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GUIDELINES

World Small Animal Veterinary Association global dental guidelines

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Dental, oral and maxillofacial diseases are the most common conditions seen in small animal veterinary practice. They may not only create significant pain but also infection. As such, the World Small Animal Veterinary Association believes that un- and undertreated oral and dental diseases pose a significant animal welfare concern. Dentistry is an area of veterinary medicine, which is still undertaught and thus is subject to many myths and misconceptions. Effective teaching of veterinary dentistry in the veterinary curriculum is the key to progression of the discipline. This will greatly improve the health and welfare for all our patients globally. The guidelines were created to provide veterinarians with the necessary foundations to provide gold standard therapy as well as define realistic minimum standards of care. Using the three-tiered continuing education system of World Small Animal Veterinary Association (based on the World Bank), the guidelines make global equipment and therapeutic recommendations and highlight the anaesthetic and welfare requirements for small animal patients worldwide. This document contains information on common oral and dental disease as well as basic diagnostic procedures and treatments. 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 are also included. A discussion of the deleterious effects of anaesthesia-free dentistry is included, as this procedure is ineffective at best and damaging at worst. Finally, the negative effects of undiagnosed/not treated dental disease are discussed under the scope of animal welfare issue. The guidelines from 2019 have been revised to reflect the advances in diagnosis and treatment. New

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sections in this revision include sections on trauma, the nurses' role in veterinary dentistry, juvenile pathology, ergonomics and an extended section on radiographic interpretation.

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INTRODUCTION

The World Small Animal Veterinary Association (WSAVA) is an "association of associations" with over 200,000 small animal veterinarians globally represented by over 116 member associations. Utilising 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 Committee was established to develop a universally relevant document that would take into consideration the worldwide differences in educational background, access to equipment, substances, drugs and treatment modalities. The guidelines committee encompasses members from diverse veterinary specialties, emphasising the multimodal approach necessary to provide proper dental health services. Authors representing advanced training in dentistry, nutrition, anaesthesia, analgesia, nurses 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 recognise 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 utilised 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 for further guidance.

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) (Fig 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 (Hermanson & de Lahunta, 2018; Lewis & Reiter, 2010) (Fig 2).

There are six clinically important foramina in the jaws present bilaterally (Lewis & Reiter, 2010)

- 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.

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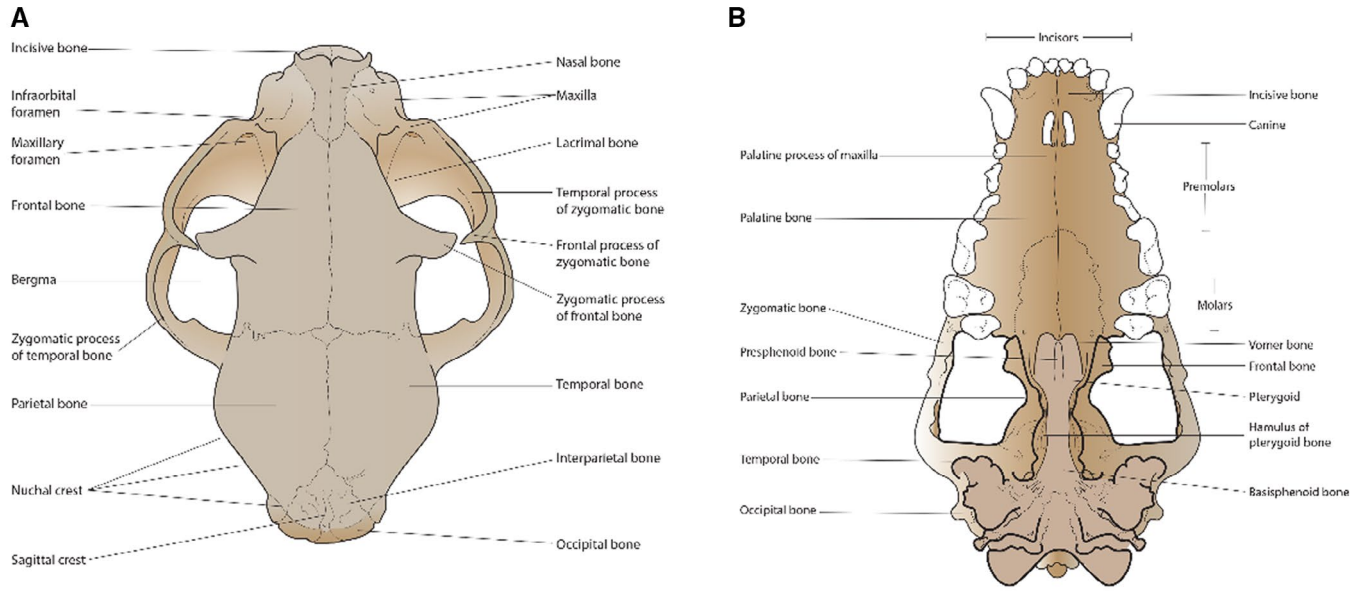

FIG 1. (A) Cat maxilla dorsal view. (B) Dog maxilla ventral view.

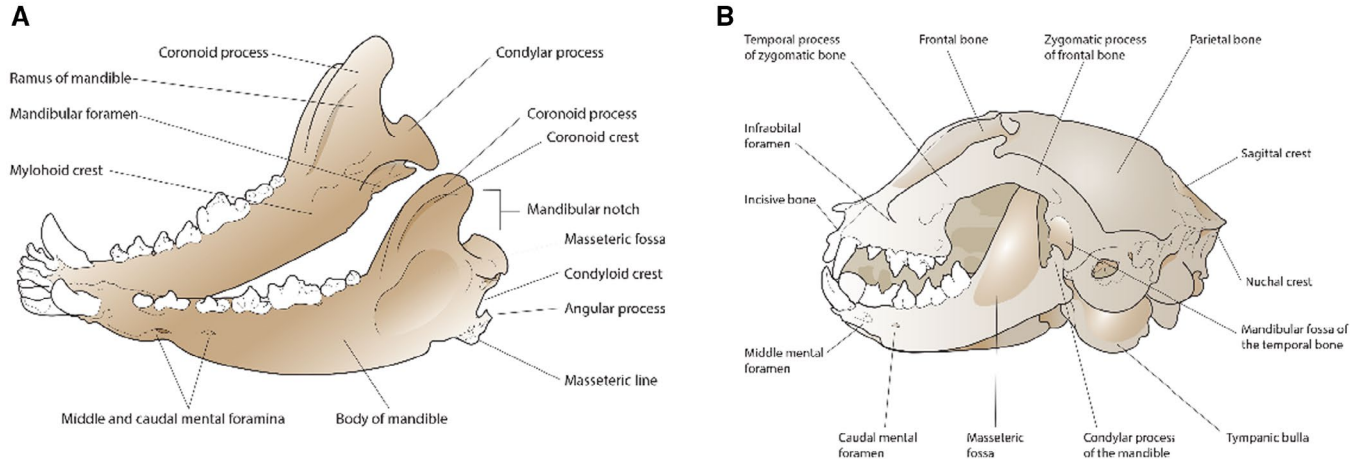

FIG 2. (A) Dog mandible. (B) Cat skull lateral.

- 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 (Evans & de Lahunta, 2013; Lewis & Reiter, 2010). The facial artery arises from the external carotid artery (Guzu et al., 2021) (Fig 3).

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

Saliva

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

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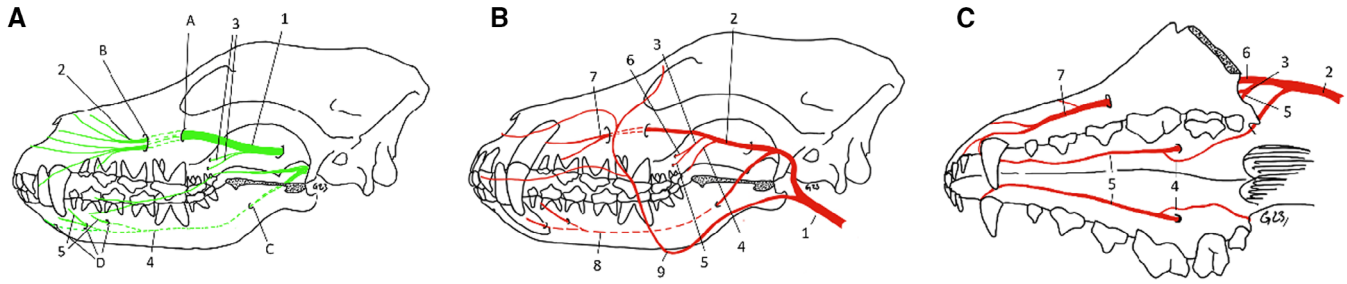

FIG 3. (A) Nerves, dog skull lateral. (B) Blood supply, dog skull lateral. (C) Blood supply, dog skull, ventral view of maxilla. A) Trigeminal nerve branches 1. maxillary, 2. infraorbital, 3.palatine, 4. mandibular, 5. mental and relevant foramina A. maxillary, B. infraorbital, C. alveolar mandibular, D. mental. B and C) relevant arteries 1. carotid, 2. maxillary, 3. descending palatine, 4. minor palatine, 5. major palatine, 6. sphenopalatine, 7. infraorbital, 8. mandibular, 9. facial.

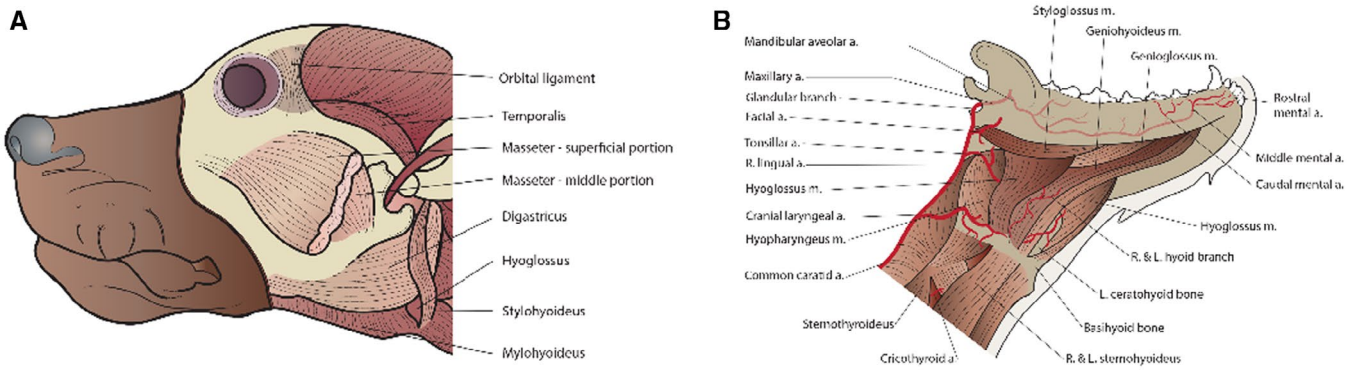

FIG 4. (A) Orofacial musculature – dog. (B) Cross section – vessels and muscles.

Lymph drainage

There are three lymph centres draining the oral cavity, head and neck. These are the parotid, mandibular (with buccal lymph nodes) and retropharyngeal lymph centres. Pathways of lymphatic drainage are unpredictable, but the main lymph draining centre or the head is the retropharyngeal lymph centre, which consists of a medial and sometimes a lateral lymph node (Evans & de Lahunta, 2013; Lewis & Reiter, 2010; Skinner et al., 2016).

Oral cavity proper and dentition

The limits of the oral cavity 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. Teeth are best described using their anatomical designation. With the modified Triadan system, it is also possible to number the teeth (Floyd, 1991) (see Recording section).

The dental formula of a dog is 2× I 3/3: C 1/1: P 4/4: M 2/3 = 42. In puppies, the dental formula is 2× i 3/3: c 1/1: p 3/3 = 28; in adult cats 2× I 3/3: C 1/1: P 3/2: M 1/1 = 30 and kittens 2× i 3/3: c 1/1: p 3/2 = 26 (Fig 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 (AVDC Nomenclature Committee, 2024; Lewis & Reiter, 2010).

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. In dogs, roots of the maxillary premolar and molar teeth are very close to the nasal cavity and infraorbital canal and roots of the mandibular premolar and molar teeth to mandibular canal (Green et al., 2022; Littles et al., 2022).

In dogs and cats, the number of the roots generally varies from single to three, although further variations are possible. Thus, imaging is mandatory prior to any oral/dental surgery to fully evaluate the anatomy and pathology.

