affected depending on the population examined (Clarke & Cammeron 1997, Gorrel C 2015). In a clinical study in dogs, 53.6% showed radiographic signs of TR (Peralta *et al.* 2010b) whereas the number of clinically affected dogs seemed to be less.

In the human dental literature, it is reported that the process does not seem to be painful if it stays below the gingival margin (Heithersay 2004). When the process reaches the cemento-enamel junction (CEJ) or the enamel collapses over the resorbed space, the dentine is exposed which results in significant pain as well as the possibility of infection in type 1 lesions. The initial pain (dentinal sensitivity) occurs due to change of capillary flow in the dentinal tubules (the hydrodynamic theory of pulp hypersensitivity) (West *et al.* 2013) The pulp is then indirectly exposed to bacterial contamination, which may result in endodontic infection. Therefore, dentinal exposure due to TR is painful and/or can create local infection.

Clinical findings

Until the process reaches the oral cavity, there will be no clinical (visual or tactile) findings. At an early clinical stage, the gingival margin may be inflamed or minor enamel and dentine defects will be covered by highly vascular tissue. With progressive resorption, partial or even complete loss of the crown is possible.

Affected patients may show secondary signs of this dental disorder (Furman & Niemiec 2013) such as:

- *change of behaviour: decreased grooming, picking at and dropping food, pawing at mouth, hiding, lethargy*
- *signs of oral discomfort:* sticky mucus on the lips and/(diminished grooming), head shaking, rubbing the mouth on the ground, tooth grinding

However, the lack of these signs should not be misconstrued as evidence that there are no lesions or that they are not painful (Holmstrolm *et al.* 1998d, Niemiec 2008a, Cohen & Brown, 2002; Rollin 1998, Le Bars 2001). The majority of cats affected by this condition show no outward signs of discomfort.

Examination and Diagnosis

The examination is based on three diagnostic modalities (Gorrel 2015):

<u>Visual examination:</u> the visual examination only allows detection of very late stage disease, once the crown is involved.

<u>Tactile exploration:</u> the entire surface of each tooth must be examined with a dental explorer, especially at the gingival margin. Intact enamel is very smooth. If there is a resorptive lesion present, the explorer catches. A rough subgingival surface can be a sign of such a lesion or subgingival calculus. If there is any doubt as to the aetiology, the defect should be re-evaluated following scaling.

<u>Dental radiographs:</u> for a complete staging and treatment planning, dental radiographs are mandatory. It is highly recommended to take a full-mouth radiographic study of all feline patients presented for dental examination. If the owner is financially limited there is an option to radiograph the mandibular 3rd premolars as sentinel teeth (Ingham *et al.* 2001) (See radiology section)

<u>Differential diagnoses:</u> tooth resorption might be mistaken for a tooth fracture, abrasion, or furcation exposure. To differentiate between a TR and furcation exposure, can be difficult because both lesions have a rough surface and intra-oral radiography will be required to help differentiate them, unless cementum is exposed, in which case it will be rough.

Treatment options

The aim of treatment is pain relief and infection control for the patient. As TR is a process caused by the patient's own cells (odontoclasts), restoration of the defects is not indicated, because it has been shown that restoring affected teeth does to stop the resorptive process. The treatment will depend on the clinical situation (DuPont 1995).

Monitoring

If tooth resorption is radiographically diagnosed, but has not progressed into the oral cavity and/or is not associated with bone loss (inflammatory resorption), clinical and radiographic monitoring is indicated. The monitoring recalls must be performed on a regular basis (q 6-12 months) to ensure that a surgical intervention may be performed expediently. If this is not possible, extraction or crown amputation should be considered.

Extraction

Best practice is the extraction of the affected tooth. It is important to make sure that all roots are removed entirely in teeth affected by inflammatory resorption. This must be confirmed radiographically. Drilling or "atomizing" the roots with a bur ("root pulverization") is strongly discouraged. (For more information see extraction section)

Crown amputation

In type 2 resorption, where the root has been fully or partly replaced by bone tissue, extraction can be very difficult if not impossible. In such cases a crown amputation may be indicated in cats (DuPont 1995) but only when the following criteria are fulfilled:

- No radiographic evidence of an endodontic system
- No periodontal ligament visible on the dental radiograph
- No clinical or radiographic signs of endodontic or periodontal pathology
- No evidence of caudal stomatitis
  - In these cases, as much of the "root" should be removed as possible.

Crown amputation **(Figure 51)** involves the creation of an envelope gingival flap (a), removal of all tooth substance down 1-2 mm below bone level with a dental bur (b), smoothing the remaining bone (c), and suturing of the gingiva (d). In cases with type 3 resorption, the type 2 root can be amputated while the type 1 root should be extracted.

Key Points:

- Tooth resorption is a progressive process.
- This condition is painful, despite the typical lack of clinical signs.
- There are two types of tooth resorption in cats, types 1 and 2, with different therapy recommended.
- There are 7 types of tooth resorption in dogs, with therapy recommended in cases with inflammatory resorption and/or exposure of the lesion to the oral cavity.
- Best practice for treatment is extraction.
- Crown amputation in cats is only indicated when the following criteria are visible on the dental radiograph:
  - Advanced type 2 resorption
  - No periodontal ligament
  - No endodontic system
  - No evidence for periodontal disease
  - No evidence for endodontic pathology
  - No evidence of caudal stomatitis

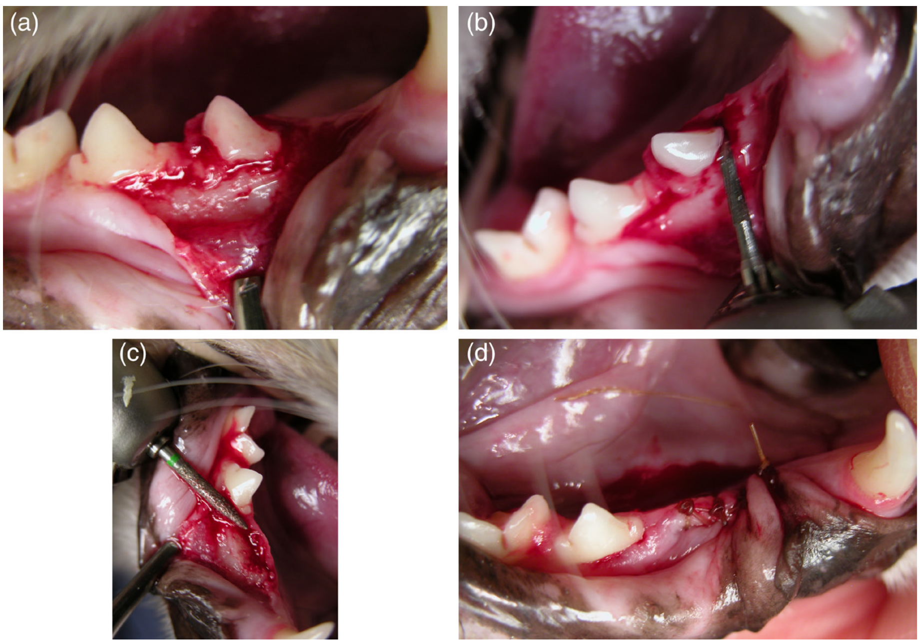

Figure 51. Crown amputation technique. a) Create a small envelope flap. b) Amputate the crown with a carbide bur (in this case a 701), c) Smooth the bone/tooth with a coarse diamond bur. d) Close the flap with simple interrupted sutures

MAXILLOFACIAL TRAUMA

Maxillofacial trauma is a fairly common occurrence and can affect the soft and hard (bones and teeth) tissues of the head, often both concurrently. Patients with maxillofacial trauma may present with complaints of facial swelling or distortion, oral bleeding, salivation, and abnormal closure of the mouth, however they often demonstrate minimal to no clinical signs.

At all times, practitioners must be cognizant of the possibility of brain oedema, and other such non-visible trauma to underlying structures of the head. In addition, the initiating trauma may have created cardiothoracic and/or abdominal injuries. Because these conditions can be life threatening, they should be evaluated for and treated prior to definitive care of the oral cavity.

Initial examination may uncover lacerations, especially to the lips and/or tongue (Saverino & Reiter 2018). The oral cavity has two advantages when compared to other soft tissues: the presence of saliva and ample vascularization. Saliva provides immunological barriers to infection such as IgA, bacteriostatic enzymes, and a physical cleansing action which flushes out bacteria. These actions assist the healing process, and provide some protection against infection. The high level of vascularization in the oral cavity is helpful with healing, which may allow for minimal rather than radical debridement.

The cosmetic repairs of facial trauma may be of concern to the owner. Consideration should be taken to create the most cosmetic result to facilitate healing. Reconstructive surgery may be necessary in order to assist in achieving a more aesthetically pleasing result. Comfort and function should be the primary aim of reconstruction. (Boudrieau *et al.* 2012)

Soft Tissue Trauma

The most common soft tissue injuries to the mouth caused by trauma are:

- Degloving injuries, especially of the lower lip, caused by high speed traumas such as vehicular accidents **(Figure 52)**
- Lip lacerations due to fighting **(Figure 53)**
- Tongue lacerations/damage due to fighting, car accidents, iatrogenic trauma, or electrical shock **(Figure 54)**
- Gingival lacerations **(Figure 55)** and periodontal trauma
- Hard palate lesions such as high-rise syndrome **(Figure 56)**
- Soft tissue trauma from caustic agents or electric shock **(Figure 57)**

Reparative surgery should be performed expediently for all oral soft tissue lesions, if the patient is stable (see above). Diseased/non-vital tissue should be debrided prior to closure (Swaim 2012, Saverino & Reiter 2018). Closure should be delayed if further necrosis is expected (as with injuries due to caustic or electrical shock) (Niemiec 2012a; Swaim 2012). However, due to the high vascularity, moderately damaged tissue can be maintained (Swaim 2012). One important aspect to be taken into consideration is the preservation of the attached gingiva during soft tissue surgery. All teeth should have by at least 2 mm of gingiva where possible; however, teeth can be healthy despite less coverage (Takas 1995, Lewis & Reiter 2005, Wolf *et al.* 2005).

There are many suitable options for suture material when addressing oral trauma. The sutures should be simple interrupted and placed 2-3 mm apart (Niemiec 2008d, Lobprise 2019) **(Figure 58).** Absorbable non-braided sutures are preferred on a swedged-on reverse cutting needle are generally recommended (Silverstein & Kurtzman 2005). (see equipment chapter).

Hard Tissue Trauma

The various types of hard tissue trauma include maxillofacial fractures **(Figures 59 & 60),** TMJ fractures and luxations, **(Figure 61)** and tooth luxations **(Figure 62)** and avulsions **(Figure 63)** (Taney & Smith, 2010, Soukup *et al.* 2013, Soukup & Snyder 2014). When teeth or bones are affected, always conduct a thorough oral examination. Initial examination can be attempted while awake, but a full examination and dental radiographs are only possible under general anaesthesia.

Maxillofacial Fractures

When bones of the face are fractured, basic orthopedic principles must be kept in mind. However, there are several major differences between maxillofacial and long bone fractures (Boudrieau & Verstraete 2012). Two of these are anatomic: the tooth roots in the jaws and neurovascular structures within the mandibular and infraorbital canals. These structures must not be injured during therapy. **(Figure 64)** This means that no invasive fixation methods (pins or plates) can be inserted into or through them. Therefore, external fixation is strongly discouraged for maxillofacial fractures, because of the risk of traumatic pin placement (Gioso *et al.* 2001, Taney & Smith 2010). **(Figure 65)**. Mini bone plates may be useful in certain situations, but care must be taken to ensure atraumatic placement of the screws (Boudrieau 2012b, Arzi & Verstraete 2015) **(Figure 66).**

Another variance between long bone fractures and maxillofacial is the need for maintenance of proper occlusion. Therefore, techniques for oral fracture repair must keep alignment in mind or traumatic malocclusion can result.

An additional difference between appendicular and maxillofacial fractures is the commonality of pathological fractures (Niemiec 2013b). These may occur due to neoplastic or cystic **(Figure 67)** causes, but in the clear majority of cases they are secondary to

Figure 52. (a) right mandible of a cat and (b) rostral mandible of a dog suffering from degloving injuries.

Figure 53. Laceration of the right lip in a dog.

Figure 54. Severe iatrogenic laceration of the tongue in a Daucshund which resulted from attemtping to section a mandibuar first molar with a diamond disc. The damage to the blood supply required that most of the tongue be amputated.

Figure 55. A ginvival laceration of the maxillary left canine (204). This laceration occured due to the complicated crown root fracture.

Figure 56. Hard palate disruption caused by high rise syndrome.

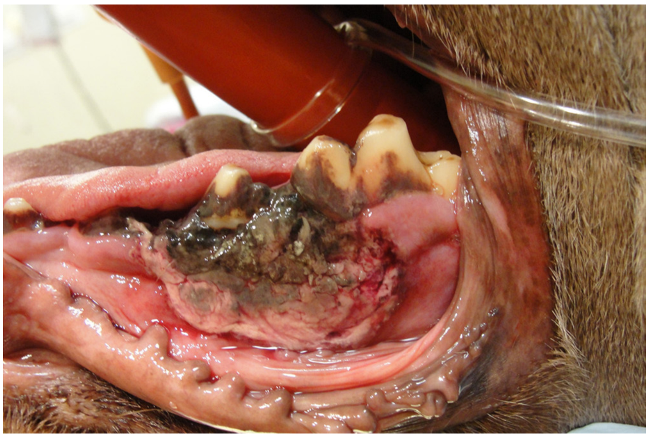

Figure 57. Significant gingival necrosis secondary to an electrical cord injury.

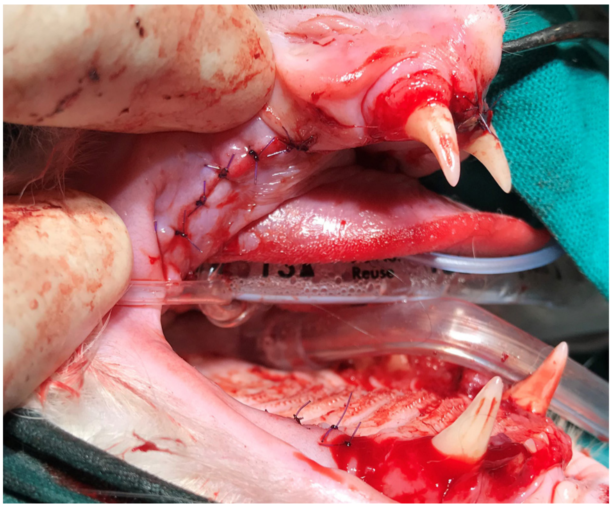

Figure 58. An oral surgical site with simple inturrupted sutures placed 2-3 mm apart.

Figure 59. Left mandible in a canine patient with a jaw fracture.

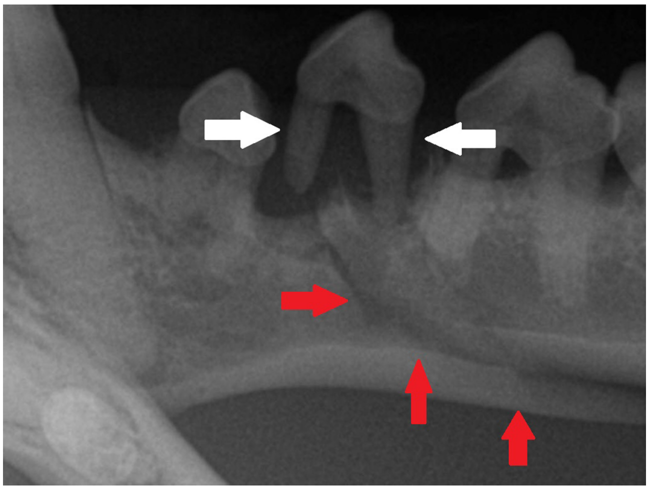

Figure 60. Intraoal dental radiograph of the rostral left mandible in a dog with a mandibular fracture (red arrows). The second premolar (306) has significant periodontal bone loss (whte arrows), which may have contributed to the fracture.

Figure 61. A cat with a malocclusion possibly secondary to right TMJ luxation.

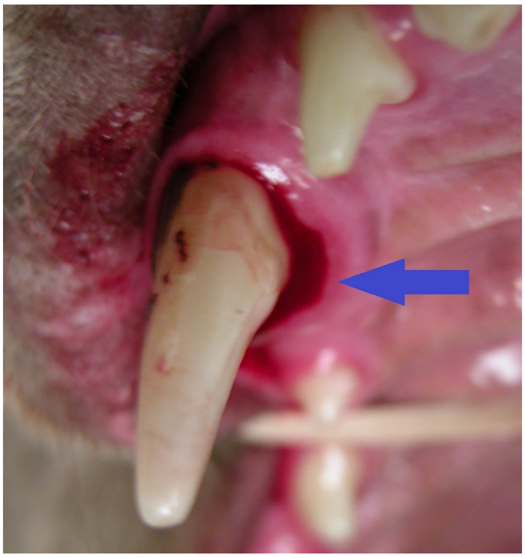

Figure 62. Luxated right maxillary canine (104) in a dog (blue arrow).

Figure 63. An avulsed left maxillary canine tooth (204) in a dog.

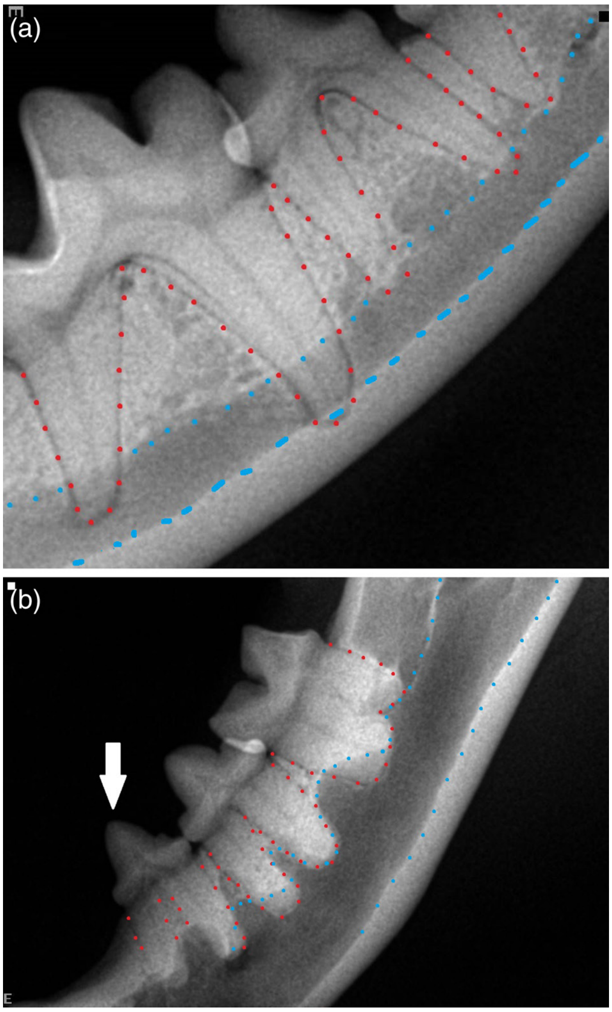

Figure 64. Intraoral dental radiograph of the right mandible in a dog (a) and left mandible of a cat (b). The roots are outlined in dashed red lines and the mandibular canal in dashed blue lines. All of these structures need to be avoided during fracture repair. The minimal amount of bone not involved with these structures makes placement of invasive fixators (pins, wires, screws), challenging. Thefore, most veterinary dentsists prefer non-invasive techniques (acrylic splints) when possible.

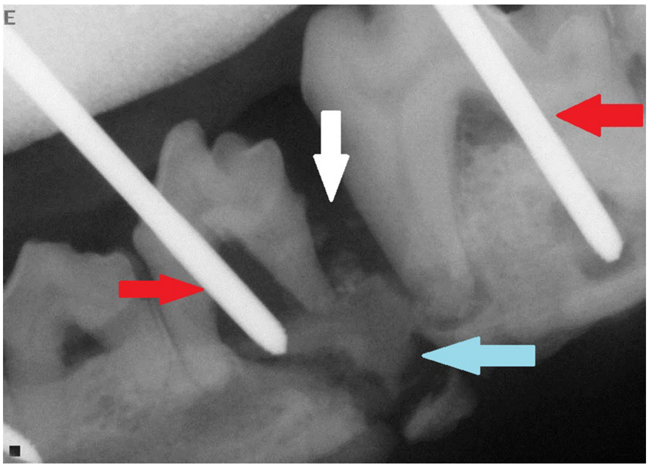

Figure 65. Intraoral dental radiograph of a failed mandibular fracture repair with an external fixator. The biggest issue is that the infected teeth were not extracted, which will not allow for successful healing. In addition, there is a bony sequestrum (blue arrow). The result is a non-union fracture (white arrow). In addition, the implants went through the teeth creating pain and potential infection. Cases like this are best treated with other methods following exposure of dental radiographs.

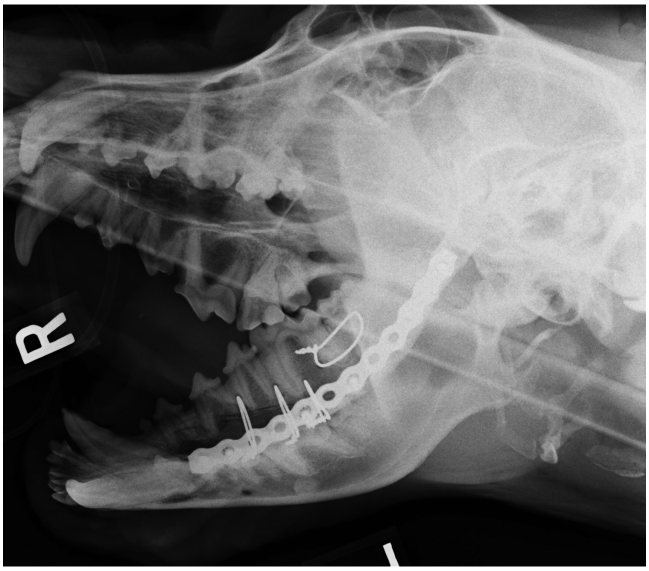

Figure 66. Post-operative extraoral (skull) radiograph of a successful treatment of a mandibular fracture with a bone plate. Note the ventral placement of the appliance missed the tooth roots and mandibular canal.

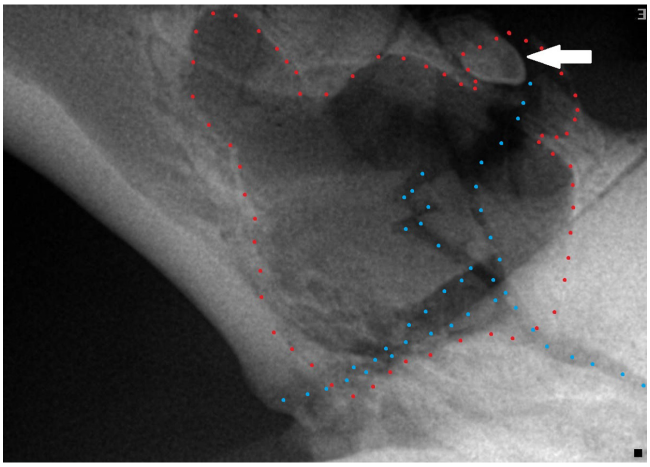

Figure 67. Intraoral dental radiograph of a pathologic mandibular fracture secondary to a dentigerous cyst (red dotted line) associated with a retained right mandibular Premolar 1 (405), white arrow. Blue dots outline the fracture.

advanced periodontal disease. These fractures typically occur in the mandible (especially the area of the canines and first molars) due to extensive periodontal attachment loss which weakens the bone in affected areas (Niemiec 2008b) **(Figures 68 & 69)**. This condition is more common in small breed dogs (Mulligan *et al.* 1998), owing mostly to the fact that their teeth (especially the mandibular first molar) are larger in proportion to their mandible in comparison to large breed dogs **(Figure 18 a & b)** (Gioso *et al.* 2003). Therefore, small breed dogs have a very minimal amount of bone apical to the tooth root, putting this area at high risk of fracture when periodontal bone loss occurs. Diagnosis is only possible with dental radiography.

Pathologic fractures (see periodontal disease section) carry a guarded prognosis for several reasons (Taney & Smith, 2010). Adequate healing is difficult to obtain due to lack of remaining bone, low oxygen tension in the area, and difficulty in rigidly stabilizing the caudal mandible (Niemiec 2012a, Niemiec 2008b). There are numerous options for fixation, but the use of invasive techniques is generally required. Regardless of the method of fixation, the periodontally diseased root(s) must be extracted for healing to occur (Taney & Smith 2010, Niemiec 2012a) **(Figures 70 & 71)**.

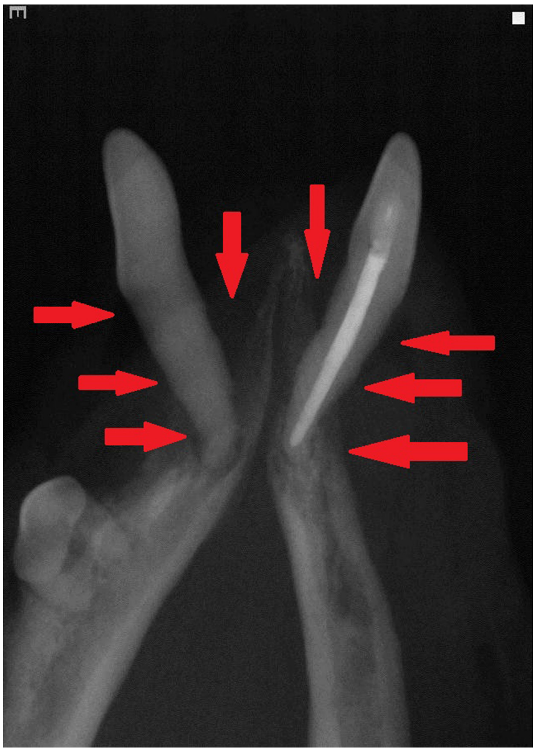

Figure 68. Intraoral dental radiograph of the mandibular canines in a small breed (3 kg) dog. There is extensive bone loss (red arrows) secondary to periodontal disease. This markedly weakens the jaw in the area and makes is highly susceptable to a pathologic fracture. Note that the left canine (304) has previously been treated with root canal therapy.

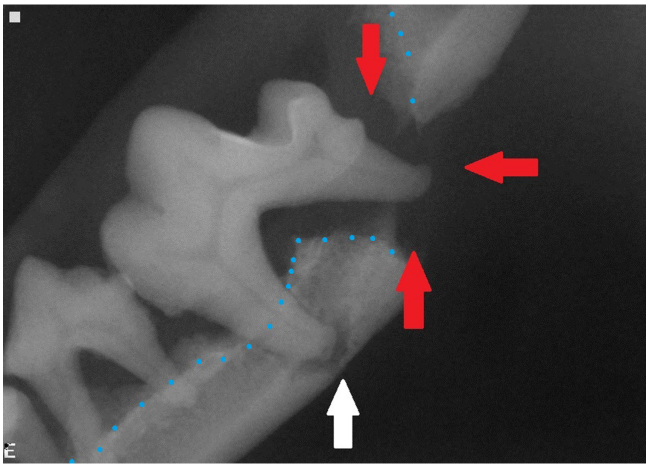

Figure 69. Intraoral dental radiograph of the left mandible of a small breed (2.5 kg) dog. There is significant alveolar bone loss accross the visible mandible (dashed blue line). There is also a pathologic fracture at the distal root (red arrows). The tooth is non-vital due to a type II perio-endo lesion as evidenced by the periapical lesion at on the mesial root (white arrow).

Diagnosis

Standard medical radiography equipment has limitations when evaluating oro-maxillo-facial fractures (Bar-Am *et al.* 2008); however, when CT, CBCT, and/or dental radiographs are not available this modality can provide useful information (Gawor 2018). **(Figure 72)** In tier 1 and some tier 2 countries, they are considered minimally acceptable. However, dental radiographs are recommended whenever possible and should be considered a minimum requirement in tier 3 countries. **(Figure 73)** Computerized Tomography or cone beam CT (CBCT) scans are ideal for maxillofacial fracture diagnosis and treatment planning (Hirsch 2009, Foley 2013, Soukup 2015b, Tundo *et. al* 2018, Winer *et al.* 2018)). **(Figure 74)**

Therapeutic Measures

There are invasive (insertions into bone), and non-invasive (stabilization without insertion into bone) methods of fracture stabilization. The invasive methods include interfragmentary wiring, **(Figure 75)** external fixators, and mini-plates (Boudrieau 2012 a&b; Tsugawa & Verstraete 2012) **(Figure 76)**. Invasive methods should only be used in carefully selected cases taking the anatomy and occlusion into account. In addition, invasive methods require a future surgery for removal of the implants, unless biocompatible plating material is used (e.g. titanium (Wiggs & Lobprise 1997, Taney & Smith, 2010, Tsugawa & Verstraete 2012).

The noninvasive methods utilize interdental or circummandibular wires **(Figure 77 a & b)** and/or acrylic resins **(Figure 78)** for fracture fixation (Niemiec 2003a, Taney & Smith 2010, Smith & Legendre 2012, Guzu & Hennet 2017). These techniques can be cost-effective and easy to learn. The reader is directed to Verstraete *et al.* (2012) for these techniques.

A very simple emergency (and in some cases, especially in juvenile animals, also final) treatment is placing a (tape or nylon) muzzle or elastic face mask to provide support to the fractured bones (Taney & Smith 2010) **(Figure 79)**.

Tooth luxation/avulsion

An avulsed tooth has been traumatically torn out of the alveolus (Taney & Smith 2010, Gracis 2012). A luxated tooth is partially distracted from the alveolus but is still attached. The tooth may be luxated in the buccal direction, which usually involves frac-

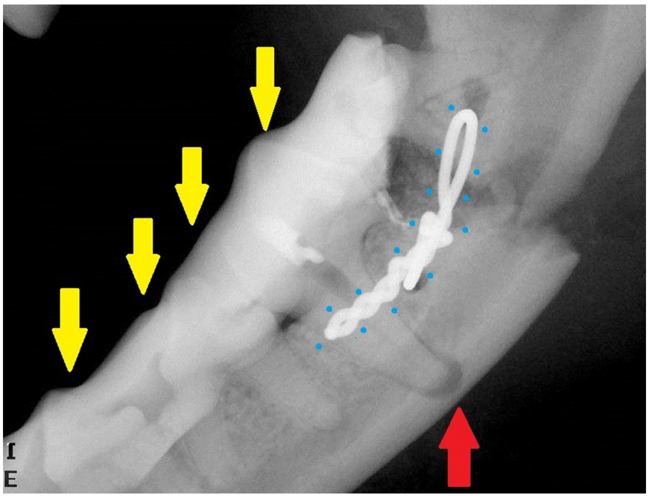

Figure 70. Post-operative intraoral dental radiograph of the left mandible of a dog. The patient had a pathologic fracture associated with the distal root of the first molar (309). The distal root was extracted and the mesial root treated by removing the pulp an placing and antibacterial medication and temporary restoration. Following this, the fracture was reduced and stabilized employing a combination of acrylic splint (yellow arrows) and interfragmentary wire (dashed blue line). There was slight periapical lucency associated with the mesial root (red arrow).

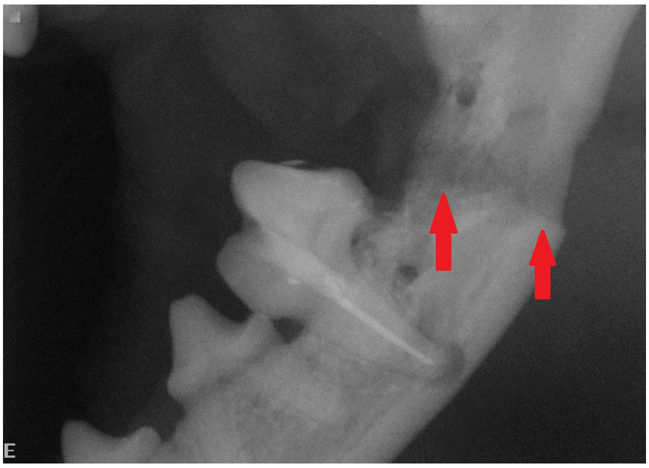

Figure 71. Post-operative intraoral dental radiograph of the patient in Figure 70 two months following fracture repair. The wire and acrylic splint were removed and the second molar (310) was extracted. The surgery was a success with good reduction, healing, and alignment (red arrows). The endodontic treatment was completed at this time.

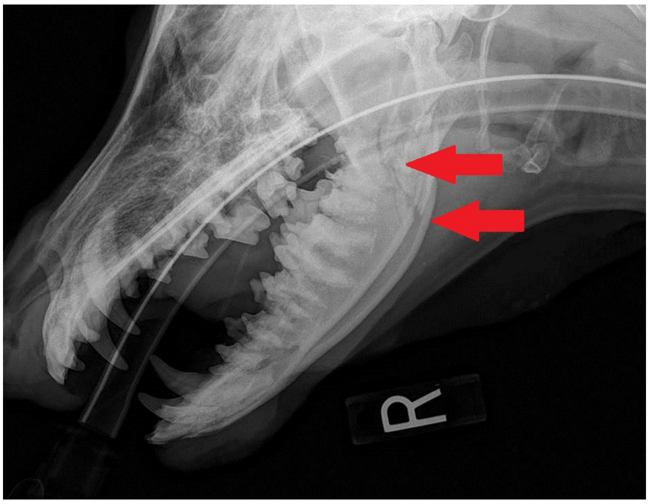

Figure 72. Extraoral (skull) radiograph redundant of a dog. On this image a distal mandibular fracture can be identified (red arrows). Note the overlapping of the mandibles makes defintive diagnosis of small injuries difficult to impossible.

Figure 73. Intraoral dental radiograph of the left mandible of a cat revealing a fracture at the level of the third premolar (307) (red arrow).

ture of the buccal alveolar wall as well. This most commonly occurs with the canine teeth (especially maxillary), but incisors can be affected as well (Wiggs & Lobprise 1997). This typically occurs following dog fights, but can also result from significant cage biting or trauma (Spodnick 1992, Gracis & Orsini 1998). These conditions may also occur following other forms of trauma like falls and vehicular trauma (Ulbricht 2004). Tooth intrusion injuries are severe in that they most commonly result in disruption of the neurovascular structures.

Clinical presentation

These patients will either present with a swelling on the muzzle or a missing tooth (Niemiec 2012a). Oral examination reveals a displaced tooth or an empty alveolus **(See Figures 62 & 63).**

Figure 74. Three dimensional rendering of a cat head from a CT scan. The excellent detail makes this the best modality for oral trauma and neoplasia treatment planning.

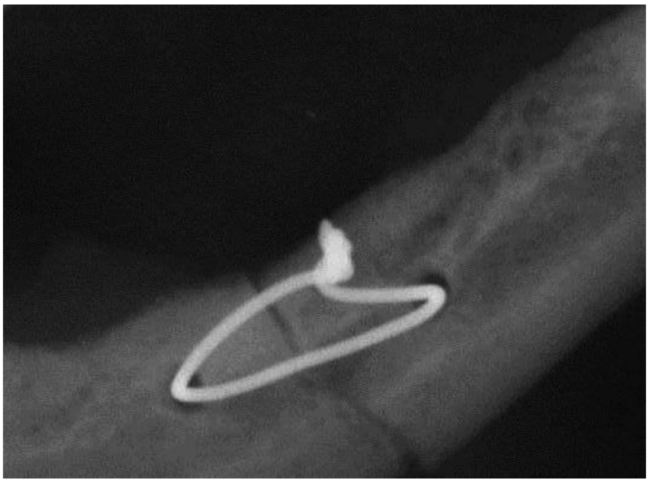

Figure 75. Post-operative intraoral dental radiograph of the left mandible of a dog. The fractured mandible was repaired with a single interfragmentary wire. The edentulous situation negated interdental wiring or an acrylic splint. A bone plate could also have been employed, but this technique is much less invasive to the bone.

Figure 76. Post-operative extraoral (skull) radiograph of the mandible of a dog. This radiograph is of no clinical use due to superimposition.

Diagnosis

Skull films are useful, however are typically not detailed enough to diagnose subtle problems such as root fractures **(Figure 80),** periodontal disease **(Figure 81)** or small areas missing bone (Niemiec 2011). Therefore, dental radiography is recommended prior to fixation (Boudrieau *et al.* 2012), and CT should be considered also to rule-out other maxillofacial trauma (Soukup *et al.* 2015b).

Where possible, these cases should be referred to a veterinary dentist as soon as possible for reimplantation and stabilization. However, if this is not feasible due to schedule or the stability of the patient, good results may still be possible despite a short delay. The fixation method is typically a figure-8 wire and acrylic splint (Gracis 2012, Niemiec 2012a) **(Figure 82)**. However, these teeth require root canal therapy due to non-vitality secondary to disruption of the blood supply (Gracis 2012). Therefore, if root canal therapy is not an option, extraction is preferred. Extraction is always performed for luxated deciduous teeth.

Key Points

- Initially, minimal debridement is generally recommended for oral trauma due to the rich blood supply.
- Non-invasive methods (acrylic splints and interdental wiring) are preferred for fixation of oral fractures.
- External fixators should only be used in carefully selected cases.

Figure 77. Post-operative intraoral dental radiograph of a cat who's symphyseal separation was successfully repaired with a circummandibular wire.

Figure 78. A acrylic splint utilized for stabilizaton of a bilateral mandibular fracture. Following healing, the patient is placed under anaesthesia and the splint carefully removed from the teeth.

Figure 79. Muzzles used for temporary stabilization of a mandibular fracture. This is an excllent means of first aid, supporting the jaw while waiting for definitive care. Depending on the type of fracture, this may be the sole means of therapy (e.g. undisplaced fracture in young patient). a) Tape muzzle applied in a labrador puppy. Since this is a young patient, this may represent the sole means of stabilisation. b) Loose nylon muzzle employed for emergency stablization in this older small breed dog. The advantage of this type of muzzle is that it can easily be removed and replaced in case of emergency or for cleaning following meals.

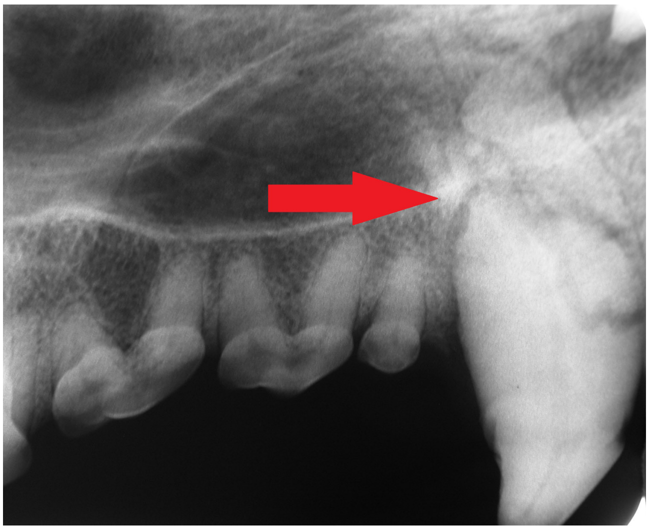

Figure 80. Intraoral dental radiograph of the right maxillary canine (104) in a dog. Upon oral exam, this tooth appeared to be luxated, however dental radiographs confirmed that it actually had a root fracture as well (red arrow). This tooth would not have responded well to replacement therapy, and therefore it was extracted. This may have been missed without the fine detail provided by dental radiology.

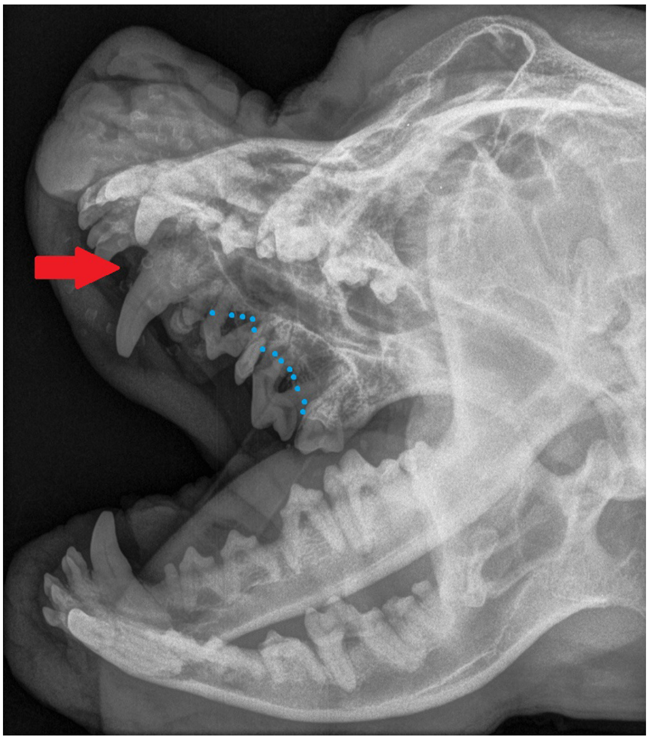

Figure 81. Pre-operative extraoral (skull) radiograph of the left maxilla in a patient with a luxated tooth. This image is sufficent to identify the alveolar bone loss on the second to fourth premolars (206-8) (dashed blue line), however the root facture and periodontal loss is not obvious on the canine (red arrow). Dental radiology or CBCT are vastly more diagnostic.

Figure 82. An acrylic splint across the palate for stabilisation of the luxated right maxillary canine (104). This is the patient in figure 62. The tooth has been replaced, and the soft tissues closed. A figure of 8 wire was placed around the canines and the acrylic placed over that, note the endodontic access on the right tooth just above the splint (white arrow). The pulp has been removed and temporary medication and restoration was performed. The root canal therapy was completed when the splnt was removed 6 weeks later.