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 (AVDC Nomenclature Committee, 2024; Lewis & Reiter, 2010). In small dogs, the mandibular first molar tooth is proportionally larger relative to the mandibular height compared to larger dogs (Gioso

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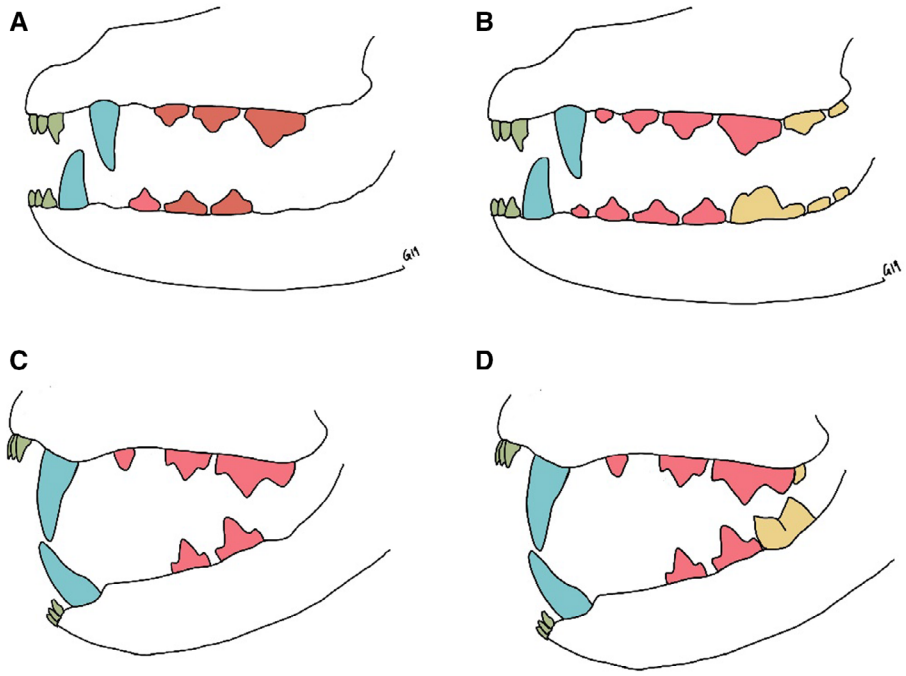

FIG 5. (A) Puppy deciduous dentition. (B) Adult dog permanent dentition. (C) Kitten deciduous dentition. (D) Adult cat permanent dentition. Grey = incisors, Blue = Canines, Red = premoalrs, Yellow + molars.

et al., 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, 2022).

Deciduous teeth are smaller, slimmer and sharper compared to the permanent teeth; however, they have proportionally longer roots (Lewis & Reiter, 2010). Exfoliation starts around 3 months in dogs and cats, starting from central incisors. Some factors influence exfoliation, namely breed in dogs. However, approximately all incisors exfoliate between 3 and 5 months, canine teeth around 4 to 6 months and definitive dentition is complete for most animals around 8 months of age (Hale, 2005).

Structure of the teeth and tooth supporting apparatus

The majority of the (adult) tooth is comprised of dentine, which is formed by odontoblasts at the periphery of the pulp. Primary dentine is formed during tooth development (up to closure of root tip apexogenesis), while secondary dentine is laid down after root formation is complete and signifies normal ageing of the tooth (Fig 6). Tertiary dentine

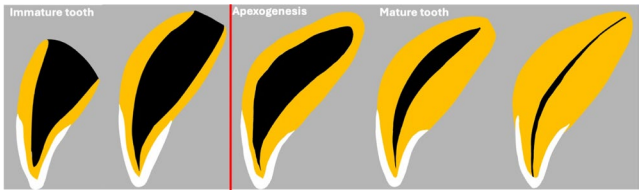

FIG 6. Maturation of canine tooth. The root initially lenthens and then the canals gradually constrict.

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 mineralised tissue in the body. Enamel is formed by ameloblasts only prior to the tooth eruption (Lewis & Reiter, 2010; Nanci, 2013b; Pashley & Liewehr, 2006). Enamel thickness varies from 0.1 to 1 mm in cats and dogs (Crossley, 1995). The root of the tooth is covered by cementum, which is mineralised connective tissue similar to bone, formed by cementoblasts (Lewis & Reiter, 2010; Nanci, 2016; Pashley & Liewehr, 2006) (Fig 7).

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 to 1 mm in cats and 0 to 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

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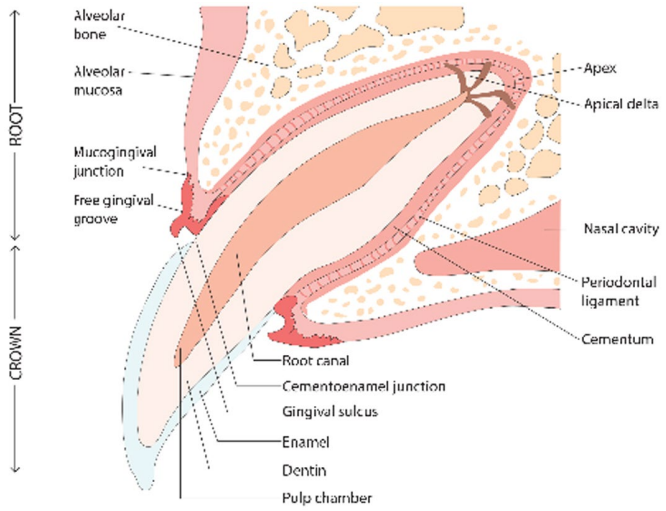

FIG 7. Dental, periodontal and surrounding tissues, cross section.

on one side and the alveolar bone on the other and thus holds the tooth in the alveolus (Lewis & Reiter, 2010; Wolf et al., 2005).

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 basic anatomy and physiology knowledge.
- Basic anatomy and physiology familiarity includes awareness of the structure and function of the maxillofacial bones, muscles of mastication, innervation and vascularisation, lymph drainage, salivary glands, oral cavity proper and dentition (including structure of the teeth and tooth supporting apparatus).

Conditions seen in juvenile patients

A juvenile patient is defined as the one in age between birth and complete development of dentition. At this time, the occlusion, maxillofacial skeleton and maturation of the teeth is in progress but close to completion (Fulton et al., 2014; Wiggs & Lobprise, 1997c). Major areas associated with head injuries in juvenile patients are teeth fractures and damages to maxillofacial structures (Goldschmidt & Hoyer, 2022).

Persistent deciduous teeth

A deciduous tooth becomes persistent when its normal exfoliation is delayed. Exfoliation occurs after root resorption, usually in the presence of an erupting definitive successor but not exclusively (Niemiec, 2010a; Wiggs & Lobprise, 1997b). Therefore, the main reasons for a deciduous tooth to remain in the arcade are that the corresponding permanent tooth followed an incorrect path of eruption (Harvey & Emily, 1993c; Hobson, 2005). On some occasions, root resorption of the deciduous tooth still occurs with consequent exfoliation. It is critical to note that deciduous teeth are considered persistent as soon as the permanent tooth begins to erupt and the deciduous tooth is not exfoliating (Hobson, 2005).

The malpositioning of the permanent teeth may have genetic tendency, since it is more common in certain breeds and head types (Harvey & Emily, 1993c), especially in small and toy breed dogs (Hobson, 2005; Wallis et al., 2024). The most common teeth to be persistent are the canines, followed by the incisors and finally premolars, often bilateral (Harvey & Emily, 1993c).

Possible causes of persistent deciduous teeth include impaction or ankylosis of the deciduous tooth (Wiggs & Lobprise, 1997c). Other causes include nutritional/hormonal imbalances or absence of permanent successor (Wiggs & Lobprise, 1997b).

Crowding (Fig 8) and malocclusions (Fig 9) are the immediate consequences, followed by periodontal disease (Fig 10) (Harvey & Emily, 1993c; Hobson, 2005; Niemiec, 2010c, 2013b).

Considering that permanent dentition typically erupts between 3 and 6 months, this group of authors recommends monitoring eruption weekly during this period and these recommendations should be included in the consultation protocol for vaccination (Hale, 2005; Wallis et al., 2023; Wiggs & Lobprise, 1997c).

FIG 8. Persistent deciduous maxillary incisors with crowding.

FIG 9. Persistent deciduous left maxillary canine tooth with malocclusion.

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Extracting deciduous teeth can be challenging due to the considerable length and thin walls of deciduous teeth (Hale, 2005; Harvey & Emily, 1993c). Further, there is often resorption and/or ankylosis of the persistent deciduous tooth (Fulton et al., 2014). Therefore, dental radiographs are critical for proper therapy (Fulton et al., 2014; Niemiec, 2010b). Anatomical knowledge and dental radiographs will help the practitioner to determine deciduous from permanent teeth, exact location of the developing permanent teeth and most importantly integrity of the deciduous tooth root structure (see Extractions). Finally, if the root of a deciduous root is not *completely* resorbed, it must be fully extracted (Fig 11). Once the permanent tooth has erupted, there is no impetus for the deciduous to resorb. Thus, persistent deciduous tooth roots may become infected (Fig 12). Complete extraction of intact root structure is mandated (Fulton et al., 2014).

Supernumerary teeth

Supernumerary teeth are not an uncommon finding in veterinary patients. The incidence of supernumerary teeth was found to be 3.5%. Large brachycephalic (*e.g.* Boxers and Mastiffs) are prone to supernumerary maxillary first incisors (Wiggs & Lobprise, 1997a) (Fig 13). Large mesaticephalic dogs were the second most common

FIG 10. Persistent deciduous left mandibular canine tooth with periodontal disease.

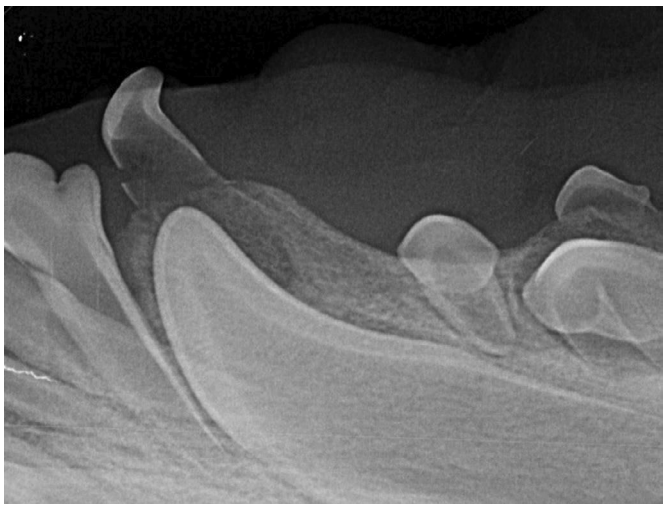

FIG 11. Radiograph of persistent deciduous left mandibular canine tooth. Note the severe resorption of the deciduous tooth.

FIG 12. Radiograph showing retained root remnants of deciduous left maxillary canine tooth with associated bone lucency, suggesting infection.

FIG 13. Supernumerary maxillary incisor.

FIG 14. Supernumerary maxillary left premolar.

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breeds to be affected (Pavlica et al., 2001). In fact, some breeds (German Shepherds, Doberman Pinchers) may be bred for them. Maxillary first premolars (Fig 14) are the most common supernumerary teeth in these breeds followed by the second incisors and finally third premolars (Pavlica et al., 2001). While incisors, premolars and mandibular third molars are most common, any tooth can develop supernumerary teeth and they are occasionally seen in the deciduous dentition (Harvey & Emily, 1993b).

In cats, maxillary second premolars and mandibular third premolars are the most common supernumerary teeth (Fig 15). A study of 155 adult domestic cats showed a similar prevalence rate as in dogs of 3.7% (Verstraete & Terpak, 1997). The most involved teeth were the maxillary second and mandibular third premolar teeth, with others being exceedingly rare (Verstraete & Terpak, 1997). These findings corresponded to the results from previous articles on the subject (Roux et al., 2009; Verstraete et al., 1996a).

Supernumerary teeth result from an abnormal tooth bud, which results in two teeth instead of one (Wetering, 2011). While the aetiology is unknown (Rajab & Hamdan, 2002), the current theory is continued proliferation of the primary dental lamina produces an additional tooth germ resulting in an additional tooth in the arcade (Pavlica et al., 2001). While supernumerary teeth may occur due to an event during tooth development, the fact that it is often seen in breed lines suggests a genetic component (Harvey & Emily, 1993b).

Supernumerary teeth are broken into two types according to their shape. If they have a normal shape and size (eumorphic), they are termed supplemental teeth. Conversely, teeth with an abnormal shape and a smaller size (dimorphic) are designated rudimentary (Startup, 2013).

One must also differentiate supernumerary teeth from other similarly appearing pathologies such as twinning or bigemination (Boy et al., 2016) (Fig 16). The best way to distinguish two separate teeth from two crowns sharing a root is via dental radiology (Huffman, 2010; Wiggs & Lobprise, 1997c). Some other conditions,

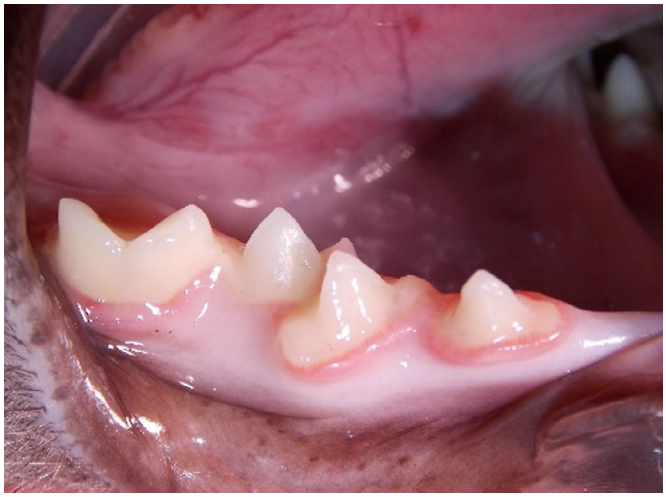

FIG 15. Supernumerary mandibular right premolar in a cat.

FIG 17. Supernumerary left mandibular fourth premolar malformation – peg tooth.

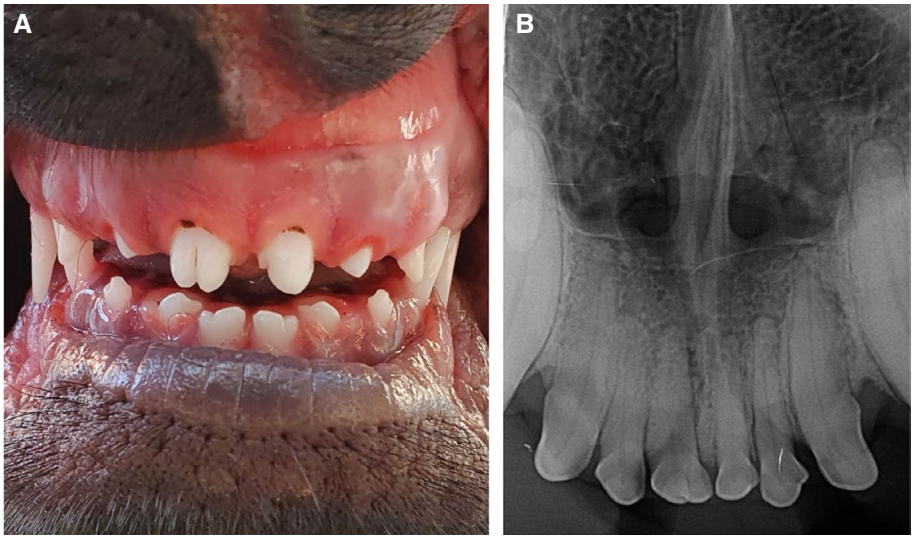

FIG 16. (A)Gemination of the right maxillary first incisor. (B) corresponding radiograph.

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which may appear similar to supernumerary, are persistent deciduous teeth (Startup, 2013) and ectopic teeth (Klim et al., 2023).

The most common problem caused by supernumerary teeth is periodontal disease (Startup, 2013). This occurs due to crowding and secondary loss of normal/natural plaque reduction (Fig 17) (Buckley, 1972; DeBowes, 2010). In addition, they can interfere with the eruption of surrounding teeth and/or normal occlusion as well as soft tissue damage (Startup, 2013).

Early extraction of supernumerary teeth resulting in crowding can help slow the progression of periodontal disease (Niemiec, 2013a). In addition, it will resolve any trauma from tooth on tooth or soft tissue contact. However, if neither crowding nor occlusal trauma is occurring, no treatment is required (Harvey & Emily, 1993b; Startup, 2013). This is typical with supernumerary premolars in large dolichocephalic breeds (Dole & Spurgeon, 1998).

Hyperdontia in cats rarely produces any issues, and thus therapy is rarely required (Verstraete & Terpak, 1997). This is especially the case with maxillary second premolars. However, mandibular third and fourth premolars often create crowning and/or occlusal interference, and extraction is mandated (Harvey & Emily, 1993b; Verstraete & Terpak, 1997).

Missing teeth

Finding missing (permanent teeth) on the oral examination is most often an incidental finding (Fig 18). However, this is an important finding, as it may cause problems to the animal. Therefore, complete oral examination and dental radiographs under general anaesthesia are recommended to determine the nature of the problem (Kirby & Miller, 2018; Kuntsi et al., 2018).

Congenitally missing teeth

This condition usually causes no clinical problem to the animal and the reason for a missing tooth is mostly unknown but may be hereditary. Oligodontia or hypodontia may also be linked to specific genetic syndromes (Lewis et al., 2010; Moura et al., 2019) or diseases (Bittegeko et al., 1995).

FIG 18. Apparently missing left mandibular second premolar tooth.

Unerupted teeth

The tooth will also be missing clinically, if it has failed to erupt (*e.g.* unerupted tooth, impacted tooth), which is diagnosed by dental radiographs (Fig 19). Extraction of an unerupted tooth is usually indicated, especially if previous operculectomy has failed or is deemed inappropriate. Extraction may be difficult, and it depends on the position of the tooth (impacted or abnormally positioned unerupted teeth) (Legendre & Reiter, 2018). If an unerupted permanent tooth is left in place, chances are this will lead to a formation of a dentigerous cyst (Fig 20) or other pathology (Babbitt et al., 2016; Bellei et al., 2019; MacGee et al., 2012; Mulherin & White, 2021).

A tooth (deciduous or permanent) may start to erupt but not be able to complete eruption if the crown is covered in tough

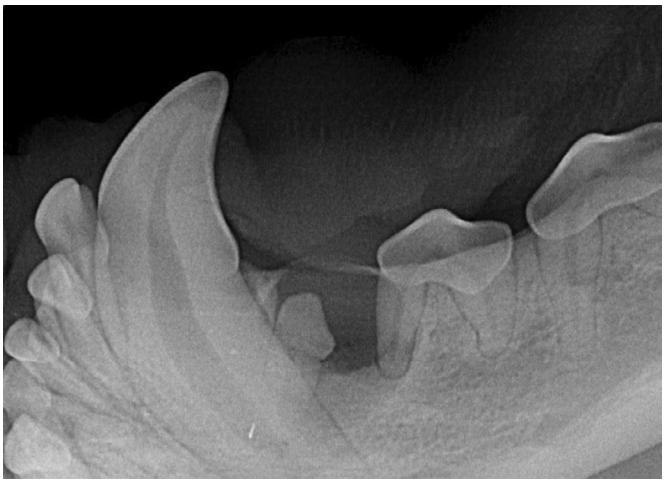

FIG 19. Radiograph of an unerupted left mandibular first premolar tooth with likely dentigerous cyst formation.

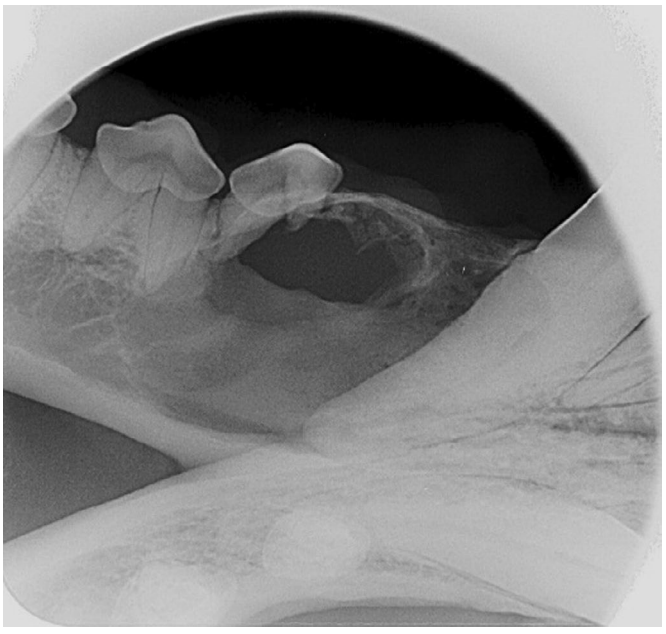

FIG 20. Radiograph of an unerupted right mandibular first premolar tooth with likely extensive dentigerous cyst formation.

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gingival tissue called an operculum (Carle & Shope, 2014). This tissue (and sometimes alveolar bone) can be removed (operculectomy) to allow full eruption that will likely occur if the apex of the tooth is not closed.

The tooth can also be missing if it has been lost due to severe periodontitis (rarely in juvenile dogs and cats) or as a result of periodontal trauma (avulsion) (Gracis, 2020).

A tooth may also be clinically missing after it has fractured or resorbed, with root remnants possibly persisting in the bone, which can be seen on dental radiographs. Retained roots are the source of infection and pain and should be removed in the vast majority of cases. Complete removal of the roots should be confirmed radiographically (Moore & Niemiec, 2014; Ng et al., 2020).

Another reason for a missing tooth is previous dental extraction. Healing of the alveolus is rapid and active bone remodelling with radiographic evidence of new bone formation is visible in 6 to 8 weeks, and (radiographic) healing of the extraction site is completed after 6 to 8 months. Once the vacated alveolus has (radiographically) healed, it is usually impossible to determine the reason for a clinically missing tooth (Shetty & Le, 2020).

Key points

- Lack of presence of the tooth in the oral cavity may be due to congenital absence, failure of the tooth to erupt, dental or periodontal pathology or previous extraction.
- Dental radiographs are needed to determine the reason for a clinically missing tooth and properly plan treatment if needed.

Malocclusions

A malocclusion is classically defined as any occlusion which is not standard for the breed (Roux & Howard, 2010). However, the WSAVA Dental Guidelines committee considers any malocclusion, which creates any degree of occlusal trauma to be a malocclusion. This includes class III malocclusion (undershot) in brachycephalic dogs, which causes significant trauma to the soft tissues of the floor of the mouth, mandibular gingival tissues, as well as potentially the mandibular canine teeth.

Some malocclusions are only cosmetic, and as such, no treatment is recommended. As a matter of fact, therapy of non-traumatic malocclusions is prohibited by both the American Kennel Club and AVDC. When occlusal trauma is present, it creates significant pain and discomfort for the patient. Further, if left untreated significant complications such as oronasal fistula formation, tooth attrition and/or fracture and potentially tooth death may occur (Brine, 1999; Niemiec, 2010b).

It is important to understand that the occlusion can only be accurately assigned after skeletal maturity (generally 12 months of age). During development, it is not uncommon for the occlusion to change significantly (normal to abnormal and vice versa). The occlusion should be evaluated utilising a 6-point evaluation.

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

It is well established in human dentistry that most malocclusions are genetic in nature (Lundstrom, 1954; Mossey, 1999). In veterinary medicine, jaw length (or skeletal) malocclusions (Angle class II, III, IV) are considered genetic or heritable (Stockard & Johnson, 1941). Conversely, when the jaw lengths are normal and only a tooth is out of position, that is non-skeletal discrepancies (class I), it may have a non-genetic cause. However, many class I malocclusions are hereditary in nature. This includes mesiocclusion of the maxillary canines (lance effect) seen in Shetland sheepdogs and Persian cats (Bellows, 2004; Gawor, 2013a). In addition, mesioclused mandibular canines are anecdotally far more common in dolichocephalic dogs.

CLASS I MALOCCLUSION: NEUTROCCLUSION

This is defined as an occlusion where the jaw lengths are normal (scissor bite); however, one or more teeth are out of alignment. As stated above, these conditions are typically considered non-genetic; however, the high prevalence of some syndromes in certain breeds (see above) indicates a genetic predisposition (Lewis & Reiter, 2010). Potentially, class I malocclusions may result from lip/cheek/tongue pressure (or lack thereof), significant systemic or endocrine issues. In addition, infectious (periodontal), neoplastic or cystic aetiologies may result in tooth deviation (Anderson & Harvey, 1993). Previously, it was supposed that persistent deciduous teeth deflected the permanent dentition. However, it is now known that deciduous tooth persistence is typically caused by improper eruption of the permanent teeth (Niemiec, 2018b). Class I malocclusions include: linguoversion of the mandibular canine teeth (Fig 21), mesioversion of the maxillary canines (Fig 22), anterior cross bite or malalignment of the incisor teeth (Martel, 2013; Startup, 2013; Thatcher, 2013) (Fig 23) and rarely posterior crossbite of the carnassial teeth (Fig 24). Within this category, there is also malocclusion in cats causing mandibular soft tissue trauma and pyogranuloma (Ziemann et al., 2023).

CLASS II MALOCCLUSION: MANDIBULAR DISTOCCLUSION

This may also be called "overshot" or relative mandibular brachygnathism. In the EH Angle classification system (borrowed from human dentistry), it is defined as the lower molar being positioned caudal to the upper molar (Angle, 1899; Niemiec, 2010b). This typically results from a jaw length discrepancy where the mandible is shorter than the maxilla but can occur due to an elongated maxilla. This results in the mandibular premolars being caudal to the corresponding maxillary (Fig 25). The major complication is the mandibular canines generally creating significant occlusal trauma to the palate,

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FIG 21. Linguoversion of mandibular canine tooth (three images).

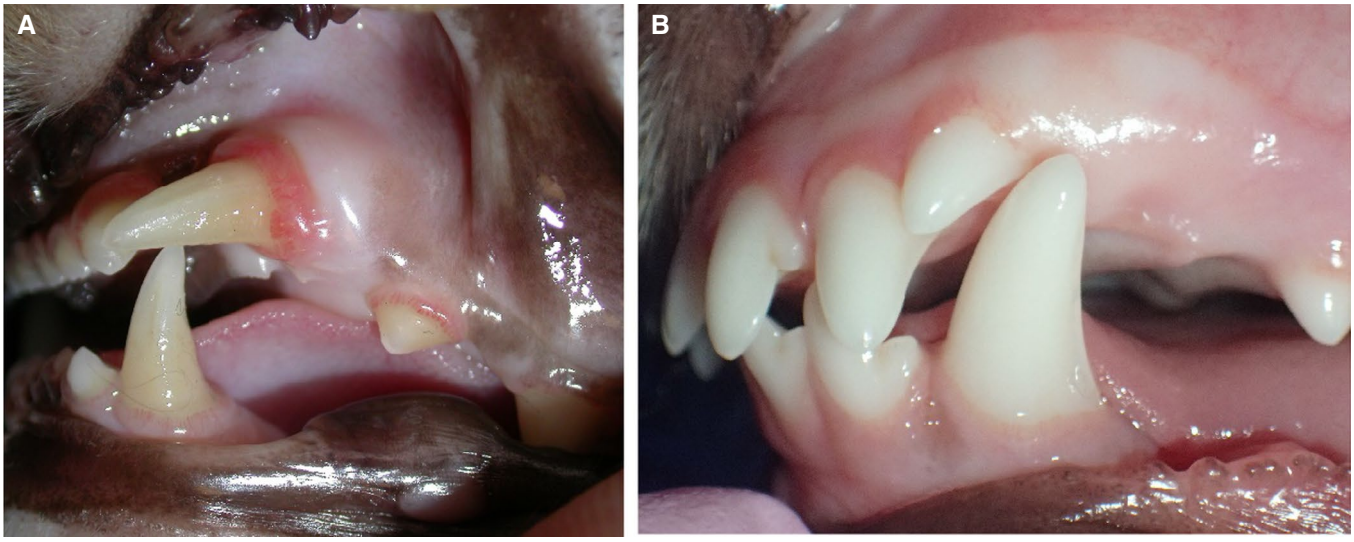

FIG 22. (A) Mesioversion of maxillary canine tooth – cat. (B) Mesioversion of maxillary canine tooth – dog.