- Properly adapted mini-plates may be indicated, but require advanced equipment and training.
- Dental radiographs provide critical information in oral trauma cases, but advanced imaging (CT or Cone-Beam CT) is superior.
- Pathologic fractures are common in small and toy breed dogs and must be taken into consideration in the management of fractures in these breeds.
- Infected teeth must be extracted from fracture sites.
- Reimplanted avulsed or luxated teeth require endodontic therapy.

ORAL TUMOURS

Tumour means "swelling", or an abnormal growth. Tumours in the oral cavity are divided into benign or malignant, and whether they are of odontogenic origin or not. The term "epulis" has been misused for decades as the description of a benign oral growth. In actuality, an epulis is any abnormal growth arising from the gingiva, which may include malignant tumours (Verstraete *et al.* 1992). Oral tumours account for approximately 5-7% of tumours in dogs and about 10% in cats (Frew & Dobson 1992, Liptak & Withrow 2007).

Benign Tumours

Benign tumours range from minor enlargements of the gingiva to locally proliferative lesions that cause tooth movement and/or tooth resorption. Oral swellings may also include cysts and abscesses.

Gingival enlargement is an area of gingival overgrowth, but needs to be differentiated histopathologically from other oral masses. This condition is generally caused by gingival hyperplasia, which is an overgrowth of fairly normal gingival tissues. **(Figure 83)** Gingival hyperplasia (GH) can have a genetic predisposition (e.g. Boxers), (Burstone *et al.* 1952; Sitzman 2000) be caused by certain medications (i.e. cyclosporine, phenobarbital, calcium channel blockers), or be attributed to plaque-induced gingival inflammation. (Waner *et al.* 1988; Heijl *et al.* 1989; Thomason *et al.* 2009; Force & Niemiec 2009) If the GH is caused by a drug, discontinuation of the medication, if possible, will often allow the gingiva to return to normal. (Thomason *et al.* 2009) Plaque-induced GH is responsive to gingivoplasty and gingivectomy, and can be controlled by daily tooth brushing and effective dental home care. When overgrowth is determined to be genetically induced and other sources have been ruled out, it is best treated by gingivectomy. (Force & Niemiec 2009) However, eventual regrowth is expected. (DeBowes 2010, Niemiec 2013e)

Peripheral Odontogenic Fibromas

Peripheral odontogenic fibromas (previously called fibromatous epulis of periodontal ligament origin) are very common oral growths in dogs, and can be fibrous or ossifying (DeBowes 2010, Chamberlain *et al.* 2012). They arise from the periodontal ligament and create localized firm swellings. **(Figure 84)** While marginal excision may suffice for control, excision of the tooth and complete debridement of its periodontium is required to achieve a cure, which can also be performed as "en-block" excision with a margin of healthy tissues.

Odontomas

Odontomas are comprised of regular dental tissue that has grown in an irregular manner (hamartomas) (Niemiec 2010). Compound odontomas are hamartomas which contain numerous complete tooth-like structures **(Figure 85)**. (Valentine *et al.* 1985) Complex odontomas contain structures derived from individual tooth components – enamel, dentine, cementum and pulp (Figueiredo *et al.* 1974) **(Figure 86)**. Marginal excision will prove curative for both of these lesions. However, it is very common to create large voids during surgery which should be addressed with bone augmentation and fastidious closure. (Head 2008; Klima 2007)

Figure 83. Right side of a Boxer with advanced gingival enlargement. This most likely represents gingival hyperplasia, but must be confirmed histopathologically. Gingivectomy is the treatment of choice.

Figure 84. Rostral mandible of a dog with a large peripheral odontogenic fibroma. Dental radiographs revealed no evidence of boney destruction. The mass was removed and submitted for histopathology, which confirmed the presumed diagnsosis.

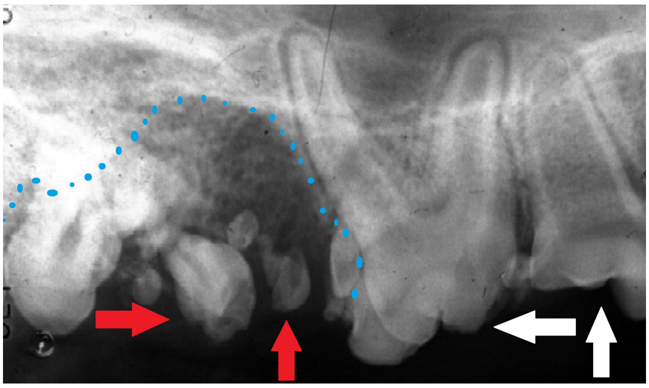

Figure 85. Intraoral dental radiograph of the left maxilla in a dog with a compound odontoma. There is bony destruction (dashed blue line) with mature appearing but malformed teeth within the mass (red arrows). The other teeth in the arcade are also malformed (white arrows). Marginal excision of the mass should prove curative.

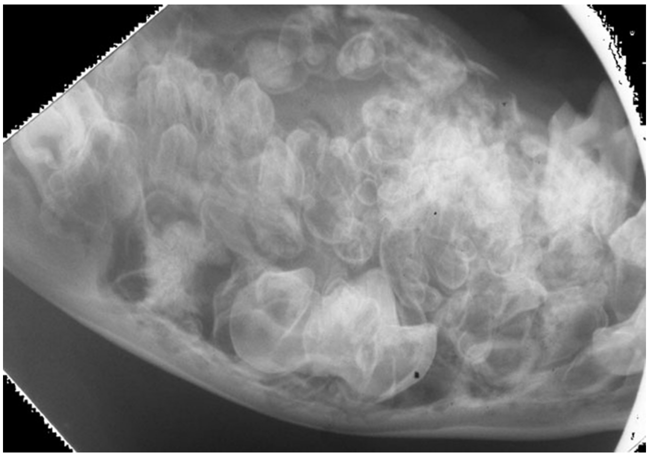

Figure 86. Intraoral dental radiograph of the right mandible in a dog with a large complex odontoma. Note that structures in the area are not identifiable as teeth. Again, marginal excision should be curative.

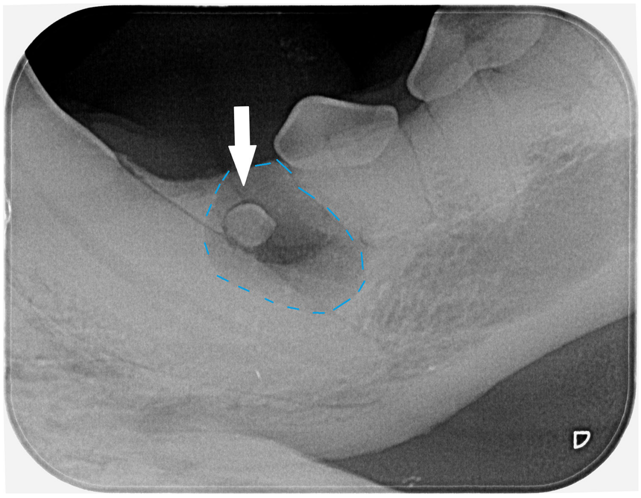

Figure 87. Intraoral dental radiograph of the left mandibular first premolar area of a dog. The first premolar is rotated 90 degrees mesially and is embedded in the gingiva (white arrow). Consequentially, a dentigerous cyst has formed surrounding the crown of the retained tooth (dashed blue line). This is an early/small lesion and can be easily treated by surgical removal of the offending tooth and meticulous debridement of the cyst.

Oral cysts

Oral cysts include dentigerous cysts, which arise from remnants of the enamel organ of a tooth that is embedded or impacted (failed to erupt into the mouth) (Head 2008, Niemiec 2010b). The cysts are often associated with impacted mandibular P1 teeth, especially in brachycephalic breeds (Babbitt 2016) **(Figure 87)**. The incidence of cystic formation in impacted teeth in dogs was reported to be 29% (Babbit *et al.* 2016) hence the necessity of taking radiographs of all "missing" teeth (Niemiec 2011).

Cysts can range from small and almost invisible radiographically, to extensive, causing resorption of the bone and/or roots of the premolars occasionally extending from mandibular P1 rostrally to P4 caudally **(Figure 88)**. These cysts can even extend rostrally beyond the canine, causing bone resorption around some of the ipsilateral incisors. Occasionally, cysts are palpable as fluctuant enlargements of the gingiva, but most often are identified on dental radiographs. Cysts can generally be diagnosed radiographically, but should be confirmed histopathologically.

Treatment involves removal of the affected tooth / teeth and complete debridement (enucleaton) of the cystic epithelial lining. The resultant cavity is allowed to fill with blood and suturing the gingiva closed will enable new bone to develop within the jaw. While the blood clot supplies all necessary products for bone healing, larger defects may benefit from bone augmentation. About 3 months

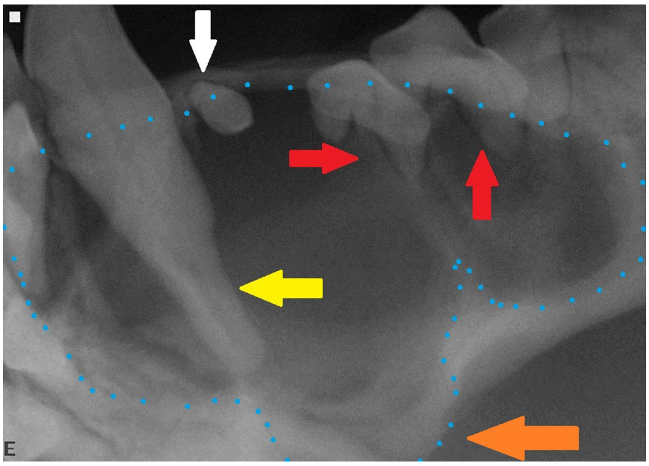

Figure 88. Intraoral dental radiograph of the left mandible in a dog with a significant dentigerous cyst. The impacted (and rotated almost 180 degree) first premolar is the cause of the problem (white arrow). The large area of bony destruction is outlined by the dashed blue line. In addition, there is minimal bone left in the area of the apex of the canine (304) (orange arrow), predisposing this area to a pathologic fracture. In addition, the premolar teeth are being moved caudally (red arrows), and the canine is being resorbed (yellow arrow). Treatment for this lesion will require a large surgery including extractions of all teeth from the first incisor to fourth premolar and meticulous debridement of the cystic lining. This is one reason why exposing dental radiographs of all missing teeth early on is important.

Figure 89. A large acanthomatous ameloblastoma on the rostral mandible of a dog. The location of the incisors and the fleshy apparence is typical for this tumor. However, the diagnosis must always be confirmed via histopathology. Resection with 0.5-1 cm margins is generally curative for this lesion.

following surgery, new bone will be found to completely fill the original cyst site and lamina dura and periodontal ligament space will be evident around previously bone-denuded teeth roots.

Acanthomatous Ameloblastoma (AA)

Acanthomatous ameloblastoma (AA) (also known as acanthomatous epulis of dogs) is a benign tumour that is locally invasive and typically causes movement of the dentition (Mayer & Anthony 2007), Chamberlain & Lomner 2012). The peripheral type causes bone enlargement and movement of some teeth, while the central lesion may be associated with a cyst-like lesion within the jaw (Amory *et al.* 2014). These growths often have a fleshy appearance and are most commonly seen around the canine and incisor teeth **(Figure 89)**. Golden Retrievers, Akitas, Cocker Spaniels, and Shetland Sheepdogs were overrepresented among dogs with CAA (Fiani *et al.* 2011). These lesions are best treated by excision with at least 5-10 mm margins, depending upon the site of the lesion. These tumours are also quite radiation sensitive, resulting in up to a 90% control rate (Thrall 1984, Theon 1997) However, this modality can have significant negative consequences (e.g. malignant transformation or osteoradionecrosis), so is generally reserved for inoperable cases or old dogs (Thrall 1981, McEntee *et al.* 2004). Finally, intralesional bleomycin has been shown to be an effective treatment modality (Yoshida *et al.* 1998, Kelly *et al.* 2010).

Plasmacytoma

This is an uncommon oral tumour, that may present as multiple lesions. They are very locally aggressive, but do not metastasize. Surgical excision with 5-10 mm margins is curative in most cases, providing that it is not a part of systemic disease. (Wright *et al.* 2008, Smithson *et al.* 2012).

Transmissible Venereal Tumours (TVT) of Dogs

While typically found on the genitals, these tumours can also be found in the oral cavity **(Figure 90)**. They are virtually unheard of in tier 3 countries, but must be on the differential list in geographic areas where TVT are prevalent (typically tropical and subtropical climates) (Lapa 2012, Ganguly 2016). Histopathology is necessary to differentiate them from lymphoma and other round-cell lesions (Kabuusu 2010, Chikweto 2013). The typical therapy is IV vincristine, which is generally curative (Das *et al.* 2000, Scarpelli *et al.* 2010). However, it has been reported that these tumours may also be self-limiting, and the host is then immune (Welsh 2011).

Papillomatosis

Papillomas may present in the oral cavity and on the lips of young animals **(Figure 91)**. Generally viral in origin, they can also be idiopathic. They are white, grey, or flesh colored masses which are generally pedunculated. They occur both singly and in bunches.

Figure 90. A canine patient severely affected by transmissible venerial tumor in the face/oral cavity.

Figure 91. Two viral pappilomas on the hard palate of a 9-month old dog. These lesions are typically self limiting, but excision and biopsy can be considered in severe or chronic cases.

While these lesions are usually self-limiting (Nicholls *et al.* 2001*,* Sancak et al. 2015) in severe cases the lesions become secondarily infected and can affect appetite. Malignant transformation to SCC has been known to occur (Regalado Ibarra *et al.* 2018). In advanced cases, surgical excision or debulking with histopathology is recommended. Alternative therapeutic modalities include azythromycin treatment (Yağci *et al.* 2008) autogenous vaccination and traumatic crushing; efficacy, however, may vary (Moore *et al.* 2003, Niemiec 2010b).

Eosinophilic Granuloma Complex (ECG)

These lesions are a group of related masses in the mouths of cats, but can also affect dogs. The most common is the indolent ulcer variety found on the upper incisor lip and/or philtrum, colloquially called "rodent ulcers" **(Figure 92)**. Linear granulomas can be seen anywhere in the mouth, and are the more aggressive type, possibly resulting in mandibular fracture or oronasal fistulas (Woodward 2006b) **(Figure 93)**. Finally, collagenolytic granulomas appear as a firmly swollen, but non-inflamed, lip in the rostral area of the mandible. These are most commonly seen in young, female cats (Scott 1975).

In the majority of cases, the aetiology of these lesions is unknown. However, a local accumulation of eosinophils and their release of granule contents is proposed to initiate the inflammatory reaction and secondary necrosis. The accumulations commonly result from local (food) or systemic allergies; although these lesions have been seen in cases where allergic disease has been ruled out. Additional proposed causal agents include response to irritation, genetic predisposition, insect bites (flea and mosquito), and bacterial, fungal, viral, and autoallergen stimuli (Mason *et al.* 1991; Russell 1988).

Dogs may also develop these lesions, and Siberian Husky and Cavalier King Charles Spaniels are over represented (van Duijn 1995, Bredal *et al.* 1996, Woodward 2006b) Lesions are usually seen on the soft palate just caudal to the hard palate mucosa **(Figure 94)**. They may have raised edges with ulcerated centres. Affected animals are often presented due to inappetence and gagging when attempting to swallow.

While occasionally classic in appearance, histopathology is always recommended to differentiate these from other oral tumours. The first step in any therapy is to rule out any possible underlying allergic cause. Flea treatment, food trial, and allergy testing should all be performed. If possible, referral to a dermatologist is recommended. If an allergic cause is discovered, treatment should be directed to removing/treating this issue. Medical therapy for idiopathic cases can include antibiotics, corticosteroids, and cyclosporine (Woodward 2006b, Wildermuth *et al.* 2012).

Malignant Tumours

The more caudal in the mouth the lesion is located, the poorer the prognosis. Lesions in the rostral part of the mandibles or maxilla or the rostral half of the tongue carry a much better prognosis, and excision with clear margins may be curative (Dhaliwal 2010 Mc Entrée 2012).

Malignant melanoma (MM) (30-40% of malignant oral tumours in dogs; rare in cats)

This is the most prevalent oral tumour in dogs (mean age 12 years). (Todoroff & Bradley 1979)

These lesions are often incidental findings during routine oral examinations, and are usually advanced at the time of diagnosis. Presentation is characterized by pigmented or unpigmented lesions that are initially smooth but later ulcerate **(Figure 95 a & b)**.

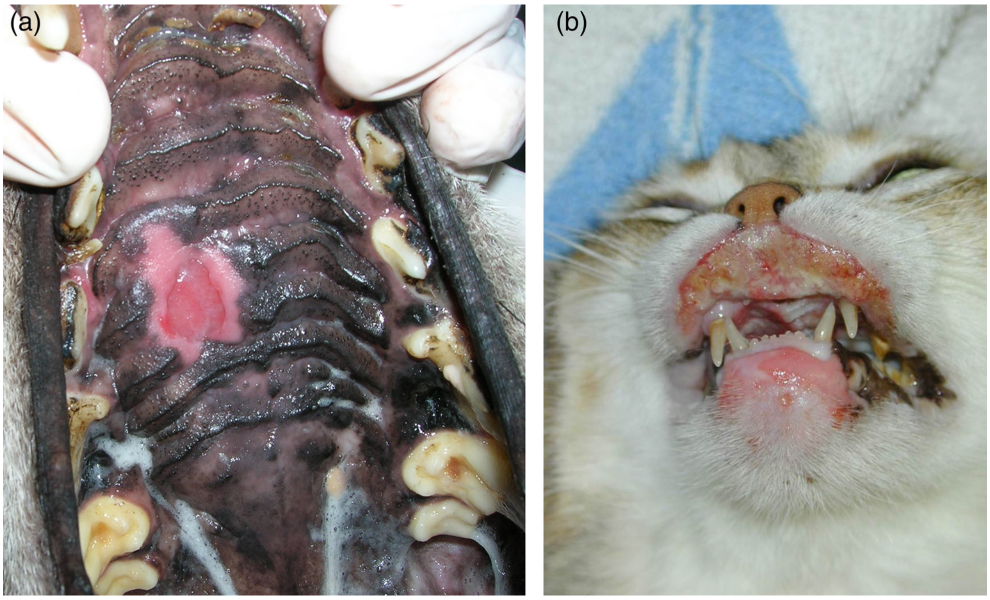

Figure 92. Eosinophillic granuloma on the palate of a dog (a) and on the upper lip of a cat (b). These ulcerative lesions can mimic neoplasia and therefore definitive diagnosis via histopathology is recommended.

Figure 93. Cat with an oronasal fistula secondary to a chronic eosinophillic granuloma lesion. This patient had suffered with this lesion for 5 years as their family vet 'diagnosed' squamous cell carcinoma without a biopsy. Following the biopsy, a veterinary dermatologist was consulted and the inflammatory area cleared with immunotherapy. Following this, the canine, second, and third premolars were extracted and the ONF closed with a mucogingival flap. All oral lesions should be sampled and submitted for histopathology regardless of appearance.

Figure 94. A Cavalier King Charles Spaniel with several eosinophillic plaque lesions at the convergence of the soft and hard palates.

They are predominantly sessile. They are highly locally aggressive, generally resulting in bony reaction. Breeds with highly pigmented oral tissues appear to be over represented (Dhaliwal *et al.* 1998 a&b).

These tumours may be melanotic with variable amounts of pigment or amelanotic (lacking pigment). Special histochemical stains are often required to make a positive diagnosis for both forms of this tumour (Ramos-Vara 2000). The tumour is locally invasive and spreads to the local lymph nodes (70% of cases) and lungs (66%). Therefore, the prognosis is guarded to poor, unless diagnosed and excised prior to metastasis. However, with new multimodal approaches, and especially the development of immunotherapies, this disease may become more treatable. The main treatment modality is still en bloc surgical removal with 1-2 cm margins depending

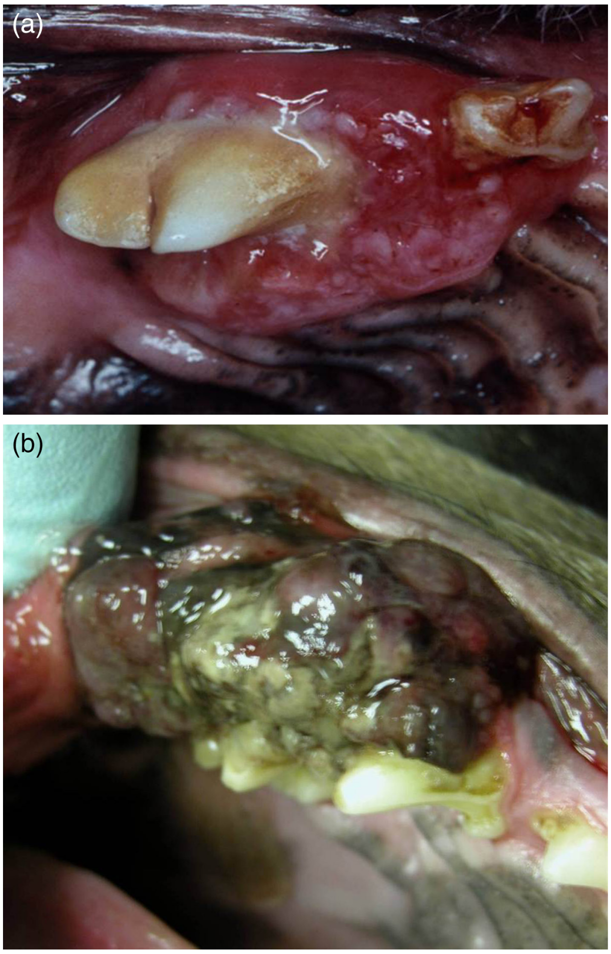

Figure 95. Oral malignant melanoma over the right maxillary fourth premolar (108) in 2 dogs. In (a) the lesion is amelanotic, whereas (b) is the more classic melanotic lesion. These tumors have a very guarded prognosis due to early metastasis.

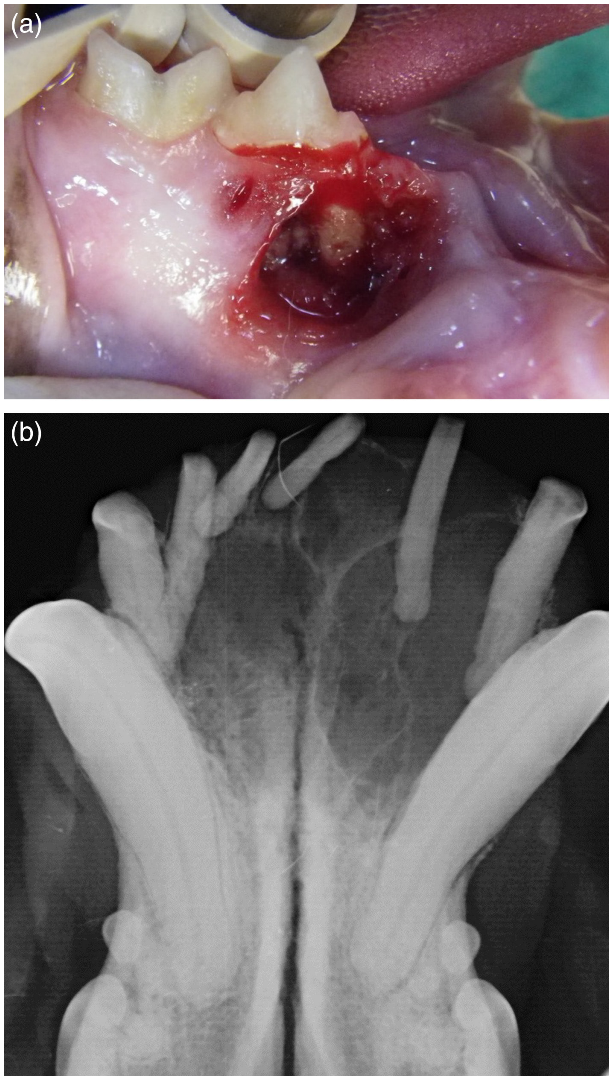

Figure 96. a) Cat with an ulcero-destructive form of squamous cell carcinoma. The soft tissue and bone have been completely destroyed by the neoplastic process and the roots have been exposed. b) Intraoral dental radiograph of a canine patient with a large squamous cell carcinoma affecting the rostral mandibles. Note the significant amount of bone proliferation, causing extensive displacement of the incisors in the area which is indicative of malignancy.

on the reference (Salisbury 1986 Arzi & Verstraete 2010, Sarowitz *et al.* 2017). Additional and multimodal therapeutic options are radiation therapy (Cancedda *et al.* 2016, Kawabe *et al.* 2015*)*, combined with immunotherapy approaches (Hoopes *et al.* 2018), or other immunotherapy approaches including a melanoma vaccine (Bergman *et al.* 2003, Bergman 2006, Bergman 2007, Grosenbaugh *et al.* 2011) and gene therapies (Milevoj *et al.* 2018). The tumor is generally considered fairly resistant to chemotherapy (Brockley *et al.* 2013).

Squamous Cell Carcinoma (SCC) (24 - 30% of malignant oral tumours in dogs; 64-75% in cats)

This is the second most prevalent oral tumour in dogs (mean age 8 years) and the most common oral tumour in cats (mean age 12.5 years). (Todoroff & Bradley 1979) Lesions may be tonsillar or non-tonsillar and may also affect the tongue. Several subtypes have been described (Nemec *et al.* 2012b, Soukup *et al.* 2013b, Nemec *et al.* 2014,), including a primary intraosseous type in a cat (Pavlin *et al.* 2018). These lesions tend to be ulcero-proliferative and can destroy extensive areas of the jaws, disrupting teeth and occasionally result in mandibular fracture **(Figure 96 a & b)**. These lesions may also be found under the tongue or on the tongue dorsum (Dhaliwal 2010, Niemiec 2015).

The prevalence of oral SCC is greater in animals living in major cities which may be due to higher levels of air pollution. Cats which wear flea collars and/or live in smoking households are at a greater risk of oral SCC (Bertone 2003).

As with all oral malignancies, wide excision (1-2 cm depending on reference) is the treatment of choice (Seguin 2012, Verstraete & Lomner 2012, Sarowitz *et al.* 2017). Prognosis with complete removal is excellent in dogs (Fulton et al. 2013). Accelerated radiation protocols have been found to be beneficial (and in some cases curative) in dogs and cats with inoperable tonsillar / pharyngeal SCC as well as in cases of incomplete excision (Theon 1997, Rejec *et al.* 2015, Riggs *et al.* 2018), however facilities which offer this service are still rare. Classically, SCC in cats has not responded to radiation therapy, however recent studies (especially when combined with chemotherapy) have shown some positive effects (Dhaliwal 2010, Fidel *et al.* 2011, Rejec *et al.* 2015). Recent use of intratumoural injection of radioactive Holmium (^{166}Ho) microspheres shows promise for increasing effectiveness of excisional surgery (van Nimwegan *et al.* 2017).

Fibrosarcoma (FSA) (17-25% of oral tumours in dogs; 12-22% in cats)

Fibrosarcoma appears at a mean age of 8-9 years in dogs, and 10 years in cats. These lesions usually present as sessile lesions on the palate; smooth and slightly paler than surrounding tissue **(Figure 97)**. Large breed dogs appear to be over represented (especially Golden Retrievers) and they are typically younger (4-5 years) when first diagnosed.

Although surgical excision of these tumours is the preferred treatment, regrowth is very common, even when the surgical margins were reported to be "tumour free" (Frazier *et al.* 2012*,* Sarowitz *et al.* 2017, Martano *et al.*2018). Fibrosarcomas may present as histologically low grade but clinically high grade, where the oral lesion is rapidly enlarging but it appears more benign microscopically

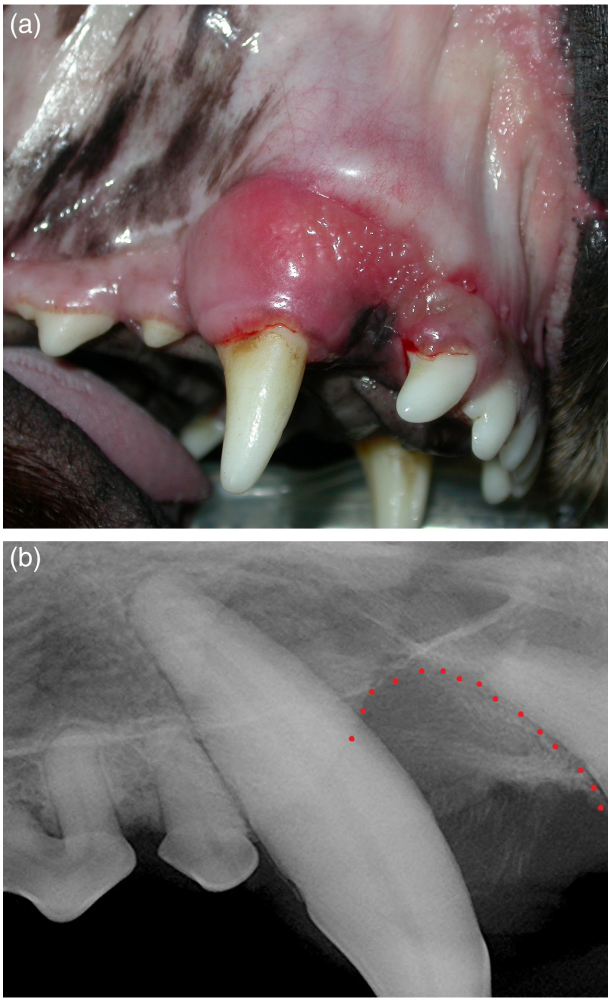

Figure 97. Fibrsarcoma in a dog. a) Canine patient with a fibrosarcoma affecting the right maxillary third incisor and canine (103 and 104). The clinical findings are more subtle than what is evident on the radiograph in Figure 97. b). b) Intraoral dental radiograph of the same area as shown in (a). The significant bony resorption is evident on the image (dashed red line). This case demonstrates the importance of careful oral evalution as part of the conscious and sedated examinations, and examination under anaesthesia and as the value of dental radiographs.

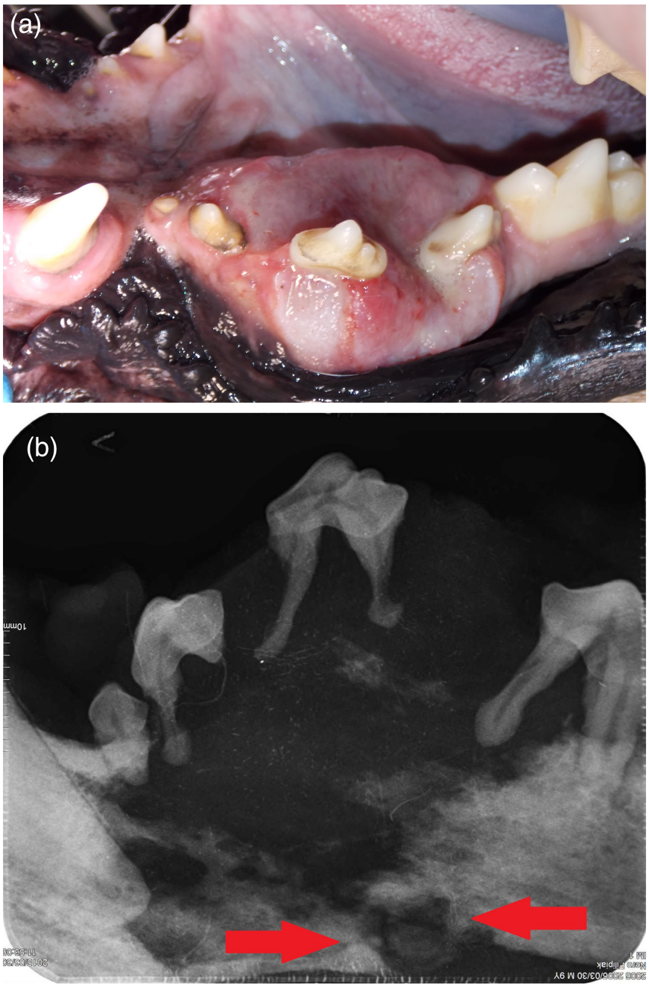

Figure 98. Osteosarcoma in a dog. a) Left mandible of a dog with a large osteosarcoma. Note the significant swelling and the movement of the teeth from their normal position. b) Dental radiograph of the patient in (a). Note the significant bony destruction displacement of teeth, and partial root resorption as well as the pathologic fracture (red arrows).

(Ciekot *et al.* 1994). Golden Retrievers are highly overrepresented for this specific presentation of the tumour. Ideal therapy for this tumor has not yet been determined. Different treatment modalities, including surgical excision with or without radiation therapy, radiation therapy alone, and radiation with or without localized hyperthermia, prolonged the survival times in some dogs (Ciekot *et al.* 1994, Martano *et al.* 2018). Curative intent surgery combined with radiation therapy appears to provide the best prognosis (Gardner *et al.* 2015). However, this tumor appears to be far more radiation resistant than SCC (Riggs *et al.* 2018), a combination of acupuncture and herbal medicine was reported to have favorable results in one case (Choi & Flynn 2017).

Lymphosarcoma

Lymphomas may occur in the oral cavity and account for approximately 5% of oral tumours. There are tonsillar and non-tonsillar types. Epitheliotropic T-cell lymphomas (ETCL) are oral manifestations of an alimentary canal tumour, but may be a part of a skin disease as well. ETCL lesions typically present as chronic gingivostomatitis or periodontitis (Nemec *et al.* 2012a). The lesions can extend to the muco-cutaneous junction and in some cases the lesions have a blueish tinge due to extravascular pooling of blood (Niemiec 2015). Biopsy with immunohistochemistry is necessary for definitive diagnosis (Nemec *et al.* 2012a). Historically they have been considered difficult to treat, however recent studies on radiation therapy show promising results (Berlato *et al.* 2012).

Osteosarcoma

Oral osteosarcomas are rare in dogs and comprise only about 2% of oral tumours in cats (Stebbins *et al.* 1989, Heyman *et al.* 1992). 7% of osteosarcoma tumours in the dog involve the skull. Lesions may cause bony destruction or bone proliferation, while some may appear to be cyst-like radiographically **(Figure 98)** (Soltero-Rivera *et al.* 2015). Like axial osteosarcomas, these tend to metastasize late during disease and therefore may have a better prognosis for cure (Dickerson *et al.* 2001, Farcas *et al.* 2014). Wide excision (2-3 cm) is generally curative, however mandibulectomy is the preferred therapy in mandibular cases (Dhaliwal 2010, Soltero-Rivera *et al.* 2015, Sarowittz *et al.* 2017). Radiation and chemotherapy can also be used as it is in the more common appendicular form (Dickerson *et al.* 2001).

Mast Cell Tumour (MCT)

Oral MCT accounts for about 6% of oral tumours, and is twice as commonly found in males than females. Excision with 3 cm margins is recommended and therefore any reconstruction must be well planned prior to the surgery (Macy 1986). Lung and lymph node metastases should be ruled out prior to surgical excision as these will significantly decrease the prognosis (Elliott *et al.* 2016). Without lymph node involvement, long term survival (over 4 years) is reported, but with metastasis the median survival was only 14 months (Hillman *et al.* 2010).

A potential complication of surgery can be anaphylactic type reaction due to histamine release from mast cell degranulation. Preoperative administration of a histamine blocker (e.g., diphenhydramine [1 to 2 mg/kg SC 30 to 60 minutes before surgery]) may decrease this complication.

Other options for therapy in non-resectable and/or incompletely resected tumors or when clients decline surgery include radiation therapy, electrochemotherapy (+/- peritumoral interleukin-12 (IL-12) gene electrotransfer) and intralesional Triamcinolone (LaDue *et al.* 1998, Hahn *et al.* 2004, Cemazar *et al.* 2017, Lowe *et al.* 2017, Case *et al.* 2018;).

Key Points:

- The oral cavity is a common location for tumours.
- Benign and malignant conditions can appear very similar clinically, therefore histopathology is mandatory.
- The most common oral malignant tumour in the dog is malignant melanoma followed by SCC.
- The most common feline oral malignancy is SCC followed by fibrosarcoma.
- Prompt and aggressive therapy offers the best chance for cure and therefore regular oral examinations are necessary.
- Surgical excision is the treatment of choice for most oral tumours with the margins based on the type of growth and tissue planes.
- Chemotherapy, immunotherapy and radiation therapy may be used as palliative or adjunct means if available.
- In some cases, accelerated radiation protocols are curative.

MALOCCLUSIONS

A malocclusion is any occlusion which is not standard for the breed (Roux 2010). However, the WSAVA Dental Guidelines committee considers any malocclusion which creates occlusal trauma to be a malocclusion. This includes class III malocclusion (undershot) in brachycephalic dogs which causes significant trauma to the mandibular gingiva as well as mandibular canine teeth.

Malocclusions may be purely cosmetic or result in occlusal trauma. In cases of occlusal trauma there is significant pain and discomfort for the patient and if left untreated can result in significant complications such as oronasal fistulation, tooth wear and subsequent fracture and/or tooth death. In general, jaw length (or skeletal) malocclusions (Angle class II, III, IV) are considered genetic or heritable. Conversely, tooth (non-skeletal) discrepancies (class I) are considered nongenetic, with the notable exception of mesiocclusion of the maxillary canines (lance effect) seen in Shetland sheepdogs and Persian cats, which is considered genetic. (Bellows 2004, Gawor 2013a)

Class I Malocclusion: Neutrocclusion

This is defined as an occlusion with normal jaw lengths (scissor bite), where one or more teeth are out of alignment. These conditions are generally considered nongenetic, however, there is a high prevalence of some syndromes in certain breeds (see above) which indicates a genetic predisposition in some cases. Class I malocclusions can result from lip/cheek/tongue pressure (or lack thereof), significant systemic or endocrine issues, and less commonly neoplastic or cystic formation may also result in tooth deviation. Displacement in some situations was previously believed to result from persistence of the deciduous teeth. However, research shows that deciduous tooth persistence is caused by improper eruption of the permanent teeth. (Hobson 2005) This class of malocclusion includes: linguoversion of the mandibular canine teeth, **(Figure 99)** mesioversion of the maxillary canines (lance teeth) **(Figure 100)**, rostral cross bite or malalignment of the incisor teeth (Martel 2013, Startup 2013, Thatcher 2013) **(Figure 101)**.

Class II Malocclusion: Mandibular Distocclusion

This is also termed overshot or mandibular brachygnathism. In the EH Angle classification system (human) is defined as the lower molar positioned caudal to the upper molar (Angle 1899, Niemiec 2010b). This is a jaw length discrepancy where the mandible is pathologically shorter than the maxilla, with the mandibular premolars caudal to the corresponding maxillary premolars **(Figure 102)**. The major issue is that the mandibular canines typically cause significant occlusal trauma to the palate, gingiva, and/or maxillary canine teeth **(Figure 103)**. Therefore, intervention is almost always required (Storli 2013).

Class III Malocclusion: Mandibular Mesiocclusion

This is also called undershot and is a jaw length discrepancy typically where the maxilla is shorter than normal **(Figure 104)**. This condition is often caused by line breeding for a specific size and shape of the head. (Stockard 1941,) The great variety in the size and structure of the canine maxilla and mandible as well as tooth size between breeds, in combination with cross breeding have also resulted in malocclusions. Further evaluation of these findings supports the theory that malocclusions likely occur secondary to the degree to which achondroplasia is expressed within the patient. (Stockard 1941) Early trauma with bone scarring or physeal closure may also result in this condition; however, this diagnosis should be supported by a history of trauma. This condition, while common and "normal" in certain breeds often creates painful gingival and tooth trauma **(Figure 105)**. However, as in all malocclusions, it is rare to have the patient show clinical signs. Nevertheless, therapy of the traumatic malocclusion is recommended (Yelland 2013).

Class IV Malocclusion: Maxillomandibular Asymmetry

This is a jaw length discrepancy in which one of the mandibles is shorter than the other resulting in a shift of the mandibular midline **(Figure 106 a)**. A true class IV malocclusion occurs when one mandible is longer than the maxilla and the other is pathologically shorter. An asymmetry can occur in one of three directions: rostrocaudal, dorsoventral or side to side. In general, this malocclusion causes palatine or gingival (+/- tooth) trauma **(Figure 106 b)** and if this is occurring, therapy is recommended (Hardy 2013).

Figure 99. Linguoversion of right mandibular canine (404). This tooth is creating significant palatine trauma, despite this the patient was eating and acting normally. Ideally, this malocclusion is treated with an incline plane, however crown reduction and vital pulp therapy or extraction are acceptable.

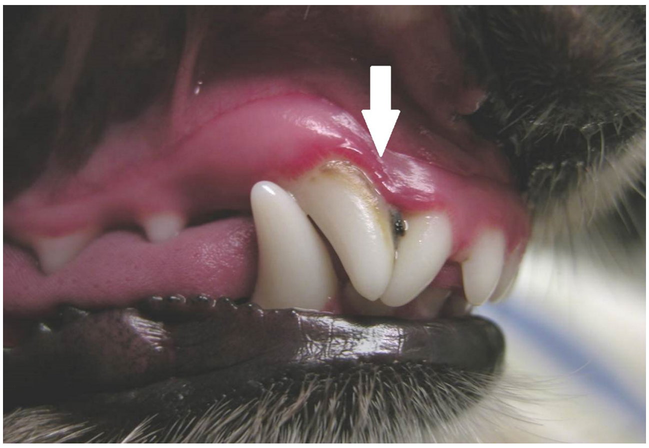

Figure 100. Right side of a 9-month-old Shetland Sheepdog with a mesioclused maxillary right canine (104). Obliteration of the diastema between this tooth and the third incisor (103) has decreased the natural cleaning ability in the area resulting in early onset gingivitis (white arrow).

Figure 101. Partial rostral cross-bite affecting some incisors in a young dog. The teeth (particularly left mandibular incisors) are malaligned. This has caused the mandibular incisors (301 and 303) to be labial to the corresponding maxillary incisors. This may result in attrition and/or periodontal disease.