FIG 23. Anterior cross bite.

gingiva and/or maxillary canine teeth (Fig 26). Therefore, intervention is almost always required (Niemiec, 2010b; Niemiec et al., 2020; Storli, 2013).

FIG 24. Posterior cross bite.

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FIG 25. Premolars in MAL 2.

FIG 26. Mandibular canine teeth traumatising palate.

CLASS III MALOCCLUSION: MANDIBULAR MESIOCCLUSION

This is also termed "undershot" and is a jaw length discrepancy with the maxilla being relatively shorter than mandible (Fig 27). This condition is typically caused by line breeding for a specific size and shape of the head (Stockard & Johnson, 1941). The great variety in the size and structure of the canine jaws and teeth between breeds in combination with cross breeding have also resulted in malocclusions. The accepted theory is that these malocclusions occur secondary to the degree to which achondroplasia is expressed (Stockard & Johnson, 1941). Other potential (non-genetic) causes would include early trauma with bone scarring or physeal closure; however, this diagnosis should be supported by a history of trauma.

This condition, while quite common and "normal" in brachycephalic breeds, often creates painful soft tissues, gingival and tooth trauma (Fig 28). However, as with most oral conditions, it is rare for the patient to exhibit clinical signs. Regardless, therapy of all traumatic malocclusions is recommended (Yelland, 2013).

FIG 27. Soft tissue trauma in MAL 3.

CLASS IV MALOCCLUSION: MAXILLOMANDIBULAR ASYMMETRY

This is also known as a "wry" bite in layman's terms. It is a jaw length discrepancy where one of the mandibles is shorter than the contralateral, which results in a shift of the midline (Fig 29). However, a true class IV malocclusion occurs when one mandible is longer than the maxilla and the other is shorter. This asymmetry can occur in one of three directions: rostro caudal, dorsoventral or side to side. This malocclusion typically causes palatine, gingival (± tooth) trauma (at least on one side) (Fig 30). If trauma is present, therapy is mandated (Hardy, 2013).

Options for therapy

The therapeutic options for malocclusions fall into several categories (Martel, 2013; Moore, 2013; Startup, 2013; Storli, 2013; Thatcher, 2013; Yelland, 2013).

1. For purely cosmetic cases no therapy is recommended. In fact, it is strongly discouraged by the AVDC, AKC and many other organisations for ethical reasons (Gawor, 2013b).
2. Surgical – generally consisting of extraction of offending teeth (*i.e.* those causing occlusal trauma) (Angel, 2016). This is likely the treatment of choice in tier 1 and 2 countries. Extraction is the treatment of choice for traumatic malocclusion of deciduous teeth, although this will not necessarily impact the (mal)occlusion of the permanent dentition (Godziebiewski et al., 2023; Herrmann & Taney, 2022; Ringen et al., 2024).
3. Orthodontic: This involves moving the malocclusion teeth into the correct or at least a non-traumatic position via the use of various appliances (Blazejewski, 2013; Kim et al., 2015). This is typically performed in linguoversed mandibular canines. However, mild class II malocclusions can potentially be treated in this manner (Storli, 2013; Taylor et al., 2023). In cases of

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FIG 28. (A–C) Teeth trauma in Class 3.

FIG 29. Shift of the midline in Class IV.

FIG 30. Soft tissue trauma in Class IV (2 images).

very mild lingual malocclusion of mandibular canine teeth, ball therapy (Verhaert, 1999) may be sufficient to move teeth into an appropriate position.

4. Coronal amputation and endodontic/restorative. When the teeth cannot be easily moved into the correct position (*i.e.* when the opposite tooth blocks the movement), this therapy

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can be an alternative to extraction. Typically, the teeth creating the trauma are shortened and treated endodontically (vital pulp therapy or root canal treatment) (Thatcher, 2013). In mild cases, they can be slightly reduced (odontoplasty) and then the exposed dentine sealed with a resin.

The latter two techniques are quite challenging and should only be attempted by dental specialists (and potentially veterinarians with advanced training).

Key points

- Malocclusions in veterinary patients typically create occlusal trauma which can result in significant morbidity and thus require treatment, despite a lack of clinical signs.
- Most malocclusions have a genetic component, often secondary to line breeding for specific traits.
- Cosmetic malocclusions should not be performed on intact patients for ethical reasons.
- There are several treatment options for traumatic malocclusions; however, in most areas of the world, extraction is the most expedient and offers the best long-term prognosis.

Enamel hypoplasia/hypocalcification

As stated in the anatomy section, the teeth are made up of three main components: pulp, enamel and dentine. The enamel is an exceedingly thin (<1 mm) coating of tooth crowns (Lewis & Reiter, 2010; Theuns, 2011). It is critical to note that enamel can *only* be produced before the tooth erupts and cannot be repaired by the patient following eruption (Niemiec, 2010b, 2008c; Theuns, 2011).

This condition may be caused by the ameloblast producing less enamel matrix producing a tooth with thin enamel that is easily damaged, termed enamel hypoplasia (Fig 31). Alternatively, enamel hypomineralisation causes enamel pitting, flakiness and discolouration (Fig 32) (Lemmons & Beebe, 2019).

Enamel hypoplasia/hypocalcification (EH) results from the disruption of normal enamel development (Dupont, 2010; Neville et al., 2002). There are several potential causes of EH including: traumatic, infectious/nutritional and genetic (King et al., 2005; Lemmons & Beebe, 2019; Niemiec, 2008c, 2010b). There appears to be a genetic component for this in the Standard poodle, Italian Greyhound and Samoyed (Gandolfi et al., 2013; Mannerfelt & Lindgren, 2009; Pedersen et al., 2017).

If one or several adjacent teeth are affected, the most likely cause is trauma to the unerupted tooth/teeth (Fig 33) (Niemiec, 2014). While this can be caused by any trauma (even intrauterine), it can also be associated with the extraction of a deciduous tooth (Felz et al., 2024). In addition, infection draining from a fractured deciduous tooth can also create this pattern of disease (Niemiec, 2010b).

It is well known that a nutritional or systemic infectious issue may also create EH. If this was the cause, most, if not all of the teeth will be affected. However, only a small part of the crown is involved in a circumferential strip, known as *Turner's hypoplasia* (Niemiec, 2014) (Fig 34). This represents the enamel, which was

FIG 31. Enamel hypoplasia.

FIG 32. Enamel hypocalcification.

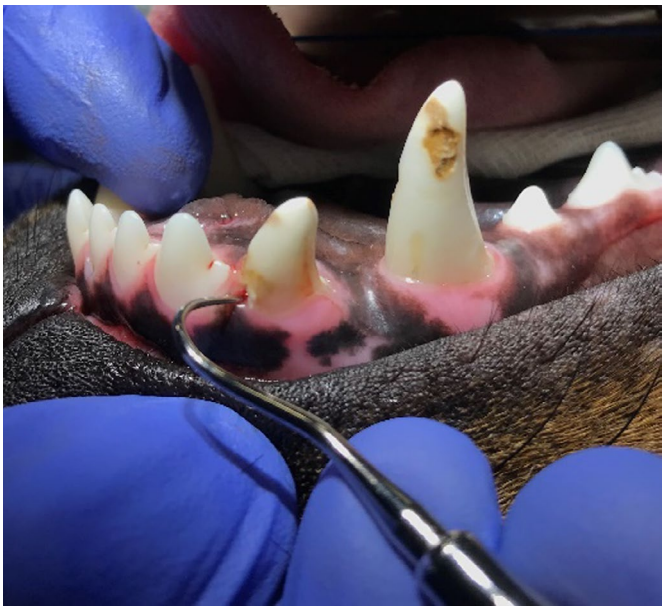

FIG 33. Enamel changes likely due to trauma to the unerupted tooth.

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being created during the offending issue. It is classically assumed that canine distemper is a common cause of this presentation, but this is not universally believed.

Finally, enamel hypoplasia may result from a hereditary condition known as *amelogenesis imperfecta* (Hytonen et al., 2019; Niemiec, 2014). This is caused by a decreased or complete lack of the ability for the patient to create the enamel matrix during tooth development. In these cases, nearly all teeth are involved on all surfaces. In these cases, other conditions can occur, and the roots may also be malformed (odontodysplasia) (Niemiec, 2010b).

Areas of EH appear stained tan to dark brown (rarely black), and typically appear pitted and rough (Fig 35) (Niemiec, 2014). However, when explored, the surface is hard, as opposed to the soft feel of caries.

Dentine exposure results in significant pain for the patient (Greenfield, 2012; Trowbridge et al., 2002). In addition, the dentine exposure is considered indirect exposure of the endodontic system and may on occasion result in endodontic disease. Finally, the rough surfaces allow increased plaque and calculus retention, hastening the onset of periodontal disease (DeBowes, 2010; Greenfield, 2012; Niemiec, 2013a; Perry et al., 2006) (Fig 36).

Due to the significant morbidity created by this condition, prompt therapy is mandated. The goals of treatment are resolving sensitivity, blocking the dental tubules and preventing endodontic consequences and smoothing the tooth surface to decrease plaque accumulation.

Preoperative dental radiographs are required to ensure tooth vitality as well as to make sure other comorbidities occur that can affect the roots, namely odontodysplasia (Fig 37) (Kot et al., 2024). Extraction may thus be the best option for therapy of the most severely affected teeth (Dupont, 2010; Holmstrolm et al., 1998b; Niemiec, 2008c, 2010b).

The best way to accomplish the treatment goals is placement of a composite restoration (Niemiec, 2014) (Fig 38A). This alleviates the pain, blocks the potential pathway for infection and smooths the tooth. Since there is minimal strength added by composite restorations, if the damage is severe and the client is interested in a permanent correction, a cast metal crown can be placed which has been shown to be effective in maintaining vitality (Fig 38B) (Brown et al., 2024; Niemiec, 2014; Ribka & Niemiec, 2022). When there are financial

FIG 34. Turner's hypoplasia.

FIG 35. Pitted and rough appearance of enamel hypoplasia.

FIG 36. Rough surfaces allow faster accumulation of plaque and calculus.

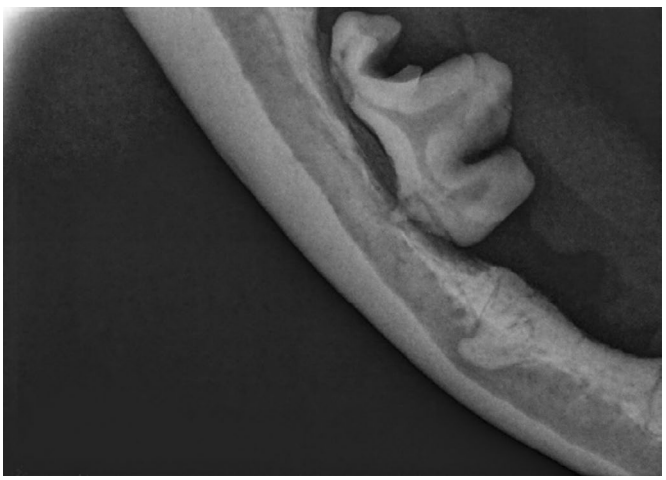

FIG 37. Radiograph of root odontoplasia.

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concerns or in cases of minor teeth, smoothing the tooth and application of a bonded sealant is acceptable (Niemiec, 2014) (Fig 39).

Key points

- EH can be caused by trauma, infection or may have a hereditary cause.
- The loss of enamel creates sensitivity as well as a roughened tooth surface, which increases periodontal disease and may result in endodontic infection.
- Restoration via bonded sealant, composite or cast metal crown is recommended.

Oral papillomatosis

Papillomas may present in the oral cavity and on the lips of young animals (Fig 40) and are generally viral in origin. Papillomaviruses are widespread viruses across different species, with 24 canine papillomaviruses (CPV) and 6 feline papillomaviruses (FcaPV) so far identified. Majority of the papillomaviruses are highly species specific. Also, these viruses are commonly tissue specific but can cause epithelial lesions in different locations/organs, including the oral cavity. Papillomaviruses can be low-risk or high-risk with oncogenic potential, especially in cats (Chang et al., 2020; Medeiros-Fonseca et al., 2023).

Canine oral papillomatosis

Canine papillomavirus types 1, 2, 3, 4, 6, 8, 13, 17 and 19 can affect skin and oral cavity. Canine oral papillomatosis is contagious from one dog to another (incubation period of 4 to 8 weeks) and is most commonly caused by CPV1. Clinically, single or multiple warts on the lips and oral mucosa are usually identified (Fig 41). Clinical signs and course of the disease are usually enough to make a diagnosis, but biopsy is always recommended, especially if the lesions are atypical (Gieger & McEntee, 2020; Medeiros-Fonseca et al., 2023).

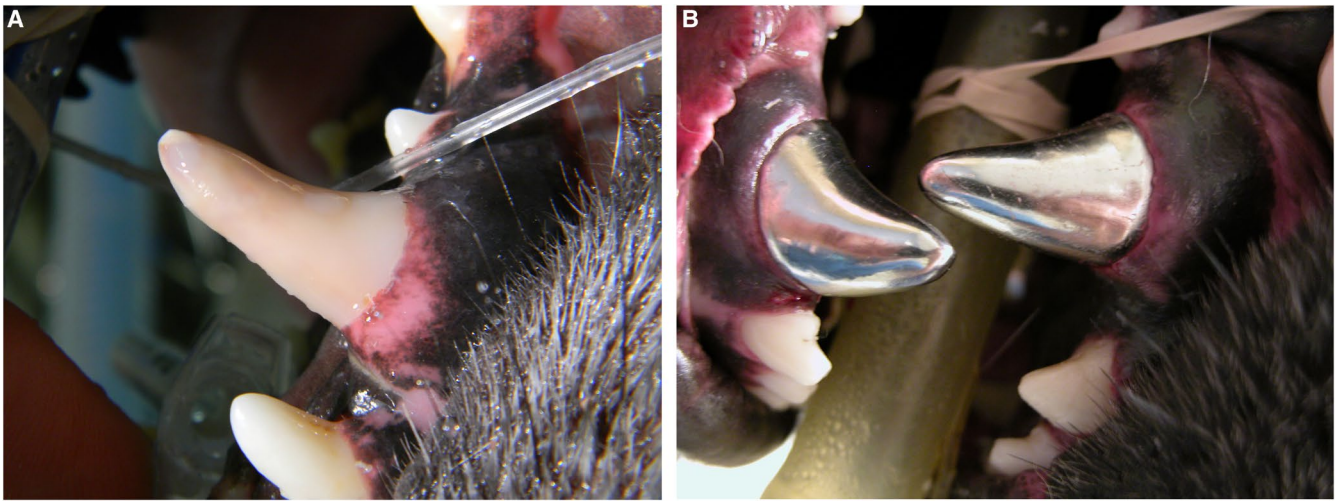

FIG 38. (A) Composite restoration for enamel defect. (B) Cast metal crown.

FIG 39. Smoothing enamel defects and placing bonded sealant.

FIG 40. Oral papilloma affecting hard palate of a dog.

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FIG 41. Oral papilloma affecting lip of a dog.

Young animals are most commonly affected, and the lesions normally regress spontaneously within 4 to 8 weeks (Medeiros-Fonseca et al., 2023), but it may take up to 1 year (Sancak et al., 2015). Dogs that regressed do not develop new oral papillomas due to CPV type-specific cell-mediated immunity, marked influx of leukocytes and/or neutralising antibodies (Ghim et al., 2000; Nicholls et al., 2001), which peak around the time of clinical recovery (Sancak et al., 2015). In general, these lesions do not pose a major health concern; however, malignant transformation has been reported (Regalado Ibarra et al., 2018).

No treatment is usually needed/indicated in most of the dogs. However, azithromycin treatment (Yağci et al., 2008) or, recently described, a combination of homeopathic drugs (Raj et al., 2020) may help with earlier recovery (1 to 2 weeks). Also, vaccination can protect against the infection (Stanley et al., 2001). Excisional surgery, laser surgery or cryosurgery may help in cases with severe lesions that interfere with eating (Gieger & McEntee, 2020). Rarely, in older dogs or dogs that develop persistent and/or severe oral lesions, underlying (immune) disease should be identified (Gieger & McEntee, 2020). Response to surgical treatments in these cases may not be satisfactory, and evidence on successful use of autogenous or recombinant vaccine (Gieger & McEntee, 2020; Kuntsi-Vaattovaara et al., 2003) is scarce; humane euthanasia may need to be considered in these cases.

Feline oral papillomatosis

Feline papillomavirus types 1, 4 can affect skin and oral cavity, especially the tongue. Similar to dogs, oral warts (although they are less frequent) regress spontaneously, although the time to complete resolution may be longer (Gieger & McEntee, 2020; Medeiros-Fonseca et al., 2023; Munday et al., 2015).

Key points

- Papillomas are mostly of viral origin and mostly affect young dogs and cats.
- Normally, viral papillomatosis is self-limiting in otherwise healthy animals.
- Infection and malignant transformation can occur.

Oral and maxillofacial trauma in juvenile patient

Deciduous teeth injuries

Deciduous teeth are weaker than adult teeth and therefore have an increased susceptibility to fracture (Hale, 2005). Combined with the fact that the pulp chamber is relatively large, this makes pulp exposure a common occurrence. Pulp exposure has negative impact because of its inflammation, infection, subsequent pulp necrosis and potential abscess which can affect the developing permanent tooth. Even though the primary dentition will generally exfoliate, all injured (fractured or luxated) deciduous teeth must be extracted expediently to resolve the pain and potential infection (Gawor & Niemiec, 2021a).

Immature permanent teeth injuries

Management of fresh uncomplicated fractures of immature permanent teeth is described as dentinal bonding and always requires further clinical and radiographic monitoring of the treated teeth (Theuns & Niemiec, 2011).

The treatment used for preservation of immature fractured teeth with pulp exposure is referred to as a vital pulp therapy. This involves amputation of the most coronal part of the pulp and placement of dressing material (preferably MTA) directly onto the pulp and then restoration of the fracture to prevent ingress of bacteria (Perry, 2017) (Fig 42). This procedure requires proper skill, materials, equipment and instrument station described in trauma chapter. Similar to management of uncomplicated crown fractures, vital pulp therapy requires monitoring of treated teeth routinely recommended at least at 6 to 8 months following surgery. In the case of a non-vital tooth with an incomplete apex, advanced procedures such as apexification, apexogenesis and regenerative endodontics can be attempted but are best performed by specialists (Zacher & Marretta, 2021).

FIG 42. Fractured deciduous right maxillary canine with discoloration and likely apical abscess with parulis drainage.

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Dental extraction in juvenile patients

In case of irreversible pulp diseases, severe odontodysplasia (Kot et al., 2024) or other irreparable malformation, ectopic teeth (Klim et al., 2023) causing problems or comminuted fracture – extraction is indicated (Goldschmidt & Hoyer, 2022; Hale, 2005). Dental extractions must be complete and confirmed by postoperative radiographic assessment (Gawor & Niemiec, 2021b).

Maxillofacial fractures and their repair

Developing bones and tissue are less resistant to trauma; however, they are more prone to regeneration and repair, provided the fixation preserves vascularisation and innervation of damaged areas. It is also important to allow the development of the facial skeleton and occlusion during treatment and not to use techniques that may arrest such development (Castejón-González et al., 2022).

In these patients, open reduction techniques should be avoided (Snyder, 2020). Preferred methods for management are minimally invasive such as tape muzzle or labial buttons (Goodman & Carmichael, 2016) (Fig 43). Alternatively, if enough dental surface is available intraoral splints can be utilised (Snyder, 2020; Wolfs et al., 2022). The list of potential complications includes: damage of developing teeth due to disrupted amelogenesis, incorrect eruption, tooth resorption or pulp necrosis (Niemiec, 2010b). Further problems are associated with abnormal development of the jaws and occlusion so monitoring must include systematic diagnostic imaging of the treated sites (Wolfs et al., 2022).

Key points

- Dental and maxillofacial trauma in immature patients always require action and thorough diagnosis, supported by appropriate imaging techniques.
- Minimally invasive techniques are imperative in juvenile patients, which minimise complications and problems with healing, although development of malocclusion is likely.

FIG 43. Tape muzzle for conservative management of maxillofacial trauma in a kitten.

Oral tumours in juvenile animals

Certain odontogenic tumours can affect the oral cavity of young animals (Schmidt et al., 2010a, 2010b). While malignant non-odontogenic tumours are rare, these can also affect juvenile animals. Therefore, regardless of the age of the patient, biopsy (and other staging as indicated) is always warranted to confirm the nature of the lesion.

Odontogenic tumours

Odontoma is a type of benign inductive tumour typical for young dogs and cats and can also be considered non-neoplastic hamartoma (tumour-like malformation due to local cellular hyperactivity during development). Clinically an expansile enlargement of the jaw can be observed (Fig 44). If tooth-like structures are identified radiographically within the lesion, this is referred to as

FIG 44. Odontoma – right mandible of a dog.

FIG 45. Radiograph of the lesion in a dog from FIG 44. - compound odontoma with tooth-like structures.

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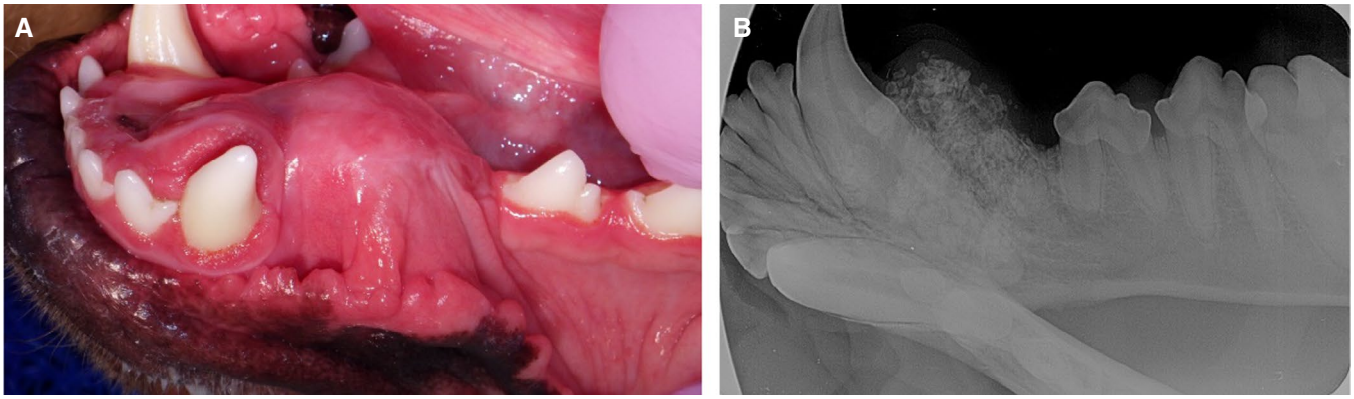

FIG 46. (A) Complex odontoma. (B) Radiograph of complex odontoma with disorganised dental tissues.

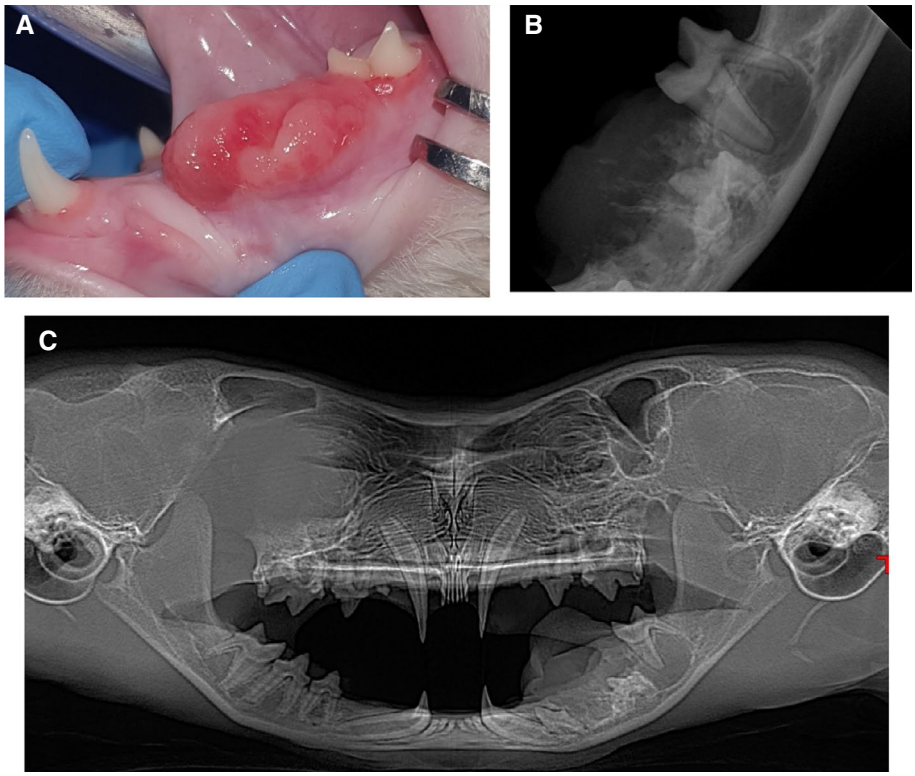

FIG 47. (A–C) FIOT – feline inductive odontogenic tumour and radiographs.

compound odontoma (Fig 45). Complex odontoma describes a conglomerate of disordered dental tissues (Fig 46). Odontoma has an excellent prognosis, even with just intracapsular excision (Fiani et al., 2020).