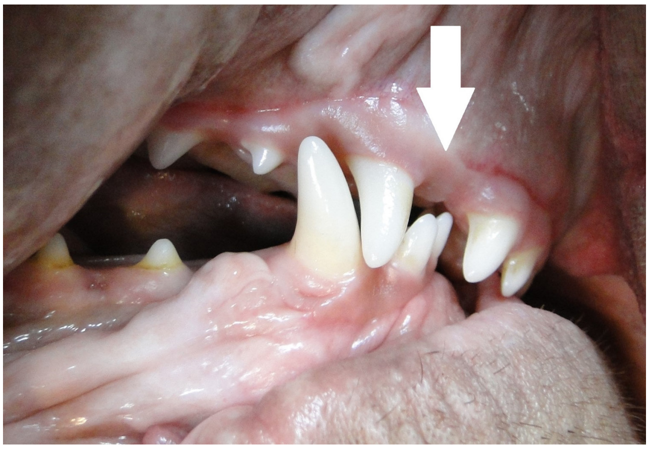

Figure 102. Right side of a canine patient with a pronounced class II malocclusion. The mandibular canine should be placed in the diastema between the maxillary third incisor and canine (white arrow). The degree of malocclussion has allowed the mandibular canine to slide out caudal to the maxillary canine, thus the malocclusion is not creating any trauma. No therapy is necessary.

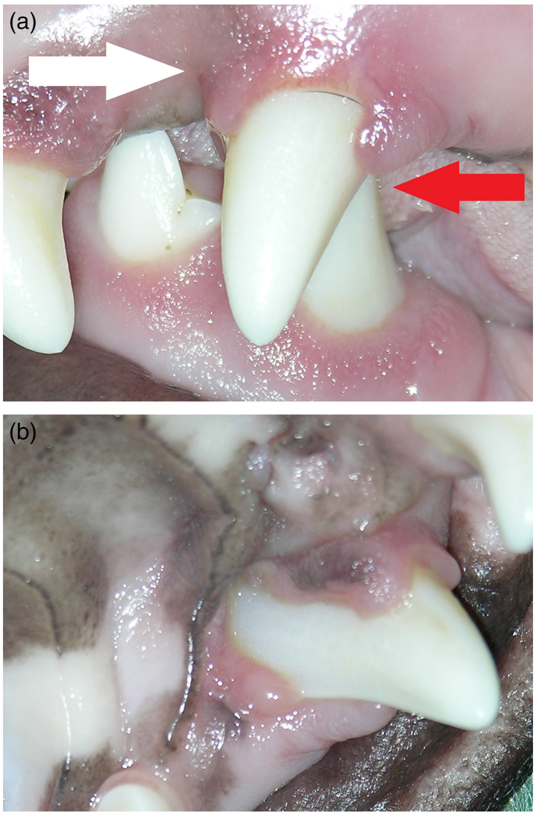

Figure 103. Class II Malocclusion with significant palatine trauma. (a) the left side of a canine patient with a pronounced class II malocclusion. The lower canine should be placed in the diastema between the maxillary third incisor and canine (white arrow). In this case, the mandibular canine is impinging on the maxillary canine (red arrow) and the palatal gingiva creating significant damage (b). The ideal therapy for this condition is crown reducation and vital pulp therapy, however extraction can be considered.

Therapy for Malocclusions:

Therapy for malocclusions can be classified into several categories (Martel 2013, Moore 2013, Startup 2013, Storli 2013, Thatcher 2013, Yelland 2013)

1. For purely cosmetic cases no therapy is recommended. It is quite common for breeder/show clients to wish cosmetic therapy; however, this is strongly discouraged by the AVDC, AKC, and other organizations for ethical reasons (Gawor 2013b).

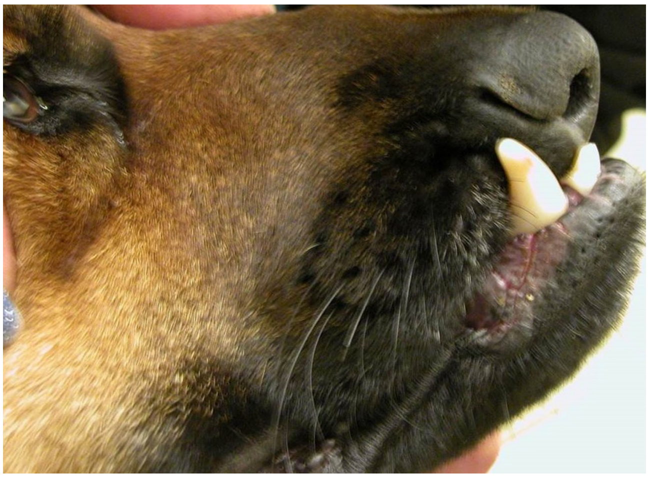

Figure 104. Significant class III malocclusion in a German Shepherd Dog. The mandibular canines and incisors extend rostrally beyond the maxillary lips. This may result in no trauma, thus no treatement may be necessary. However an examination under anaesthesia should be performed to rule out trauma from the maxillary incisors (See figure 105).

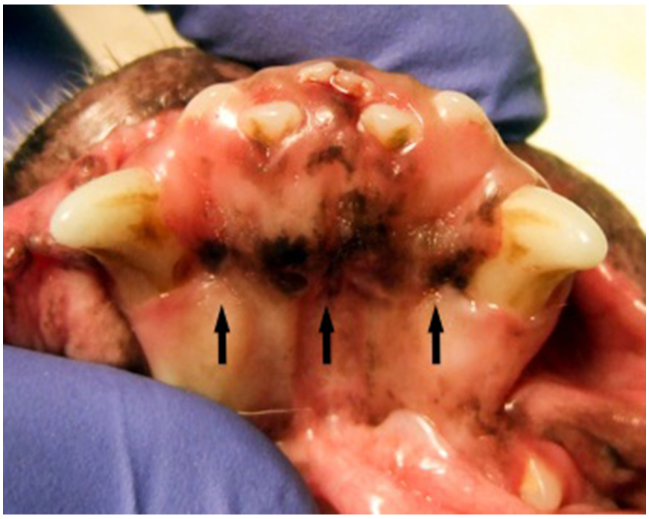

Figure 105. Trauma (black arrows) to the mandibular gingiva and canines in a dog with a class III malocclusion. This is creating significant weakening of the canines and hastening periodontal loss of the incisors, not to mention the discomfort. Extraction or crown reduction of the maxillary incisors should be performed.

Figure 106. Canine with a class IV malocclusion. a) Rostral View: The midline of the maxillary arch (blue arrow), does not align with the midline of the mandibular arch (white arrow). b) Left side: The mandibular canine, instead of being in the diastema of the maxillary third incsisor and canine, is striking the third incisor. This is a painful/damaging condition and requires therapy, extraction of the third incisor will allow the canine to occupy that area and thus the canine can be maintained. Alternatively, crown reduction and vital pulp therapy of the offending canine can be performed. c) Right side: The teeth are in normal occlusion and no therapy is needed.

2. Surgical - which generally consists of extraction of teeth causing occlusal trauma (Angel 2016). This should be the treatment of choice for traumatic malocclusions in tier 1 & 2 countries.
3. Orthodontic: This is where the maloccluded teeth are moved into the correct or a non-traumatic position via the use of various appliances (Blazejewski 2013, Kim *et al.* 2015). In cases of very mild lingual malocclusion of mandibular canine teeth ball therapy (Verhaert 1999) can be sufficient to move teeth in appropriate position.
4. Coronal amputation and endodontic/restorative - where the offending teeth are shortened and undergo endodontic therapy (vital pulp therapy or root canal treatment) or their shape is changed by odontoplasty and a restoration/sealant placed (Storli, Menzies, & Reiter, 2018).

The latter two are challenging techniques and should only be attempted by dental specialists (and potentially veterinarians with advanced training). Linguoverted mandibular canine teeth can be treated by all 3 categories of orthodontic treatment: preventive, interceptive and corrective. Published studies have shown that temporary crown extension (TCE) is a viable treatment option to correct this orthodontic condition in young dogs.

Key Points:

• Malocclusions in veterinary patients often cause trauma which can result in significant morbidity and therefore require treatment, regardless of lack of symptoms.

- The majority of malocclusions have a genetic component, often secondary to line breeding for specific traits.
- Unless a malocclusion can be unequivocally shown to be of traumatic origin it should not be corrected by orthodontics for ethical reasons. Orthodontics can be performed in neutered animals which display a heritable malocclusion, to improve function and eliminate pain and discomfort.
- There are several treatment options for traumatic malocclusions, however in most areas of the world, extraction is the most expedient.

SECTION 2: ANIMAL WELFARE ISSUES CONCERNING DENTAL HEALTH

INTRODUCTION

In many countries, a veterinary oath is sworn to uphold animal health and welfare as part of one's professional and ethical requirements. At the core of animal welfare assessments are the five central tenets of animal welfare, also known as the Five Freedoms, which include caring for animals in ways that minimize stress, fear, suffering and pain, as well as be free to express natural behaviours (Brambell 1965). Additional concerns about quality of life have been raised when animals are asked to endure stimuli and physiological challenges for which they do not possess coping mechanisms (Fraser *et al*., 1997). Regular, thorough, quality dental care is necessary to provide optimum health and quality of life in veterinary patients. If left untreated, diseases of the oral cavity can create unrelenting pain, contribute to other serious local or systemic diseases (DeBowes 1996, Pavlica 2008, Niemiec 2013 b & f, Finch 2016), and potentially prevent natural expression of oral and facial behaviours (Palmeira *et al*. 2017). Failure to properly address oral and dental conditions may create significantly deleterious impacts on an animal's welfare, which must be considered when veterinarians are choosing appropriate levels of care for their patient.

Prevalence of Dental Disease

Historically, it was a commonly held belief that companion animals required little if any dental care; however, we now know that dental disease is one of the most common medical conditions in companion animals. Studies show that over 80% of dogs (some papers report 90%) and 70% of cats have evidence of periodontitis by two years of age (Lund *et al*. 1999, Kortegaard *et al*., 2008, Fernandes 2012, Marshall 2014). Further, 10% of dogs have a fractured tooth with painful direct pulp exposure (termed complicated crown fractures) (Golden 1982; Chidiac 2002), and Bellows (2010b) found 20-75% of mature cats are clinically affected with oral resorptive lesions, depending on the population examined. It is estimated that 50% of large breed dogs have small fractures (termed uncomplicated crown fractures) with painful dentin exposure (Hirvonen *et al*. 1992) (See oral pathology section). A large majority of veterinary patients are dealing with significant pain, infection, or both on a daily basis.

Associations with Pain and Suffering

Pain is an experience unique to each individual, and behavioural demonstrations of pain are incredibly species specific. It is well documented in humans that dental pain can be extreme (Bender 2000; Hasselgren 2000; Hargreaves *et al*. 2004). Multiple published articles link dental pain to decreased productivity sleep disturbance, and significant social and psychological impacts (Reisine *et al*., 1989; Anil *et al*., 2002; Heaivilin *et al*., 2011; Choi *et al*., 2017). Animals in comparison may show fewer behaviours one can directly link to oral pain, but their experience of that pain and infection is likely equally present (Holmstrolm *et al*. 1998d; Cohen & Brown, 2002; Niemiec 2005a), given that the pain thresholds of people and animals are quite similar (Bennett *et al*., 1988; Rollin 1998).

Non-human mammals have been found to be excellent models for dental pain in man (Le Bars 2001), and have been prolifically utilized in nociception research. Research in human pulpitis, a condition reported to cause extreme pain responses in people, has found small rodents to be an excellent model. Notable and repeatable behavioural changes due to pulpal pain include decreased weight gain, increased time to complete meals, shaking, open-mouthed facial grimaces, freezing and decreased activity (Chidiac 2002; Chudler *et al*. 2004). Dogs and cats have also been utilized to show behavioural changes with pulpal and non-pulpal pain (Le Bars, 2001). It is interesting to note that despite the common belief amongst veterinary professionals and owners alike that dental pain will lead to dramatic decrease or total cessation of appetite, this has rarely been noted in the published research. Additional research is strongly recommended into better understanding oral pain and how it should best be assessed in companion animal species.

There is substantive belief within the profession that despite not always being able to prove an animal is in pain, we should seek to relieve any pain we suspect them to have at all times (Mathews *et al*. 2014). When oral pain can be reasonably suspected, effective therapy is recommended to alleviate this pain. While temporary measures may be possible with pharmaceuticals, the only way to remove pain is to address the issue with appropriate dental therapy.

Behaviour Changes Noted

Behavioural scoring systems to evaluate pain exist for a variety of systems and species (Mathews *et al*., 2014) and are described in more depth in the anaesthesia section. However, it is important to note that dental pain indicators are often vague and non-specific.

Conditions which may cause oral pain for our patients include periodontal disease, tooth and jaw fractures, tooth resorption, caries, traumatic malocclusions, feline orofacial pain syndrome, and some oral neoplasias. It is important for practitioners to understand that the absence of a notable behavioural change does not mean that the pain is not there, nor does it imply any lack of severity. Many dogs and cats simply do not show the pain they are forced to endure daily in an easily observable or understandable way to their owners or veterinarians (Merola & Mills 2016). Behaviours that have been well attributed to dental pain include pawing, rubbing, drooling, mutation of the mouth, and slightly decreased appetite (Rusbridge *et al*. 2015).

Interpreting behavioural signals of oral pain can be complex, however it is a simple fact that animals will continue to eat despite debilitating and extreme dental pain. Animals require nourishment to survive, and the instinct to survive is stronger than the desire to avoid pain. It is important to remember that while the majority of animals will demonstrate normal oral behaviours, such as playing with toys, marking with facial glands, or using their mouth to explore their environment despite experiencing dental pain, others may be prevented from expressing these natural and essential behaviours due to chronic discomfort. Additionally, clients report that they are happier to know their pets are not in pain (McElhenny 2005). Whether or not behavioral changes are observed, the underlying pain should not be a condition which the animal is expected to endure, either by the veterinary community or by owners.

While a definitive behavioural guide for assessing behavioural changes due to oral disease and discomfort is not available at this time, the authors strongly suggest this is an area that deserves further research.

Physiological Signs of Stress

Endodontic and periodontal disease may incur a significant bacterial disease burden on the body (DeBowes *et al*. 1996, Niemiec 2012b, Niemiec 2013f). Unchecked pain and infection lead to potentially deleterious consequences as the body's natural stress responses are activated (Broom 2006). While these may be appropriate in the short term, chronic stressors negatively affect multiple body systems. Immune function impacts may be first noted with the development of an acute stress leukogram, progressing to leukopenia and immunosuppressive inflammatory cytokine changes with chronicity (Hekman *et al*., 2014). Several publications have linked chronic stress responses to decreased ability to eliminate bacterial infection and increased susceptibility to disease in humans and mice (Biondi *et al*., 1997; Karin *et al*., 2006; Kiank *et al*., 2006). Untreated dental disease can lead to chronic inflammation and infection of the oral tissues. As in other areas of the body, unchecked infection is an ethically unacceptable condition to leave without appropriate therapy.

Client Education Matters

As veterinarians, it is our responsibility to proactively diagnose, treat, and relieve pain and suffering for our animal patients. When resistance is met to our treatment plan, additional client education may allow for increased understanding of the decreased welfare associated with the individual animal's condition and may assist in increasing compliance with our recommended treatment plan. To allow untreated dental disease to cause continuous pain without therapy is a significant animal welfare issue.

At the practitioner level, a simple questionnaire or discussion with the owner during regular health examinations regarding current oral and facial behaviours, and any changes that have been noted, should be performed and recorded in the patient's medical record. While anecdotally it appears that most owners and many veterinarians feel oral pain will decrease appetite (and therefore in its absence lead to misreported changes), we encourage practitioners to consider a more universal view to the wide variety of changes that may be noted as sequalae to oral disease (Table 1) (DeForge 2009). When taking a history from an owner, it is important for

Table 1. Possible Observable Changes Associated with Dental Pain
• Changed patterns of contact: pet with owner • Hypersalivation • Aggression • Withdrawal • Disturbances in sleep pattern • Reduced grooming • Changes in eating behaviour • Change in food preference-hard to soft • Food tossing into mouth: swallowing food whole • Chewing on one side of mouth only • Smacking of lips • Mouth chattering • Tooth grinding: especially in feline • Tongue hanging out of mouth • Change in play behaviour • Blood in food or water bowl • Bloody discharge from nose • Rubbing face or pawing at face • Hair loss noted around muzzle • The feline withdrawing from cheek rubbing for affection • Dropping food outside of the food bowel-reluctance to masticate

the veterinarian not to ask leading or closed ended questions, but appeal to the owner to evaluate any changes they may or may not have noticed regarding these issues. Equally important is following up on these, or any additional changes the owner has noted since professional dental therapy has been completed. Follow-up at 2 weeks and 2 months is commonly advised in order to get a full picture of the improvements noted following therapy.

Welfare Implications of Veterinary Handling Techniques

The welfare needs of our patients begin from the time they enter our practices. Dental treatment must be conducted by properly trained veterinary professionals. Handling must be gentle and humane at all times. Low stress and feline friendly handling techniques are recommended during initial examination and introduction of anaesthetic agents, and commonly accepted recommendations have been outlined in many publications (Rodan *et al*. 2011, Carney *et al*. 2012, Herron *et al*. 2014, Yinn 2009). The human-animal bond is tenuous, and fear experienced during handling for veterinary procedures can disrupt this bond quickly (Knesl *et al*., 2016). Education on, and commitment to reducing stress involved with handling for oral examinations and procedures related to dental therapy needs to be considered when addressing dental disease in our patients.

All procedures in the oral cavity (including professional teeth cleaning) must be performed under general anaesthesia with a secured airway (endotracheal intubation). All precautions, safety measures, monitoring rules and standards apply, as referenced in the Anaesthesia section.

Gentle, efficient and thoughtful tissue handling (minimally invasive surgery) is recommended to prevent excessive pain and swelling post-procedure. In addition, appropriate choice of, or avoidance of mouth gag use altogether may help to prevent trauma (Hyperlink to Anaesthesia). Local and regional anaesthetic blocks, and adequate pre- and postoperative pain management are necessary for controlling the pain that may be experienced from proper dental therapy.

Welfare Implications of Anaesthesia Free Dentistry (AFD)

Veterinary organizations worldwide agree that performing dental procedures without anaesthesia, referred to in this document as Anaesthesia Free Dentistry (AFD) but occasionally known as non-anaesthetic dentistry or natural dentistry, is not medically beneficial. Animal welfare scientists maintain that preventable and predictable pain, stress, and anxiety should be addressed during veterinary care for both moral and ethical reasons. Effective evaluation of periodontal health requires thorough periodontal probing. Performing a thorough and accurate probing on all surfaces of the tooth, especially the caudal teeth and all lingual/palatal surfaces, on a typical awake animal is exceedingly challenging, and therefore likely to be inaccurate. Challenges include animal head movement, tongue interference, and difficulty for visualization. While this may be a procedure that creates minimal pain and stress in healthy individuals, probing diseased tissues such as resorptive lesions elicits a significant and predictable pain response. Determining which animals will experience pain on probing is rarely accurate based upon visual cues, and as such, a practitioner has little accurate information before probing to ensure the process will not be painful or stressful to the patient.

Individuals performing a dental procedure without anaesthetic cannot conduct radiological examination of the subgingival anatomy, which in Tier Three countries is considered an essential procedure for thorough evaluation. Without effective evaluation of the supra- and subgingival areas, meaningful treatment cannot be delivered to the patient. As a result, removal of supragingival tartar and polishing of the visible surfaces of the teeth may lead to a cosmetically improved oral cavity, but persistent infectious, inflammatory, and/or painful conditions not recognized or identified remain untreated. Therefore, not only is the procedure essentially ineffective for relieving pain and infection present, it often results in a false sense of security for the owner and lead to delays in appropriate professional care.

This directly opposes the welfare benefits and improvements to quality of life, that are at the centre of these guidelines. Additionally, stress or discomfort incurred during this time-consuming cosmetic procedure are wholly avoidable when a reasonable alternative is utilized (appropriate anaesthesia), and indefensible from a medical and ethical standpoint. As such, the World Small Animal Veterinary Association strongly objects to the practice of veterinary dental procedures without appropriate anaesthesia, as it is inadequate and provides a substandard level of care which may be misleading to the pet owner.

Higher Education Welfare Applications

Veterinary dental care is an essential component of a preventive healthcare plan, and yet it is largely ignored in the veterinary educational system. As noted elsewhere in these Guidelines, the university's role in the education and promotion of educational opportunities for not only diagnosis and therapeutic techniques in dentistry, but also oral pain detection and behavioural changes associated with its pathology, must be addressed by veterinary curriculum internationally. Without educational reform and prioritization, welfare and quality of life improvements achievable from increased quantity and quality of dental care will be impeded.

Conclusions

As advocates of humane animal husbandry and veterinary care, the veterinary profession is called to continuously improve in the ways we safeguard the welfare needs of our animal patients. As a profession, we must continue to voice the need for optimal oral health for companion animals, advocate for proper dental care for our patients, and educate our clients on the importance of quality dental care to the daily welfare of their pets. By utilizing the five tenets of animal welfare as our guide, regular dental examination and proper therapy will help to address infection, control pain, relieve suffering and allow return to regular behavior.

Key Points

- Modern animal welfare science looks to veterinarians to advocate for animal health initiatives that minimize pain, stress, suffering, and fear, and allow our patients to express natural behaviours.
- Dental disease is one of the most common medical conditions faced by companion animals, and has significant welfare implications when left undiagnosed and untreated.
- Dental disease can lead to unrelenting pain and chronic infection, create immunological and physiological stress, cause serious local and systemic disease, and prevent natural behavioural expression.
- Behavioural changes due to oral pain can be vague and non-specific, rarely include loss of appetite (despite commonly held beliefs), and need to be discussed and assessed with owners both before and after dental procedures.
- Learning and promoting proper handling techniques for our dental patients pre-, during, and post-therapy is important for maintaining the human-animal bond and minimizing pain and psychological suffering
- The WSAVA Dental Guidelines Committee feels strongly that practicing Anaesthesia Free Dentistry (performing dental procedures without appropriate anaesthesia or analgesia) is inadequate, and provides a substandard level of care that may lead to significant welfare and quality of life issues.
- Veterinarians need to change the way they discuss dental disease and improve our advocacy for our patients, in order to help our clients understand the welfare issues of pain, infection, and disease risk their companion animals face with inadequate dental care.

SECTION 3: ANAESTHESIA AND PAIN MANAGEMENT

INTRODUCTION

The vast majority of dogs and cats have some form of dental and/or oral disease (Lund *et al.* 1999). These disorders often create significant pain and inflammation with an ultimate impact on quality of life (QoL), nutritional status and patient welfare. However, outward clinical signs of distress are not always noted, and thus most pets suffer unnecessarily (Niemiec 2012a) *(see Oral Anatomy and Common Pathology section)*.

The WSAVA Global Pain Council has published extensive guidelines on prevention, assessment and treatment of pain in companion animals. This document can be downloaded at http://www.wsava.org/sites/default/files/jsap_0.pdf (Matthews et al. 2014) and should be used as supplemental reading material to the WSAVA Dental Standardization, WSAVA Nutritional Assessment (Freeman *et al.* 2011), and WSAVA Welfare (Ryan *et al* 2019) guidelines.

Oral and maxillofacial disorders require general anaesthesia for appropriate clinical and radiographic examination and treatment. Professional oral care, including dental cleanings, is generally associated with mild pain. More invasive dental procedures, such as advanced periodontal therapy, tooth extractions, root canal therapy, and oral surgeries such as mandibulectomy/maxillectomy and jaw fracture repair, are typically associated with moderate to severe pain. Proper anaesthesia and effective analgesia play a crucial role in dentistry.

This section provides recommendations and suggests the *best practices* in anaesthesia and pain management for canine and feline patients with oral/dental diseases. Some review articles have been published elsewhere with additional information on the subject (Woodward 2008b, Beckman 2013, de Vries and Putter, 2015).

Position on “Anaesthesia Free Dentistry”

Anaesthesia free dentistry has been advocated by some lay people and veterinarians for routine preventive dentistry. The *American College of Veterinary Anesthesia and Analgesia* has published a position statement on this issue (http://acvaa.org/docs/Anesthesia_Free_Dentistry.pdf) which is aligned with the standards of the *American Animal Hospital Association* (AAHA), the *European Veterinary Dental Society* (EVDS) and the *American Veterinary Dental College* (AVDC). In addition, the *American Veterinary Medical Association* (AVMA) position statement reported that “when procedures such as periodontal probing, intraoral radiography, dental scaling and dental extractions are justified by the oral examination, they should be performed under anesthesia” (https://www.avma.org/KB/Policies/Pages/AVMA-Position-on-Veterinary-Dentistry.aspx). The *Australian Veterinary Association* published a position statement considering anaesthesia free dentistry as a matter of welfare: “Anaesthesia free dentistry is highly likely to negatively affect the welfare of the animal and have negative psychological and behavioural consequences. It also poses a risk of injury to the operator. It is not possible to perform a professionally thorough and complete dental examination in the fully conscious animal; general anaesthesia is required in dogs and cats” (http://www.ava.com.au/node/85991).

The WSAVA Dental Standardization Committee strongly opposes this practice and reasons are discussed in the welfare and prophylaxis area as well as its own section. From an anaesthesia perspective, some other reasons are discussed below:

- The risks of anaesthesia in healthy or even mildly compromised pets is low especially when performed by trained individuals and avoiding anaesthesia is not a valid concern.
- Sedation is not always safer than general anaesthesia and veterinarians/owners are not always aware of this issue. Some sedatives that are required for chemical restraint are often contraindicated in particular cases. Most importantly, cardiopulmonary monitoring may not be easily achieved during sedation.
- Oral and dental procedures may increase prevalence of aspiration of blood, saliva and debris which can occur in animals under sedation because the airways are not protected.
- General anaesthesia allows airway protection, appropriate ventilation and close monitoring of the cardiorespiratory function. Anaesthetic protocols can be adjusted on a case-by-case basis.
- Analgesia is usually not provided in anaesthesia free dentistry.
- The goal is to provide great quality of care for animals and clients. We can do better as a profession and anaesthesia free dentistry is not part of this concept.
- General anaesthesia is required for complete diagnosis and treatment of dental disease (Wallis et al. 2018).

Patient Preparation and Assessment

Adequate handling and restraint will minimize stress and facilitate sedation. Most defensive or aggressive behaviour is associated with fear and anxiety. Difficult animals should be handled with patience and gentle touch. It may be of benefit to allow cats to stay in their carrier during the preoperative period. The *American Association of Feline Practitioners* (AAFP) and the *International Society of Feline Medicine* (ISFM) have published guidelines on cat-friendly handling practices (http://icatcare.org/sites/default/files/PDF/ffhg-english.pdf) (Rodan *et al.* 2011). "Scruffing" is a controversial method of restraint and has been abandoned by many clinics.

Good anaesthetic management starts with good planning. A proper pre-anaesthetic examination assesses the suitability of a patient for anaesthesia and provides an appreciation of risk factors. It will help in the prevention of complications and determine equipment/material requirements. The *Association of Veterinary Anaesthetists* has published a checklist for preparation of anaesthesia (http://www.ava.eu.com/information/checklists). This includes patient identification, history, signalment, identification of concomitant diseases and medications, physical examination, risks associated with surgical procedures, fasting, risk assessment (Table 2) and equipment/material set-up/check-up. In general, the risk of anaesthetic-related death in dogs and cats varies between 0.05 and 0.3%. (Brodbelt *et al.* 2007, Brodbelt *et al.* 2008, Matthews *et al.* 2017). Morbidity and mortality are greater in patients with poor anaesthetic risk assessment (ASA ≥ III) demonstrating the importance of pre-anaesthetic assessment and health status classification. If possible, canine and feline individuals with co-existing disease should be stabilized before general anaesthesia with the administration of fluids and correction of electrolyte and acid-base disturbances.

Serum chemistry and haematology, and additional imaging examination are recommended when abnormalities are identified from the history and physical examination and in patients with coexisting diseases. This may also represent a unique chance for the patient to get a "work-up" and a closer investigation into its general health. However, results of a serum chemistry and haematology will rarely impact anaesthetic protocols and blood sampling can be a significant source of stress for some patients (Alef *et al.* 2008).

Mouth Gags in Cats

Mouth gags have been reported as a risk factor during anaesthesia in cats and as a cause of temporary and permanent post-anaesthetic blindness following oral procedures (Stiles *et al.* 2012; de Miguel Garcia *et al.* 2013). Mouth gags apply a continuous force against the teeth of the maxilla and mandible which may compress the maxillary artery which provides blood flow/oxygenation to the retina and brain in cats. Excessive opening of the mouth narrows the distance between the medial aspect of the angular process of the mandible and the rostrolateral border of the tympanic bulla; the maxillary artery courses between these two osseous structures (Barton-Lamb *et al.* 2013; Martin-Flores *et al.* 2014; Scrivani *et al.* 2014). This is particularly true with spring-loaded mouth gags; therefore, these should not be used. Alternative methods such as properly sized plastic gags (e.g. cut syringe barrels) may be considered, however their use should be minimized and must be released/removed periodically.

Table 2. ASA Physical Status Classification System (with permission). (ASA House of delegates, 2014)

ASA Classification*	Definition
ASA I	A normal healthy patient
ASA II	A patient with mild systemic disease
ASA III	A patient with severe systemic disease
ASA IV	A patient with severe systemic disease that is a constant threat to life
ASA V	A moribund patient who is not expected to survive without the operation

*Each classification is further subdivided with the inclusion of an "E" to represent an emergency surgery, where delay may affect outcome

Anaesthetic Management

Anaesthetic protocols should be tailored to the patient needs based on individual requirements, risk assessment, co-existing disease and drug availability. The goal of premedication is to produce anxiolysis, pain relief, and muscle relaxation while decreasing anaesthetic requirements and providing smooth anaesthetic induction and recovery. In addition, it can decrease the endocrine stress response to surgery and facilitate intravenous catheterization.

Neuroleptanalgesia is the combination of a sedative/neuroleptic with an opioid and it aims to decrease doses and adverse effects of both classes of drugs while maximizing their beneficial effects. Protocols for sedation and premedication commonly include a combination of an opioid with either acepromazine, dexmedetomidine or a benzodiazepine (e.g. diazepam or midazolam), however the administration of an opioid alone, or in combination with a benzodiazepine is often used in ASA III or IV patients with co-existing disease. Suggested indications, advantages and disadvantages of drugs used for sedation and premedication are described in Table 3.

Anaesthetic induction can be accomplished via administration of propofol, alfaxalone, thiopental, etomidate or a combination of ketamine/diazepam. Each anaesthetic agent has its own advantages and disadvantages (Table 4) and drugs should be given "to effect" to minimize cardiorespiratory depression.

Volatile anaesthetics (e.g. isoflurane and sevoflurane) are the preferred method for anaesthetic maintenance. However, high concentrations of volatile anaesthetics can produce peripheral vasodilation, reduce myocardial contractility and cardiac output which debilitated patients may not tolerate. Hypotension can be best avoided with reduced anaesthetic concentrations by using balanced anaesthesia; drugs that decrease volatile anaesthetic requirements and provide good hemodynamic stability and analgesia (e.g. opioid infusions or boluses) (Steagall *et al.* 2015, Gutierrez-Blanco *et al.* 2013). This is especially important in cases where geriatric or compromised patients are involved. This population has decreased physiological reserves and anaesthetic drugs commonly produce a significant impact in body systems which could have dramatic consequences. Eyes should be lubricated on at least an hourly basis since tear production is reduced during sedation and general anaesthesia.

Limited Drug Availability

Volatile anaesthesia is not always available and opioids may be under strict regulation and control to veterinarians in many countries.

- Optimal anaesthetic/oral care is still possible with the use of injectable anaesthetic protocols (e.g. xylazine, ketamine and diazepam combinations, and protocols involving tiletamine-zolazepam, etc.).
- General anaesthesia requires endotracheal intubation in the dental patient.
- Ideally, the administration of fluid therapy/oxygen and adequate monitoring of anaesthesia and body temperature should be performed.
- Local anaesthetic blocks are widely available and imperative in perioperative pain management (see Table 5).
- NSAIDs are also readily available and play an important role in controlling postoperative pain and inflammation when other modalities are unavailable.
- Injectable tramadol is available in many countries in South America and Europe and can be an effective alternative if opioids are not available particularly in cats.

Table 3. Drugs used for sedation, premedication and chemical restraint in dogs and cats*

Drug	Dosage regimens**	Comments
Acepromazine	0.01-0.05 mg/kg IM, IV, SC	Mild sedation in cats Higher doses will not necessarily increase magnitude of effects; however duration of action may be increased
Diazepam†	0.2-0.5 mg/kg IV	Poor absorption after IM administration. Commonly used in combination with ketamine or propofol for anaesthetic induction
Midazolam†	0.2-0.5 mg/kg IM or IV	Commonly used in combination with ketamine or propofol for anaesthetic induction
Xylazine	0.2-0.5 mg/kg IM, IV	Sedation when (dex) medetomidine not available Vomiting and nausea are commonly produced
Dexmedetomidine	1-10 µg/kg IM, IV 10-20 µg/kg (OTM) (cats)	Lower doses are used for sedation and neuroleptanalgesia while high doses are administered for anaesthesia in combination with ketamine and opioid ("doggy" or "kitty magic") when volatile anaesthesia is not available Higher doses may be required for chemical restraint of feral dogs and cats
Medetomidine	6-20 µg/kg IM, IV	See dexmedetomidine Half-potency of dexmedetomidine (doses are doubled) Buccal administration produces excessive salivation in cats
Ketamine	3-10 mg/kg IM or PO	Ketamine may be exceptionally used for sedation/chemical restraint in cats when combined with midazolam and an opioid Oral administration is an option feral cats
Alfaxalone	0.5-1 mg/kg IM	Alfaxalone may be exceptionally used for sedation in cats when combined with midazolam and an opioid

*Lower doses should be given when the intravenous route is chosen
**Use in dentistry
†Paradoxal sedation is commonly observed after the administration of benzodiazepines in young, healthy patients

Table 4. Drugs used for anaesthetic induction and injectable anaesthesia†		
Drug	**Dosage regimens**	**Comments**
Alfaxalone*	0.5-3 mg/kg IV Up to 3-5 mg/kg (unpremedicated patients) IV	Doses are given to effect Cardiorespiratory depression can be observed Recoveries can be agitated (see drug's label)
Propofol*	0.5-4 mg/kg IV	Higher doses (6-8 mg/kg) may be required in cats Caution in hypovolemia and patients with cardiopulmonary disease Some formulations have preservatives which promote long shelf-life Anaesthetic choice in nephropathies and hepatopathies
Ketamine*	2-5 mg/kg (induction) IV 2-20 µg/kg/min (infusion in balanced anaesthesia) IV	Commonly used in combination with diazepam or midazolam for anaesthetic induction Should never be administered alone Anti-hyperalgesic effects via N-methyl D-aspartate (NMDA) receptor antagonism Good cardiopulmonary stability Potentially difficult anaesthesia recoveries
Thiopental*	2.5-5 mg/kg IV	Used when other agents are not available Cardiopulmonary depression Drug accumulation (e.g. hypothermia, hepatopathy, nephropathy) may lead to prolonged anaesthesia recovery Strictly given IV (otherwise risk of phlebitis and severe skin necrosis)
Tiletamine-zolazepam*	1-2 mg/kg IV	Option when volatile anaesthetic is not available Analgesics should be administered for pain control Potential prolonged and rough recoveries Similar pharmacological profile to ketamine

†Specific information on these anaesthetic agents should be found in appropriate text books
*Doses are given to effect. The level of sedation should be assessed before induction of anaesthesia to determine best dosage regimens of each agent. These drugs have all their unique advantages and disadvantages

Table 5. Common local anaesthetics used in veterinary anaesthesia and pain management					
Local anaesthetic*	**Onset (min)**	**Common concentrations (%)**	**Duration of the block (h)**	**Relative potency (lidocaine = 1)**	**Suggested maximum doses (mg/kg)**
Lidocaine	5–15	1, 2	1–2	1	10 (dogs) 5 (cats)
Mepivacaine	5–15	1, 2	1.5–2.5	1	4 (dogs) 2 (cats)
Bupivacaine	10–20	0.25, 0.5, 0.75	4–6	4	4 (dogs) 2 (cats)
Ropivacaine	10–20	0.5, 0.75	3–5	3	3 (dogs) 1.5 (cats)
Levobupivacaine	10–20	0.5, 0.75	4–6	4	2 (dogs) 1 (cats)

*Volumes of injection (0.25 – 1 mL) vary according to the size and patient's anatomy and body weight. Anaesthetic blocks can be repeated according to the duration of procedure, interest of postoperative analgesia and using less than maximum recommended doses (see text)

- Dipyrone (metamizole) and paracetamol (acetaminophen) are widely used as analgesics in some countries. They can be used as part of multimodal analgesia, however knowledge on these drugs as analgesics as well as their adverse effects are not well known in companion animals. Paracetamol should not be administered to cats.
- Table 6 provides suggested anaesthetic and analgesic protocols for the dental patient considering different drug availabilities.

Intubation

Endotracheal intubation is mandatory for dental procedures even if there is limited availability of drugs and lack of volatile anaesthesia.

- Cuffed endotracheal tubes are used for intubation, provide airway protection and means of assisted ventilation. This is particularly important in oral procedures due to the increased risk of aspiration of contents.
- Oropharyngeal packing is recommended (see section on prophylaxis).
- Endotracheal intubation is required during general anaesthesia and veterinarians should avoid cuff overinflation, particularly in cats, since it may cause tracheal damage/necrosis especially during patient movement (Mitchell *et al*. 2000).
- Patients should be always disconnected from the breathing circuit when turned from one side to the other.

Fluid Therapy

Venous access should be established in all patients as part of best quality care, ideally using an intravenous catheter. It allows the administration of fluids, emergency drugs, antibiotics, analgesics and anaesthetics during the perioperative period. The 2013 AAHA/AAFP fluid therapy guidelines provide comprehensive information on this subject in dogs and cats (Davis *et al*. 2013b).

Table 6. Perioperative pain control in dogs and cats undergoing treatment of oral disease: examples of protocols with different drug availability

Treatment of oral disease will often involve pain and inflammation. An analgesic plan should be in place during the perioperative period and for several days to a week after hospital discharge. Please see Tables 3, 4 and 5 for specific doses. In all cases, ***local anaesthetic techniques*** including the infraorbital, inferior alveolar mandibular, maxillary, palatine, mental nerve blocks should be used according to the areas of interest.	
Suggested protocol without limited drug availability	***Premedication:*** the combination of acepromazine, an agonist of alpha-2 adrenergic receptor (i.e. dexmedetomidine, xylazine, medetomidine) OR a benzodiazepine (i.e. midazolam) with an opioid. The choice of opioid (i.e. hydromorphone, methadone, morphine, butorphanol or buprenorphine) will be based on the severity of pain ***Induction of anaesthesia***: propofol (3-5 mg/kg), ketamine (5 mg/kg) + diazepam or midazolam (0.25 mg/kg), OR alfaxalone (2-5 mg/kg) IV to effect ***Maintenance of anaesthesia***: inhalation anesthesia with isoflurane or sevoflurane ***Post-operative analgesia***: NSAID. These drugs should be administered for several days depending on the label and species. Doses of opioid may be repeated depending on the severity of pain
Suggested protocol without controlled drugs	***Premedication:*** the combination of acepromazine OR an agonist of alpha-2 adrenergic receptor (i.e. dexmedetomidine, xylazine, medetomidine) and injectable tramadol. If the injectable formulation is not available, tramadol can be given orally ***Induction of anaesthesia***: propofol (3-10 mg/kg), alfaxalone (2-5 mg/kg) or tiletamine/zolazepam (1-2 mg/kg) IV to effect. Induction of anesthesia can be performed by the intramuscular route of administration when tiletamine/zolazepam is administered as premedication ***Maintenance of anaesthesia***: inhalation anesthesia with halothane, isoflurane or sevoflurane. Propofol or alfaxalone IV to effect. Tiletamine/Zolazepam ***Post-operative analgesia***: NSAIDs. These drugs should be administered for several days depending on the label and species. Metamizol (dipyrone; 25 mg/kg IV every 12 hours) OR acetaminophen (paracetamol; 12.5 mg/kg PO every 12 h) can be administered in **dogs but not in cats.** These two drugs can be administered in combination with NSAID for better post-operative analgesia when opioids are not available.
Suggested protocol with limited availability of analgesic drugs	***Premedication:*** Xylazine ***Induction and maintenance of anaesthesia***: pentobarbital (2-5 mg/kg), thiopental (2-8 mg/kg), propofol (3-5 mg/kg) to effect IV. Tiletamine/Zolazepam IV or IM ***Post-operative analgesia***: same as *suggested protocol without controlled drugs*

- Fluid therapy compensates for ongoing losses, prevents and treats dehydration and hypovolemia, and provides a source of electrolytes.
- Most anaesthetic drugs will cause some level of cardiovascular depression and the administration of balanced crystalloid solution will optimize hydration status and tissue perfusion during anaesthesia.
- The choice will be based on patient's needs and requirements. In general, it is accepted that lower (2-3 mL/kg/hour) than surgical crystalloid rates (5 mL/kg/hour) are used in anaesthetised patients undergoing oral surgery since there is less insensible fluid loss.
- Fluid overload is a risk in dogs and cats especially considering that these procedures could be long in duration. Higher fluid rates may be administered, if deemed necessary and in cases of hypovolemia without concomitant cardiac disease.
- Patients with advanced renal disease may benefit from preoperative fluid administration to establish proper hydration.