Feline inductive odontogenic tumour (FIOT) is a tumour type typical for young cats. Clinically a submucosal soft tissue mass of the rostral maxilla can be diagnosed (Fig 47). This tumour is locally invasive but has no known metastatic potential. Therefore, wide surgical excision is recommended and considered curative if clean margins are achieved (Fiani et al., 2020; Kim, Kwak, et al., 2023).

Amyloid producing odontogenic tumour (APOT) is a rare tumour of ameloblasts that can affect young dogs and cats. It grows by expansion and radiographically it may have a cystic appearance. The tumour is locally aggressive but without metastatic potential; therefore, early diagnosis and surgical removal with clean margins will result in a cure (Fiani et al., 2020).

Non-odontogenic tumours

Squamous cell carcinoma (SCC) can affect puppies, especially the papillary subtype. However, papillary SCC is not unique to young dogs (Nemec et al., 2014). These tumours are locally invasive with prominent bone involvement and can metastasise (Gieger & McEntee, 2020), although no metastatic disease was found in a cohort of nine young dogs in one study (Soukup, Snyder, et al., 2013). Recently, viral pathogenesis was confirmed to be unlikely (Thaiwong et al., 2018). With radical surgical treatment (surgical resection with 1 to 2 cm margins) prognosis is very good

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(Soukup, Snyder, et al., 2013). Radiosensitivity is expected as for any SCC, but radiotherapy of the maxillofacial area in young dogs with prolonged survival may lead to the development of late side effects of radiotherapy.

Fibrosarcoma can affect young dogs (and even puppies), especially of the large breeds (Gieger & McEntee, 2020).

Undifferentiated malignant tumour of young dogs is a very rare entity with an unknown tissue of origin. These lesions are locally aggressive with apparently high metastatic potential and poor prognosis (Gieger & McEntee, 2020).

Any other non-odontogenic tumour, including those atypical (*e.g. alveolar rhabdomyosarcoma* (Snyder & Michael, 2011)), can also affect maxillofacial region of young dogs; therefore, biopsy should be recommended as soon as possible even in very young animals.

Key points

- Certain odontogenic tumours can affect the oral cavity specifically of young animals, while malignant non-odontogenic tumours are rare, but not impossible.
- Biopsy must be performed early also in young animals to rule-in/-out oral tumours.

Conditions seen in mature patients

Periodontal diseases

Periodontal diseases are one of the most common health problems in small animal patients (Lund et al., 1999). A study from the 1980s reported that by 2 years of age, 70% of cats and 80% of dogs have some form of periodontal disease (Marshall et al., 2014). More recent studies have reported the incidence of closer to 90% of all patients (Fernandes et al., 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).

Periodontal disease is a collective term used to describe two conditions: gingivitis and periodontitis (Stepanuik, 2019; Niemiec, 2012a; Wallis, Milella, et al., 2021). Despite the prevalence, periodontal disease is 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 disease is 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 (DeBowes, 2010; Loe et al., 1965; Silness & Loe, 1964). 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; DeBowes, 2010; Novak, 2006). The inflammation results in the progressive destruction of the periodontal tissues, leading to attachment loss (Wiggs & Lobprise, 1997a). 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 >3 mm in dogs and 0.5 mm in cats. Periodontal bone loss is irreversible without advanced reparative surgery (DeBowes, 2010; Lee et al., 2023; Shoukry et al., 2007). 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 (Niemiec, 2013h).

Periodontal disease is initiated by oral bacteria, which adhere to the teeth in a substance called plaque (Boyce et al., 1995; Lindhe et al., 1975; 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; Quirynen et al., 2006; Socransky & Haffajee, 2002). 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 (Loe et al., 1965; Silness & Loe, 1964). Plaque and calculus may contain up to 10^{11} bacteria per gram (Quirynen et al., 2006; Socransky & Haffajee, 2002). More importantly, bacteria within a biofilm are 1000 to 1500 times more resistant to antibiotics and concentrations of antiseptics up to 500,000 times that which would kill singular bacteria (Elder et al., 1995; Quirynen et al., 2006; Socransky & Haffajee, 2002). Moreover, oral bacteria can develop resistance to antiseptics (Bartsch et al., 2024).

Periodontal disease is 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 most of the population in periodontal diseases (Davis, Wallis, et al., 2013; Holcombe et al., 2014; Santibáñez et al., 2021). Further, the Davis study (Davis, Wallis, et al., 2013) 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; Wallis, Saito, et al., 2021). Further, *Porphyromonas gulae* was found to be most associated with severe periodontal disease in an additional study (Niemiec et al., 2021a). Although the disease process is histologically similar between humans and dogs, differences between human and canine dental plaque formation and composition have been described (Davis, Wallis, et al., 2013; 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 dogs it is predominantly Gram-negative aerobes (Davis, Wallis, et al., 2013). Further, the initial colonisers 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 (Bardow & Vissink, 2015; Lavy et al., 2012). Be there are other microbes besides bacteria that may play a role in periodontitis. *Entamoeba gingivalis* is a

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protozoon of the oral cavity, which is frequently observed in the periodontal pockets (Bonner et al., 2018). It drives tissue destruction and may play a role in the development of periodontitis (Bao et al., 2020, 2021). *Toxoplasma gondii* has also been suggested as a periodontal pathogen (Cao et al., 2024; Dubey et al., 2020). Finally, a recent study suggests that fungi may be involved in the progression of canine periodontal disease. This is because certain species (specifically Didymellaceae, Irpicaceae and Pleosporales) are significantly associated with the various stages of disease (Niemiec et al., 2021b).

Plaque on the visible tooth surface is known as supragingival plaque (Niemiec, 2013a; Teughels et al., 2015; Wiggs & Lobprise, 1997a). 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 (Niemiec, 2008b; Quirynen et al., 2006). 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 (DeBowes, 2010; Niemiec, 2013a; Westfelt et al., 1998).

The bacteria in the subgingival plaque excrete toxins and metabolic products, which create inflammation of the gingival and periodontal tissues (Harvey & Emily, 1993a; Stepaniuk, 2019). This inflammation causes damage to the gingival tissues, or gingivitis, which eventually may lead to periodontitis, that is the loss of periodontal tissues. In addition to directly creating tissue damage, the bacterial metabolic by-products also elicit an inflammatory response from the animal, which further damages the periodontal tissues (Lang et al., 2002; Scannapieco, 2004; Thoden van Velzen et al., 1984). 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 fact that the patient's immune system plays a huge role in the progression of periodontal disease is critical information. This is because it has been well established that periodontal disease has a genetic predisposition. This has been studied extensively on the human side (Loos et al., 2008). Further, it is well established that certain breeds including Cavalier King Charles Spaniels, Greyhounds and most small breed dogs are predisposed (Dale et al., 2024; Marshall et al., 2014; Wallis et al., 2019; Wallis, Saito, et al., 2021). Finally, within breeds, littermates can be more or less susceptible to periodontal disease (Wallis et al., 2018). Other predisposing factors include retained deciduous teeth, rotated/crowded teeth, roughened tooth surfaces and gingival enlargement (Niemiec, 2013a).

The inflammation produced by subgingival bacteria, their toxic by-products and host response damages the soft tissue attachment of the tooth and ultimately decreases the bony support via osteoclastic activity (Nisengard 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 issues prior to tooth exfoliation.

Calculus is plaque which has become mineralised by salivary interaction. It is critical to note that calculus itself is relatively non-pathogenic, providing mostly an irritant effect and creating a plaque-retentive surface (Hinrichs, 2006; Niemiec, 2008a; Wiggs & Lobprise, 1997a). The level of calculus is not directly related to the level of periodontal infection, and this should not be relied upon to determine the need for professional care. A more accurate method is the level of gingival inflammation but even that misses the early cases (Stella et al., 2018). Thus, many veterinary dentists recommend annual professional periodontal treatments for all patients, regardless of the lack of outward signs.

Clinical features

Normal gingival tissues are coral pink in colour (allowing for normal pigmentation) and have a thin edge, with a smooth and regular texture (Fig 48). There should be no visible plaque or calculus.

The first *clinical* sign of gingivitis is gingival erythema, followed by oedema and halitosis (DeBowes, 2010; Fiorellini et al., 2006) (Fig 49). However, bleeding on probing, brushing or chewing may be noted prior to the colour change (Fiorellini et al., 2006; Meitner et al., 1979; Niemiec, 2013a) (Fig 50). A recent study showed that general anaesthesia is required to diagnose most periodontal pathology (Stella 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 (Fig 51) (Niemiec, 2013a). Alternatively, widespread supragingival calculus may be present with little to no gingivitis (Fig 52) (Niemiec, 2013a). Therefore, the degree of gingival inflammation should be used to judge the need for professional therapy, not the level of calculus.

As gingivitis progresses to periodontitis, the oral inflammatory changes intensify. The hallmark feature of established periodontitis

FIG 48. Normal gingival tissue.

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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, tooth roots become exposed, and the disease may be identified on conscious examination (Fig 53). However, with periodontal pocket (Fig 54) 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 (Niemiec, 2008b). Attachment loss may ultimately progress to tooth exfoliation. After tooth exfoliation (or extraction) occurs, the area generally returns to an uninfected state, but the bone loss is permanent.

Local consequences

The most common severe local consequence of periodontal disease is an oronasal fistula (ONF). ONFs are typically seen in older,

FIG 51. Gingivitis with little plaque and calculus.

FIG 49. Gingival erythema.

FIG 52. Significant plaque and calculus with little gingivitis.

FIG 50. Bleeding on probing.

FIG 53. Gingival recession and root exposure.

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small and chondrodystrophic dogs (especially Dachshunds); however, they can occur in any breed as well as in cats (Holmstrom et al., 1998a; Marretta, 1998; Smith, 2000). The palatal surface of the canine tooth is the most commonly affected (Marretta & Smith, 2005; Niemiec, 2010a; Smith, 2000), but it can occur on any surface of any maxillary tooth. This results in a communication between the oral and nasal cavities, creating chronic nasal inflammation (rhinitis) (Fig 55). Clinical signs may include chronic nasal discharge, sneezing and occasionally anorexia and halitosis. Definitive diagnosis of an ONF requires general anaesthesia. This is made by introducing a periodontal probe into the periodontal space on the affected surface of the tooth (Fig 56). ONFs can exist even when other surfaces of the affected tooth are apparently healthy (Niemiec, 2008b, 2013b). Appropriate treatment of an ONF requires extraction of the tooth and tension-free closure of the defect with a mucogingival flap following debridement of any epithelialised tissue of the fistula (Marretta, 1998; Marretta & Smith, 2005; Smith, 2000).

FIG 54. Periodontal pocket probed under general anaesthesia.

FIG 55. Deep palatal pocket at maxillary canine extends into nasal cavity – oronasal fistula and rhinitis.

In multirooted teeth, class II perio-endo lesions may occur (Niemiec, 2001). This occurs due to periodontal loss progressing to the apex of the tooth allowing bacteria to gain access to the endodontic system via the previous blood supply. Then, the endodontic infection spreads via the common pulp chamber creating periapical lesions on the other root(s) (Sunitha et al., 2008; Varughese et al., 2015) (Fig 57). In contrast, class I lesions are defined as periodontal infection extending from the root canal system where the bacteria gained access through the crown of the tooth. Finally, class III lesions are true combined lesions (Boyd, 2019; Gawor, 2018a). Class I lesions are not a consequence of periodontitis, and class III lesions are exceedingly rare in veterinary patients. Class II lesions can be treated by extraction, or if only one root is periodontally affected, tooth/root resection and endodontic therapy of the other root can be performed (Boyd, 2019; Niemiec, 2001; Varughese et al., 2015).

Pathological fractures secondary to chronic periodontitis typically occur in the mandible (especially the canines and first molars) due to weakened bone (DeBowes, 2010; Mulligan et al., 1998a; Niemiec, 2013a; Stepaniuk, 2019) (Fig 58). These are far more common in small breed dogs, due to their proportionally

FIG 56. Probe – ONF.

FIG 57. Radiograph of left mandibula with periodontal - endodontic bone loss at the first molar.

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larger teeth (especially the mandibular first molar) as compared to their jaw size (Fig 59) (Gioso et al., 2003; Snyder, Soukup, et al., 2016). Pathological fractures occur most commonly as a result of mild trauma (tooth extraction, play behaviours, eating, etc.). Pathological fractures carry a guarded prognosis, especially due to the lack of remaining bone, difficulty fixating the caudal mandible, damaged blood supply and infection. There are numerous options for fixation, but regardless of the method, the diseased tooth root(s) must first be extracted for healing to occur (Niemiec, 2008b; Taney & Smith, 2010) (Fig 60). Awareness of the risk of pathological fractures can help the practitioner to avoid them.

Severe periodontitis can lead to inflammation close to the orbit and potentially blindness due to global rupture (Anthony et al., 2010; Ramsey et al., 1996). The proximity of the tooth root apices of the maxillary molars and fourth premolars places the delicate optic tissues in danger (Fig 61).

Periodontitis is the most common cause of osteomyelitis, which can lead to osteonecrosis (Peralta et al., 2015) (Fig 62). In the presence of non-vital bone, the lack of blood supply prevents penetration of antibiotics in these tissues and surgical debridement in necessary (Marretta, 1998; Niemiec, 2008b; Wiggs & Lobprise, 1997b). Osteonecrosis is another possible sequalae of dental disease in dogs (Peralta et al., 2015).

While there are currently no studies in the veterinary literature, numerous human studies show an increased incidence of oral cancer in patients with chronic periodontal disease (Bundgaard et al., 1995; Graham et al., 1977; Guha et al., 2007; Kamarajan et al., 2020; Maier et al., 1993; Rezende et al., 2008; Rosenquist et al., 2005; Talamini et al., 2000; Wen et al., 2014; Zheng et al., 1990). 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.

FIG 58. Radiograph of pathological fracture of the left mandible due to periodontal bone loss.

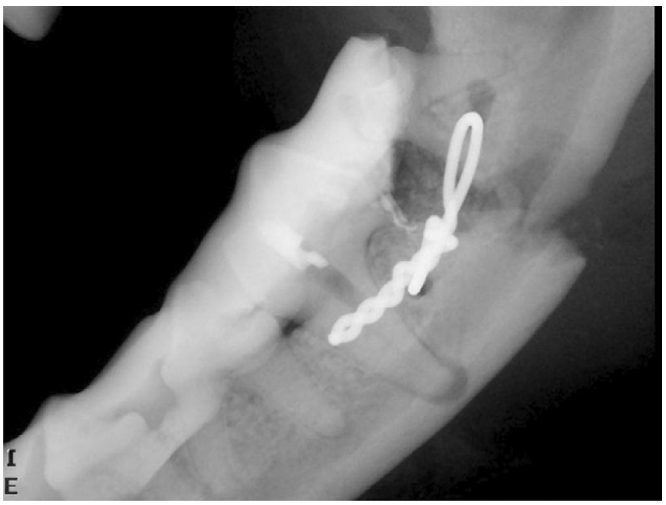

FIG 60. Extraction of diseased tooth in fracture region needed.

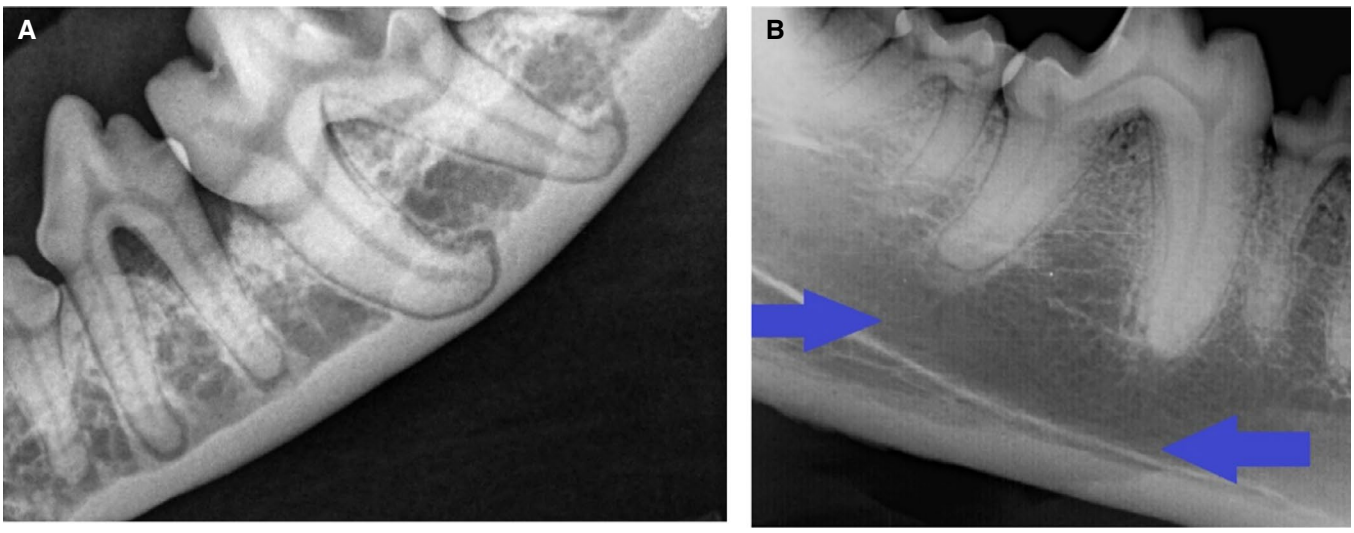

FIG 59. (A) Radiograph of small breed dog mandible. (B) Radiograph of large-breed dog mandible.

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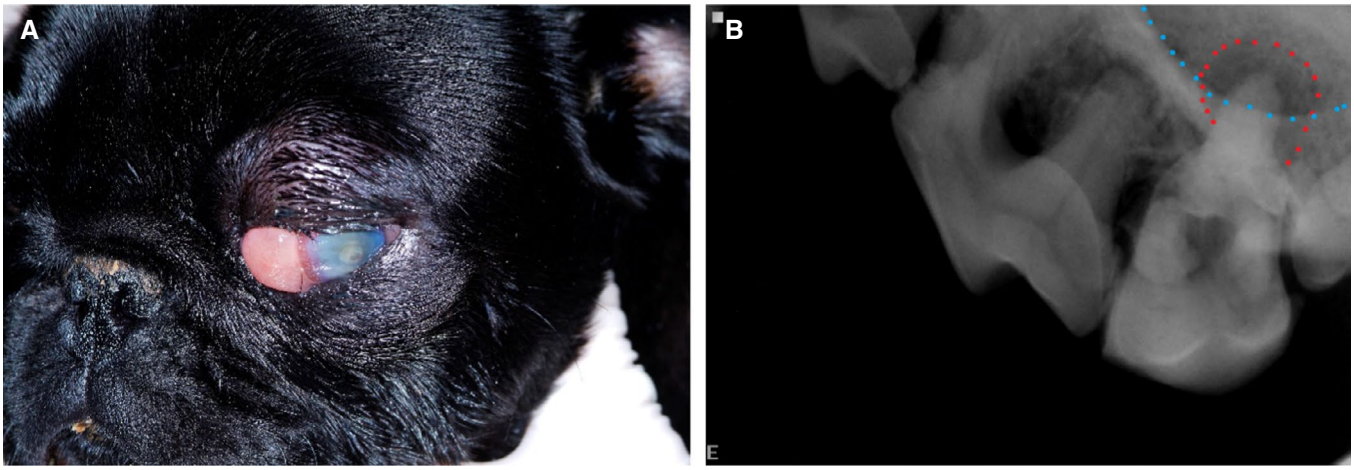

FIG 61. (A) Potential damage to ocular tissues. (B) Radiograph of left maxillary first molar; proximity of roots to optic tissues.

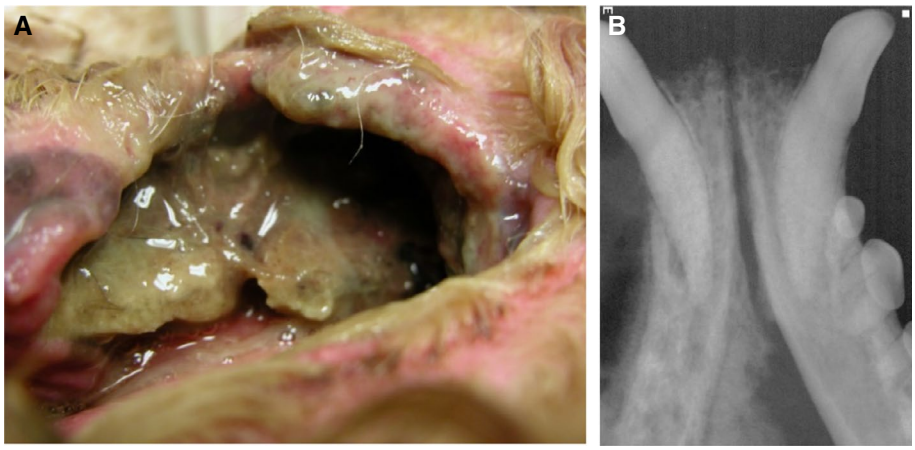

FIG 62. Periodontitis can lead to osteomyelitis and osteonecrosis (A) Clinical picture of severe osteomyelitis of the right mandible in a dog with advanced periodontal disease. (B) Dental radiograph of the same patient revealing severe bone remodeing and periosteal reaction.

Systemic consequences of periodontal diseases

Systemic ramifications of periodontal disease 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 disease on systemic health (Niemiec, 2012b).

These systemic effects begin with inflammation of the gingiva and periodontal tissues. This inflammatory response allows the body's defences to attack the bacteria, but also provides access for the bacteria and their associated inflammatory mediators (Takai, 2005) to breach the body's defences (DeBowes et al., 1996; Mealey & Klokkevold, 2006; Niemiec, 2013f; Scannapieco, 2004). 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; Pavlica et al., 2008; Rawlinson et al., 2011; Renvert et al., 1996; Scannapieco, 2004). These mediators have in turn 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; Dos Santos et al., 2019; Harvey, 2022). Pavlica et al. (2008) showed a significant relationship between the periodontal disease burden and increased inflammation in the hepatic parenchyma. Furthermore, generalised bacteraemias (some of which are plausibly oral in origin) have been shown to cause cholestasis in dogs (Center, 1990; Taboada & Meyer, 1989).

Periodontal disease has also been proposed as a risk factor for the development of chronic kidney disease in dogs and cats (Finch et al., 2016; O'Neill et al., 2013). 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 healthy dogs (Glickman et al., 2009). Pigs and mice also have been shown to have increases in cardiovascular issues secondary to inflammation created by periodontitis (Brodala et al., 2005; Lalla et al., 2003).

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It has been well established that Alzheimers and dementia in people are increasing in patients with periodontal disease. While the results are preliminary and limited to one study, periodontal disease has also been shown to be associated with canine cognitive dysfunction in dogs (Dewey & Rishniw, 2021).

A correlation between glycaemic control and periodontal health is commonly accepted in the veterinary world. Improvements in periodontal health appear to assist in control of diabetes in dogs and are frequently recommended in the approach to proper diabetic care (Nivy et al., 2024).

Increased systemic inflammatory markers, such as C reactive protein, have been noted to be increased with severe periodontal infection (Kouki et al., 2013; McFadden & Marretta, 2013). In human medicine, there is extensive interest in "inflammaging", described as the persistent, sterile inflammation that may contribute to age-related diseases such as renal disease, dementia, heart disease or diabetes. On the veterinary side, Rawlinson et al. (2011) noted significant decreases in both C reactive protein and creatinine post periodontal disease therapy; however, other studies have shown a worsening during therapy in severe cases (Hall et al., 2021). Nemec et al. (2013) noted a transitory increase in nitric oxide following appropriate periodontal therapy. Dewey's study suggested that canine cognitive dysfunction can be improved with periodontal care (Dewey & Rishniw, 2021).

Lifestyle changes, antioxidants and even the manipulation of gut microbiome have been proposed mechanisms to decrease its impact on ageing, and management of oral inflammation may play a role in senior patient health.

Conclusion

Periodontal diseases are multifactorial conditions leading to multiple negative local and systemic effects. The main aetiological agent is bacterial plaque, which initiates the inflammatory cascade, resulting in periodontal tissue 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, swelling and increased gingival bleeding that may be noted clinically in conscious patients. An accurate diagnosis of the stage of periodontal disease includes a thorough examination and probing and radiological examination. Because subgingival plaque is the most pathogenic, effective therapy needs to extend under the gumline, which cannot be effectively performed without anaesthesia. While more research is needed, the correlations between periodontal disease and systemic pathology are mounting and include negative effects on the heart, kidneys and liver. In addition, studies are 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 is essentially non-pathogenic.
- The first sign of periodontal disease is bleeding on probing or brushing, which occurs prior to a colour change.
- Periodontal diseases have been linked to numerous systemic effects related to systemic inflammation which impact the heart, liver and kidney.
- Periodontal disease has been associated with numerous severe local effects including:
  - Oronasal fistulas
  - Mandibular fractures
  - Ocular infection and blindness
  - Osteomyelitis and osteonecrosis
  - Class II perio-endo lesions
  - Possibly oral cancer

Common disorders of the teeth

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, dentine, and in advanced cases, pulp exposure is termed dental attrition. If attrition is due to malocclusion of teeth, it is termed pathological attrition (Dupont, 2010) (Fig 63). Enamel or dentine loss due to an external object, such as metal cages, sticks, balls or bones, is termed dental abrasion (Dupont, 2010) (Fig 64). 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 (Fig 64B) (Dupont, 2010; Niemiec 2014b).