Monitoring

Anaesthetic monitoring is significantly correlated with decreased morbidity and mortality. Veterinarians should not blame "anaesthesia" itself for accidental deaths in the perioperative period since most anaesthetic deaths occur when dogs and cats are not being closely monitored or often due to human errors. Simple peripheral pulse palpation and pulse oximetry can significantly decrease risk of anaesthetic-related death by 80% in cats (Brodbelt *et al.* 2007). The American College of Veterinary Anaesthesia and Analgesia has provided recommendations for monitoring veterinary patients under procedural sedation or anaesthesia (www.acvaa.org ; see "Small Animal Monitoring Guidelines").

- Pulse oximetry can be a challenge to monitor during anaesthesia for oral procedures since the probe can be easily displaced, however it can be placed over the ears and paws.
- Mean blood pressure monitoring should be maintained above 70 mmHg for appropriate tissue perfusion. This is particularly important in dogs and cats with chronic kidney disease. Doppler ultrasound can be used to measure systolic blood pressure. In cats, blood pressure monitoring with the Doppler is closely related to mean arterial blood pressure.
- Respiration should be ideally monitored using a capnograph since monitoring of respiratory rate does not provide information of the "quality of the respiratory function" (amplitude, gas exchange, metabolism, disconnection from anaesthetic breathing system, etc.).
- Body temperature should be maintained between 37 and 38°C (98.6 - 100.4°F). It should be monitored in all circumstances (Stepaniuk & Brock 2008). Prevention of hypothermia can be accomplished by avoiding contact with cold surfaces, the use of heating pads, active heating devices and blankets, and working in a warm environment. Bubble plastic wrap around the extremities can be also used for prevention of hypothermia. This material is cheap and available worldwide.

Equipment

Anaesthetic equipment including anaesthetic machine, breathing systems and endotracheal tubes should be tested before general anaesthesia. They should be clean, in good working condition and undergo routine maintenance.

Dogs and cats at high risk of anaesthetic-related death (i.e. ASA III or higher) ideally should be referred to a veterinarian with advanced training in veterinary anaesthesia where available (e.g. some countries have board-certified veterinarians who underwent strict training by the American or European College of Veterinary Anaesthesia and Analgesia).

PAIN MANAGEMENT

General Considerations

Pain management is not only important from the ethical and welfare points of view but also as a therapeutic strategy to re-establish organ function, accelerate hospital discharge and minimize financial costs (Simon *et al.* 2017). The International Association for the Study of Pain (IASP) has published a curriculum outline on pain for human dentistry based on entry level (http://www.iasp-pain.org/Education/CurriculumDetail.aspx?ItemNumber=763). A similar outline could be adapted and applied in veterinary medicine for teaching veterinary students. In veterinary dentistry, clinicians should apply validated methods of pain assessment and treat orofacial pain based on available literature and scientific evidence, when appropriate. Principles of pain management for oral and maxillofacial disorders are presented below:

- Pain is considered to be the 4th vital assessment and its assessment and treatment should be part of every patient's "work-up". An analgesic plan should be in place during the perioperative period and for several days to a week after hospital discharge.
- Analgesic protocols should be created on a case-by-case basis and dosage regimens adjusted accordingly. Dental patients present with various levels of pain and a safe and effective approach can be challenging.
- Pain management is always best addressed using a preventive and multimodal analgesic approach and may be even more important in patients with oral disease as they often do not show obvious signs of pain (Box 1).
- The "basic" analgesic protocol includes the administration of opioids, local anaesthetic blocks and nonsteroidal anti-inflammatory (NSAIDs) drugs unless contra-indicated (see Mathews *et al.* 2014 for drugs, doses and indications).
- The pros and cons of each class of analgesic should be taken in consideration.
- The administration of adjuvant analgesics is recommended in cases of moderate and severe pain, and for patient discharge. Hospitalization is recommended for invasive surgical procedures where patient requires frequent assessment and treatment with opioid and ketamine infusions, for example.

Pain Assessment

Pain assessment in dogs and cats represent a challenge for the veterinarian since specific instruments/tools for the evaluation of pain in patients with oral disease have not been published. An instrument is currently under investigation and it is generally accepted that these animals have pain in most cases especially those where a chronic infection or trauma exists. (Della Rocca *et al.* 2019). Oral disease and associated pain is a welfare issue since it impacts quality of life and nutritional status (Box 2). Dental extractions as well as most other dental therapies are clearly associated with pain (Steagall & Monteiro 2019).

In general, pain associated with oral disease may create specific and/or nonspecific clinical signs which will improve after oral treatment. Signs of dental pain include ptyalism, halitosis, decreased appetite, rubbing or pawing the face, changes in demeanour and reluctance to play with toys. Pain recognition and assessment can be performed using the Glasgow pain scoring tools for dogs (Reid *et al.* 2007) and cats (Reid *et al.* 2017). These instruments have not been specifically validated for patients with oral disease but they provide an idea of the "overall" picture and can be used for any medical/surgical condition. The Feline Grimace Scale has good to excellent inter-reliability for cats undergoing dental extractions and can be used for pain recognition (Watanabe *et al.* 2020). This is a valid, reliable and simple tool for pain assessment in cats.

Perioperative Pain Control

Opioids are the first line of treatment in acute pain management and they have been reviewed in detail elsewhere. (Simon & Steagall 2016, Bortolami & Love 2015).

BOX 1 :
Preventive analgesia describes all types of perioperative interventions and efforts to address and minimize postoperative pain. Administration of analgesics is performed at any time and for varying duration in the perioperative period to prevent allodynia and central sensitization. *Multimodal analgesia* is the administration of two or more analgesic drugs with different mechanisms of action. These drug combinations should present substantial synergism which allows the use of lower doses of each class of analgesics with minimal adverse effects.

BOX 2 :
For example, it is not uncommon to observe increased body weight and activity, and better sleeping patterns/quality of life after treatment of oral disease. Some animals become friendlier after the procedure than before indicating a potential emotional and affective component of pain and inflammation. Analgesic management reduces pain and suffering and has a welfare benefit (see section of welfare).

- They produce varying levels of sedation (depending on the drug and patient's health status), reduce anaesthetic requirements in a dose-dependent manner (dogs) and have the benefit of reversibility.
- Different opioids have variable effects based on their receptor affinity, efficacy, potency and individual responses.
- This discussion is beyond the scope of the guidelines, however most full opioid agonists (e.g. morphine, hydromorphone, methadone, fentanyl, remifentanil) will provide dose-dependent analgesia, increase vagal tone inducing bradycardia without changes in systemic vascular resistance or myocardial contractility, offering hemodynamic stability.
- Buprenorphine is a partial agonist of μ-opioid receptors and its use has been reviewed in cats (Steagall *et al.* 2014). Both buprenorphine and methadone can be administered via the buccal route and provide significant analgesic effects in this species. This is of interest in dental patients, however there might be liability issues of prescribing these medications to be administered by owners. In a recent study, cats with gingivostomatitis showed lower bioavailability and shorter absorption half-life after buccal administration of buprenorphine when compared with healthy cats. However, buprenorphine produced an analgesic effect in these patients and inflammation seemed to affect absorption but not the overall analgesic efficacy of the drug (Stathopoulou et al. 2018).

Most oral and maxillofacial disorders and therapies involve inflammation and tissue damage/trauma. The administration of NSAIDs is strongly recommended in these cases and veterinarians should be aware of their approved dosage regimens in their countries.

- Unless contraindicated, NSAID therapy is commonly administered for approximately 3-7 days depending on type of oral disease/procedure.
- NSAIDs may also be administered to cats for several days (Monteiro *et al.* 2019). This may be particularly important after significant oral surgery, such as full-mouth extractions due to feline chronic gingivostomatitis. Some NSAIDs are licensed for daily long-term administration in cats in Europe and they could be an option for these patients.
- Maxillofacial trauma, and invasive and complex procedures (e.g. maxillectomy and mandibulectomy) can produce excruciating pain; they are commonly addressed with balanced anaesthesia/multimodal analgesia (systemic administration of analgesic infusions such as opioids, lidocaine and ketamine) during early postoperative period (24-48 hours) in combination with NSAIDs (Watanabe *et al.* 2019).
- Analgesic infusions are important especially when oral administration of analgesics is not an option due to severe trauma or trismus (masticatory muscle myositis), among others.
- Analgesic prescription for "take-home" is an important part of pain management.
- NSAIDs are ideally combined with oral adjuvant analgesics such as tramadol, amitriptyline, gabapentin and/or amantadine.

Local Anaesthetic Techniques of the Oral Cavity

Local anaesthetic drugs produce a reversible block of sodium and potassium channels and transmission of nociceptive input. Local anaesthetic techniques provide perioperative (and immediate postoperative) analgesia and reduce volatile anaesthetic requirements in a cost-effective manner (Gross *et al.* 1997; Gross 2000; Snyder & Snyder 2013; Aguiar *et al.* 2015). Further, they blunt the initial surgical trauma, decreasing recovery times. These blocks require minimal training and can be used for a variety of dental procedures including extractions or surgery of the oral cavity such as maxillectomy, mandibulectomy, among others. Some considerations are presented below:

- Unfortunately, local anaesthetic techniques are not widely employed in veterinary medicine due to the lack of familiarity with use. The WSAVA Dental Standardization committee strongly supports the use of these techniques in perioperative pain control especially in scenarios with limited analgesic availability.
- These drugs are readily available and should be incorporated in the anaesthetic management of patients with oral and maxillofacial disorders.
- It is important to note that techniques used in dogs cannot be directly extrapolated to cats due to anatomical differences between species.
- Descriptions and diagrams depicting various loco-regional anaesthetic techniques have been described in the WSAVA Guidelines on the recognition, assessment and management of pain (Mathews et al. 2014). These techniques can be watched on the YouTube channel of the Faculty of Veterinary Medicine, Université de Montréal (links are provided below) (Steagall *et al.* 2017).

Materials

Loco-regional anaesthetic techniques of the oral cavity require simple and low-cost materials such as disposable 1 mL syringes, 25-mm to 30-mm 27-G or 25-G needles. Larger needles should be avoided as they may cause nerve and vascular damage while smaller needles may produce excessive pressure at injection and result in local tissue damage.

Drugs

Table 5 shows common doses and concentrations of local anaesthetics. Levobupivacaine or bupivacaine may be preferred over lidocaine for local anaesthetic techniques of the oral cavity due to their prolonged duration of action. However, self-mutilation has been anecdotally reported if the oral cavity and particularly the tongue are still anaesthetised hours after the end of procedure/after extubation. Anaesthesia of the lingual and mylohyoid nerves may occur during a mandibular nerve block and result in desensitization of the rostral two-thirds of the tongue. The idea is to have excellent intraoperative and early postoperative analgesia with local anaesthetics and opioids whereas postoperative pain relief is achieved with the administration of opioids, NSAIDs and adjuvant analgesics. Some veterinarians combine opioids such as buprenorphine (0.003-0.005 mg/kg) with local anaesthetics for blocks of the oral cavity. In humans, the administration of buprenorphine enhances and prolongs the effects of bupivacaine after minor oral surgery (Modi *et al.* 2009). In dogs, bupivacaine alone or in combination with buprenorphine reduced isoflurane requirements by approximately 20%. The addition of buprenorphine did not extend the duration of nerve blockade but it produced long-term isoflurane-sparing effect in some individuals (Snyder *et al.* 2016b).

Mixing local anaesthetics

Historically, lidocaine 2% and bupivacaine 0.5% have been mixed together to decrease the onset of action of bupivacaine while increasing the duration of action of lidocaine. However, these drugs have different pKa, % protein binding and there is little evidence that this combination is better than bupivacaine alone. The results may be unpredictable and the duration of action actually decreased (Shama *et al.* 2002). However, the mixture lidocaine-bupivacaine should provide longer duration of action if compared with lidocaine alone (Pascoe 2016).

Volumes

A small amount of local anaesthetic is required for these techniques. In general, volumes vary between 0.1- 0.2 mL in cats to 0.2 to 1 mL in dogs of lidocaine or bupivacaine as long as toxic doses are calculated taking account all dental blocks required (see below). The oral cavity is widely innervated by branches of multiple cranial nerves and it is not uncommon that a block will fail (Krug & Losey 2011). Veterinarians should use a combination of techniques which can be repeated if toxic doses (see complications below) are respected, however other analgesic techniques should always be considered. Intraosseous or intraligamentary anaesthesia might be an option when other techniques have failed, however these blocks produce intrinsic pain at injection.

Avoiding Complications

There are some important considerations before the administration of any local anaesthetic block to avoid complications:

- Calculation of toxic doses - Local anaesthetic toxicity may occur when dosage regimens and intervals of administration are not properly calculated (Table 5).
- In dogs and cats, it is well accepted that doses higher than 10 mg/kg (dogs) and 5 mg/kg (cats) of lidocaine, and 2 mg/kg of bupivacaine (both species) might induce clinical signs of toxicity such as seizures, cardiorespiratory depression, coma and death (Chadwick 1985; Feldman *et al.* 1989; Feldman *et al.* 1991; Woodward 2008b).
- The administration of lidocaine spray for endotracheal intubation in cats should be taken in consideration for dose calculations.
- Negative aspiration of blood - Veterinarians should always check for negative aspiration of blood to avoid accidental intravenous administration before drug administration especially when administering bupivacaine due to its cardiotoxic profile (Aprea *et al.* 2011). If bupivacaine is administered intravenously, dysrhythmias such as ventricular premature contractions may be observed.
- Intravenous administration is a not an issue with lidocaine, however block may not be effective and hematoma/bleeding may occur (Loughran *et al.* 2016). Hematoma is best avoided using digital pressure after the administration of the local anaesthetic for 30-60 seconds.
- Resistance to injection – A local block should not be performed if resistance to injection is encountered since this could indicate nerve needle penetration and risk of nerve damage. The needle should be withdrawn or readjusted in this case.

Complications after local anaesthetic blocks of the oral cavity are rare but have been reported and include globe penetration most often requiring enucleation (Perry *et al.* 2015). Orbital penetration may also be caused by dental extractions and therefore may not be associated with the administration of anaesthetics (Smith *et al.* 2003; Guerreiro *et al.* 2014). Veterinarians should not be afraid to use these techniques; however, they should be used with caution utilizing appropriate landmarks. Local blocks should be avoided in the presence of abscesses or neoplasia due to the risk of dissemination of infection or neoplastic cells, respectively.

Inflammation and Failure of Local Anaesthetic Blocks

Local anaesthetics have a pKa between 7.5 and 9 and are formulated as acid solutions of hydrochloride salts (pH 3.5 – 5.0). This formulation gives a net prevalence of the ionized form and is thus water soluble. When a local anaesthetic solution is injected into body tissues with a physiological pH (7.4), the non-ionized lipid-soluble form will prevail. This is critical for the drug effect since the non-ionized form crosses biological membranes. In inflamed tissues, the ionized form prevails, explaining why local anaesthetics may be ineffective under such conditions (acidic pH and inflammation). Administration of a local anaesthetic block should be performed in non-inflamed areas to improve efficacy. For example, an inferior alveolar nerve block should produce anaesthesia of distal inflamed teeth because the block is performed proximally (distant) to the area of inflammation.

Specific techniques

1. Inferior alveolar nerve block (https://www.youtube.com/watch?v=2q8ndh5Bn6U)
   Anaesthesia of sensory and motor innervations of the mandible including teeth, lower lip, part of the tongue, hard and soft tissues. This foramen may be difficult to palpate in cats but the block can still be performed successfully. Cats do not have the concavity of the ventral margin of the body of the mandible which can be easily located in dogs.
2. Palatine nerve block (https://www.youtube.com/watch?v=-xsDqqGRrjI)
   Anaesthesia of palatine nerves and palate.
3. Infraorbital nerve block (https://www.youtube.com/watch?v=H3L1LHBcM-g)
   Anaesthesia of the skin and soft tissues inside the oral cavity, maxillary canine teeth, dorsal part of nasal cavity, maxillary bone rostral to the infraorbital foramen and incisive teeth. This block does not always anesthetize the maxillary fourth premolar, first or second molar teeth on the treatment side (Pascoe 2016). Instead, a maxillary nerve block should be considered in dogs and cats for extraction of these teeth.
   Caution must be taken with this block, as the infraorbital foramen is located just ventral to the orbit. A bony ridge can be easily palpated in cats. The infraorbital canal is much shorter in cats and brachycephalic dogs than in meso- and dolichocephalic dogs. It is only a few millimetres in length. To avoid eye penetration, the needle should be introduced ventrally and advanced only approximately 2 mm.
4. Middle mental nerve block (https://www.youtube.com/watch?v=r9j06VVGvMw)
   Anaesthesia of the rostral lower lip and mandible, including the ipsilateral incisor teeth. In cats and small breed dogs, the foramen is small and it should not be penetrated to avoid nerve damage.
5. Maxillary nerve block (https://www.youtube.com/watch?v=1AYNmsyzCv0)
   Anaesthesia of the ipsilateral maxilla, teeth, palate, and the skin of the nose, cheek and upper lip. Another approach for the maxillary nerve has been described. Using an infraorbital approach, the tip of a catheter (without stylet) is advanced until the point where imaginary lines parallel to the infraorbital canal and its perpendicular drawn to the lateral canthus transect (Viscasillas et al. 2013). The upper lip is elevated and the infraorbital foramen is located (approximately dorsal to the third premolar tooth). The catheter is introduced approximately 2-4 mm into the foramen and the size of the catheter is selected by veterinarian in advance.

Key Points:

- Oral and maxillofacial disorders require general anaesthesia for appropriate treatment. Therefore, anaesthesia and pain management are crucial areas of veterinary dentistry.
- "Anaesthesia free dentistry" is not only unacceptable from the welfare standard point of view but it also poses a risk to the operator, and it is inadequate in terms of prophylaxis and treatment of oral disease.
- Appropriate anaesthetic management includes planning, and patient preparation/assessment based on individual requirements, risks, co-existing disease, equipment and drug availability.
- Anaesthetic/analgesic protocols are tailored to the individual and disease.
- Endotracheal intubation, anaesthetic monitoring and administration of fluids are part of best practices in anaesthesia, as they help prevent complications.
- Pain is the 4th vital assessment and its assessment and treatment should be part of every patient's "work-up".
- An analgesic plan including a multimodal approach should be in place during the perioperative period and for several days to a week after hospital discharge.
- Local anaesthetic techniques of the oral cavity (dental blocks) must be part of each dental treatment protocol.

SECTION 4: ORAL EXAMINATION AND RECORDING

An accurate oral diagnosis is based on the results of the case history, clinical examination and charting, dental radiography and laboratory tests if indicated. The examination must be performed in a systematic way to avoid missing important details. All findings should be recorded in the medical record.

EXAMINATION OF CONSCIOUS PATIENT

Some parts of the examination can be performed on a conscious patient during the first consultation. The results provide an overview of the level of disease and allows for the formulation of the preliminary treatment plan. This should be thoroughly discussed with the owner, including the fact that this is only an initial plan and further therapy is often necessary based on the examination and radiographs obtained under anaesthesia (Wallis C et al 2018).

Oral/Dental Examination

The examination starts with a thorough history, including symptoms which may indicate dental disorders such as: halitosis, change in eating habits, ptyalism, and head shaking. The clinical investigation begins with the inspection of the head by evaluating the eyes, symmetry of the head, swellings, lymph nodes, nose and lips. Next, the occlusion and the functionality of the temporomandibular joint (TMJ) should be evaluated. The dental examination includes noting the stage of dentition (primary/permanent), as well as any missing, fractured, or discoloured teeth. The examination of the soft tissues of the oral cavity includes oral mucosa, gingiva, palate, dorsal and ventral aspect of the tongue, tonsils, salivary glands and ducts. The examiner should evaluate the oral soft tissues for masses, swelling, ulcerations, bleeding and inflammation. The conscious periodontal examination should focus on gingival inflammation, calculus deposits and gingival recession. Furthermore, a periodontal diagnostic test strip for measurement of dissolved thiol levels can be a very useful examination room indicator for gingival health and periodontal status (Manfra *et al.*, 2012). This product has been shown to improve client compliance with dental recommendations.

Oral Health Index (OHI)

The first step in every case is the collection of a minimum clinical database. The Oral Health Index (OHI) (Gawor *et al.*, 2006) is a useful tool created from a basic examination on a conscious patient and gives a good overall clinical impression. The examination includes not only the oral cavity and adjacent regions, but also life style and nutrition. The examined criteria are: lymph nodes, dental deposits, periodontal status, nutrition and oral care (professional and homecare). Each criterion is scored with respect to the clinical findings and a total score is then determined. The result helps in decision making and determining whether further examination and/or treatment is indicated **(Table 7)**.

Occlusion

According to the nomenclature committee of the American Veterinary Dental College (AVDC Nomenclature Committee 2019), the ideal occlusion is described as "...perfect interdigitation of the maxillary and mandibular teeth. In the dog, the ideal tooth positions in the arches are defined by the occlusal, inter-arch, and interdental relationships of the teeth of the archetypal dog (i.e. wolf)" (Full information can be found here: www.avdc.org/nomenclature). Abnormalities are defined as either a skeletal malocclusion or malposition of single (See section on malocclusions).

Table 7.

Clinic	**DogBeachDoctor**		
Address	Bay ve 123		
ZIP, City	San Diego		
Phone	0123 456 78 90		
ORAL HEALTH INDEX (OHI)			
Date:	16-05-2017		
Owner:	Jane Doe		
Pet's name:	Donald		
Lymph knodes			
	normal	0	0
	palpable	1	
	enlarged	2	
Dental deposits			
	none	0	
	less than 25% of crown	1	1
	less than 50% of crown	2	
	more than 50% of crown	3	
Inflammation status			
	no inflammation	0	0
	Gingivitis	1	
	Periodontitis	3	
	Stomatitis	3	
Diet			
	dry	0	
	dry and soft	1	
	soft	2	2
Home care			
	Daily active oral care	0	
	Passive ad/or seldom active	1	
	None	2	2
Scorend Points			**5**
Results:			
0-3 points	prophylactic recomendations		
4-7 points	radical change required, surgery likely		
8-12 points	immediate surgery required		

Checklist for dental occlusion (Gorrel 2004):

1. Head symmetry
2. Incisor relationship
3. Canine occlusion
4. Premolar alignment
5. Caudal premolar/molar occlusion
6. Individual teeth positioning

EXAMINATION UNDER GENERAL ANAESTHESIA

A thorough examination can only be performed under general anaesthesia. Pre-anaesthetic workup and anaesthesia are described in Section 3 (Anaesthesia). Following induction of anaesthesia, ET tube placement, cuff inflation and securing of the ET tube, and stabilising the patient, the examination should be performed in a detailed and systematic way with the charting performed simultaneously. After the visual inspection of the entire oral cavity, the tactile examination is performed in two steps utilizing the appropriate instruments. First, the teeth themselves are examined for defects such as tooth wear, resorption, caries, pulp exposure, and enamel disease with a dental explorer. Following this, pocket sulcus/pocket and furcation exposure are evaluated with a periodontal probe. It is crucial to know the anatomy of the involved structures to create a proper diagnosis (See Oral and Dental Anatomy and Physiology section). It is very helpful to work four-handed with one person examining and the other recording what is reported (Huffman 2010).

Examination Step-by-Step:

1. **Inspect the oropharynx**: it is advisable to make a quick inspection of the oropharynx and tonsils in the fauces before endotracheal intubation and placing a throat pack **(Figure 107)**.

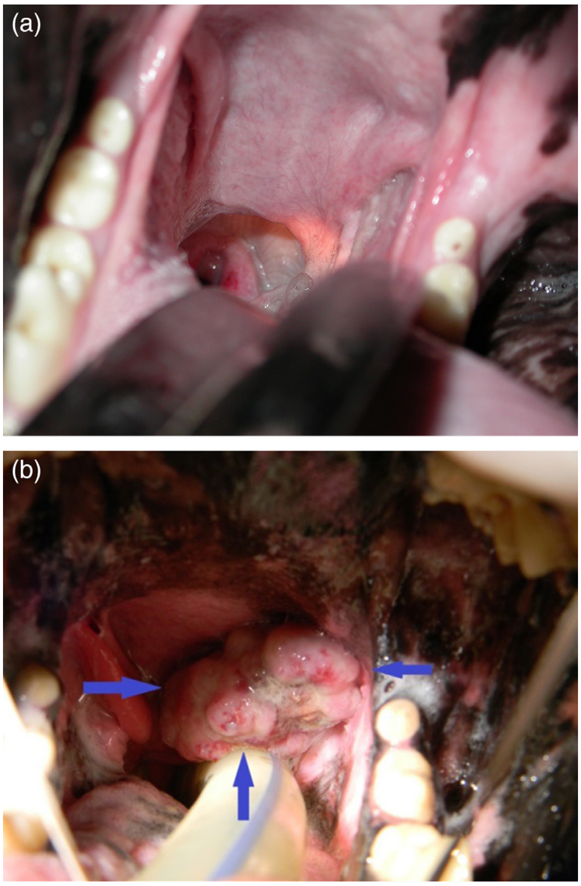

Figure 107. a) evaluation of a normal caudal oral cavity and oropharynx during intubation. b) large neoplastic mass on the left side of the caudal oropharynx (blue arrows).

2. **Take preoperative photographs**: preoperative photographs should be taken before any procedure. It is recommended to take one of each side and one from the rostral aspect. The photographs serve as proof of pre-operative dental condition as well as provide visual evidence to the owner. It is recommended to use a lip retractor or dental mirror to better visualize the entire dentition and surrounding structures **(Figure 108)**.
3. **Decrease the bacterial load:** rinse the oral cavity with 0.12% chlorhexidine oral rinse.
4. **Assess and identify the dentition**: primary, permanent, or mixed.
5. **Assess the soft tissue**: the entire oral cavity and vestibular tissues should be examined, including oral mucous membranes (for colour, moistness, swelling), lips and cheeks, palate, tongue and sublingual tissue for abnormalities and oral masses.
6. **Initial scaling of the teeth**: for better visibility of the tooth surfaces and gingiva an initial cleaning with a dental scaler is recommended.
7. **Intraoperative photograph**: it is advised to take a photograph of any pathology revealed by the scaling **(Figure 109)**.
8. **Dental examination with dental explorer**: each tooth must be examined with a dental explorer, beginning with the first incisor of each quadrant and progressing caudally tooth by tooth to cover the entire arch. **(Figure 110)** A dry tooth surface improves clarity (Baxter 2007) and a dental mirror can be very helpful. A normal tooth surface is smooth; any roughness is an indication of pathology. The entire surface of each tooth should to be explored, especially the area just below the gingival margin to detect resorptive lesions. The examination should note:
   a. **Presence (or absence) of the teeth**: the absence of a tooth can mean hypodontia (congenitally missing teeth), an unerupted (or impacted) tooth, a retained tooth root, or a previously extracted or exfoliated tooth (Niemiec 2010b). Occasionally, a

Figure 108. Pre-operatve picture of the right side of a canine patient demonstrating the level of disease present prior to cleaning. Note the mild to moderate dental calculus and gingivitis throughout, however there is gingival recession and slight purulent exudate between the fourth premolar and first molar (108 & 109) (white arrow) and some gingival recession at 104.

Figure 109. The patient in figure 109 after teeth scaling which may uncover pathology hidden under the dental calculus (e.g. TRs and fractures).

Figure 110. Demonstrating use of a dental explorer along the gingval margin of the right mandibular canine (404) in a cat to evaluate for pathology. In this case small TR lesion was identified just above the gingival margin of the buccal aspect of the tooth. This careful examination allowed for diagnosis and treatment of this painful condition.

"missing" tooth will actually be a malformed tooth. Dental radiographs are always indicated for every instance of a "missing" tooth (Niemiec 2011). Supernumerary teeth may be present.
   b. **Tooth surface**: any irregularity is suspicious for a pathologic process. Differentials for a roughened tooth surface include: tooth fracture (uncomplicated/complicated) (See common disorders of teeth section), enamel defect (e.g. hypomineralisation), caries, attrition/abrasion (DuPont 2010), or tooth resorption (See section on Tooth Resorption)
   c. **Colour**: Intrinsic staining (a purple, yellow, pink or gray tooth) indicates pulpitis (i.e. a nonvital tooth) or the use of certain antibiotics during tooth development. **(Figure 111)** teeth suspected to have pulpitis or pulp necrosis require root canal therapy or extraction. Extrinsic staining may be due to wear, metal chewing. These teeth generally require no therapy, but dental radiographs are indicated (DuPont 2010).
9. **Periodontal examination**:
   a. **Periodontal probing depth (PPD):** the periodontal probing depth has to be measured with a graduated periodontal probe. The sulcus/pocket must be measure circumferentially around the whole tooth and recording of 4-6 places can be done. (Some charts only record the deepest pocket as it is the most significant) (Holmstrom SE *et al.*, 2004). The normal PPD in dogs is 0-3 mm, and in cats in cats 0-1 mm (Niemiec 2013c). (See periodontal therapy section)
   b. **Gingival enlargement**: enlargement of the gingiva can lead to pseudo pockets **(Figure 112)**
   c. **Gingival recession**: is an indication of periodontal disease although the PPD does not necessarily increase **(Figure 113)**
   d. **Furcation involvement**: furcation involvement indicates bone loss between the roots of multi rooted teeth. **(Box 3) (Figure 114)**
   e. **Mobility**: the grade of mobility has to be determined **(Box 4)**
   f. **Total Mouth Periodontal Score (TMPS)**: this method allows for a very accurate determination of the patient's periodontal health (Harvey *et al.* 2008)
10. **Expose dental radiographs**: dental radiographs are a very important part of the dental examination and should be taken whenever possible (Niemiec 2011). **(Figure 115)** (See radiology section)
11. **Staging of periodontal disease**: staging can be performed by combining the clinical findings and the dental radiographs (AVDC Nomenclature Committee 2019) **(Box 5)**
12. **Definitive cleaning and polishing**
13. **Additional therapy:** Based on all available information (visual, tactile, and radiographic) determine and execute the final treatment plan.
14. **Postoperative radiographs and photographs (Figure 116 & 117)**

Dental radiographs are a critical part of the oral examination, however at the time of this paper, they are not widely utilized (See Necessary Equipment section). In this situation, a thorough examination with a dental explorer, a periodontal probe and a mirror will give fairly accurate information about status of the oral cavity. Periodontal staging without dental x-ray is very inaccurate but if there is no option it still may be of some help.

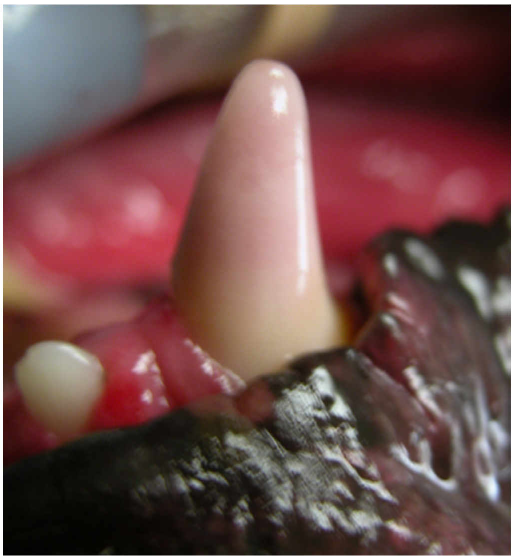

Figure 111. Left mandibular canine (304) in a dog which is intrinsically stained (discoloured). The vast majority of these teeth are non-vital regardless of radiographic signs. Therefore, it is recommended that they be treated with root canal therapy or be extracted.

Figure 112. Small area of gingival enlargement on the right maxillary canine (104) of a dog. Gingivectomy is indicated, and the excised tissue must be submitted for histopathology to rule our neoplasia.

Figure 113. Demonstrating correct use of a periodontal probe to measure gingival recession on the mandibular right canine (404) of a dog. In this case there is 12-mm of gingival recession, indicative of advanced periodontal disease, despite the fact that there is no periodontal pocketing. Extraction is the treatment of choice for this tooth.

BOX 3 : Furcation Index

Stage 1 (F1): Furcation 1 involvement exists when a periodontal probe extends less than 1/3 under the crown in any direction of a multirooted tooth with attachment loss. (a)

Stage 2 (F2): Furcation 2 involvement exists when a periodontal probe extends greater than half way under the crown of a multirooted tooth with attachment loss but not through and through. (b)

Stage 3 (F3): Furcation exposure exists when a periodontal probe extends under the crown of a multirooted tooth, through and through from one side of the furcation out the other. (c)

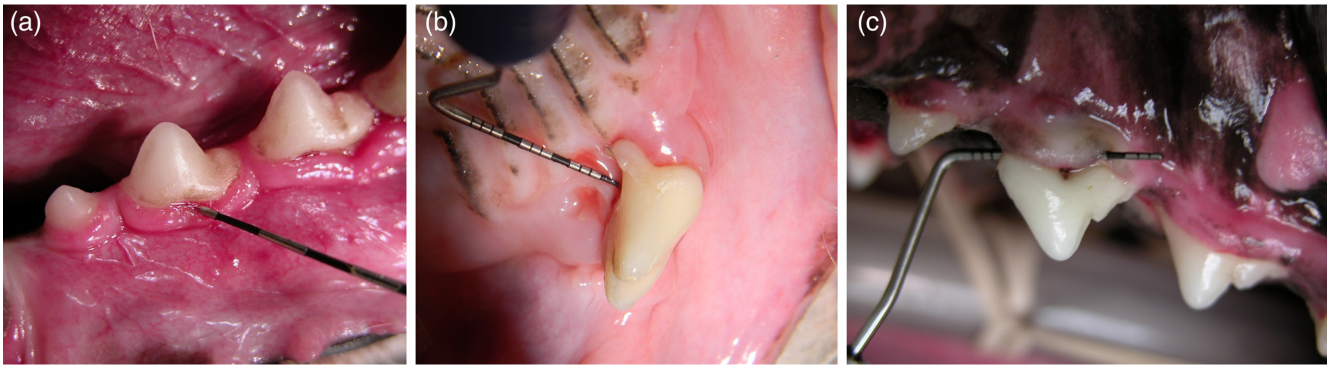

Figure 114. a) demonstrating correct use of a periodontal probe to evaluate the level of furcation exposure on the buccal aspect of the left mandibular second premolar (306) of a dog. In this case there is a grade I furcation, meaning that the probe enters the furcation, but less than 1/3 of the root width. This level of exposure can be effectively cleaned closed (ie. without a flap). b) Evaluation of furcation exposure on the palatal surface of the left maxillary fourth premolar (208) of a dog. In this case, there is a grade II furcation, meaning that the probe enters the furcation more than 1/3 of the root width, but does not pass all the way through. This level of exposure requires periodontal flap surgery to effectively clean the furcation. Alternatively, extraction can be considered. This demonstrates the importance of a complete oral exam. If a careful examination was not performed, this lesion would have been missed. c) Evaluate the level of furcation exposure on the palatal surface of the left maxillary second premolar (206) of a dog. In this case there is a grade III furcation, meaning that the probe passed all the way through. This level of exposure requires extraction of the affected tooth.

BOX 4 : Tooth Mobility Index

Stage 0 (M0): Physiologic mobility up to 0.2 mm.

Stage 1 (M1): The mobility is increased in any direction other than axial over a distance of more than 0.2 mm and up to 0.5 mm.

Stage 2 (M2): The mobility is increased in any direction other than axial over a distance of more than 0.5 mm and up to 1.0 mm.

Stage 3 (M3): The mobility is increased in any direction than axial over a distance exceeding 1.0 mm or any axial movement.

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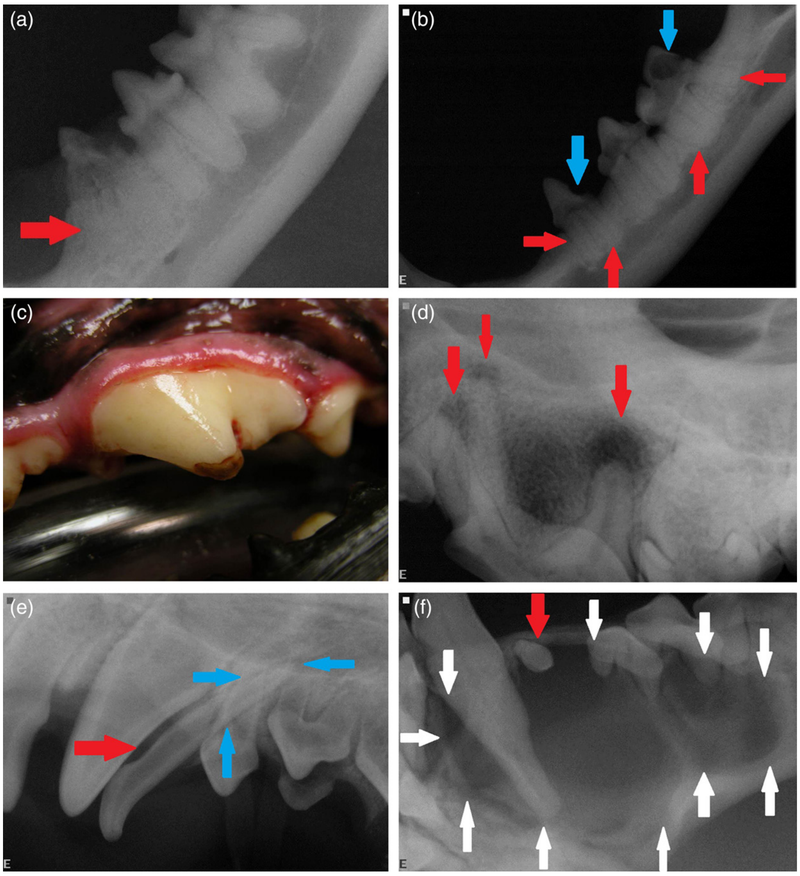

Figure 115. The importance of dental radiographs. (a & b) Tooth resorption (TR): Extracting feline teeth affected by tooth resorption can be very challenging due to ankylosis and resorption. Crown amputation has emerged as an accepted form of thereapy for this condition, but only if certain criteria are met, which must be determined by dental radiology. a) Intraoral dental radiograph of a patient with an advanced type 2 TR on the left mandibular P3 (307) (red arrow). This tooth is an accpetable crown amputation candidate. b) Left mandible of a cat with advanced type 1 TR (blue arrow). In type 1 TR, there is no replacement and therefore the roots are still visible. Complete extraction is required. (c & d) Uncomplicated crown fractures (UCF):
c) Left maxillary P4 (208) of a dog with an uncomplicated crown fracture. There are no clinical signs of infection. d) Intraoral dental radiograph of the tooth in (c). This image confirms periapical lesions around to all three roots of the affected tooth (red arrows). This is indicative of tooth death. Root canal therapy or extraction is indicated. The information provided by the dental radiographs allowed proper therapy of the tooth. e) Intraoral dental radiograph of a persistent deciduous left maxillary canine (604). There is resorption at the neck of the tooth (right at the gingival margin) (red arrow). This is going to greatly increase the risk of root fracture during the extraction. However, the remainder of the root is normal (blue arrows). Contrary to popular belief, this root will not resorb on its own. Therefore a surgical approach is likely the best choice, especially if the tooth breaks. f) Intraoral dental radiograph of the rostral left mandibular premolars in a dog with a 'missing' first premolar (305). The radiograph reveals the impacted tooth (red arrow) as well as a large lytic lesion, which is most likely a dentigrous cyst (white arrows). Dental radiographs allowed for proper diagnosis and treatement, and should be exposed of all 'missing' teeth.

BOX 5 : Stages of Periodontal Disease

The degree of severity of periodontal disease (PD) relates to a single tooth; a patient may have teeth that have different stages of periodontal disease.

Normal (PD0): Clinically normal; gingival inflammation or periodontitis is not clinically evident.

Stage 1 (PD1): Gingivitis only without attachment loss; the height and architecture of the alveolar margin are normal.

Stage 2 (PD2): Early periodontitis; less than 25% of attachment loss or, at most, there is a stage 1 furcation involvement in multirooted teeth. There are early radiologic signs of periodontitis. The loss of periodontal attachment is less than 25% as measured either by probing of the clinical attachment level, or radiographic determination of the distance of the alveolar margin from the cementoenamel junction relative to the length of the root.

Stage 3 (PD3): Moderate periodontitis - 25-50% of attachment loss as measured either by probing of the clinical attachment level, radiographic determination of the distance of the alveolar margin from the cementoenamel junction relative to the length of the root, or there is a stage 2 furcation involvement in multirooted teeth.

Stage 4 (PD4): Advanced periodontitis; more than 50% of attachment loss as measured either by probing of the clinical attachment level, or radiographic determination of the distance of the alveolar margin from the cementoenamel junction relative to the length of the root, or there is a stage 3 furcation involvement in multirooted teeth.

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RECORDING

A thorough examination can only be performed on an anaesthetized patient. The results of the clinical examination must be recorded on a dental chart to enable the creation of a proper treatment plan in all tiers (Clarke & Caiafia 2014). They must also be kept as part of the medical record and may be used to illustrate concerns to the owner when explaining the clinical findings and treatment performed.

Triadan System

The most widely accepted dental scoring system is the Triadan System which provides a consistent method of numbering teeth across different animal species. In the cat, the Modified Triadan System is used (Floyd 1991) to accommodate for fewer teeth in cats. Each tooth has a three-digit number which identifies the quadrant, position and whether it is a primary or a permanent tooth. The first

Figure 116. Post-scaling to demonstrate the clean teeth. Furcation exposure is evident on the third premolar (white arrow) and periodontal loss on the mesial aspect of the third incisor (blue arrow).

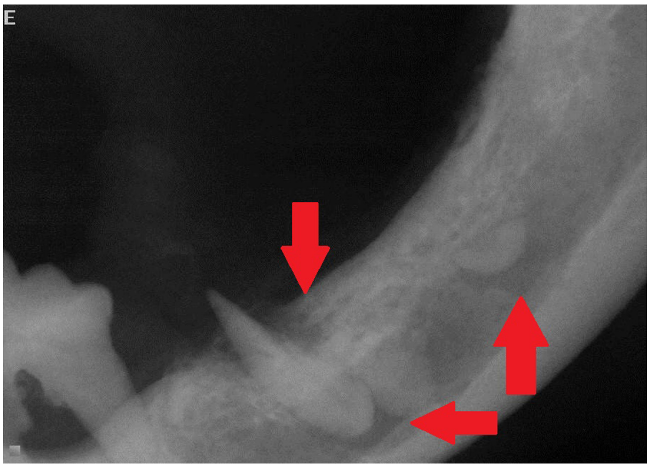
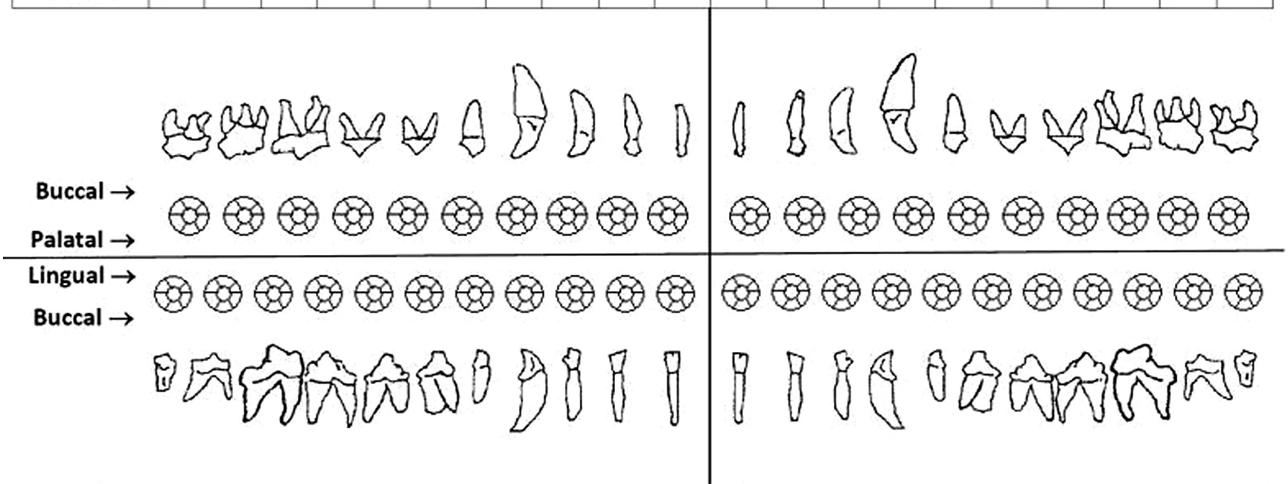


Figure 117. Intraoral dental radiograph of the left mandibular first molar (309) of a dog which was 'extracted' several years previously. There are retained tooth roots with associated periapical lesions (red arrows) indicating inflammation. Post-operative dental radiographs would have revealed these roots and saved this patient from unnecessary suffering.

Tooth	110	109	108	107	106	105	104	103	102	101	201	202	203	204	205	206	207	208	209	210
Furcation (F)																				
Periodontal Dz (PD)																				
Mobility (M)																				



Tooth #	411	410	409	408	407	406	405	404	403	402	401	301	302	303	304	305	306	307	308	309	310	311
Furcation (F)																						
Periodontal Dz (PD)																						
Mobility (M)																						

Figure 118. Sample basic dental chart demonstrating the Triadan Numbering system.

digit denotes the quadrant, which is numbered clockwise beginning at the right maxillary quadrant and ends at the right mandibular quadrant. (1-4 for permanent dentition, 5-8 for primary dentition). The second and third digits refer to the position within the quadrant, with the sequence always starting at the midline with the first incisor **(Figure 118)**.

The advantages of the Triadan and Modified Triadan Systems are that it allows for easy identification of a tooth, is understood throughout the world without language barrier, is suitable for all species, faster than writing out the tooth description, and ideal for digitalized recording and statistics.

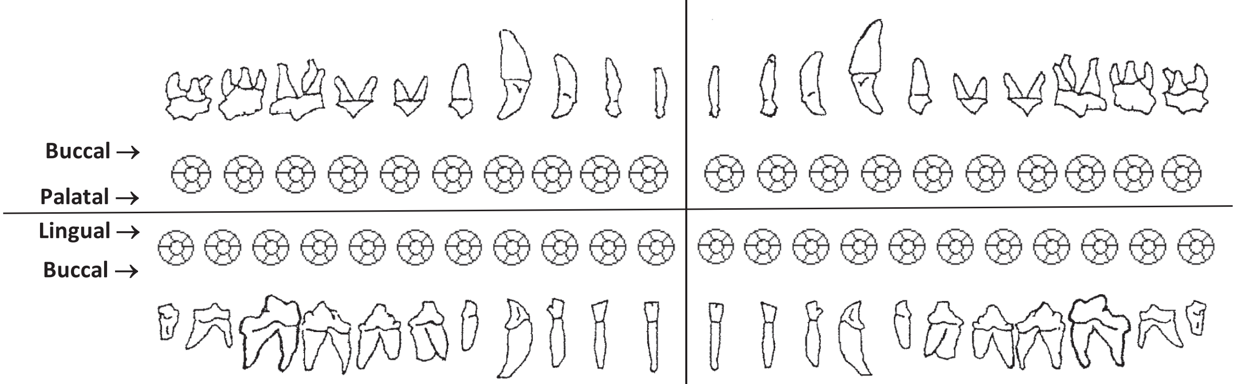
Patient Name: ______________________

Patient #: ______________________

Date: ______________________

Skull Type:	Mandibular Symphysis:	Occlusion:	Oral Exam Findings:		
O Brachycephalic O Mesocephalic O Dolichocephalic **Temporomandibular Palpation:** O Normal O Pain O Crepitus O Clicking O Inhibited O Luxated	O Intact O Separation O Laxity -Mild/Mod/Severe **Upper Airway:** O Elongated Soft Palate O Palate Defect O Stenotic Nares O Tonsilitis O Oroantral Fistula (OAF) O Oronasal Fistula (ONF)	O Ideal/Normal O MAL/1-Neutrocclussion O Distoversion O Labioversion O Linguoversion O Mesioversion O Rostral Crossbite O Caudal Crossbite O MAL/2-Mand Distocclusion O MAL/3-Mand Mesiocclusion O Edentulous	AB- Abrasion AT- Attrition CA- Caries CWD- Crowding E/D- Enamel Defect E/H- Enamel Hypocalcification/Hypoplasia FB- Foreign Body GH- Gingival Hyperplasia/Hypertrophy GR- Gingival Recession IE- Infraerupted	LAC- Laceration O- Missing Tooth OM- Oral Mass PE- Pulp Exposure RD- Retained Deciduous Tooth RO- Rotated Tooth SE- Supraerupted SN- Supernumerary ST/CU- Contact Ulcer Stomatitis T/A- Avulsed Tooth	T/FX/EF- Enamel Fracture T/FX/ EI- Enamel Infraction T/FX/UCF- Uncomplicated Crwn Fracture T/FX/CCF- Complicated Crwn Fracture T/FX/UCRF- Uncomplicated Crwn-Rt Fracture T/FX/CCRF- Complicated Crwn-Rt Fracture T/FX/RF- Rt Fracture T/ LUX- Luxated Tooth T/NV- Non-Vital Tooth TR- Tooth Resorption

Tooth #	110	109	108	107	106	105	104	103	102	101	201	202	203	204	205	206	207	208	209	210
Furcation (F)																				
Periodontal Dz (PD)																				
Mobility (M)																				



Tooth #	411	410	409	408	407	406	405	404	403	402	401	301	302	303	304	305	306	307	308	309	310	311
Furcation (F)																						
Periodontal Dz (PD)																						
Mobility (M)																						

Radiograph:	Exodontia:	Other Surgical:	Subgingival:
DTC- Dentigerous Cyst (suspect) FX- Fracture pRC- Prev Root Canal Therapy RTR- Retained Tooth Root SYM- Symphyseal Separation -Type 1 / 2 / 3 T/E- Embedded Tooth T/I- Impacted Tooth TR- Tooth Resorption pVP- Prev Vital Pulp Therapy	CRA- Crown Amputation CRR- Crown Reduction X- Simple Closed Extract XS- Non-Sx Extract with Sectioning XSS- Surgical Extraction **O** Buccal Cortical Bone Removal **O** Alveoloplasty **Periodontal Surgery:** GV- Gingivoplasty/Gingivectomy OP- Operculectomy **Restoration:** BD- Bonded Sealant	BG- Bone Graft OAF/R- Oroantral Fistula Repair ONF/R- Oronasal Fistula Repair **Suture:** **O** Chromic Gut___ **O** Monocryl___ **Diagnostics:** B/E- Biopsy Excisional B/I- Biopsy Incisional CS- Culture/Sensitivity	RPC- Root Planing Closed RPO- Root Planing Open **Subgingival Antibiotics:** CLIN-Clindoral DOX- Doxirobe **Prophylaxis:** PRO- Perio Prophylaxis **O** Hand Scaling **O** Ultrasonic Scaling **O** Subgingival Curettage **O** Chlorhex/Pumice Polish **O** Fluoride **O** OraVet **O** Sanos

Comments:____

____

____

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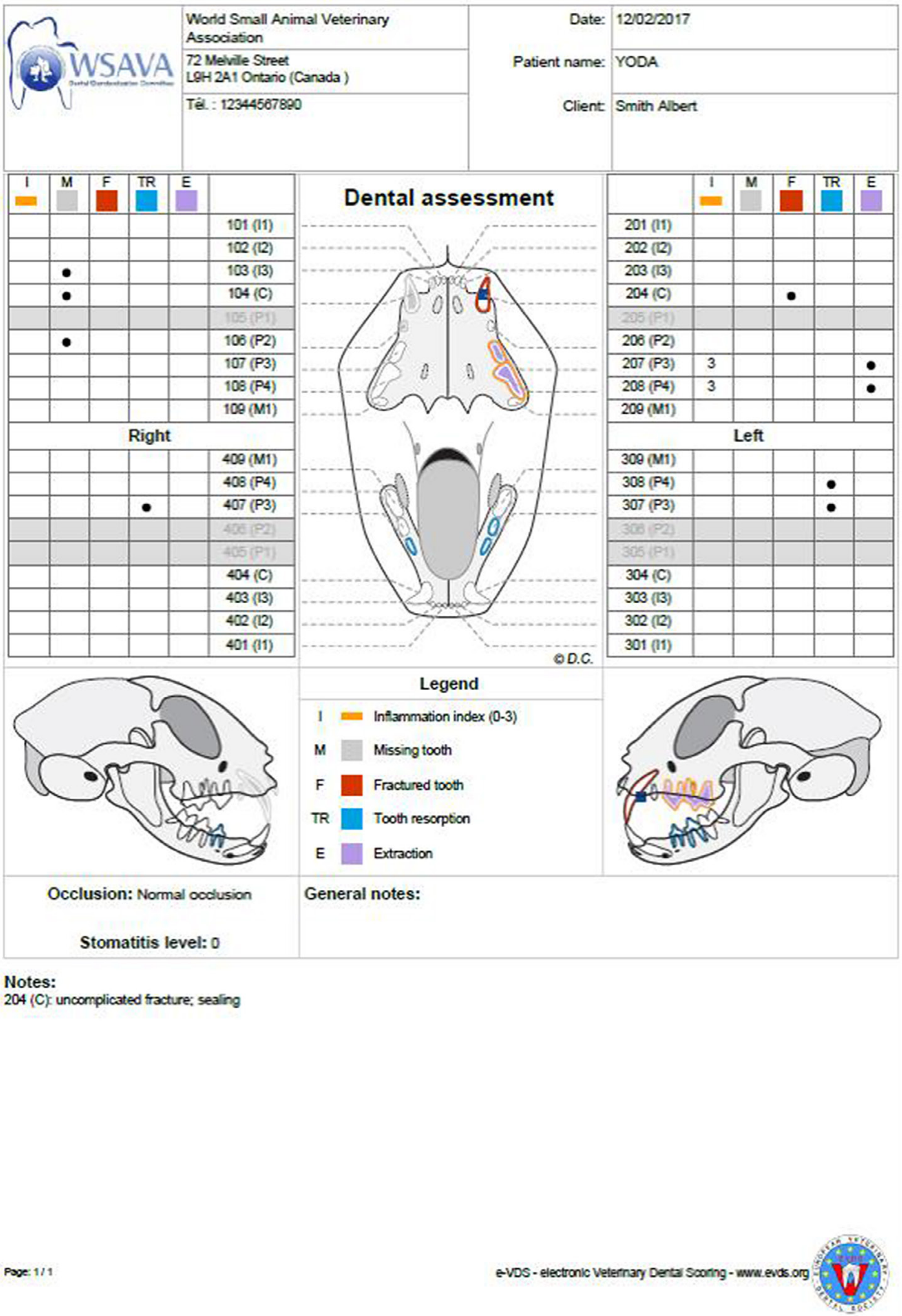
Figure 119. Sample dental chart.



WSAVA

World Small Animal Veterinary Association
72 Melville Street
L9H 2A1 Ontario (Canada)
Tél. : 12344567890

Date: 12/02/2017
Patient name: YODA
Client: Smith Albert

Dental assessment

Right

I	M	F	TR	E	Tooth
					101 (I1)
					102 (I2)
	•				103 (I3)
	•				104 (C)
					105 (P1)
	•				106 (P2)
					107 (P3)
					108 (P4)
					109 (M1)
					409 (M1)
					408 (P4)
			•		407 (P3)
					406 (P2)
					405 (P1)
					404 (C)
					403 (I3)
					402 (I2)
					401 (I1)

Left

Tooth	I	M	F	TR	E
201 (I1)					
202 (I2)					
203 (I3)					
204 (C)			•		
205 (P1)					
206 (P2)					
207 (P3)	3				•
208 (P4)	3				•
209 (M1)					
309 (M1)					
308 (P4)				•	
307 (P3)				•	
306 (P2)					
305 (P1)					
304 (C)					
303 (I3)					
302 (I2)					
301 (I1)					

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Legend
I Inflammation index (0-3)
M Missing tooth
F Fractured tooth
TR Tooth resorption
E Extraction

Occlusion: Normal occlusion
Stomatitis level: 0
General notes:

Notes:
204 (C): uncomplicated fracture; sealing

Page: 1 / 1
e-VDS - electronic Veterinary Dental Scoring - www.evds.org

Figure 120. Printout from the free electronic detal scoring system from EVDS. The practice can insert their own logo on this form and print it out for the client.

Manual Scoring

The clinical findings can be recorded manually **(Figure 119).** Dental charts for several species are available for free download at (http://cpd.vetdent.eu). The results can either be hand drawn into a dental chart or marked in an attached multiple-choice spreadsheet. The most common signs for dental recording are a circle for a missing tooth (O), a hash mark for a fractured tooth (#) and a cross for an extracted tooth (X). For more detailed instructions see the periodontal therapy section.

Electronic Scoring

The results can also be recorded digitally. The European Veterinary Dental Society provides a free online dental charting software (Electronic Veterinary Dental Scoring) available for all veterinarians in five screen languages (English, French, German, Spanish, Portuguese). It is a simple tool to support the practitioner in their daily work. The basic clinical findings can be scored with a simple mouse click onto the dental charts. The scored criteria are: missing tooth, persistent deciduous tooth in dogs/resorptive lesions in cats, fractured tooth, inflammation index, extraction. The reports may be saved in the clinic software as a PDF and/or printed out for the owner in one of six common languages (English, French, German, Italian, Spanish, Portuguese) or easily changed into any other by hand. With a few clicks the clinic data and logo can be inserted, and an individual report created **(Figure 120).** The programme is also equipped with a tutorial which is based on photographs. The feature serves as educational tool, diagnostic and treatment planning aid, and may be used for illustrating the condition to the client. Access to the program is via: www.evds.org.

Tier 2 & 3 are recommended to use a more detailed commercial programme. There are several options available (in alphabetical order: www.chartific.com; www.evds.org; www.vetdentalcharts.com).

Key Points:

- The conscious examination is important but is of very limited value, as a complete examination is only possible under general anaesthesia. This is one of the many reasons this committee strongly discourages Anaesthesia Free Dentistry (AFD).
- A thorough oral examination MUST be part of every dental procedure.
- The Triadan and Modified Triadan Systems and anatomical names can be used for recording dental examination and treatment.
- The examination of the oral cavity must be performed in a systematic and repeatable fashion.
- Dental radiographs are an essential part of the examination.
- Proper recording of clinical findings and treatments is crucial.

SECTION 5: PERIODONTAL THERAPY

BASIC PROFESSIONAL THERAPY

There are numerous therapeutic options available for periodontal disease, however, the basis of periodontal therapy remains plaque control. It has recently been shown that a professional dental cleaning will have a significant positive effect on the oral microbiome, quickly restoring it to healthy levels (Flancman R, et al 2018).

Plaque removal and control consists of 4 aspects depending on the level of disease. These therapies include (Niemiec 2008c)

1. Professional dental cleaning (previously called dental prophylaxis, cleaning, Oral ATP, (assessment, treatment, prevention) or COHAT (Comprehensive Oral Health Assessment and Treatment) (Bellows 2010a)
2. Homecare
3. Periodontal surgery
4. Extraction

This section will cover the complete dental prophylaxis/cleaning as well as basic indications for periodontal surgery and extractions. Homecare and basic extraction techniques will be covered elsewhere in this document, however periodontal surgery is beyond the scope of these guidelines.

Regardless of the name, the goal of this procedure is not only to clean and polish the teeth, but also to evaluate the periodontal tissues and entire oral cavity. Any professional periodontal therapy for veterinary patients must be performed under general anaesthesia, with a well-cuffed endotracheal tube (Holmstrom 1998; Niemiec 2003b; Colmery 2005; Holmstrolm 2013; Niemiec 2013c). Only when the patient is properly anaesthetized can a safe and effective cleaning and oral examination be performed (Wallis C *et al*. 2018). A recent study proved that non-professional teeth scaling resulted in significantly *worse* periodontal disease (Stella JL *et al*. 2018).

It is important to note that proper periodontal/dental/oral therapy takes time and patience and therefore adequate time should be allotted for all dental cases. Some patients will require more treatment than others necessitating addition time. Professional periodontal therapies must be performed with quality (not quantity) in mind.

Procedure

A professional dental cleaning should include the following minimal steps (Wiggs & Lobprise 1997; Holmstrolm *et al*. 1998; Niemiec 2003b; Bellows 2010a; Niemiec 2013c):

Step 1: Pre-surgical examination and consultation: (Huffman 2010)

The veterinarian should perform a complete physical and oral examination. The physical examination, in combination with preoperative testing, screens for general health issues which may exacerbate periodontal disease or compromise anaesthetic safety (Joubert 2007) (See anaesthesia section).

The conscious oral examination will identify some oral pathologies as well as allow for a preliminary assessment of periodontal status. The use of a periodontal diagnostic strip by the examining veterinarian can improve the accuracy of the conscious periodontal evaluation.

The veterinarian can then discuss the various disease processes found on the examination as well as the available treatment options with the owner. This face-to-face discussion will improve client understanding of the disease processes and associated sequela.

Based on the oral examination findings, the practitioner can create a more accurate estimate both of procedure time and financial costs to the client. The client should be made aware at this point that a complete oral examination is **not** possible on a conscious patient.

Staff and patient protection

Numerous studies have shown that ultrasonic and sonic scalers create significant bacteria laden aerosols (Pederson *et al.* 2002; Harrel 2004; Szymańska 2007). The infectious organisms are not only supplied by the patient's mouth, but also the water lines of the mechanized handpieces (ultrasonic scalers and high speed handpieces) (Shearer 1996; Meiller *et al.* 1999; Wirthlin *et al.* 2003). Staff members performing dental prophylactic (or any dental) procedures should be instructed to wear personal protective equipment (mask, goggles, and gloves) at all times to decrease contamination (Harrel *et al.* 1998; Holmstrolm *et al.* 1998a Pattison & Pattison 2006). Furthermore, a bacterial water filter or chlorhexidine flushing of the system is recommended to decrease contamination (Bellows 2004). Dental procedures also must **not** be performed in "sterile" environments such as surgical suites. Furthermore, they should not be performed near any sick or compromised patients, or near any clean procedures. (Bellows 2004) Dental procedures are best confined to their own designated room (Legnani *et al.* 1994; Osorio *et al.* 1995; Leggat & Kedjarune 2001; Al Maghlouth 2007).

Step 2: Chlorhexidine lavage:

The oral cavity is a contaminated area and thorough dental cleanings are mildly invasive. This means that dental cleanings result in a transient bacteraemia, which is more severe in patients with periodontitis (Daly *et al.* 2001; Forner *et al.* 2006; Lafaurie *et al.* 2007). Dental cleanings cause bacterial aerosolization and contamination of the office environment when ultrasonic instruments are used. Rinsing the oral cavity with a 0.12 or 0.2% solution of chlorhexidine gluconate prior to commencing the prophylaxis, has been shown to decrease the bacterial load (Fine *et al.* 1992; Bellows 2004).

Step 4: Supragingival cleaning

Very large accumulations of calculus can be quickly removed using calculus forceps. However, this must be done very carefully to avoid tooth and gingival damage. Supragingival scaling can be performed via mechanical or hand scaling, but is best performed using a combination of the modalities (Bellows 2004; Pattison & Pattison 2006).

Mechanical scalers

Mechanical scalers include both sonic and ultrasonic types. (Holmstrolm et al. 1998a; Jahn 2006a). The most common used mechanical scaler in veterinary dentistry today is the ultrasonic model. There are two main types (magnetostrictive and piezoelectric) (Wiggs & Lobprise 1997). Both of these ultrasonic scalers vibrate at approximately 25,000-45,000 Hertz. Both types of ultrasonic scalers are very efficient and provide the additional benefit of creating an antibacterial effect in the coolant spray (cavitation) (Arabaci *et al.* 2007; Felver *et al.* 2009).

Sonic scalers run on compressed air and vibrate at only 2,000-6,500 hertz, although rates of up to 9,000 Hz have been reported. At slower rates of vibration, they generate minimal heat, and therefore may be a safer alternative to ultrasonics (See equipment section for a complete discussion of mechanical scalers).

Mechanical scaling

When using any of the mechanical scalers, the first concern is the power level setting of the instrument. Ultrasonic tips have a recommended oscillation (Hz) range and this should be determined and set prior to initiating scaling. The power should be set low and adjusted upward to the *minimum* required power. The area of maximum oscillation for ultrasonic scalers is 1-3 mm from the tip. (DeBowes 2010) Do not use the sharp pointed tip of the instrument, but the flat plane of the instrument, as the point will damage the enamel of the tooth.

Next, it is important to ensure that there is adequate coolant being delivered through the working end of the scaler. A fine but significant spray should be evident when the unit is activated **(Figure 121)**. Utilizing a mechanical scaler without sufficient coolant can cause numerous deleterious effects including tooth death (Nicoll & Peters 1998). It is important to note that standard periodontal tips must not be introduced under the gingival margin. (Wiggs & Lobprise 1997) The water coolant will not reach the working area of the instrument, which results in overheating and possible tooth and gingival damage, especially when using the magnetostrictive scalers.

Specific low-powered periodontal tips are available for subgingival use, and clinicians and staff should familiarize themselves with this equipment prior to their use. Units supplied with periodontal tips also have settings on the machine appropriate for subgingival scaling.

The instrument should be gently grasped to increase tactile sensitivity, decrease operator fatigue and provide superior cleaning.

Place the side of the instrument in contact with the tooth surface with a very light touch (DeBowes 2010, Jahn 2006a) **(Figure 122)**. Additional pressure on the instrument will not improve its efficiency, and can result in damage to both the instrument and the tooth (Brine *et al.* 2000). Excessive downward pressure on the scaler tip may stop the oscillation entirely.

Run the instrument across the entire tooth surface using numerous overlapping strokes in different directions. Keep the instrument in motion at all times to avoid tooth damage.

Figure 121. A fine but adequete water coolant spray is important to avoid overheating the teeth.

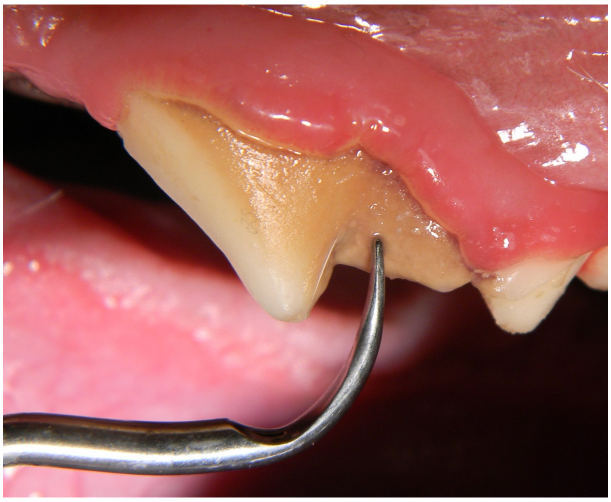

Figure 122. Correct orientation of an ultrasonic scaler on the tooth. The last 2-3 mm of the side of the instrument is placed against the tooth. Continually moving and adjusting position on the tooth is important for proper cleaning.

It has long been recommended to strictly limit the amount of time ultrasonic scalers linger on one tooth. Typically, it is recommended that they be kept in constant contact with tooth for no more than 6-8 seconds. In addition, heat damage is generally caused by lack of water cooling (Nicoll & Peters 1998; Vérez-Fraguela *et al.* 2000).

Once the instrument loses contact with the tooth, the scaler can no longer be effective duplication. Plaque can be microscopically present on all surfaces of the tooth, regardless of the fact that the tooth appears clean, and such each square mm of every tooth surface should be treated. Scaling is predominantly for calculus removal and polishing is for plaque removal - after plaque disclosing solution is applied. Only areas with disclosed plaque and the subgingival areas need to be polished.

Damage affecting the terminal 1-mm of the tip reduces efficiency of an ultrasonic scaler by 25% and 2-mm by 50% (Bellows 2004). Therefore, new tips should be used when old ones wear out.

Rotosonic scaling, while popular in the past, is no longer a recommended form of scaling (Bellows 2004). This is due to the fact that these instruments produce a significantly rougher surface compared to hand and ultrasonic/sonic power scalers (Brine *et al.* 2000). In addition, they are by far the most damaging mechanical scaling instrument (Wiggs & Lobprise 1997).

HAND SCALING:

Equipment

Supragingival hand scaling is performed with a scaler. This is a triangular instrument with two sharp cutting edges and a sharp tip. Typically, the universal scaler blade is positioned at 90 degrees to the shaft. Scalers are designed for supra-gingival use only, as the shape of the instrument as well as the sharp back and tip can easily damage the gingiva (Theuns & Niemiec 2012). (See the equipment section for a detailed description of periodontal hand instrumentation)

Note, periodontal hand instruments are only effective when sharp. This means they need to be sharpened on a regular basis (at least weekly if used regularly).

Technique

Hand instruments are typically held with a modified pen grasp **(Figure 123),** but, other grips may be necessary in certain situations. The instrument is gently held at the textured or rubberized end, between the *tips* of the thumb and index finger. The middle finger is placed near the terminal end of the shaft and is used to feel for vibrations which signal residual calculus or diseased/rough tooth/root surfaces. Finally, the 4th and 5th fingers are rested on a stable surface, generally the target tooth or nearby teeth. This grasp and described method of cleaning allow for maximum control during the scaling procedure.

Hand instruments must also be used with a gentle touch. The instrument is held with the terminal shank parallel to the tooth surface and the blade placed at the gingival margin **(Figure 124).** Hand scalers are used in a pull stroke: avoiding gingival damage by pulling away from the soft tissue (Bellows 2004; Pattison & Pattison 2006).

Step 5: Subgingival plaque and calculus scaling

This is the most important step of the dental cleaning, as *supra*gingival plaque control is insufficient to treat periodontal disease. (Westfelt et al. 1998)

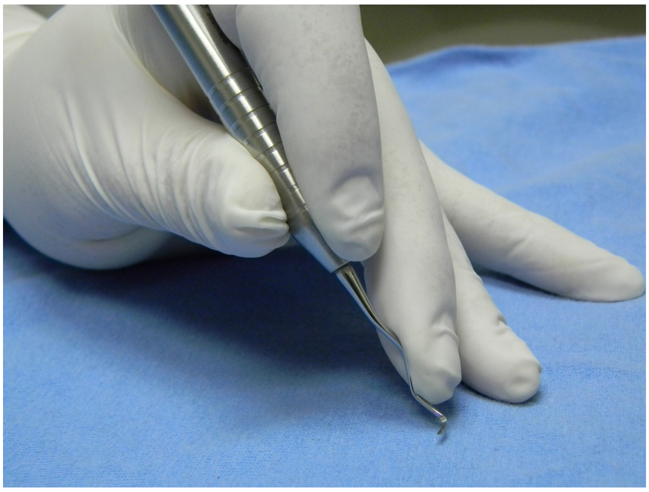

Figure 123. Modified pen grasp for hand scaling. The instrument is held between the thumb and index finger. The middle finger is placed near the end of the instrument and the fourth and fifth fingers are used as a rest on the patient or table.

Figure 124. Correct adaption of a scaler against the tooth. The shank (white arrow) is placed parallel to the long axis of the tooth. This places the blade in the proper position for effective cleaning. It is important that on the pull stroke, the instrument is maintained in this position with the blade engaged on the tooth.

Subgingival scaling has classically been performed by hand with a curette, but advances in sonic and ultrasonic tips now allow their use under the gingival margin. While some may achieve satisfactory results using ultrasonic scalers alone, it is generally recommended to use a combination of ultrasonic (or sonic) and hand scaling for best results (Holmstrom 1998; Bellows 2004; Pattison & Pattison 2006).

Hand scaling

A curette has two cutting edges (however only the one which lies against the tooth is actually used) with a blunted toe and bottom. The blunted bottom will not cut through the delicate periodontal attachment, assuming excessive force is not applied. There are two types of standard curette, universal and Gracey. Universal curettes usually have a 90-degree angle and are designed to be used throughout the mouth provided that the instrument is adapted to the tooth correctly. Gracey curettes are area specific, and are designed with different angles to provide superior adaptation to specific areas of the dentition. The proper curette should be selected based on its angulation. Curettes are labelled by numbers which correlate as: the lower the number (i.e. 1-2) the smaller the terminal angle of the shank, and the further rostral in the mouth the instrument is used (Theuns & Niemiec 2012; Niemiec 2013g) (See equipment for a complete discussion of hand instruments).

Manual subgingival scaling is a very technically demanding procedure and although it will be described here, the practitioner is directed to continuing education programs to hone their skills. Subgingival scaling is performed as follows:

1. Place the blade of the instrument on the tooth surface just coronal to the free gingival margin, with the lower shank parallel to the tooth surface. **(Figure 125)**
2. Rotate the instrument so that the flat "face" of the blade is against the tooth surface.
3. Insert the instrument *gently* to the base of the sulcus or pocket. **(Figure 126)**
4. Once the bottom of the pocket is reached, the instrument is rotated to create a 90-degree working angulation. This is when the terminal portion (or shank) is parallel to the tooth **(Figure 127).**
5. Slight pressure is applied down onto the tooth surface.
6. Remove the instrument from within the pocket in the coronal direction with a firm/short stroke. **(Figure 128)** This technique is repeated with numerous overlapping strokes in different apical to coronal directions until the tooth/root feels smooth.

Mechanical scaling

Traditional ultrasonic scalers (especially magnetostrictive) should not be used subgingivally to avoid damage to the gingiva, periodontal tissues, and pulp (Jahn 2006a) sonic and ultrasonic scalers with specialized periodontal tips have been developed for subgingival use. These instruments are much easier to use and thus may provide a superior cleaning in the hands of novices, however this has not been confirmed by clinical studies (Kocher *et al.* 1997). To accomplish subgingival scaling, these instruments are used in a similar fashion as supragingival scaling described above, but more care should be taken not to damage the root surface. Again, this technique is performed with a *gentle* touch using numerous overlapping strokes until the root feels smooth.

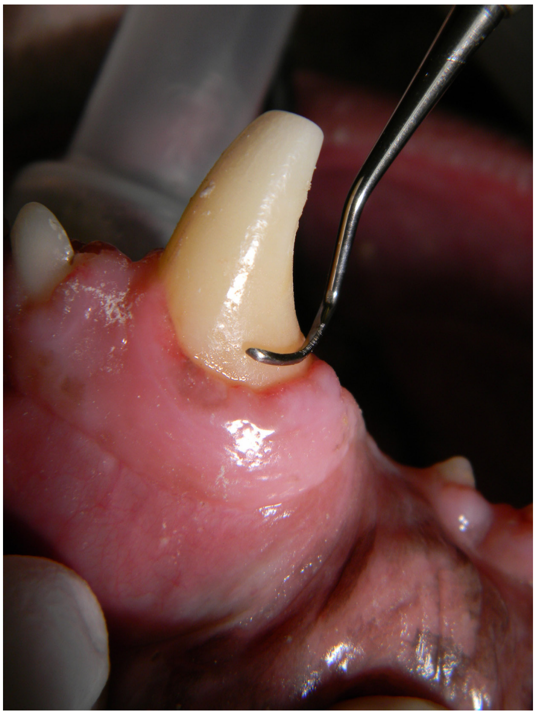

Figure 125. Subgingival hand scaling: Begin with the shank parallel to the long axis of the tooth.

Figure 126. Subgingival hand scaling: Rotate the instrument lingually to place the blade against the tooth and decrease the profile of the instrument. This will allow it to easily slide into the gingival sulcus and over the calculus.

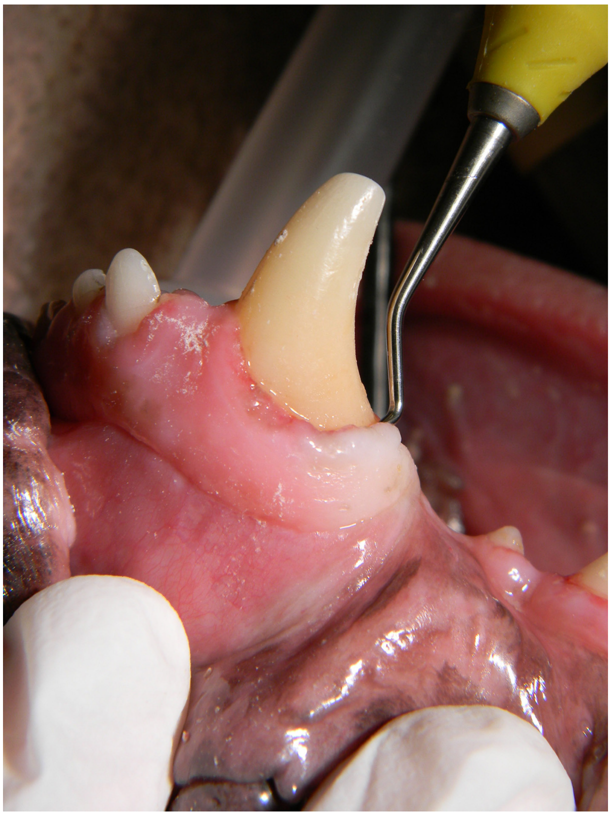

Figure 127. Subgingival hand scaling: Insert the instrument *gently* into the bottom of the pocket.

Figure 128. Subgingival hand scaling: Rotate the instrument back to where the shank is parallel to the long access of the tooth. Place slight pressure against the tooth and pull firmly. Make sure to mantain the proper angulation.

Step 6: Residual plaque and calculus identification

After scaling, it is recommended to check the teeth with an explorer, feeling for any rough areas which indicate small areas of dental pathology or residual calculus. Residual plaque and calculus may also be identified by utilizing a plaque disclosing solution or by drying the tooth surfaces with air (residual calculus will appear chalky) (Pattison & Pattison 2006).

Step 7: Polishing

Dental scaling (both mechanical and hand) generally results in microabrasion and roughening of the tooth surface, which will result in increased plaque adherence. (Silness 1980; Berglundh 2007) Polishing smooths the surface of the teeth, thus retarding plaque attachment. (Bellows 2004). In human dentistry, the polishing step is controversial due to the cumulative loss of enamel throughout the lifetime of the patient and the fact that proper scaling with high quality hand or ultrasonic instruments has been shown to leave a very smooth surface. (Pattison & Pattison 2006) However, veterinary dental cleanings are often performed by less experienced operators with lesser equipment, which typically leaves the tooth surface (especially the root) rough, leading to increased plaque attachment. For this reason, polishing continues to be recommended in veterinary patients (Fichtel *et al*. 2008; DeBowes 2010; Niemiec 2013c).

Practices can choose to use a commercially available polish, or make their own slurry of flour of pumice and chlorhexidine solution or water. These can be mixed in a dappen dish for each patient.

The polishing procedure is typically performed with a rubber prophy cup, on a slow-speed hand-piece with a 90-degree angle (prophy angle). (Fichtel *et al*. 2008) The hand-piece should be run at a slow speed, no greater than 3,000 RPM. Faster rotation will not improve the speed or quality of the procedure, and may result in overheating the tooth. In addition, it is important to use an adequate amount of polish at all times. Using the prophy cup without paste is not only inefficient; it may also overheat the tooth.

As with scaling, every mm^2 of tooth surface should be polished. Slight pressure must be placed down onto the tooth to flare the edges of the prophy cup so as to polish the subgingival areas. **(Figure 129)** One tooth may be polished for a maximum of five seconds at a time, to avoid overheating.

Step 8: Sulcal lavage

During the cleaning and polishing steps, debris such as calculus and prophy paste (some of which is bacteria laden) accumulates in the gingival sulcus (or periodontal pockets). The presence of these substances allows for continued infection and inflammation, and therefore a gentle lavage of the sulcus is strongly recommended to improve healing. Sulcal lavage is performed with a small (22-25)

Figure 129. Correct positioning for polishing the teeth. The prophy angle is held perpendicular to the long axis of the tooth. Slight pressure against the tooth will flare the edges of the cup and enable subgingval polishing.

Figure 130. Correct use of a periodontal probe to measure the pocket depth on the buccal surface of a left maxillary canine (204) in a dog. This must be performed circumferentially around the surface of every tooth.

gauge blunt-ended cannula. The cannula is placed gently into the sulcus and the solution injected while slowly moving along the arches.

Sterile saline can be used as a lavage solution, but most dentists favor a 0.12% Chlorhexidine solution. (Jahn 2006b)

Step 8: Periodontal probing, oral evaluation, and dental charting

This is a critically important step of a complete dental prophylaxis, but is unfortunately often poorly performed or completely omitted. The entire oral cavity must be systematically evaluated using both visual and tactile senses.

The periodontal evaluation should begin with measuring pocket depth. The only accurate method for detecting and measuring periodontal pockets is with a periodontal probe, as pockets are not always diagnosed by radiographs. (Carranza & Takei 2006; Tetradis *et al*. 2006, Niemiec 2011, Niemiec 2013c)

The periodontal evaluation should be initiated at the first incisor of one of the quadrants. The measurements are then continued distally one tooth at a time. Starting at midline and moving systematically distal in this fashion will decrease the chance of a tooth being skipped. Periodontal probing is performed by gently inserting the probe into the pocket until it stops and then slowly "walking" the instrument around the tooth (Bellows 2004; Carranza & Takei 2006; Niemiec 2008c, Niemiec 2013c) **(Figure 130).** Depth measurements should be taken at six spots around every tooth (Carranza & Takei 2006). The normal sulcal depth in dogs is 0-3 mm, and in cats is 0-0.5 mm (Wiggs & Lobprise 1997; DeBowes 2010).

All abnormal findings must be recorded on the dental chart. Dental charting is easier and more efficient if performed 4-handed (Huffman 2010). This means that one person evaluates the mouth and calls out the findings of pathology to the assistant who records it on the chart. Using the modified Triadan system will also greatly increase efficiency of this step.

The modified Triadan system uses numbers to identify the teeth (Floyd 1991; Huffman 2010). First, each quadrant is numbered starting with the maxillary right quadrant as the 100 series. This progresses clockwise so that the maxillary left is 200, mandibular left is 300, and the mandibular right is the 400 series. Next, starting at the rostral midline, the teeth are counted distally starting with the first incisor which is tooth 01. The canines are always number 04 and the first molars are 09. For example, the maxillary left fourth premolar is tooth 208. This has been extrapolated from the fact that the complete dentition of the ancestral carnivore has been determined by anatomists to consist of each quadrant containing 3 incisors, 1 canine tooth, 4 premolars and 3 molars.

It is important that dental charts be of sufficient size to allow for accurate placement of pathology (see oral examination section).

Step 9: Dental radiographs

When available, dental radiographs should be taken at a minimum of every area of pathology noted on dental examination (See oral examination section). This includes any periodontal pocket which is larger than normal, fractured or chipped teeth, masses, swellings, or missing teeth. In addition, numerous studies support full mouth radiographs on all dental patients to further eliminate missed pathology (Tsugawa & Verstraete 2000; Verstraete *et al*. 1998 (a & b)).

Step 10: Treatment planning

In this step, the practitioner uses all available information (visual, tactile, and radiographic findings) to determine appropriate therapy. It is important to consider overall patient health, the owner's interest and willingness to perform homecare, and all necessary follow-up (Niemiec 2008c, Niemiec 2013c).

It is very important to note that if a patient requires extensive treatment that would entail a lengthy anaesthesia, or if the practitioner would be unduly rushed, rescheduling the remainder of the dental work is definitely an acceptable alternative. The two parameters which directly affect long-term morbidity and mortality in anesthetized patients are hypothermia and hypotension, (Torossian 2008, Brodbelt 2008) which become more pronounced with extended anaesthesia time. In fact, anesthetic length has been shown to increase the complication rate in both humans and animals (Tiret *et al*. 1986; Brodbelt 2008) (See anaesthesia section).

Step 11 (optional): Application of a dental sealant

Currently, there are 2 sealants commercially available to prevent the re-attachment of plaque and calculus after dental cleaning. The first is a hydrophobic wax-based sealer that binds electrostatically to tooth enamel, creating a barrier that helps prevent attachment of plaque-forming bacteria. A home care plaque prevention gel is then reapplied weekly by the pet owner (Gengler et al., 2005). The second is a self-curing hydrophilic polymer accepted by the VOHC that "seals" the subgingival sulcus or small pocket against the accumulation of plaque and tartar. The hydrophilic design of the sealant is engineered to attract water and allow oxygen to pass through to create an unfavorable environment for anaerobes. The hydrophilic polymer sealant is applied by the veterinary care provider and does not require home reapplication (Saltzman 2013).

Key Points:

- A professional dental cleaning is an involved procedure with numerous steps.
- All periodontal therapeutic procedures must be performed under general anaesthesia.
- Each step must be properly performed to achieve a positive outcome.
- Sufficient time must be allotted for the procedure to have significant clinical benefit.
- Subgingival scaling is the most important step of a professional dental cleaning.
- A complete oral examination and charting is a critical part of the procedure.

DENTAL HOMECARE

Introduction

Homecare is a critical aspect of periodontal care. Bacterial plaque attaches to the tooth surface within twenty-four hours of cleaning (Boyce *et al.* 1995, Holcombe *et al.* 2014)). In addition, without homecare, gingival infection/inflammation quickly returns (Corba 1986; Fiorellini et al. 2006a). Furthermore, a review of studies reported in man, professional cleanings were of little value without homecare (Needleman *et al.* 2005). In fact, one consensus review emphatically states "Forty years of experimental research, clinical trials, and demonstration projects in different geographical and social settings have confirmed that effective removal of dental plaque is essential to dental and periodontal health throughout life" (Lang *et al.* 1998).

Homecare discussion/instructions

The benefits of routine homecare must be conveyed to each client on a regular basis. Dental care (including homecare) should be discussed with the client on their first visit to the practice, which is often the well puppy/kitten or vaccination visit, and should come from the whole staff (Wiggs & Lobprise 1997). Early institution of homecare not only leads to the greatest benefit, it also makes training easier.

Goals of home plaque control

The primary goal of homecare is to reduce the amount of bacterial plaque on the teeth (Perry 2006). This in turn should decrease the level of gingival inflammation and ultimately periodontal disease.

It is important to note that supragingival plaque and calculus has little to no effect on periodontal disease. It is the plaque at and below the gumline that creates inflammation and initiates periodontal disease (Westfelt et al. 1998, Niemiec 2008b, Niemiec 2013a). Keep this in mind when determining which homecare methods to recommend. Information on the suitability of different methods for marginal and subgingival plaque control is covered along with their descriptions below.

Brushing is by far the most effective means to mechanically remove the plaque. (Hale 2003) Chew based products can be effective if properly formulated, however, oral sprays, rinses, and water additives are generally insufficient, due to the tenacity with which plaque adheres to the teeth and the increased resistance of the plaque biofilm to antiseptics (reportedly up to 500,000 times that of singular bacteria) (Elder *et al.* 1995; Socransky et al., 2002; Quirynen *et al.* 2006).

Types of homecare

The two major types of home plaque control are active and passive. Both types can be effective if performed correctly and consistently, but active homecare is currently recommended as the most effective means of plaque control. Active homecare involves the participation of the pet's owner, such as brushing or rinsing. Passive methods are typically based on chewing behaviours via treats or specially formulated diets. It has been shown that active homecare is most effective on the rostral teeth (incisors and canines) In contrast, passive homecare (chew based) is more effective on the caudal teeth (premolars and molars). This difference is intuitive because the front teeth are easier for clients to access, while passive homecare is more effective on the caudal teeth where chewing occurs.

Active homecare

Tooth brushing

When properly performed, tooth brushing has been proven to be the most effective means of plaque control. (Hale 2003) Therefore, it should be the goal of all veterinarians to promote tooth brushing for their patients by educating their clients.

Materials and methods for tooth brushing

Brushes: The only critical piece of equipment is a tooth brush. There are numerous veterinary brushes available, and a proper brush should be selected based on patient size. Double and triple sided as well as circular feline brushes are effective products and should be considered depending on patient size and temperament. Gauze and washcloths are generally not recommended due to their inability to clean below the gumline. (Holmstrolm et al. 1998a)

In addition to veterinary products, soft human tooth brushes with nylon filaments may be substituted. A child's toothbrush is often the correct size for small patients, and may be more effective than the larger veterinary version. An infant brush may work best for toy breed dogs, cats, or juvenile patients.

Mechanized (sonic and especially rotary) brushes have been shown to be superior to traditional brushes in human studies. (Deery *et al.* 2004; Moritis *et al.* 2008) In addition to the numerous human product options, there is currently a mechanized veterinary brush available. The only negative aspect to these brushes is that the movement/vibration is an unusual sensation which may scare the patients (Holmstrolm et al. 1998a). Therefore, mechanized brushes should only be used in patients with accepting temperament.

Pastes

There are a number of veterinary toothpastes available, which greatly increase the acceptance of the toothbrush by the pet. Toothpastes may also contain a calcium chelator which has been shown to decrease the level of calculus deposits on the teeth (Liu *et al.* 2002; Hennet *et al.* 2007). It is important to note however, that calculus itself is largely nonpathogenic. As such, the paste is not a significant contributor in the reduction of plaque and gingivitis. The mechanical removal of plaque by the movement of the brush/instrument is the key to control. (Hale 2003) Human tooth pastes are not recommended as they usually contain detergents and fluoride which may cause gastric upset or fluorosis if swallowed, and products such as baking soda (sodium bicarbonate) (Wiggs & Lobprise 1997; Niemiec 2008c).

Antimicrobial preparations (see chlorhexidine rinses below) are also available. These products will improve plaque and gingivitis control beyond that of pastes when used with brushing, and therefore should be considered instead of toothpaste in high-risk patients and in cases of established periodontal disease (Eaton *et al.* 1997; Hennet 2002).

Brushing technique

To safely and effectively initiate tooth brushing in veterinary patients, the following training is recommended. Keep in mind, the ideal technique may only be possible in the most tractable patients. Clients should be encouraged to work toward this level of care, but to accept any success as valuable. Forcing homecare on a patient is counterproductive and may damage the client-animal bond (Wiggs & Lobprise 1997; Niemiec 2013d).

The keys to compliance with brushing can be stated as follows.

1. **Start early:** young patients are more amenable to training.
2. **Go slow:** start with just holding the mouth and then allow the pet to lick the paste off of the toothbrush and finally start brushing slowly.
3. **Be consistent:** make this a learned behaviour.
4. **Make it positive:** using food, treats, or playtime as a reward will greatly increase the likelihood of acceptance.
5. **Discuss the risks:** handling animals near their mouths can potentially put the owner at risk of being bitten. Always counsel owners of this risk as part of the tooth brushing discussion.

Proper tooth brushing technique begins with the brush held at a 45-degree angle to the long axis of the tooth. The brush is then placed at the gingival margin and moved along the arcades utilizing a circular motion. The buccal surfaces of the teeth are the most accessible and fortunately are the most important, as these are the surfaces which generally have higher levels of calculus deposition. Make sure to counsel owners not to attempt to open the pet's mouth on initiation of this procedure. Most veterinary patients greatly dislike their mouth being forced open, and this approach may result in increased resistance. Instead, clients should be instructed to begin by effectively brushing the buccal surfaces with the mouth closed. The caudal teeth can be accessed by gently inserting the brush inside the cheek. Correct positioning and brushing technique will improve with time. If the patient is amenable, the client should progress to brushing the palatal/lingual surfaces of the teeth. To open the mouth, begin by placing the thumb of the nondominant hand behind the lower canines. This is the safest place in the mouth to rest the finger.

Regarding the frequency of brushing, once a day is ideal, as this level of care is required to stay ahead of plaque formation. For patients with established periodontal disease, daily brushing is required to maintain oral health, and twice daily may be recommended (Corba *et al.* 1986, Tromp *et al.* 1986a&b; Gorrel & Rawlings 1996). Consistency with homecare is critical. If brushing is suspended for as little as a month, the level of gingival inflammation will return to the same level as patients with no therapy (Ingham & Gorrel 2001).

Antiseptic rinses

The other option for active homecare is the application of antiseptic/antiplaque solutions. The traditional antiseptic of choice is chlorhexidine. Outside of Pseudomonas *spp*., there is no known bacterial resistance to this product, and it is very safe (Robinson 1995; Roudebush et al. 2005). Chlorhexidine has been shown in numerous studies to decrease gingivitis if applied consistently over time (Hamp *et al.* 1973 (a & b); Tepe *et al.* 1983; Hennet 2002). Chlorhexidine reportedly has a quick onset and minimal systemic uptake, making it an excellent choice for oral antisepsis (Salas Campos *et al.* 2000). An additional benefit of this product is that it maintains antiseptic effects for up to 7 hours after application (Bonesvoll 1977; Cousido *et al.* 2009). One concern with the use of these products is the lack of palatability, which may hinder homecare efforts. (Holmstrolm *et al.* 1998a)

Proper application of these products requires only a small amount of the solution be used. Ideally, the rinse should be directly applied to the surface of the teeth and gingiva. In most cases, however, getting the solution between the cheek and teeth is the best the client can achieve.

An additional option for active home oral care is the use of soluble zinc salts. Studies show that these products can be effective in decreasing viable plaque biomass (Wolinsky *et al.* 2000). One veterinary labelled oral zinc ascorbate gel has been proven to decrease plaque and gingivitis, (Clarke 2001b) and provides the additional advantage of being tasteless, which should improve acceptance. Ascorbic acid has been shown to support/induce collagen synthesis, which may improve healing following dental scaling and/or oral surgery (Murad *et al.* 1981; Pinnel *et al.* 1987)

Barrier Sealants

A final option for active homecare is the application of a commercially available barrier sealant, which has been shown to decrease the accumulation of plaque and calculus. One of the commercially available sealants functions by binding electrostatically to the teeth and creating a hydrophobic surface which is designed to prevent plaque attachment (Gengler WR 2005). The other is a hydrophilic polymer that dries clear and rapidly to seal the gingival sulcus against plaque formation and has pores designed to allow water and oxygen to pass through (Sitzman C 2013).

Passive Homecare

Since passive homecare requires minimal effort by the owner, compliance is more likely. This is important since long term consistency is the key factor in the efficacy of home dental care (Ingham & Gorrel 2001). It has been shown that the compliance rate with tooth brushing with highly motivated pet owners is only around 50% after 6 months (Miller & Harvey 1994). In fact, one study showed that passive homecare may be superior to active homecare simply due to the fact that it is actually performed (Vrieling *et al.* 2005).

Pet foods, supplements and treats are often used as adjuncts to or substitutes for tooth brushing for home plaque control. These products and techniques should always be used in combination with professional dental care. These methods are considered "passive" forms of homecare, meaning the client is not "actively" removing the plaque or applying rinses or gels (Niemiec 2013d).

Dental foods or treats may help as an adjunct for control of plaque and calculus. It is critical to remember that tartar is generally non-pathogenic and plaque control above the gingival margin does not improve periodontal disease (Westfelt *et al.* 1998; Niemiec 2008b; DeBowes 2010). As an example, wild carnivores have reportedly had significantly less calculus on their teeth but had a similar level of periodontal disease to their domestic counterparts (Verstraete *et al.*, 1996; Clarke & Cameron 1998; Steenkamp & Gorrel 1999). Furthermore, one human study found that clinical attachment gains were not related to the degree of residual calculus (Sherman 1990). Therefore, when making recommendations to our clients we must look for products which clean beneath the gingiva for subgingival effect (see below).

Pet Food Regulations and the Veterinary Oral Health Council (VOHC)

Many diets and treats claim that they improve dental health. These claims may include: "cleans teeth", "freshens breath", "promotes healthy gums", or "aids in prevention of periodontal disease" (Logan *et al.*, 2006). While by labelling regulation, claims should be true, some can be too vague to come under the regulations and therefore may have little evidence as to their effectiveness. The Association of American Feed Control Officials (AAFCO) and the European Pet Food Industry Federation (FEDIAF) do not allow claims for prevention of treatment of dental (or any other) disease for pet foods or treats (AAFCO.org; FEDIAF.org), although AAFCO does discuss claims for dental tartar.

The best way to determine if a product is effective is to look for published-peer reviewed research which validates the claims. If this is available, you can recommend it as effective, so make sure to ask representatives for study information. However, this research will take a bit of effort, therefore a valuable tool for busy practitioners is the Veterinary Oral Health Council (VOHC) (vohc.org). The VOHC provides an objective means of recognizing commercially available products that meet pre-set standards of effectiveness in controlling accumulation of dental plaque and calculus (tartar) in dogs and cats. If a pet food or treat is approved by the VOHC, there is reasonable assurance that it is effective in preventing or decreasing plaque or calculus. However, as stated above, published studies and the VOHC only provide whole tooth scoring, which may or may not actually improve periodontal status. The VOHC is a nonregulatory agency which includes representatives from professional dental colleges as well as allied veterinary groups. The VOHC council consists of nine veterinary dentists and dental scientists with experience of scientific protocols and study design, and a non-voting Director.

The VOHC does not test products; rather they establish the protocols and standards and review the research. The research is performed by the company itself and a detailed report of the testing submitted for review. The VOHC provides independent and objective reviews of the tests of products submitted. Claims may be based on mechanical or chemical means of improving dental health. The VOHC awards a Seal of Acceptance for two categories: helps control plaque and helps control tartar. Furthermore, to obtain VOHC approval, the product must also be a safe consistency for the patient to chew and not damage the teeth.

Pet Food Effects on Oral Health

Passive homecare alone will not be able to maintain clinically healthy gingiva and is only a part of the plaque control regimen. The downfall of most chew-based products is that pets typically do not chew with the entire mouth and therefore areas will be missed. Passive homecare is most effective on the chewing teeth, and in contrast, active homecare is superior for the incisor and canine teeth. Therefore, a combination of active and passive homecare is best.

Wet, Dry and Homemade Diets

The diet can affect the oral environment via maintenance of tissue integrity, metabolism of plaque bacteria, effects on salivary flow and composition, and the effects of contact on the tooth and oral surfaces. A common conception in small animal practice is that feeding dry pet foods decreases plaque and calculus and canned foods promote plaque formation. This is because the crunching action of biting into a hard kibble should clean the teeth. Further, dry food leaves less residue in the mouth for oral bacteria to feed on and so plaque accumulates at a slower rate. Despite that, many animals fed on commercial dry diets still have heavy plaque and calculus accumulations and periodontal disease (Harvey *et al*. 1996; Logan *et al*. 2006). In one study, dogs and cats eating soft foods did have more plaque and gingivitis than animals eating a more fibrous food (Watson 1994). In other studies, moist foods have shown a similar effect to a typical dry food on plaque and calculus accumulation (Boyce & Logan 1994; Harvey *et al*. 1996). Finally, standard dry foods break apart at the incisal edge of the teeth, providing minimal to no cleaning at the gingival margin, which is where it matters (Westfelt, *et al*. 1998; Niemiec 2008c). A study comparing home prepared foods vs commercial wet and/or dry foods showed that feeding a home prepared diet increased the probability of oral health problems in cats. There was a significant benefit of feeding commercial food compared to home prepared when at least part of the diet was a dry pet food for dogs and cats (Buckley *et al*. 2011). Another study showed an improvement in periodontal disease, dental deposits (tartar) and decreased prevalence of lymphadenopathy in cats fed a dry food compared to a soft or homemade food (Gawor *et al*. 2006).

For dry diets, the kibble size, texture and composition significantly affect the effect of the kibble on the teeth. The effects include alteration of plaque bacteria, cleaning of the tooth, and maintenance of tissue integrity. Dietary fibre also exercises the gums, promotes gingival keratinization and has some teeth cleaning effects (Logan 2006). Dietary fibre can affect plaque and calculus formation; however, as the pet bites into most standard kibbles they may shatter and crumble, which provides little to no mechanical cleaning (Logan *et al*. 2010).

Dental diets

Several commercial dry diets for adult dogs and cats have been formulated with increased oral cleaning ability compared with standard pet foods. The mechanical action of these foods is provided by a kibble with a larger size and texture which promotes chewing and maximizes contact with the teeth. Foods with the right shape, size and physical structure can provide plaque, stain and calculus control (Jensen *et al*. 1995; Logan 2006). One important point is that even though these products may decrease plaque and calculus, they are typically most effective on the areas around the cusp tips and not at the gingival margin. If the diet is properly designed, the teeth sink into the kibble before it splits. As the tooth is penetrating the kibble, the fibre in the food gently abrades the tooth surface, thereby removing plaque (Jensen, *et al*. 1995). Studies have shown that some dental foods can provide significant plaque, calculus and stain control in cats and dogs, especially when used with dental prophylaxis (Jensen *et al*. 1995; Logan *et al*. 2002;). Currently, only one diet has published evidence to actually have a positive effect on gingival inflammation. A six-month study comparing feeding this dental diet to a typical maintenance diet revealed approximately a 33% reduction of plaque and gingival inflammation with dental diet (Logan *et al*. 2002). These diets are usually high-fibre maintenance diets for adult animals, which would not be appropriate to support growth, gestation/lactation, or any pet with a high calorie requirement. Dental diets are intended to be fed as the main food source. Research has found that the best results were obtained when a dental diet is the main food, but that there was still a measurable but declining benefit when a prescription diet was fed as 75%, 50% and even 25% of the total calorie intake. Using a dental diet simply as a treat will not meet expectations for the product (Hale 2003).

Dental treats

Plain baked biscuit treats and chew toys (e.g. string and rope toys) have not shown to be of benefit for the prevention of periodontitis (Roudebush *et al*. 2005). Dental chews made from a compressed wheat, cellulose incorporated into treats, and rawhide chews have good evidence for efficacy (Hennet P 2001; Roudebush *et al*., 2005; Stookey 2009; Beynen *et al*., 2010). Furthermore, the addition of chlorhexidine has shown benefit in the reduction of plaque in animal studies. (Rawlings 1998) Some have received VOHC approval, although there are no dental chews with a VOHC seal of approval for plaque reduction in cats (vohc.org). Of the available products, only a handful have been clinically proven to decrease gingivitis (Gorrel & Bierer 1999; Gorrel *et al*. 1999; Brown & McGenity 2005; Stookey 2009, Clarke *et al*. 2011, Quest BW 2013). A food additive product containing the brown algae, *Ascophyllum nodosum*, has been shown to improve oral health status (Gawor *et al*. 2018). Canines and incisors are not effectively cleaned by most chew-based products.

Risks of Dental Chews

While uncommon, esophageal foreign body obstruction due to dental chews has been reported in dogs, especially in smaller breeds (Leib & Sartow 2008). In addition, there have been two case reports of tongue entrapment by a chew toy with a round opening (Rubio *et al*. 2010). Some dental chews are relatively high calorie, and can contribute to weight gain and obesity if the calorie content is not taken into account in the pet's overall consumption. Excess consumption of chews can also unbalance the diet as they are usually not formulated to be a complete source of nutrients. Those treats which can be chewed and swallowed may also result in gastrointestinal upset in some pets.

Tooth fractures are a risk for very hard dental treats such as antlers, hooves, or nylon bones. The British Veterinary Dental Association notes that "Many veterinary dentists are reporting that they are seeing fractured teeth as a direct result of chewing on antler bars; in particular, the maxillary fourth premolar tooth" (BVDA 2017). Recommendations of techniques that can be utilized to evaluate for excessive treat hardness include being able to dent the treat with a fingernail (Hale 2003).

Additives

Some diets and treats contain antiseptics or additives to retard or inhibit plaque or calculus accumulation. Sodium hexametaphosphate (HMP) forms soluble complexes with cations (e.g. calcium) and decreases the amount available for forming calculus. (White *et al.* 2002; Hennet 2007). Adding HMP to a dry diet decreased calculus in dogs by nearly 80% (Stookey *et al.* 1995), however, tartar is not a major player in the development of gum disease. Studies have shown no difference in plaque or calculus when HMP-coated biscuits were fed to dogs for 3 weeks (Stookey *et al.* 1996; Logan *et al.* 2010).

The addition of antiseptics to treats or water additives are an attractive method for treating periodontal disease. However, as previously noted, plaque bacteria have resistance to concentrations of antiseptics up to 500,000 times that which would kill singular bacteria (Elder *et al.* 1995; Socransky et al., 2002; Quirynen *et al.* 2006). Therefore, while the substance may have a positive effect on singular bacteria, in most cases at standard concentrations it is beneficial but not when diluted in the drinking water.

Chlorhexidine has been proven to have efficacy as an oral antiseptic which may reduce plaque, especially as a perioperative or preprophylaxis rinse (Roudebush *et al.* 2005) although it may enhance mineralisation of plaque to calculus (Hale 2003). However, sufficient contact time is likely not achieved when using as a rinse. In addition, reports of efficacy are variable (for example the addition of chlorhexidine to rawhide chews provided a reduction in plaque but had no effect on the degree of gingivitis) (Rawlings 1998; Brown & McGenity 2005). Along with chlorhexidine, a new chew additive is the anti-plaque agent delmopinol, which has been shown to decrease plaque and calculus (Claydon N *et al.* 1996), however not as effectively as chlorhexidine (Reddy R 2017).

Enzyme systems may contain glucose oxidase and lactoperoxidase, lysozyme or lactoferrin. These are well studied on the human side and there is even low-grade evidence for efficacy in dogs and cats for oral anti-bacterial effects (Hale 2003).

Water additives

A study on the effects of a xylitol drinking water additive showed reduced plaque and calculus accumulation in cats (Clarke 2006). Concerns about xylitol will limit the use of this ingredient, as at high concentrations it may cause hypoglycaemia. However, in veterinary products, the concentration is very low and has been proven to be safe for healthy dogs when used at the recommended dose (Anthony 2011). There are other products in this category without published evidence of efficacy; however, some may have VOHC approval.

Vitamin and mineral deficiencies

Deficiencies in vitamin A, C, D and E and the B vitamins folic acid, niacin, pantothenic acid and riboflavin have been associated with gingival disease (Logan *et al.* 2010). Diets deficient in calcium may result in nutritional secondary hyperparathyroidism, which can cause periodontal disease (Roudebush et al. 2005). These vitamins and minerals are adequate in diets which meet AAFCO or FEDIAF guidelines but can be deficient in diets which don't meet those guidelines, such as many homemade diets.

Natural diets and feeding raw bones

Proponents of feeding raw bones have claimed that this improves the cleanliness of teeth in pets. Further claims are sometimes made that feeding commercial pet food contributes to the high prevalence of periodontal disease in domesticated cats and dogs. However, the skulls of 29 African wild dogs eating a "natural diet", mostly wild antelope, also showed evidence of periodontal disease (41%), teeth wearing (83%) and fractured teeth (48%) (Steenkamp & Gorrel 1999). A study in small feral cats on Marion Island (South Africa) which had been eating a variety of natural foods (mostly birds) showed periodontal disease in 61% of cats, although only 9% had evidence of calculus (Verstraete *et al.* 1996). In a study in Australia of feral cats eating a mixed natural diet there was less calculus compared to domestic cats fed dry or canned commercial food, although again there was no difference in the prevalence of periodontal disease between the two groups (Clarke & Cameron 1998). In a study on eight Beagle dogs fed cortical bone (bovine femur) there was an improvement in dental calculus, although no effect on plaque was reported (Marx *et al.* 2016).

These studies show that feeding raw bones may aid in cleansing teeth, however, there are currently no published studies that they are beneficial for periodontal disease. There is also the risk of fractured teeth and potentially of the spread of zoonotic disease (LeJeune & Hancock 2001; Lenz *et al.* 2009, Furtado *et al.* 2007).

Probiotics

Nitric oxide (NO), an important inflammatory mediator, has been shown to be increased in human periodontitis (Matejka *et al.* 1998; Lappin *et al.* 2000; Hirose *et al.* 2001) and agents blocking the production of NO or its effects might be therapeutically valuable (Paquette & Williams 2000). *Lactobacillus brevis (L brevis)* is a probiotic bacterium which contains high levels of arginine deiminase. High levels of arginine deiminase inhibit NO generation by competing with nitric oxide synthase for the same arginine substrate. Studies in humans showed topical application of probiotics *containing L brevis decreased* inflammatory mediators involved in periodontitis (Della Riccia *et al.* 2007). Studies using probiotics in treatment of periodontal disease in humans have shown improved gingival health, as measured by decreased gum bleeding. The probiotic strains used in these studies *include L. reuteri strains, L. brevis (CD2), L. casei Shirota, L. salivarius WB21, and Bacillus subtilis. L. reuteri and L. brevis (Haukioja 2010), Preliminary results of a study of topical L brevis CD2 in dogs* showed a reduction of gingival inflammatory infiltrates.

Conclusions

Homecare is a critical aspect of periodontal therapy, but it is often ignored. Early and consistent client education is the key to compliance. There are numerous options available, but tooth brushing remains the gold standard. While the common myth of dry food cleaning the teeth is appealing, standard dry foods do not appear to significantly decrease the risk of periodontitis. Dental diets or treats may confer some benefit and it is recommended to look for products that have published peer reviewed research and/or the VOHC seal of approval, especially for plaque reduction. Products need to clean down to and below the gingival margin. Feeding standard dry foods or raw bones may decrease dental calculus, but there is not much evidence for a decrease in the risk of periodontitis.

Key Points:

- Daily homecare is recommended since plaque accumulates in 24 hours.
- Without homecare, the efficacy of professional periodontal therapy is severely limited.
- Tooth brushing is the gold standard and is most effective on rostral teeth.
- Passive homecare methods may or may not be effective, and any provided benefit will be mainly on the caudal teeth.
- Standard dry dog and cat food is not beneficial for oral health.
- A combination of active and passive methods is likely the best choice.

SECTION 6: DENTAL RADIOLOGY

DENTAL RADIOGRAPHY FOR DOGS AND CATS

Full-mouth dental radiographs are performed as part of the dental patient diagnostic work-up, especially if the animal is presented for the first time, or if the clinical condition has changed significantly since the previous visit. Dental radiographs aid in diagnosis and guide treatment. They are also an important part of the legal record, and can be extremely valuable in client education. Full-mouth dental radiographs will reveal about 40% more pathology than was found on the clinical examination (Verstraete *et al.* 1998a, b) (see oral pathology section). Due to costs, practitioners are often forced to balance the desire for a full-mouth set of radiographs with their client's financial constraints. However, at least obtaining dental radiographs of the teeth clinically found to be diseased is mandatory.

Equipment and Techniques

Dental radiography requires a dental x-ray unit (e.g., wall-mounted, mobile, hand-held) and a detection system (e.g., conventional intraoral dental films, "direct" digital radiography (DR), or computed radiography (CR)) (Niemiec 2010c, Niemiec *et al.* 2004a,

Figure 131. Demonstrating the parallel technique for imaging the mandibular premolar and molar teeth on a model.

Wiggs & Lobprise 1997). However, in tier 1 countries, medical x-ray equipment with extra-oral plates will provide diagnostic information (Mulligan TM *et al.* 1998) (see section on Equipment).

There are three standard techniques to obtain dental radiographs: parallel technique (for mid to caudal mandibles), extra-oral or near-parallel technique (for caudal maxillae in cats), and bisecting angle technique for all other areas (Wiggs & Lobprise 1997; Mulligan *et al.* 1998) Niemiec *et al.* 2004a; Niemiec & Furman 2004a&b; AVDC 2016). All radiographs are obtained with the patient under general anaesthesia. (See anaesthesia section)

Parallel technique

Place the film/sensor/phosphor plate intra-orally, positioned lingually to the teeth to be radiographed, so that the film is parallel to the long axis of the target teeth. The film must project beyond the ventral margin of the mandible and dorsal to the crowns of the tooth/teeth. When imaging large teeth with a size 2 sensor, two radiographs may be necessary. A clear 3 mm margin of film must be evident around the tooth being radiographed. Position the x-ray tube so that the central x-ray beam is perpendicular to the film **(Figure 131, black lines)**, and bring the x-ray tube as close as possible to the object (tooth) **(Figure 132).** Finally, make sure the area of interest is within the circumference of the tube (AVDC 2016).

Bisecting angle technique

The bisecting angle technique is used when the film cannot be placed parallel to the tooth and perpendicular to the x-ray beam due to anatomy of the oral cavity and teeth – i.e. for all maxillary and rostral mandibular teeth. The film is placed in the mouth so that the

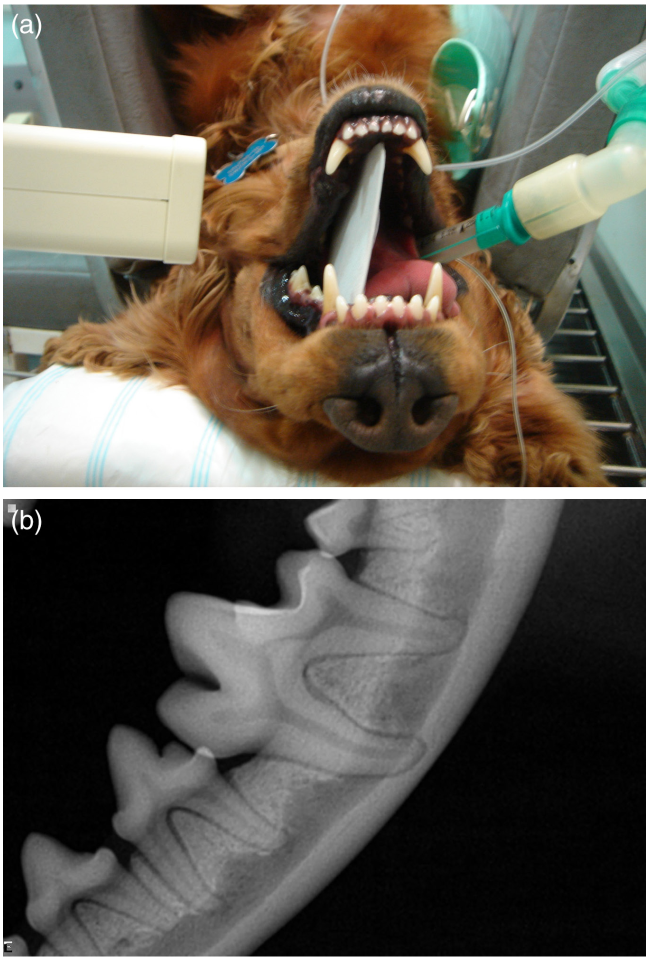

Figure 132. Demonstrating the parallel technique for imaging the mandibular premolar and molar teeth in a canine patient. a). The film is placed parallel to the teeth/tooth roots and the beam is angled perpendicular to both (131 black arrows). b) The resulting image of the molar and distal premolar teeth.

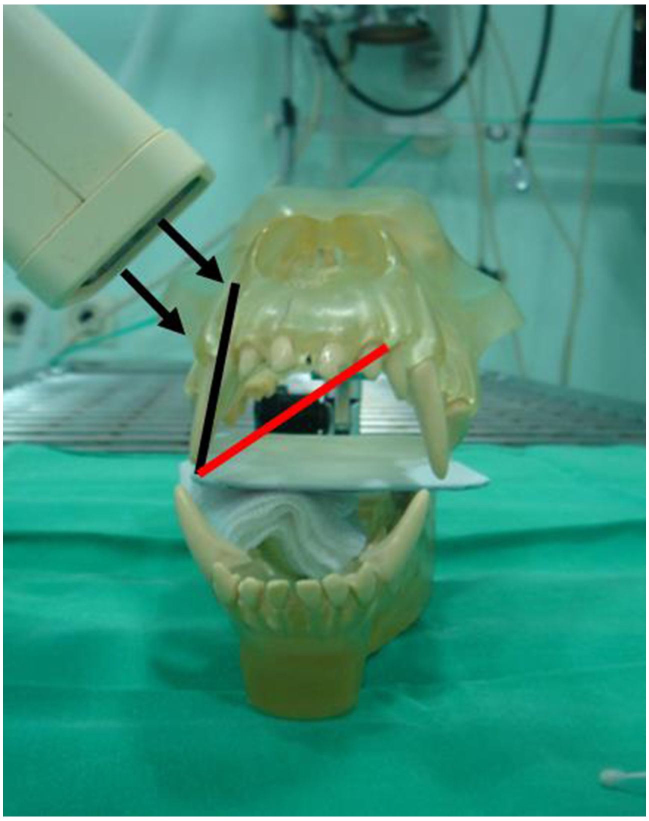

Figure 133. Demonstrating the bisecting angle technique on a model. Approximate the angle formed by the long axis of the tooth to be radiographed (black line) and the plane of the film. Then bisect this angle with an imaginary line (red line) and position the x-ray tube so that the central x-ray beam is perpendicular to the imaginary bisecting line (black arrows).

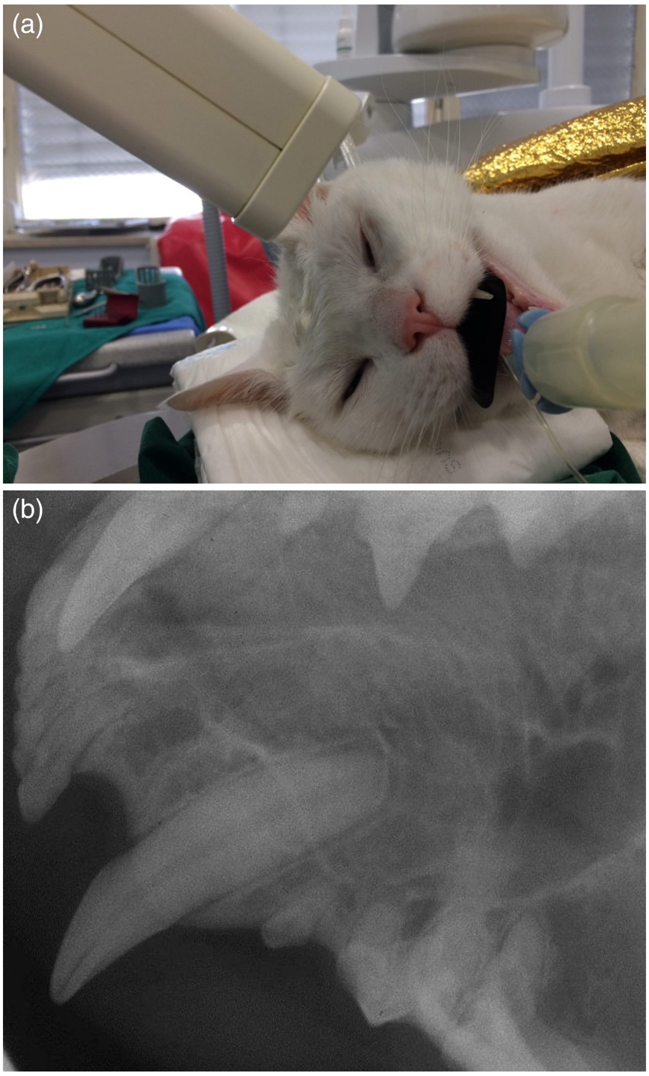

Figure 134. a) Correct positioning of the tube head to image the maxillary canine in a feline patient. b) Resultant image of the maxillary canine.

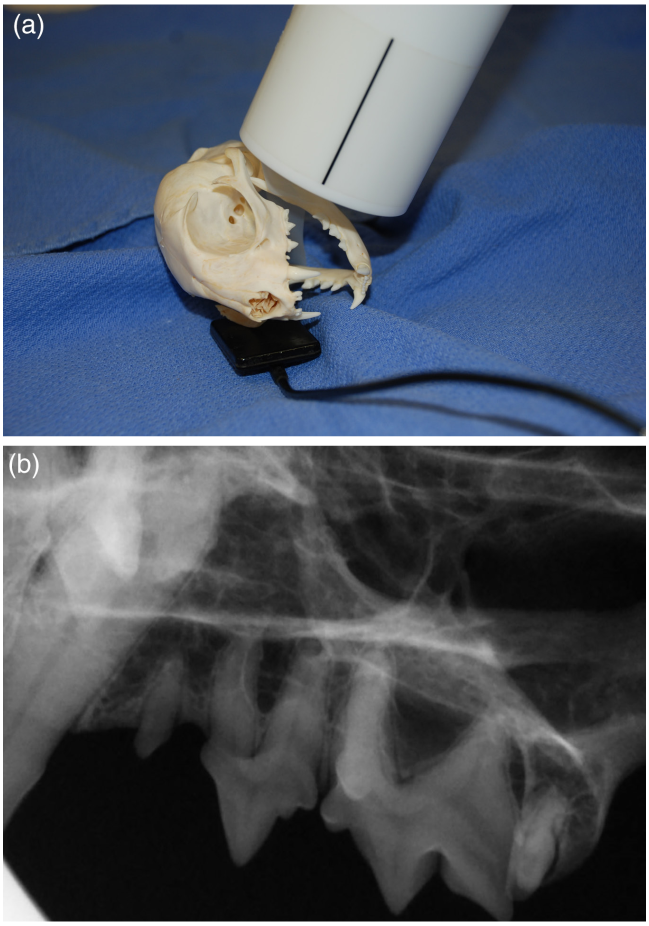

Figure 135. a) Correct positioning of the tube head and transducer to perform the extraoral technique to image the maxillary premolars and molars without zygomatic arch interference. b) Resultant image of the maxillary premolars and molars. When evaluating these radiographs it is important that they are opposite of what would be the case with intra-oral films. Therefore, these images should always be marked "Extra-oral".

tip of the film will rest on the crown of the tooth being examined while the remainder of the film will span across the mouth/palate. Visualize the angle formed by the long axis of (tip of the root to tip of the crown) the tooth to be radiographed **(Figure 133 black line)** and the plane of the film. Then bisect this angle with an imaginary line **(Figure 133 red line)** and position the x-ray tube so that the central x-ray beam is perpendicular to the imaginary bisecting line (**Figure 133 black arrows and 134).** Place the x-ray tube as close as possible to the tooth and check that the teeth of interest are within the circumference of the tube (AVDC 2016). If using size #4 or #5 draw the tube slightly away from the tooth/jaw so that the divergent beam leaving the tube will expose the whole plate. If too close, coning-off will happen (part of the plate is not exposed).

Extra-oral near parallel technique

The extra-oral near-parallel technique is used to radiograph the maxillary premolar and molar teeth in cats to avoid superimposition of the zygomatic arch over the roots of the teeth of the caudal maxilla, which often happens when using the intraoral bisecting angle technique (Niemiec 2018a; Niemiec & Furman 2004b; AVDC 2016a). Position the cat in lateral recumbency and place a film on the table under the cat's head/maxilla (the side to be radiographed is closer to the table/film). The patient's mouth is held open using a gentle gag (only use a gag for a short period of time – e.g., just to obtain the radiograph – to avoid possible complications associated with mouth gag use – See anaesthesia section). Then, one option is to position the cat's head slightly obliquely (to avoid superimposition of the contralateral maxillary teeth) and position the x-ray tube so that the central x-ray beam is perpendicular to the film. To use the maximum amount of the film (e.g., if using #2 size film), position the head so that the tips of the cusps of the teeth to be radiographed are lined up along the edge of the film **(Figure 135)**.

Intra-oral near-parallel technique

To utilize this technique, the film is placed diagonally across the mouth, keeping the mouth open (acting somewhat as a mouth gag). It should rest on the palatal surface of the opposite maxillary teeth and on the lingual surface of the ipsilateral mandibular teeth. The beam is then placed almost parallel to the plate (almost perpendicular to the tooth roots). (Woodward TM 2009) **(Figure 136).**

Standard views

Standard views for the dog include 1) occlusal view of maxillary incisors and canine teeth (bisecting angle technique), 2) lateral view of the maxillary canine teeth (bisecting angle technique), 3) rostral maxillae (P1-P3; bisecting angle technique), 4) caudal maxillae (P4-M2; bisecting angle technique), 5) occlusal view of the mandibular incisors and canine teeth (bisecting angle technique), 6) lateral view of the mandibular canine teeth (bisecting angle technique), 7) rostral mandibles (P1-P3; bisecting angle technique) and 8) caudal mandibles (P4 - M3; parallel technique) (AVDC 2016).

Standard views for the cat include 1) occlusal view of the maxillary incisors and canine teeth (bisecting angle technique), 2) lateral view of the maxillary canine teeth (bisecting angle technique), 3) extra-oral (near-parallel) view of the maxillae (P2-M1), 4) occlusal view of the mandibular incisor and canine teeth (bisecting angle technique), 5) lateral view of the mandibular canine teeth (bisecting angle technique), 6) caudal mandibles (P3-M1; parallel technique).

In addition, other view(s) for separation of the superimposed mesiobuccal and mesiopalatal roots of the maxillary fourth premolar teeth should be included (Niemiec & Furman 2004a; AVDC 2016).

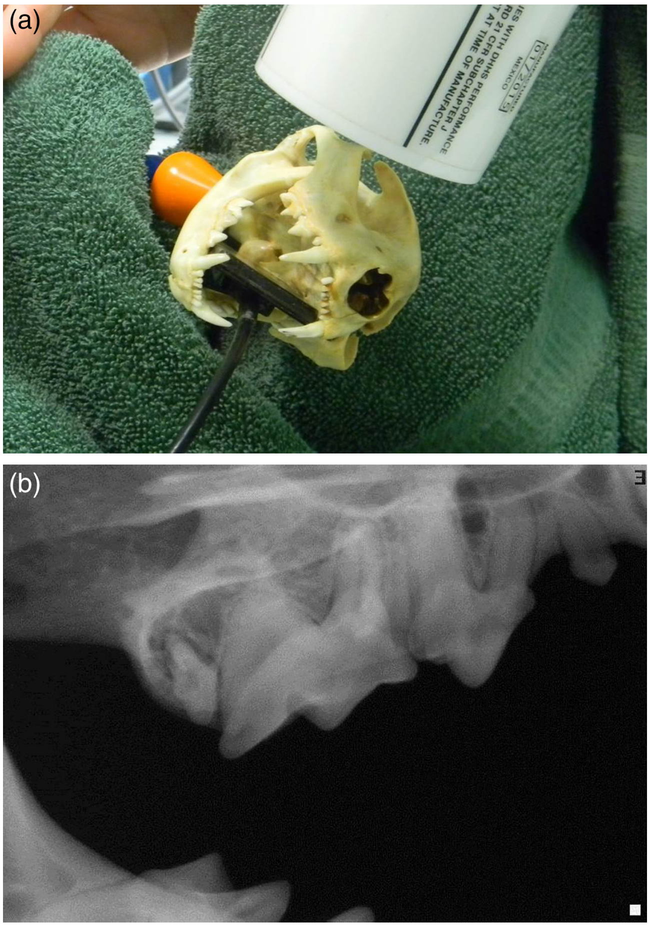

Figure 136. a) Positioning of the tube head and transducer to perform the near parallel technique to image the maxillary premolars and molars without zygomatic arch interference. b) Resultant image of the maxillary premolars and molars.

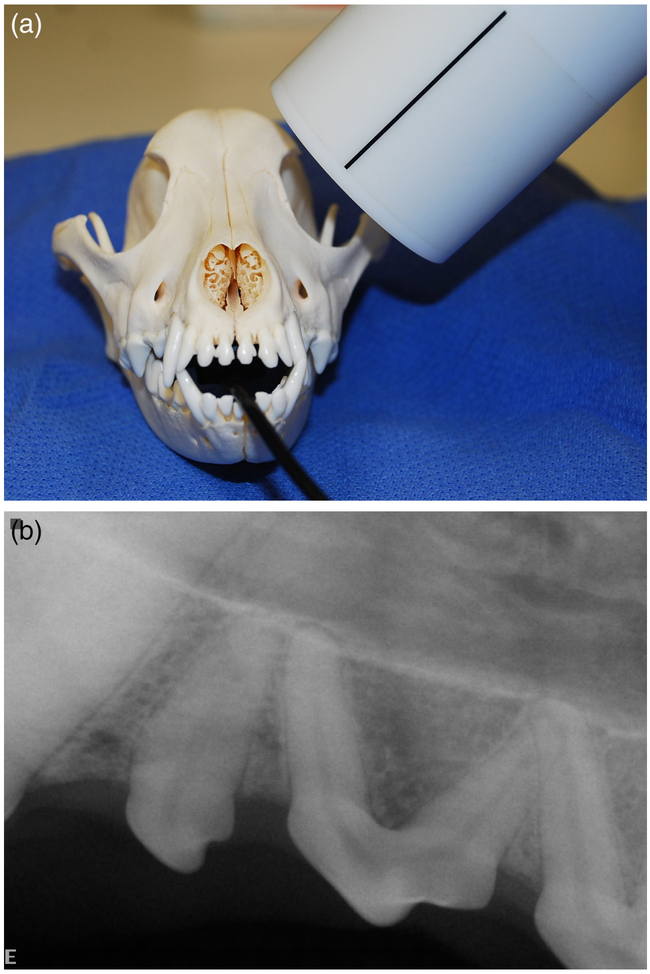

Figure 137. a) Positioning of the tube head (45 degrees to the transducer) to image the maxillary premolars and molars in a canine patient. b) Resultant image of the maxillary first and second premolars in a canine patient. To image the caudal teeth, the sensor and tube head angle are maintained with both being moved caudally.

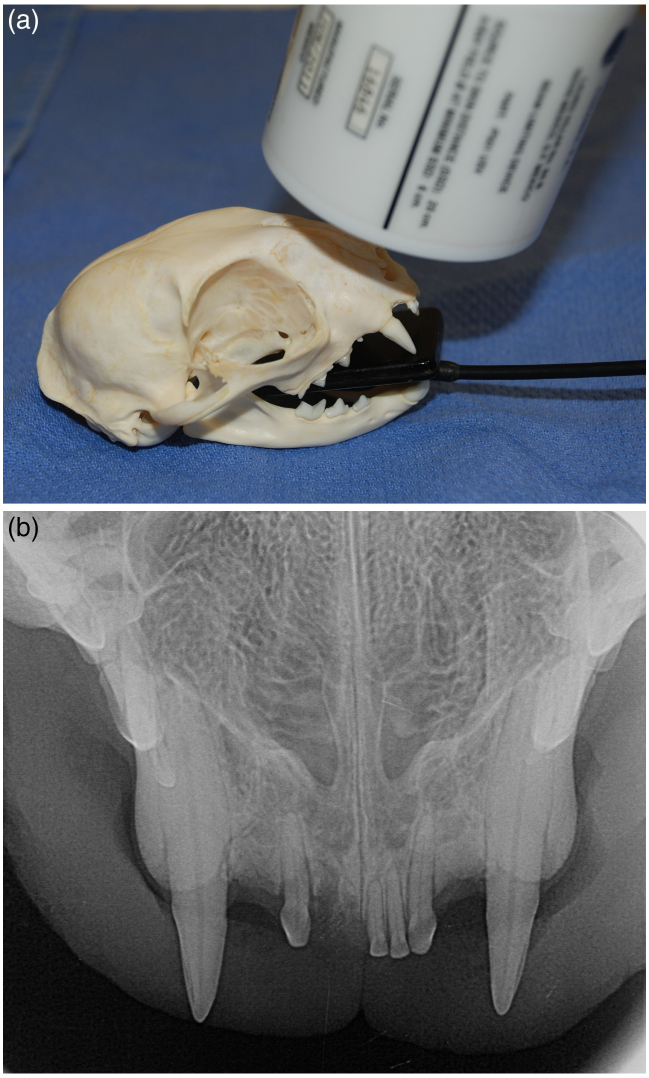

Figure 138. a) Positioning of the tube head to image the maxillary incisors in a feline patient. b) Resultant image of the maxillary incisors.

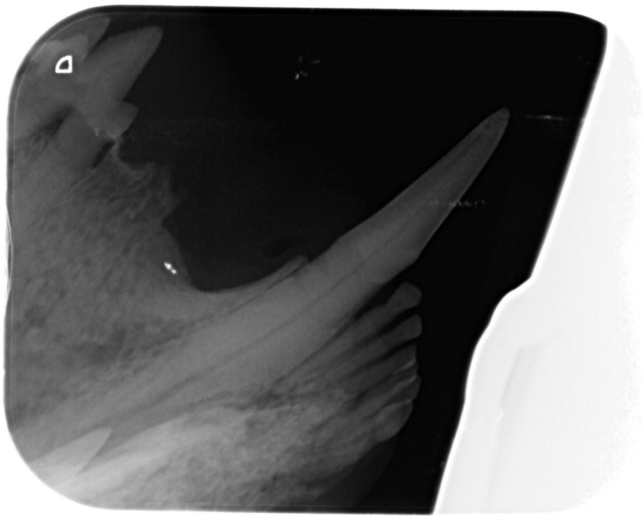

Figure 139. Intraoral dental radiograph of the mandibular right canine in a cat demonstrating significant elongation. To correct this error, angle the tubehead more perpendicular to the sensor/film.

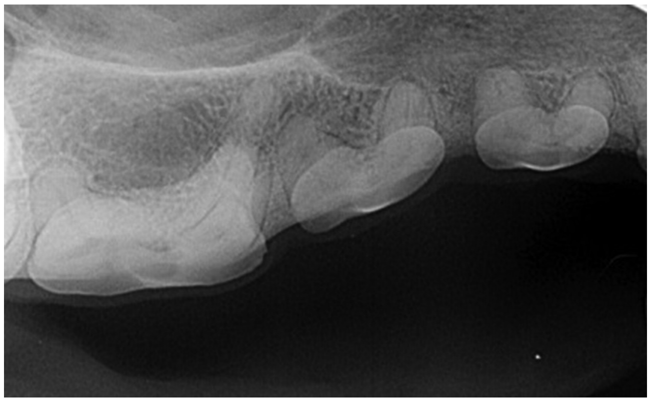

Figure 140. Intraoral dental radiograph of the maxillary premolars in a dog demonstrating severe foreshortening. To correct this error, angle the tubehead more perpendicular to the teeth.

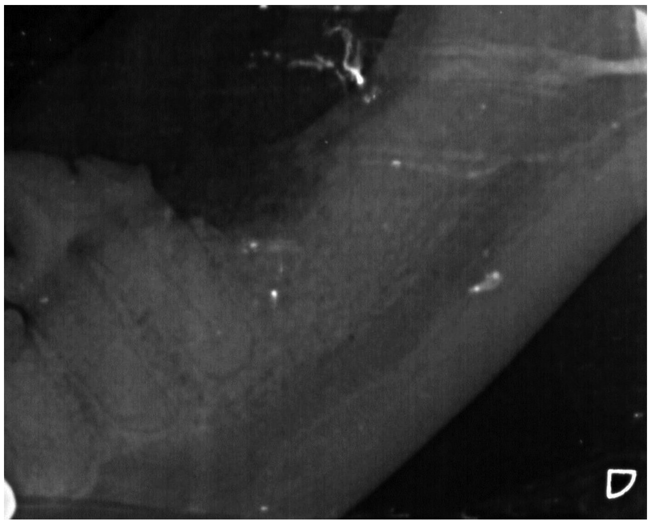

Figure 141. Non-diagnostic radiograph: "too dark", blood on the plate causing the artifacts and incorrect positioning.

The simplified approach to dental radiology was developed by Woodward (2009). This technique does not utilize direct measurement of any angle, but instead relies on approximate angles to create the image. This is not the most scientifically accurate method, but consistently produces diagnostic images. There are only 3 angles used for all radiographs in this system 20, 45, and 90 degrees.

The *mandibular* premolars and molars are exposed at a 90-degree angle (parallel technique) **(See Figure 131)**. Maxillary premolars and molars have roots that are approximately vertical from the crowns, and the sensor is positioned essentially flat across the palate, creating a 90-degree angle. Therefore, the maxillary premolars and molars are imaged with a 45-degree x-ray sensor bisecting angle. **(Figure 137)**

The roots of the canines and incisors curve caudally approximately 40-degree angle to the palate/mandibular gingiva and therefore are imaged with a 20-degree angle rostro-caudally **(Figure 138)**. Note, the mandibular canines are more curved than the maxillary, which may necessitate a slightly greater angled technique)

Interpretation of Dental Radiographs

Technical quality

Once the radiographs are obtained, they should be evaluated for technical quality (e.g., Is the area of interest on the image? Is there any elongation/foreshortening of the teeth? **(Figures 139 & 140)**. What is the quality of exposure? Are there any processing errors?) **(Figure 141)** (Mulligan *et al.* 1998, Niemiec 2018b, Niemiec *et al.* 2004b).

Mounting of dental radiographs

Radiographs should be oriented using “labial/buccal mounting”

1. If using conventional dental films ensure that the embossed dot/orientation mark faces up for all radiographs, where intra-oral technique was used. (Ensuring dot orientation is not necessary on digital systems as it is standard orientation.)
2. Crowns of the maxillary teeth should point down and crowns of mandibular teeth up.
3. Occlusal views are in the center, with first incisor teeth at the midline.
4. Molar teeth are on the periphery.

This orientation results in the radiographs of the teeth from the patient’s left side to be on the right side and vice-versa (note positioning of extra-oral views). (AVDC 2016).

For an example of proper mounting of radiographs please visit: https://www.avdc.org/Rad_Dog_3.pdf

Interpretation of dental radiographs

Diagnostic quality radiographs must be systematically examined. Interpretation of dental radiographs requires knowledge of normal dental radiographic anatomy in order to be able to diagnose any anatomical / developmental abnormalities, periodontal pathologies, endodontal pathologies and other abnormalities (Niemiec 2005b, Dupont & Debowes 2009) **(See Oral Pathology Section)**.

Key Points

- Dental radiology is critical for proper diagnosis and treatment of oral conditions.
- Standard (analog) film as well as digital systems are acceptable for dental radiology.
- Both the parallel and bisecting angle techniques are required to obtain full mouth radiographs in small animal patients
- Labial/buccal mounting is the accepted standard.
- Special techniques (e.g. extraoral/near parallel) are required to properly image the maxillary cheek teeth in cats.

SECTION 7: DENTAL EXTRACTIONS

INTRODUCTION

Dental extractions are a very commonly performed procedure in most veterinary practices, yet they are not a simple undertaking. They are typically performed to remove an infected and/or painful tooth. Indications include, but are not limited to endodontic disease (i.e. fractured or some intrinsically stained teeth), severe periodontal disease, traumatic malocclusion, persistent deciduous teeth, tooth resorption, chronic gingivo-stomatitis, and unerupted teeth.

Extractions (open or closed) are surgical procedures which in some circumstances can be very challenging and complicated. The WSAVA Dental Guidelines Committee joins the AVDC in recommending that all extractions be performed only by qualified and properly trained veterinarians.

Complete extraction of the diseased tooth almost invariably resolves the existing disease state. However, when extractions are improperly performed, even simple procedures can have numerous iatrogenic complications, including haemorrhage, osteomyelitis, oronasal fistula, forcing of a root tip into the mandibular canal or nasal cavity, jaw fracture, and ocular damage (Holmstrolm *et al.* 1998b; Taylor 2004; Smith *et al.* 2003; Smith 1998). However, the most common iatrogenic complication is retained tooth roots (Woodward 2006a; Moore & Niemiec 2014). This generally results in continued infection in and around the retained root (Woodward 2006a).

A guideline for proper and successful closed dental extractions is summarized in the following 10 steps. These steps constitute the technique for a single rooted tooth; however multi-rooted teeth are treated the same way following sectioning. Large teeth and those with root malformations are best treated with an "open" approach including mucoperiosteal flap creation and bone removal.

<u>Step 1: Obtain Consent</u>

Never extract a tooth without prior owner consent, no matter how advanced the problem, or how obvious it is that extraction is the proper therapy (Holmstrolm et al. 1998b). This consent is preferably written, but acceptable verbally via a phone call. If the client cannot be reached and prior consent was not obtained, do not extract the tooth (Niemiec 2008d).

<u>Step 2: Obtain preoperative dental radiographs</u>

Dental radiographs should be made of all teeth prior to commencing the extraction (note in tier 1 countries conventional radiology may be acceptable) (See equipment section) (Gawor 2018); Niemiec 2009, Niemiec 2014). Radiographs allow the practitioner to determine the amount of disease present, any root abnormalities, or resorption/ankylosis (Blazejewski *et al.* 2006; Niemiec 2009) Significant mandibular alveolar bone loss secondary to periodontal disease weakens the bone, and predisposes patients to an iatrogenic fracture. Dentoalveolar ankylosis makes extraction by traditional elevation practically impossible. For this reason, crown amputation and intentional root retention is acceptable for advanced Type 2 feline tooth resorption, as determined via dental radiographs (DuPont 1995). In summary, dental radiographs provide critical information for treatment planning and the successful outcome of dental extraction procedures. Finally, radiographs provide solid evidence in the medical record (Niemiec 2009).

<u>Step 3: Ensure proper visibility and accessibility</u>

Patients should be positioned to allow maximum visibility of the oral procedure area, and to allow for the surgeon to be most comfortable and therefore more successful (Holmstrolm et al. 1998c). Surgical lighting should be bright and focused on the surgical field. Suction, air/water syringes, and gauze should be utilized continually to keep the surgical field clear. Finally, magnification can be useful (Niemiec 2008d, Niemiec 2014).

<u>Step 4: Pain Management</u>

Extractions are surgical procedures causing moderate to severe pain, a multimodal analgesic approach should be employed, as this provides superior analgesia (Kelly *et al.* 2001; Lenz 2003). (See anaesthesia section)

<u>Step 5: Cut the gingival attachment</u>

This can be performed with a scalpel blade, periosteal elevator, or dental elevator. The selected instrument is placed into the gingival sulcus with the tip of the blade angled toward the tooth, which helps keep the instrument within the periodontal ligament space. Failure to do so may result in creating a mucosal defect or cutting through the gingiva. The instrument is then advanced apically to the level of the alveolar bone, and carefully worked around the entire tooth circumference (Hobson 2005; Niemiec 2008d). **(Figure 142)**

<u>Step 6: Elevation</u>

Elevation/luxation is the most delicate and dangerous step in the extraction procedure. Elevators are sharp surgical instruments and there are numerous critical and delicate structures in the area. There have been many reports of eyes that have been injured by extraction instruments as well as at least one confirmed fatality due to an elevator puncturing a patient's brain. (Smith *et al.* 2003) In order to avoid causing iatrogenic trauma in the event of instrument slippage or upon encountering diseased bone, the index finger is placed near the tip of the instrument (Blazejewski *et al.* 2006; Niemiec 2008d) **(Figure 143)**. It is important to select an instrument which matches the curvature and size of the root. (Woodward 2006a) In general "go small", as this will result in less pressure and damage being created **(Figure 144)**.

There are numerous instruments available, including the classic elevator as well as luxating and winged types. (see equipment section) Classic and winged elevators are used in an "insert and twist" motion to tear the periodontal ligament, whereas luxators are used in a rocking motion during insertion to fatigue as well as cut the periodontal ligament. Veterinarians may be tempted to gently twist luxators for elevation, but they are not designed for this and can be easily damaged when used in this manner.

Elevation is initiated by inserting the instrument firmly yet gently into the periodontal ligament space (between the tooth and the alveolar bone) (Niemiec 2014) **(Figure 145)**. The insertion should be performed while keeping the instrument at a 10 - 20-degree angle toward the tooth, to avoid slippage (Harvey & Emily, 1993a, Niemiec 2014). Once in the space between the bone and the tooth, the instrument is gently twisted (Wiggs & Lobprise 1997). Hold the position for 10-30 seconds to fatigue and tear the peri-

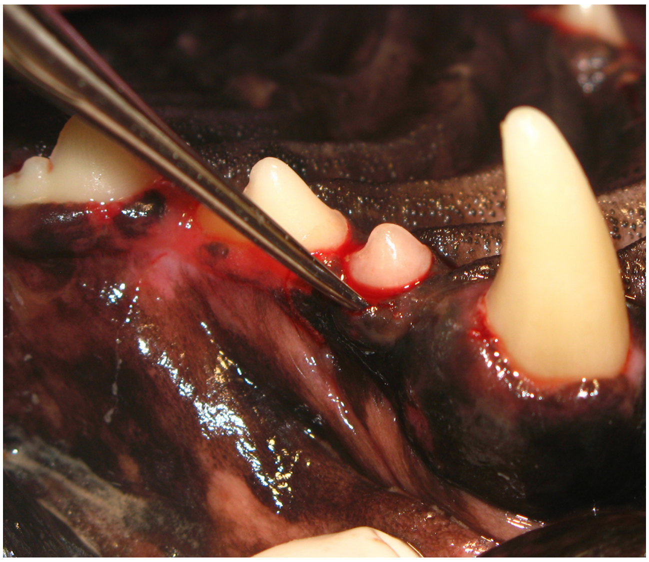

Figure 142. Cutting the gingival attachment: The bevel of the elevator is placed against the tooth and the instrument is angled approximately 20 degrees to the long axis of the tooth. The instrument is firmly but carefully inserted all the way to the alveolar margin. This is repeated all the way around the circumference of the tooth.

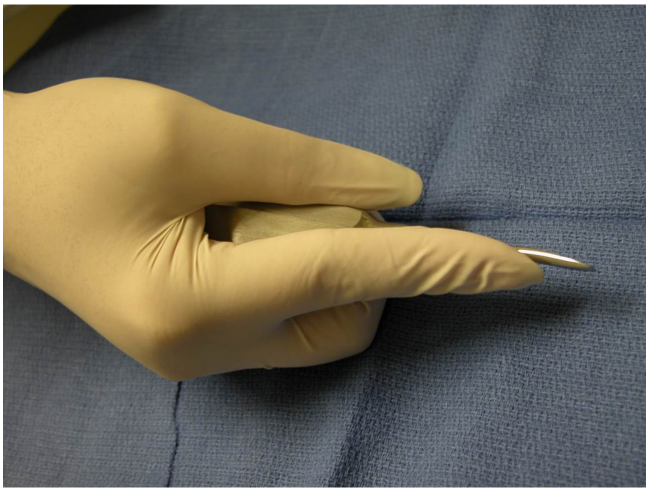

Figure 143. Correct handling of a dental elevator. The handle is gripped firmly in the palm of the hand with the index finger extended to approximately 1-cm from the tip. This will give maximum control while helping prevent iatrogenic truama if the instrument slips.

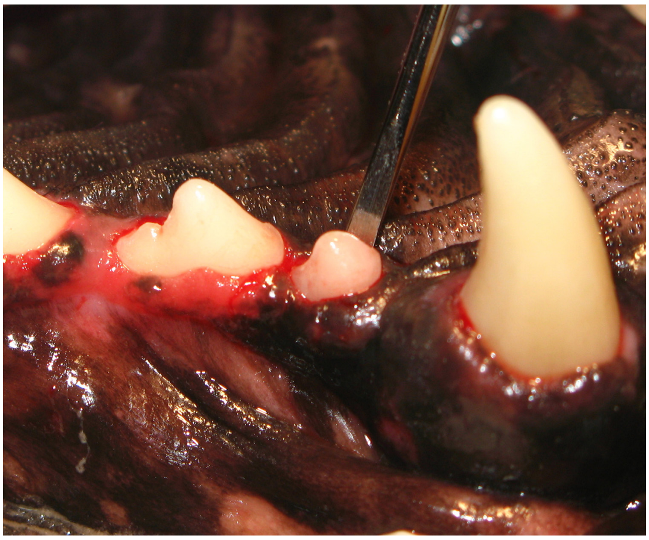

Figure 144. Selecting an elevator with a smaller width then the tooth will allow easy access to the periodontal ligamant space for proper elevation.

Figure 145. Elevation: As in figure 142, the elevator is angled approxiamtely 20 degree toward the tooth and inserted firmly but carefully into the periodontal ligamant space. Once in position, it is gently twisted and held in that position for a minimum of 10 seconds. Following this, it is repositioned and this is repeated around the tooth until it is loose enough to easily extract.

odontal ligament (Holmstrolm et al. 1998b). One important point is that the tooth should move at least slightly during elevation. If the tooth does not move, no damage is being done to the periodontal ligament.

Luxation is performed by gently inserting the luxator into the gingival sulcus and “rocking” it as the instrument is advanced apically. Many veterinary dentists use a combination of luxation and elevation when utilizing luxating elevators.

The periodontal ligament is very effective in resisting short, intense forces (Niemiec 2014). It is only by the exertion of prolonged force (i.e. 10-30 seconds) that the ligament will become weakened. Increased pressure will transfer much of the force to the alveolar bone and tooth which can result in the fracture of one of these structures. Therefore, it is important to moderate the force. After holding for 10 - 30 seconds, reposition the instrument about 1/8 of the way around the tooth and repeat the above step. Continue 360 degrees around the tooth, each time moving the elevator apically as much as possible (Wiggs & Lobprise 1997; Holmstrolm et al. 1998b; Niemiec 2014).

The key to successful elevation is patience. Only by slow, consistent elevation will the root loosen without breaking. It is always easier to extract an intact root than to remove fractured root tips (Blazejewski *et al.* 2006; Woodward 2006a; Niemiec 2008d). If

Figure 146. Correct adaption of the extraction forceps on the maxillary first premolar of a dog. Gripping the tooth at the gingival margin provides the most secure grip while decreasing the lever arm and thus lessening the chances of root fracture.

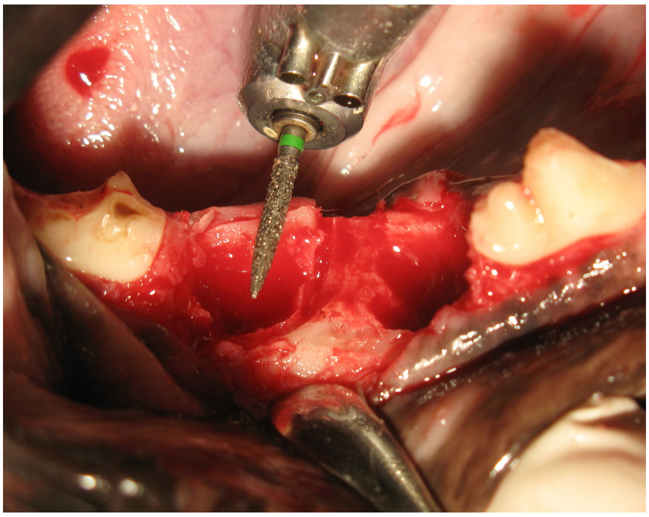

Figure 147. Smoothing the rough margins of alveolar bone with a coarse diamond bur prior to closure.

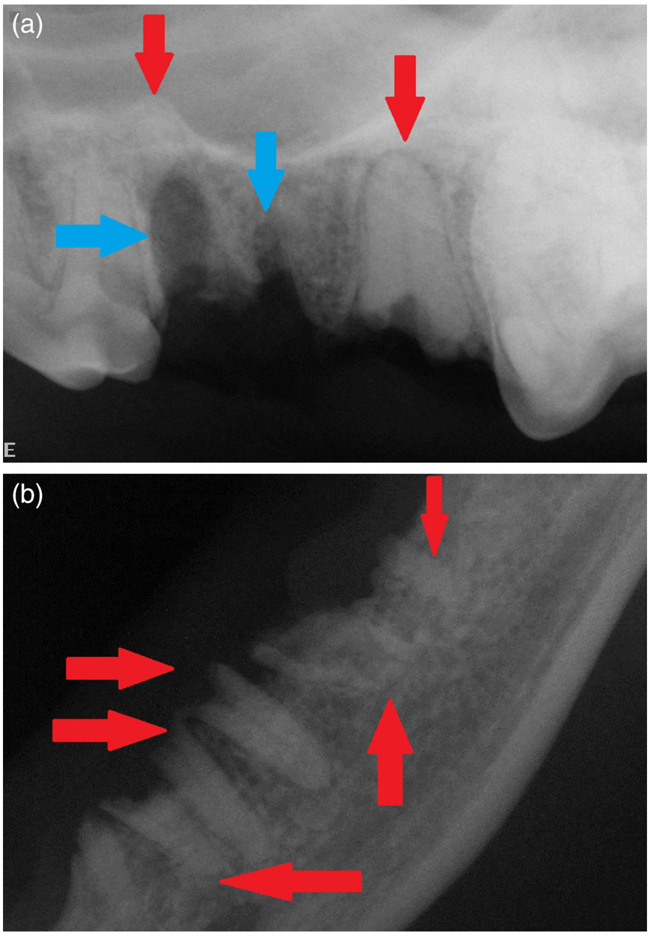

Figure 148. Dental radiographs of prior extractions of the left maxillary fourth premolar (208) in a dog (a) and left mandible in a cat (b). Both images demonstrate numerous retained roots (red arrows). In (a), atomization of roots was attempted (blue arrows). This is a contra-indicated technique as can be seen in this failed attempt. Open extraction consisting of a mucogingival flap and buccal bone removal is the technique of choice.

the elevation does not result in tooth mobility in a short period of time, there is a problem. This may be due to faulty extraction technique, or an area of dentoalveolar ankylosis. If the extraction is not going well, a surgical approach is a good option. Consider repeating the radiographs to determine if there are reasons for the lack of success.

Step 7: Extract the tooth

Removing the tooth should only be attempted after the tooth is very mobile and loose. This is accomplished by grasping the tooth with the extraction forceps and gently pulling the tooth from the socket **(Figure 146)**. If the root is round in cross-section, or mildly curved gentle rotation is acceptable; the torque should be maintained for a minimum of 10 seconds. Do not apply undue pressure as this may result in root fracture (Wiggs & Lobprise 1997; Niemiec 2008d).

It is helpful to think of the extraction forceps as an extension of your fingers. Undue pressure should not be applied. If the tooth does not come out easily, more elevation is necessary. Start elevation again until the tooth is loose enough to be easily removed from the alveolus. This is an important point, because root fractures appear to occur more commonly with extraction forceps than with elevators (Niemiec 2015).

Step 8: Alveoloplasty

This step is performed to remove diseased tissue or bone, or any rough bony edges that could irritate the gingiva and delay healing. Diseased tissue can be removed by hand with a curette. Bone removal and smoothing is best performed with a coarse diamond bur on a water-cooled high-speed air driven hand-piece or Rongeurs. (Harvey & Emily 1993a; Wiggs & Lobprise 1997; Smith 1998; Frost Fitch 2003; Taney & Smith 2006) **(Figure 147)**.

Step 9: Obtain a postoperative dental radiograph

Dental radiographs should be exposed post-extraction to document complete removal of the tooth (Holmstrolm *et al*. 1998b, Niemiec 2009). A recent study reported that 92% of carnassial tooth extraction sites in dogs and cats have retained roots (Moore & Niemiec 2014) **(Figure 148 a & b)**.

A retained root tip may become infected, or more commonly act as a foreign body creating significant inflammation (Wiggs & Lobprise 1997; Ulbricht 2003). There are rarely any clinical signs observed with this complication, but the retained root is painful and/or infected. Occasionally, this problem causes a draining tract from the retained roots, which may result in a malpractice claim (Holmstrolm *et al*. 1998b).

Step 10: Closure of the extraction site

This is a controversial subject among veterinary dentists, and thus some texts recommend suturing only in large extractions. However, many authors recommend suturing almost all extraction sites. Closure of the extraction site promotes haemostasis and improves post-operative comfort and aesthetics. It is always indicated in cases of larger teeth, or any time that a gingival flap is created to allow for easier extraction. This is best accomplished with size 0 to 5/0 synthetic, monofilament absorbable sutures on a reverse cutting needle. Closure is performed with a simple interrupted pattern with sutures 2 to 3-mm apart **(Figure 149)**. It is further recommended to utilize one additional throw over manufacturer's recommendations to counteract tongue action (Harvey & Emily 1993a; Wiggs & Lobprise 1997; Smith 1998; Frost Fitch 2003; Taney & Smith 2006).

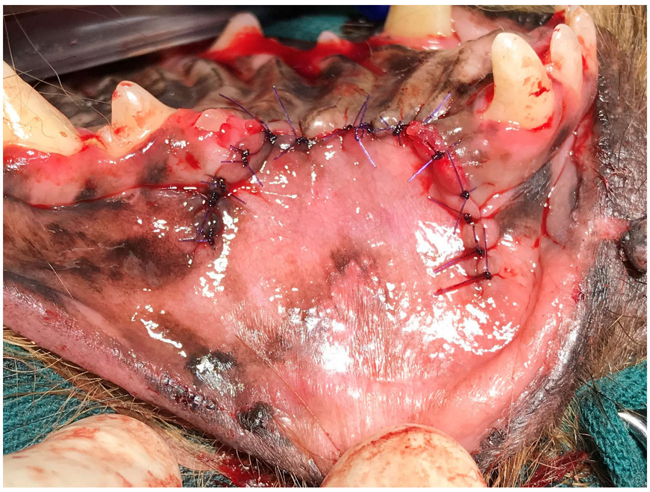

Figure 149. Closure of the extraction site of the left maxillary canine (204) using simple interrupted sutures placed 2-3 mm apart.

In regards to flap closure, there are several key points associated with successful healing (Wiggs & Lobprise 1997). The first and most important is that there must be no tension on the incision line. If there is any tension on the suture line, it will dehisce. Tension can be removed by extending the gingival incision along the arch (called an envelope flap) or by creating vertical releasing incisions and fenestrating the periosteum (Frost Fitch 2003; Blazejewski *et al.* 2006). The periosteum is a very thin fibrous tissue which attaches the gingiva and buccal mucosa to the underlying bone (Evans 1993; Grant *et al.* 1998b). The periosteum is inelastic, preventing advancement of the gingiva and alveolar mucosa and prevent closure of the defect without tension. The alveolar mucosa is very flexible and therefore can be advanced following periosteal release to close large defects. If there is no tension, the flap should stay in position when placed using fingers, then sutured in place. Fenestration can be performed with a scalpel blade; however, LaGrange scissors offer more control, ensure that all tissue edges have been thoroughly debrided as intact epithelial tissues will not heal (Blazejewski *et al.* 2006). This is most important when closing an oronasal fistula.

Extraction of Multirooted Teeth

Section all multi-rooted teeth into single rooted pieces. (Smith MM 1998, Charmichael DT 2002) The roots of almost all multi-rooted teeth are divergent, which will cause the root tips to break off if extractions are attempted in one piece **(Figure 150)** (Wiggs & Lobprise 1997; Manfra Marretta 2002). Sectioning of mobile teeth facilitates their extraction. The best tool for sectioning teeth is a bur on a high-speed air driven handpiece (Charmichael 2002; Blazejewski *et al.* 2006; Terpak & Verstraete 2012). Besides being the most efficient tool, it also has air and water coolant that will avoid overheating the surrounding bone, (which may cause necrosis). Many different styles of burs are available; however, many authors prefer a cross-cut taper fissure bur (699 for cats and small dogs, 701 for medium dogs and 702 for large breeds) (Wiggs & Lobprise 1997; Niemiec 2008d, Niemiec 2014). (See equipment section)

Section multirooted teeth, starting from the furcation and progressing through the crown. (Niemiec 2014) **(Figure 151)**. This method is used for two major reasons. First, it avoids the possibility of missing the furcation and cutting down into a root, weakening

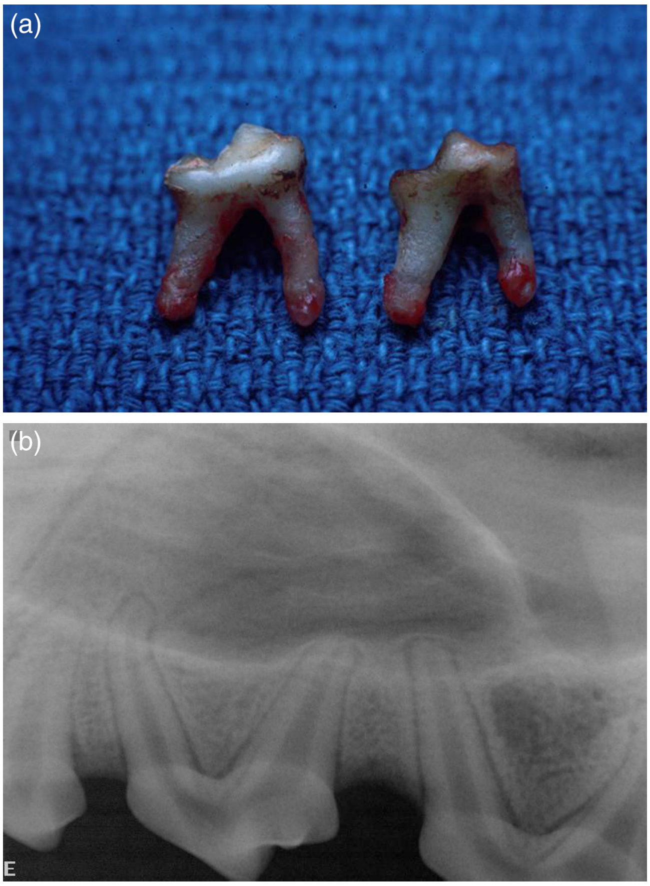

Figure 150. (a) Due to advanced periodontitis (PD4) these two excessively mobile two-rooted teeth were removed without sectioning. However, sectioning of multi-rooted teeth is highly recommended to avoid root fracture, especially if dental radiographs show significant attachment remaining or anatomical variations, such as a dilacerated mesial root as evident on the dental radiograph of this maxillary second premolar tooth in a dog (b).

it and increasing the risk of root fracture (Smith 1998). Secondly, this technique also avoids the possibility of cutting past the tooth and inadvertently damaging the gingiva or alveolar bone.

Two rooted teeth are generally sectioned in the middle to separate the tooth into two halves. The mandibular first molar in the cat is an exception due to its disproportionate roots (see below). Proper sectioning of a three-rooted molar tooth in a dog is performed by cutting between the buccal cusp tips and then just palatally to them. **(Figure 152)**. After the tooth has been properly sectioned, follow the above steps for each single rooted piece.

Open Extractions:

Difficult extractions are best performed via an open approach (Niemiec 2008d, Niemiec 2014). This is typically thought of as the canine and carnassial (maxillary fourth premolar and mandibular first molar) teeth. However, it is also beneficial for teeth with root malformations or pathology and retained roots (Frost Fitch 2003; Blazejewski *et al*. 2006; Woodward 2006a). An open approach allows the practitioner to remove a small amount of buccal alveolar bone, promoting an easier extraction process.

An open extraction is initiated by creating a gingival flap. This can be a horizontal flap along the arch (an envelope flap) or a flap with vertical releasing incisions (Blazejewski *et al*. 2006). An envelope flap is created by releasing the gingival attachment with a periosteal elevator along the teeth including one to several teeth on either side of the tooth or teeth to be extracted (Grant *et al*. 1988). The flap is created by incising the gingiva in the interdental spaces along the arch and then releasing the tissue to or below the level of the muco-gingival junction (MGJ). **(Figure 153)**. The advantage to this flap is that the blood supply is not interrupted and there is less suturing.

The more commonly used flap includes one or two vertical releasing incisions. (Holmstrolm et al. 1998b, Niemiec 2014) (Figure 26). This method allows for a much larger flap to be created, which (if handled properly) will enable closure of larger defects. Classically, the vertical incisions are created at the line angle of the target tooth, or one tooth rostral and caudal to the target tooth (Smith 2003). If there is space between the teeth, either a naturally occurring diastema or edentulous area, the incision can be made in this space rather than extending it to a healthy tooth (Niemiec 2014) **(Figure 154)**.

The incisions should be made slightly apically divergent (wider at the base than at the gingival margin) (Carmichael 2002, Manfra Marretta 2002). It is important that the incisions be created full thickness and in one motion (rather than slow and choppy). A full thickness incision is created by incising all the way to the bone, and the periosteum is thus kept with the flap (Manfra Marretta 2002; Frost Fitch 2003). Once created, the entire flap is *gently* reflected with a periosteal elevator. Care must be taken not to tear the flap, especially at the muco-gingival junction.

Following flap elevation, buccal bone can be removed with a carbide bur (Niemiec 2014; Terpak & Verstraete 2012). The amount is controversial, with some dentists removing the entire buccal covering and others removing only 1/3 of the root length of bone on the mandible and 1/2 for maxillary teeth (Smith 1998; Frost Fitch 2003). This should only be performed on the buccal side. If this does not allow for an expedient extraction, more can be removed.

Following bone removal, multirooted teeth should be sectioned (as above). Please note there are some authors that recommend sectioning prior to creating a flap. Follow the steps outlined for single root extractions for each piece. After the roots are removed (and radiographic proof obtained) the alveolar bone should be smoothed before closure (see alveoloplasty).

Figure 151. Sectioning of the left mandibular third premolar (307) tooth in a cat: a small envelope flap was created to expose the furcation of the tooth. A cross-cut taper fissure bur on a high-speed air-driven handpiece with water spray is used to section the tooth starting at the furcation and working through the crown of the tooth.

Figure 152. The maxillary first molar in dogs is sectioned in a "T" manner; a bur is held vertically and moved from mesial to distal close to the buccal cusps to section the wide palatal root from the two buccal roots, then the two buccal roots are separated through the groove between the cusps, by holding the bur vertically and moving it from buccal to palatal until connecting with the previously made cut. A soft tissue retractor should be used to avoid any damage of the buccal mucosa as evident in this case.

Figure 153. An extended envelope flap was created in this dog from the left mandibular second premolar tooth to the first molar tooth. Note moderate exposure of the alveolar bone below these teeth, enabling buccal bone removal that may be needed for successful extractions.

Figure 154. A pedicle flap was created at this right maxillary canine tooth in a dog by means of the marginal incision and two parallel vertical releasing incisions at the distobuccal line angle of the third maxillary incisor tooth and the mesiobuccal line angle of the first maxillary premolar tooth. This flap enables exposure of the alveolar bone and is mostly employed when a difficult extraction is expected or occurs during the procedure.

Figure 155. Before closure of the defect, there must be no tension on the suture line(s) that would predispose the flap to dehiscence. To achieve tension-free closure, blunt and sharp incision of the periosteum is performed at the base of the flap as demonstrated in this cadaver specimen, paying attention not to perforate the flap (preferably using scissors). However a scalpel or periosteal elevator can also be used effectively.

Closure is initiated with a procedure called fenestrating the periosteum **(Figure 155)**. The periosteum is a very thin fibrous tissue which connects the buccal mucosa to the underlying bone (Grant 1988). Since the periosteum is fibrotic, it is inflexible and will interfere with the ability to close the defect without tension. The buccal mucosa however, is very flexible and will stretch to cover large defects. Consequently, incising the periosteum takes advantage of this attribute. The fenestration should be performed at the base of the flap, and must be very shallow as the periosteum is very thin. This step requires careful attention, as to not cut through or cut off the entire flap. This can be performed with a scalpel blade; however, a LaGrange scissor allows superior control.

After fenestration, the flap should stay in desired position without sutures. If this is not the case, then tension is still present and further release is necessary prior to closure. Once the release is accomplished, the flap is sutured as described above in the closure section.

Crown Amputation

Teeth which have advanced Type 2 replacement resorption of the roots can be treated by crown amputation (Dupont 1995). Crown amputation results in significantly less trauma to the patient and faster healing than complete extraction. This procedure, although widely accepted, is still controversial. Most veterinary dentists employ this technique, however in widely varying frequency. Veterinary dentists typically use this treatment option only when there is significant or complete root replacement by bone. Unfortunately, the majority of general practitioners use this technique far too often. Crown amputation can only be performed if certain criteria are met (Niemiec 2015). (See Oral Pathology section)

These are:

- Radiographically confirmed type 2 TRs
- No evidence of endodontic disease (periapical rarefaction)
- No evidence of periodontal bone loss,
- No radiographically evident root canal
- No radiographic evidence of a periodontal ligament
- Not treating caudal stomatitis.

Practitioners without dental radiology should not perform crown amputation. Patients which have teeth suspected of having Type 2 resorptive lesions should be referred to a facility with dental radiology.

Technique

Crown amputation is initiated by creating a small gingival envelope flap around the target tooth. Next, use a cross cut taper fissure, round or pear-shaped bur on a high-speed handpiece to remove the entire crown to the level of the alveolar bone. The bone and tooth should then be smoothed with a coarse diamond bur. Following radiographic confirmation that the tooth is removed to at least the level of the bone, the gingiva is sutured over the defect. This may require slight fenestration to relieve tension.

Conclusion

Extractions are a very common procedure in veterinary medicine and can at times be very frustrating, especially for the novice. When performed correctly, this treatment is an excellent means to alleviate oral pain and infection. However, if extraction procedures are not treated with proper respect, they can (and will) result in problems such as fractured root tips and/or more serious iatrogenic problems. By following the steps outlined above, and utilizing patience, extractions will become not only easier, but also more successful and rewarding.

Key Points

- Extractions are surgical procedures and must be treated with the same level of respect as any surgery to avoid complications.
- All extractions can be reduced to simple, single root extractions via sectioning and buccal alveolar bone removal. Therefore, master the basics and any extraction can be performed.
- Extractions are painful procedures, therefore proper pain management, including regional anaesthesia, should be provided for every patient.
- Crown amputation is an accepted method of therapy for advanced type 2 TR lesions in cats, but only if certain criteria (clinical and radiographic) are met.
- Never extract a tooth without client consent.

SECTION 8: THE UNIVERSITY'S ROLE IN DENTAL EDUCATION

The WSAVA Dental Standardization project committee highly encourages teaching veterinary dentistry in the university settings at both undergraduate and graduate levels.

TRAINING IN VETERINARY SCHOOL

Although oral and dental disease is very common in small animals, veterinary dentistry is still largely neglected in the veterinary medicine curriculum in most universities. There are few veterinary faculties worldwide that include dentistry in the regular curriculum, and only a handful more offer veterinary dentistry as an elective/optional course, usually with limited enrolment (Perry 2014). Veterinary dentistry training in all universities should include, at minimum: lectures on oral and dental anatomy and physiology, oral/dental examination techniques (including dental radiography), and the most common pathology and diseases. In addition, hands-on wetlabs on oral/dental examination, dental radiography, periodontal treatment, regional anaesthesia and basic principles of tooth extraction should be provided. Rotations through the dentistry department of the teaching hospital should be made available to provide "day-1 competence" skills as described in detail in the "Joint EVDS/EVDC Statement on Clinical Competencies in Small Companion Animal Dentistry and Oral Surgery". (Available also at: http://www.evds.org/policystatements/day1skills)

Veterinary dentistry as a specialty should be included in clinical activities to provide the necessary teaching environment with clinical cases for veterinary students. (Esteghamati *et al*. 2016) Establishing a veterinary dentistry department requires some investment in equipment; however, it is generally achievable in a cost-effective manner. (See equipment section) Moreover, veterinary teaching hospitals should strive to provide veterinary dentistry services at a specialist level. This can be achieved through employment of a Board-certified veterinary dentist (Dipl. AVDC, Dipl. AVDC-Eq, Dipl. EVDC, Dipl. EVDC-Eq) who provides clinical services as well as training to undergraduate and postgraduate (i.e. interns and residents) students. Alternatively, students should be given an option to complete their rotations in veterinary dentistry as externships with veterinary dentistry specialists in private practice. If no board-certified veterinary dentist is available in the country, a veterinarian with documented advanced training in veterinary dentistry (Fellow of the Academy of Veterinary Dentistry PhD, MSc or similar) should be included in teaching veterinary dentistry.

Postgraduate Training

PhD training

A PhD is currently the highest degree achievable in postgraduate training, and emphasizes research. In the future, veterinary dentistry-focused PhD training programs should ideally be formed and followed by a residency or vice-versa to train clinician-scientists (DeLuca *et al*. 2016).

Residency training

Residency in veterinary dentistry can currently be obtained through one of the two registered colleges worldwide - AVDC (American Veterinary Dental College, www.avdc.org) or EVDC (European Veterinary Dental College, www.evdc.org). Residency training is clinically-oriented training, although a resident needs to be involved in some research activities.

To enter into residency training, a veterinarian needs to fulfill certain criteria as described by the AVDC (http://www.avdc.org/register.html) or EVDC (http://176.32.230.22/evdc.info/?page_id=40). Usually at least 1-year internship (or the equivalent) is needed before enrollment. Once registered and in training, the resident has to prove a high level of knowledge and clinical skill as described in detail in the AVDC or EVDC documents. It can take between 2.5 – 6 years (a minimum of 3 years for an approved standard or alternate residency training program in EVDC; a minimum of 30 months for any approved AVDC training program) before the resident is eligible for the entry examination to the College. Only after the candidate successfully passes the practical and written examination are, they awarded Diplomate status. Ideally in the future, residency training is followed by or combined with PhD training (Bourgeois *et al*. 2015; DeLuca *et al*. 2016; Esteghamati *et al*. 2016). Currently, the level of university involvement in veterinary dentistry training is poor to nonexistent. Establishing training and residency programs in veterinary dentistry should be one of the main priorities of veterinary faculties worldwide.

Key Points:

- Veterinary dentistry is a largely neglected field in the veterinary medicine curriculum in most universities.
- Teaching veterinary dentistry at an undergraduate level should include lectures and hands-on workshops on basic examination techniques as well as most common oral/dental diseases and treatments.
- Teaching hospitals should establish a veterinary dentistry department, striving at providing dentistry services at a specialist level to create the necessary teaching environment.
- Postgraduate training in veterinary dentistry should include residency training, ideally in the future combined with PhD training.
- Effective teaching of veterinary dentistry in the veterinary school is the key to progression in this field of veterinary medicine.

POSITION STATEMENT ON ANAESTHESIA FREE DENTISTRY (AFD)

This document has a recurrent message; anaesthesia is required to effectively and thoroughly perform dental procedures, including a professional dental cleaning, complete oral examination, dental radiography, extractions, and any other necessary therapy (Wallis C, et al 2018)

The ineffectiveness and inappropriateness of AFD has been brought up in every relevant section including anaesthesia and welfare. The authors of these guidelines state AFD holds little benefit to the animal, at potentially great expense. AFD fails to provide reasonable medical benefit, and is stressful and potentially dangerous to the patient. Furthermore, as many veterinarians and owners falsely believe the need for dental therapy is based on the amount of visible tartar on the surface of the tooth, removing only this surface pathology without diagnosing or treating subgingival pathology may delay effective therapy for painful disease. In fact, a recent study has proven that non-professional dental scaling results in patients with ***worse*** periodontal health (Stella JL, et al 2018). AFD ultimately results in patients suffering from chronic pain and infection unnecessarily, when safe and ethically appropriate alternatives for effective care are available.

For all the reasons stated above, the WSAVA Dental Guidelines committee are of opinion that AFD poses a significant animal welfare concern as well as being below the standard of care. Thus, the WSAVA joins the following veterinary associations in vehemently opposing this practice.

International Societies:

- Academy of Veterinary Dentistry
- American Veterinary Dental College
- American Veterinary Dental Society
- American Animal Hospital Association
- American College of Anaesthesia and Analgesia
- European Veterinary Dental College
- European Veterinary Dental Society
- Federation of European Companion Animal Veterinary Associations

International Non-Dental Societies:

National Societies:

- **Australia:** Australian Veterinary Association
- **Austria:** Austrian Society of Veterinary Dentistry
- **Belgium:** Belgian-Dutch Scientific dental Society
- **Croatia:** Croatian Small Animal Veterinary Section
- **Czech Republic:** Czech Veterinary Dental Society
- **Finland:** Suomen Elinlääkripraktikot ry
- **France:** French Veterinary Dental Group
- **Germany:** German Veterinary Dental Society
- **Greece:** Hellenic Companion Animal Veterinary Society (HCAVS)
- **Ireland:** Irish Veterinary Dental Society
- **Italy:** Italian Society of Veterinary Dentistry and Oral Surgery
- **Japan:** Japanese Small Animal Dental Society
- **Netherlands:** Dental Working Group of the Netherlands
- **Norway:** Norwegian Small Animal Veterinary Association
- **Poland:** Polish Small Animal Veterinary Association
- **Portugal:** Portuguese Society of Veterinary Dentistry
- **Romania:** Romanian Society of Veterinary Dentistry
- **Russia:** Russian Small Animal Veterinary Association
- **Slovenia**: Slovenian Small Animal Veterinary Association
- **Spain:** Spanish Veterinary Dental Society
- **Sweden:** Swedish Veterinary Dental Society
- **Switzerland:** Swiss Society of Veterinary Dentistry
- **UK:** British Veterinary Dental Association; Royal College of Veterinary Surgeons

American:

- California Veterinary Medical Board
- Nevada Veterinary Medical Board
- Ontario Veterinary Medical Association

SECTION 9: NECESSARY EQUIPMENT

ORAL EXAMINATION

Assessment of the Conscious Patient

The oral examination ought to be one of the most commonly performed procedures in small animal practice. WSAVA believes that an oral examination must be an integral part of any wellness examination. A systematic approach with examination of both normal and abnormal structures is necessary for a thorough oral examination (Hansen 2009).

Equipment required for a detailed intraoral conscious examination includes: adequate room lighting, magnification, and a pen light. It is advisable that the clinician wear examination gloves to assess the oral cavity, both to protect the veterinarian and patient, as well as to decrease the risk of infection transmission. While light may seem obvious, many clinicians attempt to perform an examination in a poorly lit room with the unaided eye, with less than satisfying results. A pen light (or oto/ophthalmoscope) can be used to improve visualization as well as to transilluminate the tooth to determine vitality.

Proper patient positioning should provide the mouth at an appropriate level for comfortable evaluation by the inspecting veterinarian (ergonomic positioning is advantageous) (Aller 2005; DeForge 2002).

Required equipment for conscious oral examination in tier 1, 2, 3 countries:

1. A good light source
2. Examination gloves

Examination Under General Anaesthesia

After general anaesthesia and intubation have been achieved, a complete and thorough oral examination can and should be performed. All dental procedures must be performed under general anaesthesia (see Anaesthesia section). Endotracheal intubation is critical for dental procedures. Further protection of the respiratory tract with a pharyngeal pack is recommended, as well as properly sized e-tubes to avoid tracheal injury. Use of a laryngoscope will aid with intubation and inspection of the oropharyngeal area. **(Figure 156)**

Objects used to hold the mouth open and aid in visualization during a COHAT and other dental procedures performed should consist of appropriately sized props rather than spring loaded gags. Be aware of the risk of blindness with extended mouth opening in cats (Barton-Lamb Al *et al.* 2013; Martin-Flores *et al.* 2014; Scrivani *et al.* 2014).

- Temperature maintenance equipment:
  - Tier 1: hot water warming device
  - Tiers 2&3: Forced warm air device
- Anaesthetic techniques: Inhalational anaesthesia, total intravenous anaesthesia (TIVA), access to oxygen for preoxygenation and further use during inhalation anaesthesia, equipment for local nerve blocks
- Anaesthesia monitoring: body temperature, recording of pulse, respiratory rate, recording of blood pressure, measurement of expired CO_2, (tiers 2,3)
- Additional equipment: IV infusion pump (tier 3)

Following induction of anaesthesia, the clinician should closely evaluate the soft tissues including the tongue, gingiva, mucosa, oropharyngeal and tonsillar areas. Next, assessment of the hard tissues (including maxilla and mandibles) and dentition, both as a whole and individually, should be noted, including any missing, rotated and/or fractured teeth. An assessment of periodontal health is then made including probing depths (up to 6 probing points per tooth), gingival recession and hyperplasia, mobility, furcation involvement and other oral pathology. Both normal and abnormal findings should be recorded on a dental chart (See examination section) (Tutt 2006a).

Minimum equipment (Tier 1,2,3) required for a detailed intraoral examination includes:

1. A good light source
2. Magnification (e.g. loupes or magnifying glass)
3. Photography (camera or video - a mobile phone is acceptable)
4. Periodontal probe/explorer
5. Dental mirror
6. Lip retractor
7. Mouth gag (properly sized syringe case or plastic gag)
8. Personal protective gear (eyewear, mask and examination gloves). Periodontal probes are used to measure the depth of the gingival sulcus and periodontal pockets. They are typically a metal or plastic tapered rod with a blunt end attached to a handle, with

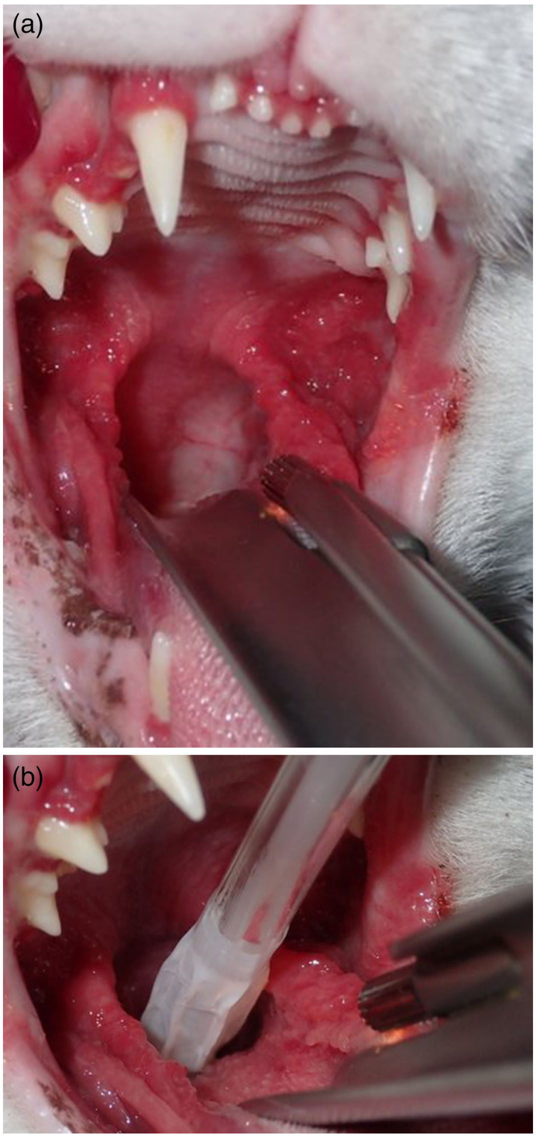

Figure 156. Just before endotracheal intubation with (if possible) a cuffed endotracheal tube, a laryngoscope is used to briefly examine the oropharyngeal area. Severe caudal stomatitis with inflammation extending into the pharynx is noted in this cat.

Figure 157. Williams 14 periodontal probe with markings at 1-2-3-5-7-8-9-10 (in millimeters).

Figure 158. A shepherd's hook dental explorer.

Figure 159. A dental mirror.

Figure 160. A Cawood minnesota soft tissue retractor.

Figure 161. Plaque on the dental and oral mucosal surfaces of this dog is visible after application of a plaque disclosing solution (2% erythrosine). The thickest plaque is where the dye is the darkest.

graduated millimeter markings. There are several types available. The Williams, Marquis, Michigan-O, UNC and Nabors, are commonly available **(Figure 157)**.

The probe allows the clinician to measure and assess gingivitis index (bleeding on probing), depth of the sulcus or pocket, degree of gingival enlargement and/or recession, and furcation exposure (in multi-rooted teeth).

An explorer is often found on the opposite end of the periodontal probe. It is a sharp tipped instrument that may be used by the clinician to explore calculus both supra- and sub-gingivally; dental defects such as resorptive lesions, pulp exposure, attrition, abrasion, lost enamel or dentine may also be assessed **(Figure 158)**.

A dental mirror is an important diagnostic aid for the assessment of the palatal or lingual surfaces of dentition as well as the caudal part of dentition and the nasopharynx **(Figure 159)**.

The lip retractor is used to improve the visualization of the caudal dentition either for assessment or for photography. It may be used during dental procedures to improve visibility of the surgical area **(Figure 160)**.

Another option for diagnosis is plaque disclosing solutions: the greater the thickness of plaque on the tooth surface, the darker the dye. The most common one stage dye is erythrosine. Prior to cleaning the teeth, a drop of 2% erythrosine is placed on the supragingival tooth surface and washed off with a gentle stream of water. Fluorescein may also be utilized. Another tool utilizes a blue light (approximately 405 nm wavelength) that causes mature plaque to glow red (due to porphyrins within the plaque). This quantitative light-fluorescence or QLF tool can be used in a darkened consultation room to demonstrate mature plaque (Wallis C *et al* 2016, Marshall-Jones *et al*. 2017). **(Figure 161).**

Radiology/Radiography

Oral radiology and radiography are important for adequate diagnosis and decision making in veterinary dentistry. Performing dentistry without radiography greatly increases the likelihood of missing pathology as well as creating iatrogenic trauma.

To produce a diagnostic radiograph, the necessary equipment includes an x-ray generator **(Figure 162)**, dental film **(Figure 163)** and developer solution or a digital dental system and a computer with appropriate software. For dental purposes, it is always better to use dental X ray machine, however diagnostic images can be obtained with the use of the full body X-Ray and appropriate technique. It should be pointed out that full body radiographs will generally be of insufficient detail for proper dental diagnosis and are very difficult to expose. Therefore, dental generators and intraoral film/sensors are always recommended. When radiographing small objects (i.e. toes) or small patients (e.g. pocket pets), the dental X-Ray machine may be utilized as a full body device.

There are several options for obtaining diagnostic dental images:

1. Conventional veterinary x-ray generator (Tier 1)
2. Dental radiology generator plus:
   a. Non-screen intra-oral dental film (Tier 2)
   b. Photostimulable Phosphor (PSP) plates (CR system)
   c. Digital sensors (DR system)

Figure 162. A wall-mounted dental x-ray generator in the dental operatory. The generator is attached to a long arm to enable to easily reach the patient on the dental table.

Figure 163. A set of conventional intraoral dental films (sizes 0, 2, 3 and 4). These films produce good quality images, but manual processing is needed, which is more time consuming and requires the use of environmentally-unfriendly chemicals.

Digital dental radiography should be used in all tier 3 countries.

Manual processing can be performed using wet chemistry within a dark-room (a room which has light blocked from entering it) or in a light proof chamber in daylight (termed a chair-side developer). These methods require the operator to place the film into tanks containing developer and fixer for a pre-determined time. The result is a wet film which must be dried prior to examination. Wet film does not show detail and will result in missed diagnoses if used for evaluation. (Niemiec *et al.* 2004b, Niemiec 2018b).

Processing can also be performed automatically, using an automatic processor. This utilizes wet chemistry, but internal rollers to move the film through the developer and fixer baths at a set rate, and the film produced is dry (Niemiec *et al.* 2004b, Niemiec 2018b).

Photostimulable Phosphor plates (CR technology) (Figure 164)

These are flexible polyester films that support photostimulable phosphor deposited in a resin on the surface. After the initial exposure, excited electrons in the phosphor material remain 'trapped' in centers in the crystal lattice until stimulated by the second illumination. These mobilized electrons release a blue-violet 400 nm luminescence produced in proportion to the number of trapped electrons which is in direct relationship to the original X-ray beam. It is then collected enabling the resulting signal to be converted into a digital image. Phosphorus plates are available in many sizes: from 0 to 9, are reusable and replacement is quite affordable.

Digital sensors (DR technology) (Figure 165)

There are numerous human and veterinary direct digital systems. These are excellent means of obtaining dental radiographs. The only major drawback is the lack of a number 4 plate with direct digital systems (sensors). The major advantages to the direct digital systems are the decrease in radiation exposure, rapidity of image creation, and the ability to reposition the sensor and/or tubehead if the view is not correct the first time.

Figure 164. An example of a CR technology using PSP plates and a scanner to produce digitised dental images, which can be further enhanced using computer software.

Figure 165. An example of a digital sensor that is used in DR systems to capture the image, which is further processed using specific computer software.

Equipment to Clean Teeth

A. The basic PROPHY KIT (Tier 1) should contain:

Diagnostic instrumentation:

See above

Scaling instrumentation: (Niemiec 2003b, 2018 d)

Tier 1:

1. Tartar removing forceps **(Figure 166)**
2. A scaler (for supragingival scaling) **(Figure 167)**
3. A selection of curettes (for subgingival scaling) **(Figure 168)**
4. Sharpening stone and oil **(Figure 169)**

Tier 2 & 3 should have the above plus:

1. A dental unit (high speed and low-speed) **(Figure 170)**
2. Mechanical scaling: sonic or ultrasonic (piezoelectric, magnetostrictive)
   a. Appropriate supra and subgingival tips. **(Figure 171)**
   Prophy paste/pumice **(Figure 172)**

Figure 166. Tartar removing forceps are used to remove big pieces of dental calculus (tartar) prior to further detailed scaling. However, great care should be taken not to fracture/damage the tooth when using this instrument.

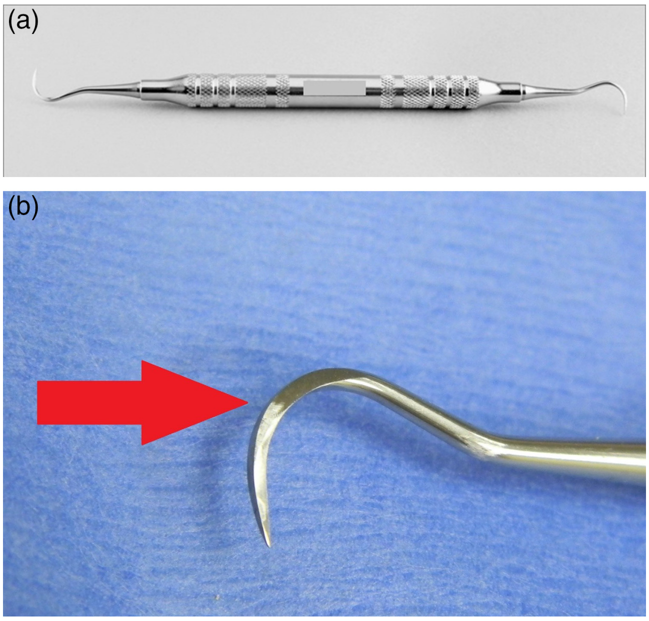

Figure 167. A sickle scaler (a) with an upclose view of the tip (b) These are fine instruments with two cutting surfaces, a sharp tip and a blade with cutting surfaces red arrow angled at 90 degrees to the handle designed for supragingival use.

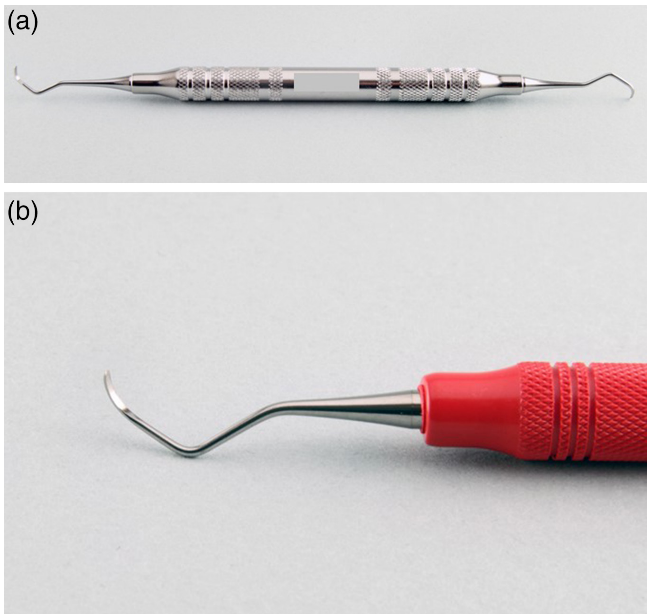

Figure 168. An example of a Gracey curette (a) with an upclose view of the tip (b) These are fine instruments with a single-sided cutting blade which is angled at 70 degrees to the shaft and a rounded toe, designed for subgingival use in a specific area of the arch.

Figure 169. A flat sharpening stone needed to regularly (ideally after each use) sharpen all hand instruments. Cylindrical and conical sharpening stones are also required.

Figure 170. A dental unit with (from left to right) a three-way syringe, a high-speed air-driven handpiece, low-speed air-driven handpiece, and an ultrasonic scaler. Several other equipment options can be added to the dental unit including electrical handpieces.

Figure 171. An ultrasonic piezoloectric scaler (a) and a selection of a supra- (bottom – red arrows) and subgingival (top - yellow arows) tips (b).

Equipment for Supragingival Scaling

Hand scalers

Hand scalers have a handle connected to a blade, which has a double-sided cutting edge that converges to a sharp point. The blade is triangular in cross section. The sharp blade is used to remove plaque, calculus and other deposits from the supra-gingival tooth surface. They are held in a modified pen type grasp. The blade is placed on the tooth surface at the gingival margin and used in a pull stroke that pulls the blade away from the gingiva. Hand scalers come in different patterns, one of which is the sickle scaler. The most common are the Universal (or H6/H7), the Jacquette and the Morse (Theuns 2012) **(See figure 167)**

Ultrasonic scalers

Ultra-sonic scalers are commonly used for removal of supra-gingival plaque and calculus. Ultrasonic scalers operate at >25kHz. The principle action of plaque and calculus removal is by a mechanical kick, or oscillation. This is achieved by the vibrating tip contacting the calculus and breaking it off. In addition, ultrasonic scalers create an effect called "cavitation", which is the implosion of bubbles formed in the coolant water by the scaler tip. Cavitation aids in calculus removal and also disrupts the membranes of spirochaetes - providing an antibacterial effect.

Ultrasonic scalers run via electricity and the working tip has one of three types of movement. The magnetostrictive type utilizes a stack of parallel nickel strips that lengthen and shorten when subjected to alternating electrical current. This causes the tip of the scaler to move in an elliptical figure eight motion. There are two classes of stacks, one vibrates at 25kHz, the other at 30 kHz. The ferrite rod type scalers use a rod, which vibrates by expansion and contraction. This causes the titanium scaler tip to move in a circular or elliptical fashion. Piezo electric scalers utilize a quartz crystal in the handle which expands and contracts when subject to alternating current. This causes the scaler tip to move in a linear back and forth motion. It vibrates at 25 to 45 kHz.

The handle of the ultrasonic scaler is held in a pen-like grip. ***(*Figure 173)** The tip is placed against the tooth surface at the gingival margin and in light contact with the calculus. The tip is moved using light strokes over the surface of the tooth. The operator should allow the vibrations to shatter the calculus. If the tip is used like a hand-held scaler, and force is placed against the calculus, the tip is likely to get damaged and stop oscillating.

Ultrasonic scalers can be safely used on any tooth surface that you can visualize. The tip of the magneto-strictive and piezo scaler become very hot with normal use. Coolant is absolutely required to prevent this from overheating the tooth and causing painful pulpitis and possible tooth death. The water spray should be directed at the end of the tip to dissipate heat. Care must be taken at all

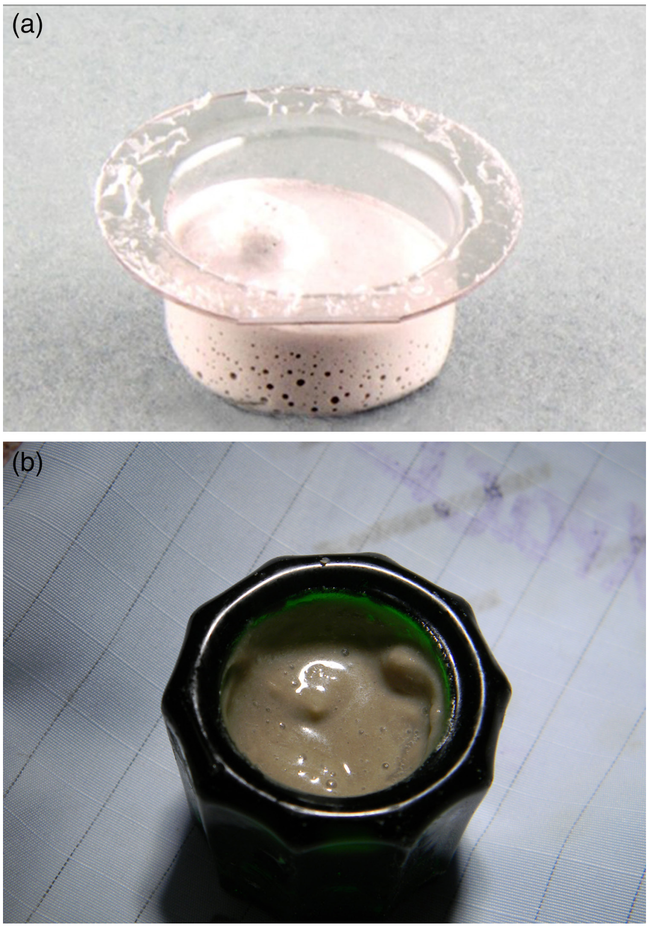

Figure 172. A single-use prophy paste (a) and pumice (b).

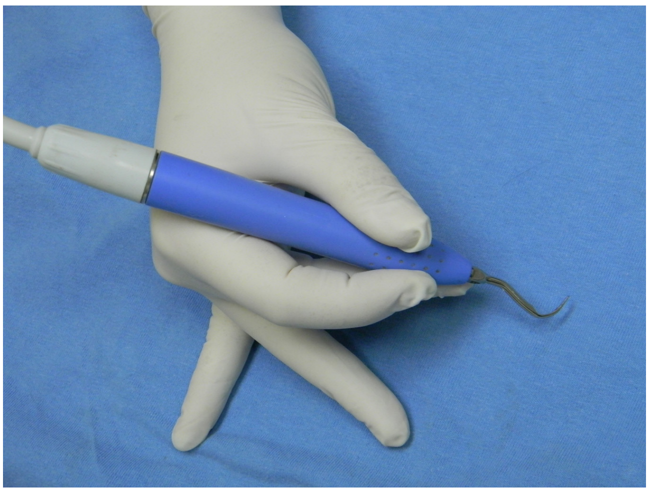

Figure 173. A piezoelectric ultrasonic scaler held in a pen-like grasp, which helps the operator manipulate the instrument securely, but without significant effort.

times to make sure the coolant is reaching the tip properly, especially if the scaler is used sub-gingivally. Properly designed subgingival tips will allow the water coolant to get to the tip and be used subgingivally.

If the ultrasonic scaler does not remove the calculus from the developmental ridges and cusps, a hand-held scaler should be employed.

Sonic scalers

Sonic scalers work using high-pressure air from a compressor or gas cylinder. The sonic scaler has a working tip that vibrates at 18-20 kHz and produces less heat when compared to ultrasonics. They usually have a jet of water spray for cooling the tooth and flushing away debris. The advantage is the reduced harm to the tooth via overheating or frequency of tip vibrations, but they can be slower with heavy calculus build-up and they may cause more tooth damage (Bellows 2004).

Sub-gingival scaling, root debridement and curettage

While scaling only the tooth crown results in an aesthetic result for the owner, it does not provide any measurable medical benefit for the treatment or prevention of periodontal disease. Complete treatment of established periodontal disease requires sub-gingival scaling and curettage. The term root debridement is used to describe scraping the necrotic cementum from the root surface while curettage describes the removal of epithelial cells, endotoxins and accumulations from the epithelial wall lining the pocket. (Niemiec 2013e &h) Subgingival debridement and sub-gingival curettage can be performed using ultrasonic and sonic scalers (using subgingival tips) or hand instruments termed curettes.

Traditionally, human dentists have used hand instruments for root bridement and sub-gingival curettage. There are two types of curettes, the Universal and the area-specific. The Universal type, which Columbia and Barnhart are examples, have two cutting surfaces, a rounded toe and a blade with cutting surfaces angled at 90 degrees to the handle. **(See figure 167)** The area-specific type, which Gracey is an example, has a rounded toe and a single sided cutting blade which is angled at 70 degrees to the shaft (the part of the instrument between the cutting blade and the handle). **(See Figure 168)**

In addition to the 70 degree offset angle, Gracey curettes also have an accessory bend at the shank which allows proper adaption to various teeth. These curettes come in a variety of angulations from 1-18. The higher the number, the greater the accessory bend and the further back in the mouth the instrument is designed to be used.

Figure 174. Polishing using a prophy paste in a rubber cup on a slow-speed air-driven handpiece. Note that light pressure is applied to the polishing cup to flare the edges of the cup enabling subgingival polishing.

Instrument sharpening

It is mandatory that scalers and curettes are kept sharp. A blunt or dull blade will not remove accumulations and will burnish the calculus against the tooth root surface. Sharpening is a skill that takes time to master, and if one person in the clinic can sharpen well, your dentistry will improve. (Niemiec 2013c)

Polishing

Polishing the tooth surface following scaling removes any microscopic plaque and calculus and provides a smooth tooth surface that retards the re-attachment of plaque and calculus. Supra-gingival scaling and root planing, even when done correctly, will leave a slightly roughened enamel surface that will encourage plaque reattachment. Polishing is performed by applying an abrasive paste in a cup to the tooth surface. Pressure on the polishing cup will flare the edges, which can then be directed slightly under the gum to polish sub-gingival. **(Figure 174)**

Generally speaking, there are two types of polishing actions. The traditional cup, which rotates continuously at 3,000 rpm and the newer type of cup with a reciprocating action, back and forward. The cups should not be applied to the tooth surface for greater than 3-5 seconds' duration as the heat generated can cause an increase in dentine temperature and an irreversible pulpitis. Pastes are available in different flavours and grades. Fine grades produce a smoother finish, whereas course grades will remove more enamel and produce a rougher surface. It is also possible to purchase paste in a multi-use jar or individual caplets. The same prophy cup should not be repeatedly dipped into the multi-use jar during teeth polishing, as it will become contaminated. The paste can be placed into separate dappen dishes for each patient. A new cup should be used for each patient. A pumice and water slurry can also be used for polishing teeth.

Extractions/oral surgery

Tooth extraction is one of the most common surgical procedures performed by veterinarians in small animal practice. While repair of fractured jaws, closure of oro-nasal fistulas and removal of oral tumours are generally considered oral surgery, extraction of a tooth is a surgical treatment and procedure that should be perfected by all practitioners.

The ideal tooth extraction is the removal of the complete tooth and all roots with minimal trauma to the surrounding soft and hard tissues. This concept of minimally invasive surgery results in a wound that heals quickly and without complications. Tooth extraction requires the veterinarian to have a detailed knowledge of anatomy, wound healing and suturing, proper dental materials and equipment, as well as technique to accomplish the procedure. Every veterinarian should endeavour to make every tooth extraction an ideal one.

ORAL SURGERY KIT (FIGURE 176)

Extraction instrumentation

1. An assortment of luxating elevators (luxators) for cutting the periodontal ligament. The luxator consists of a handle, shaft and a working end. The working end has a concave surface and opposing convex surface, the tip flares to a rounded point. The blade comes to a fine/sharp tip. **(Figure 176)**

Figure 175. A surgical extraction kit containing basic surgical instruments (e.g. scalpel handle, needle holder, tissue forceps, selection of scissors), periosteal elevator, an assortment of luxators and extraction forceps. All instruments are packed in a casette that enables sterilization of instruments after each use.

Figure 176. An example of a luxator.

2. Elevators are used for tearing the periodontal ligament and elevating the tooth. The traditional elevator is termed 'straight'. It consists of a handle, shaft and working end. The working end consists of a blade with parallel sides, a concave and opposing convex surface with a flat (perpendicular to the shaft) tip. The tip may be sharp or blunt. **(Figure 177)**
3. Extraction forceps are used for removing the loosened tooth from the alveolus. Extraction forceps have two handles and two beaks, which are opposed when the handles are squeezed together. The beaks are used to grasp the tooth crown in order to extract it from the alveolus. (Bellows 2004) **(Figure 178)**

A basic soft-tissue oral surgery kit includes: (Terpak & Verstraete 2012)

1. Scalpel handle
2. Tissue forceps
3. Periosteal elevators
4. Tissue scissors
5. Suture scissors
6. Needleholder
7. Lip retractor

Note that a variety of sizes of the above equipment should be available for cats, medium and large breed dogs.

Tier 1 country should have:

1. Soft tissue oral surgery kit
2. Elevators or luxators
3. Extraction Forceps
4. Some method for sectioning teeth

Tier 2 & 3 should have the above plus:

1. High speed dental unit and handpiece with assorted burs
   a. For sectioning teeth and cutting dental hard tissue

All equipment should be sanitized, disinfected and/or sterilized based on the category of each item's intended use (e.g., noncritical, semi-critical or critical) (Terpak CH & Verstraete FJM 2012) **(Figure 179)** FECAVA key recommendations for Hygiene and Infection Control in Veterinary Practice: http://www.fecava.org/sites/default/files/files/2014_12_recommandation_hygiene.pdf

SUTURE MATERIAL

Absorbable suture is recommended for oral surgery because suture removal within the mouth is challenging to impossible. Monofilament suture is preferred to braided as it causes the least irritation and is associated with the least amount of infection. Poliglecaprone 25 is the most popular material among veterinary dentists (Tutt 2006b).

As far as suture size, in general 4/0 to 5/0 is recommended for cats and 4/0 -3/0 for dogs. Suture needles for oral surgery must be the swaged-on type. Needle curvature is either 3/8 or 1/2 with the latter more indicated in the caudal part of the oral cavity. A reverse

Figure 177. An example of an winged elevators.

Figure 178. Extraction forceps.

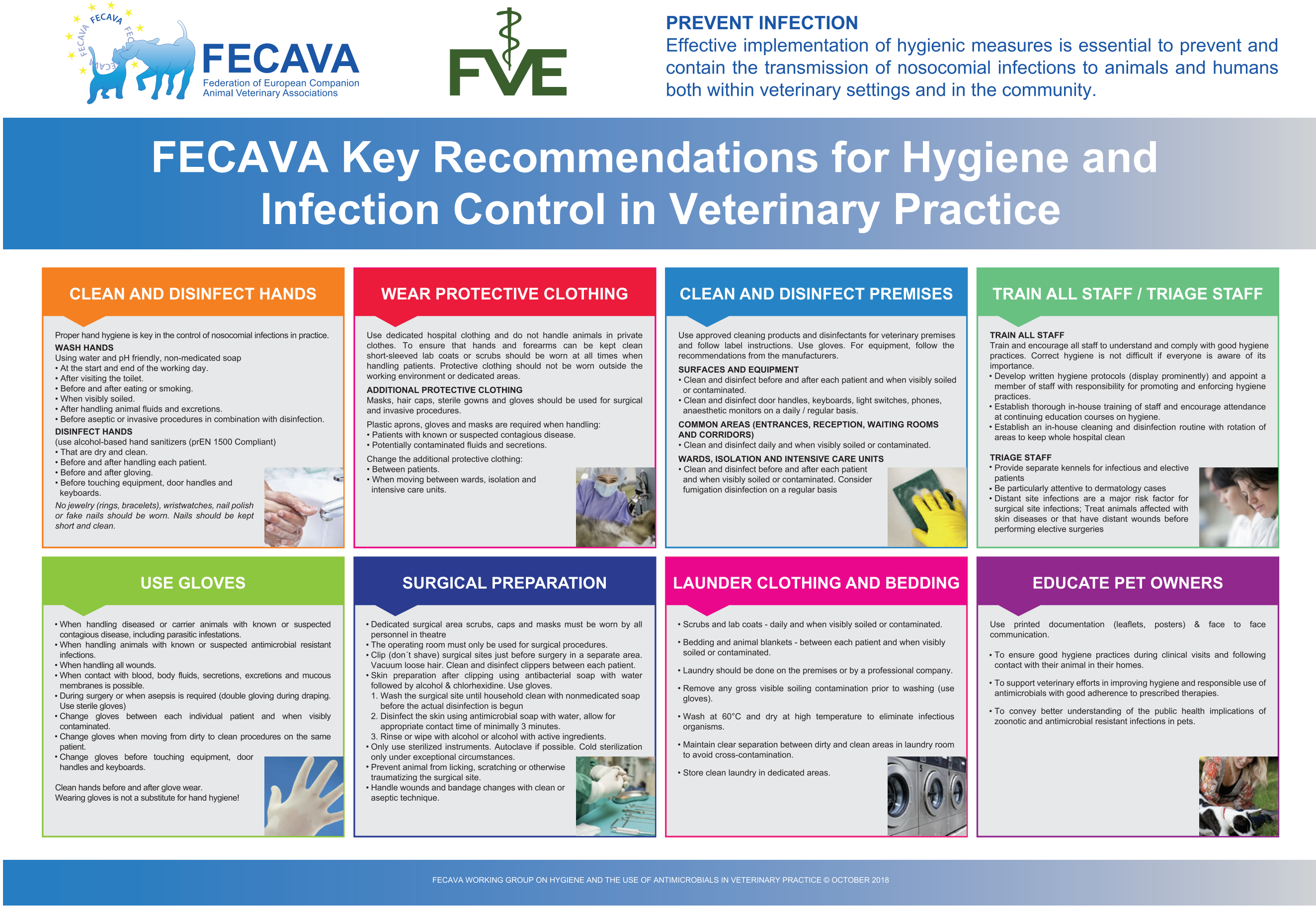

Figure 179. FECAVA key recommendations for Hygiene and Infection Control in Veterinary Practice.

cutting needle is the best for suturing gingiva and mucosa but for friable mucosa, a taper point may be effective. The needle should be inserted into tissues perpendicularly to make the smallest possible entry wound and to avoid tearing of the mucosa.

Double layer suturing in major surgical procedures is preferred to one layer if possible. A distance of 2-3 mm between the wound edge and the suture entry point and a 2-3mm distance between interrupted sutures is recommended. A simple interrupted suture is recommended in most oral procedures, although some authors suggest the use of continuous sutures after total extractions in stomatitis patients reduce the time of closure and decrease surgical time. Tension free sutures are of the utmost importance. The knot should not be placed directly over the incision. No area of denuded bone should be left uncovered and the suture line should not lie over the defect.

Key Points:

• All equipment as well as dental operatory should be sanitized, disinfected and/or sterilized on regular basis
• Dental/oral procedures require use of specific instruments and equipment
• The most common dental procedures (diagnostic, prophylaxis and extractions) cannot be properly performed without access to radiographic equipment.

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