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 26.2% of companion animals (Soukup, Hetzel, et al., 2015). 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 be involved in high impact trauma such as car accidents, sporting injuries, that is 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, that is enamel, dentine or root, as well as whether the pulp tissues are directly exposed (Fig 65). It is further classified accordingly as enamel damage or infraction (Figs 66 and 67), enamel loss

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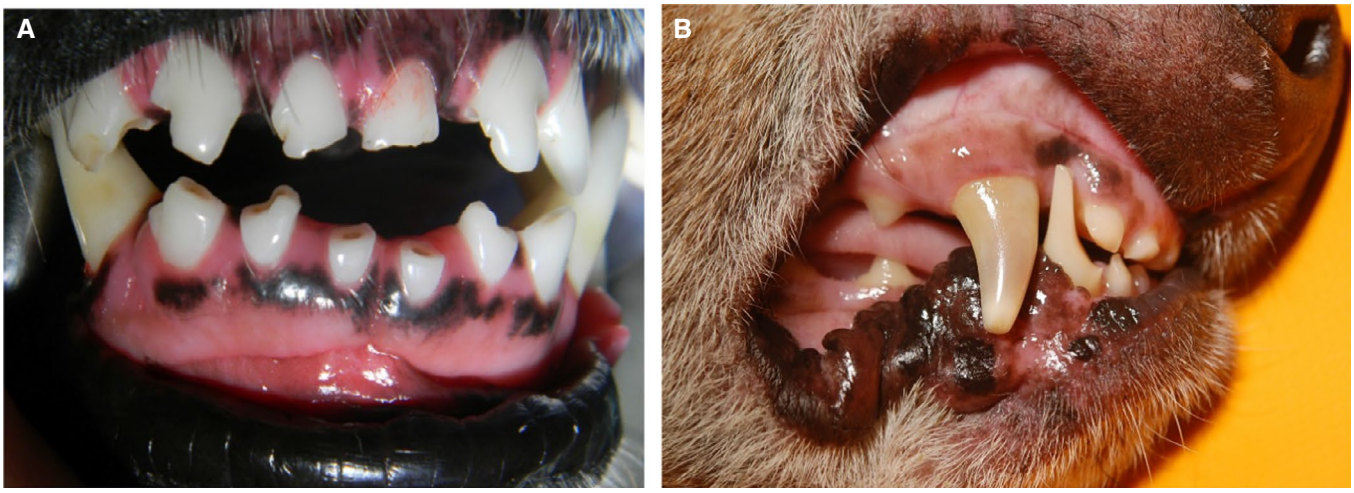

FIG 63. (A, B). Dental attrition.

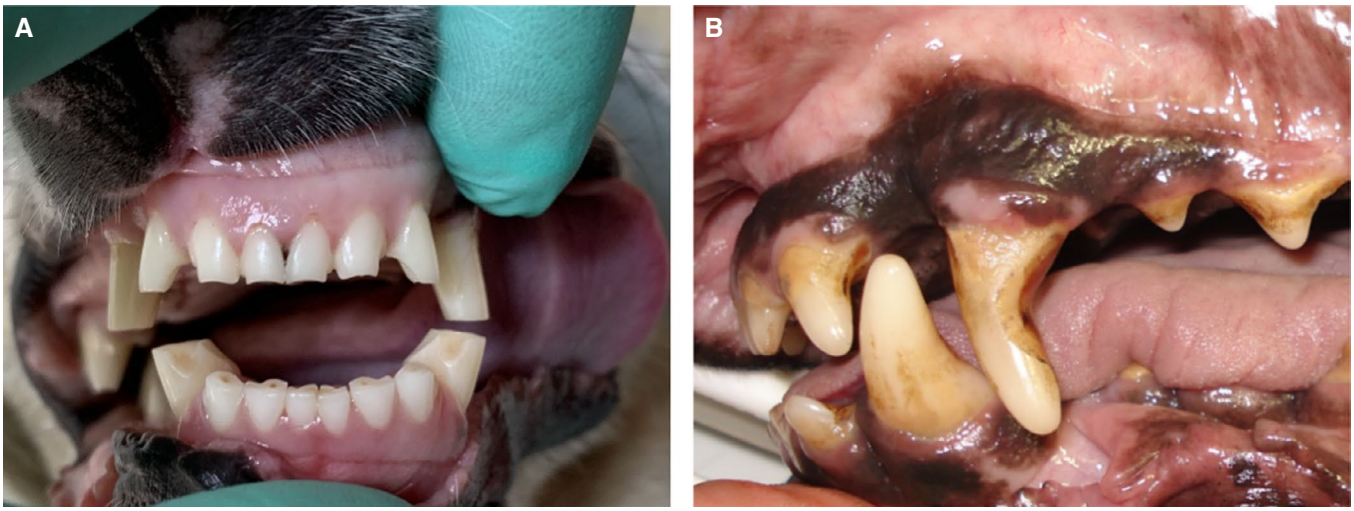

FIG 64. (A, B) Dental abrasion.

with no exposure of dentine (Figs 68 and 69), enamel and dentine exposure without pulp exposure (Figs 70 and 71), crown and root involvement without pulp exposure (Figs 72 and 73), root fracture without crown damage or pulp exposure (Figs 74 and 75), and whether there is pulp exposure, isolated to the crown (Figs 76 and 77) or involving both crown and root (Figs 78 and 79). An injury that does not expose the pulp is termed uncomplicated, while pulp exposure is termed complicated.

All vital teeth with direct pulp exposure are exceedingly painful (Bender, 2000; Hargreaves & Kaiser, 2004). Over time, these teeth will become non-vital. In most cases, a non-vital tooth which is not appropriately treated will become infected (Dupont, 2010). 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 (Fig 80A). 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 or 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). The mucogingival junction at the affected tooth is another area to look for a draining tract (Melnick & Takei, 2024).

However, even teeth without direct pulp exposure (meaning the dentine is exposed) are also known to be quite painful (Brynjulfsen et al., 2002; Snyder, 1976). This is due to a change in the fluid flow in the dentinal tubules, which will deform the A-*delta and* C-*delta* fibres and will be perceived by the patient as pain or sensitivity (Trowbridge et al., 2002). Confirmed uncomplicated crown fractures with 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 (Niemiec, 2013a; Theuns & Niemiec, 2011). Even if there is no pulp exposure, 24.3% of fractured maxillary fourth premolar

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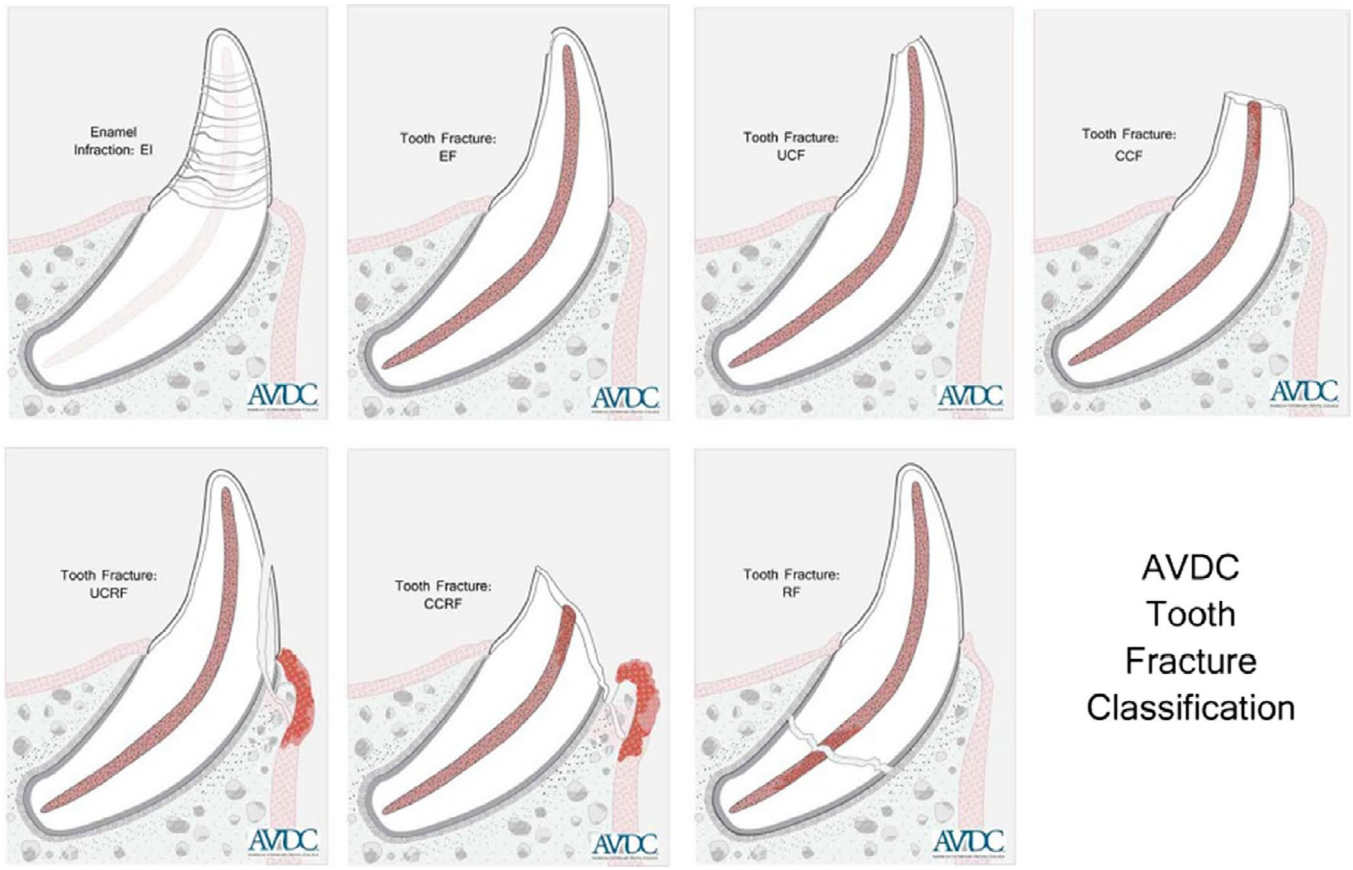

FIG 65. Line drawings of the American Veterinary Dental College Classification of tooth fractures.

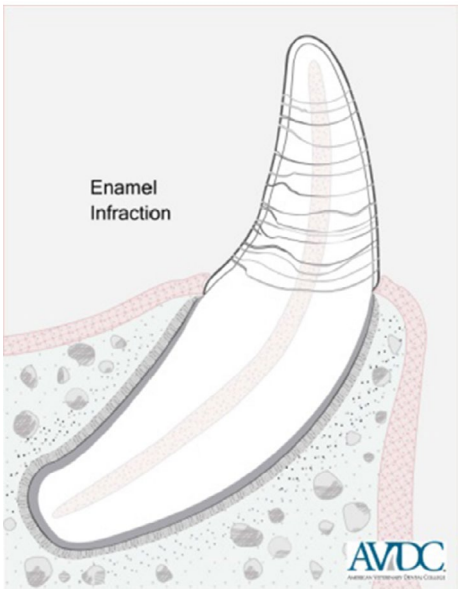

FIG 66. Line drawing of enamel infraction.

teeth in dogs were radiographically confirmed to have periapical lesions (Goodman et al., 2020).

A tooth that has suffered trauma without fracture may result in painful pulpitis and eventually pulpal necrosis. Some of these

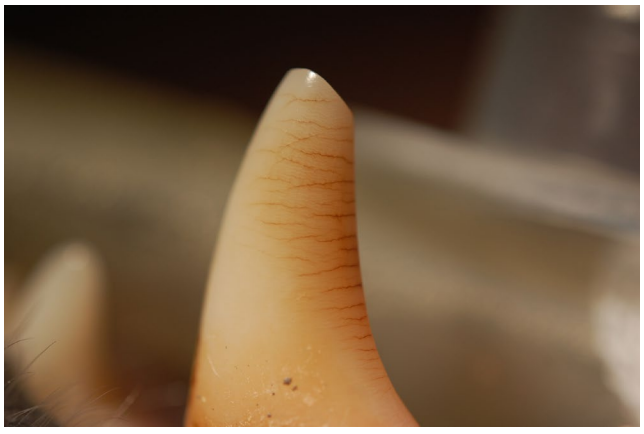

FIG 67. Left mandibular canine of a dog demonstrating enamel infraction.

teeth will appear dull or discoloured (Fig 80B) (termed intrinsic staining), and these require root canal treatment or extraction similar to a tooth with direct pulp exposure as they are most likely non-vital (see below) (Feigin et al., 2022; Hale, 2001).

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

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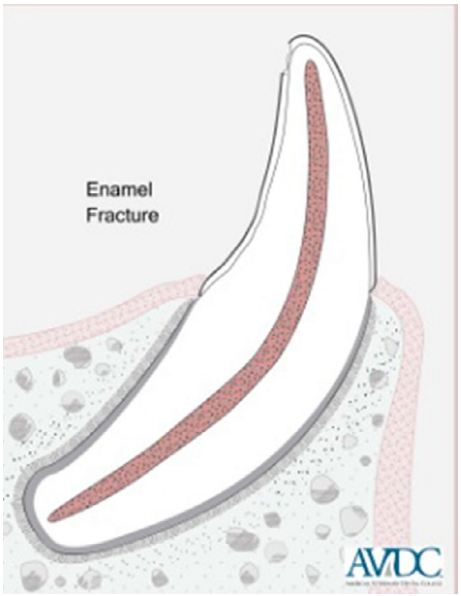

FIG 68. Line drawing of enamel fracture.

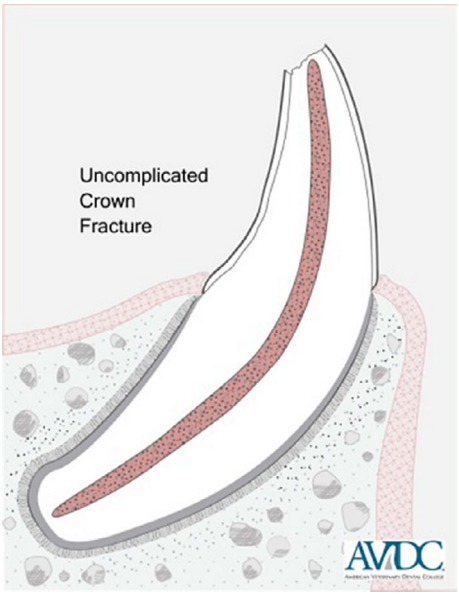

FIG 70. Line drawing of an uncomplicated crown fracture.

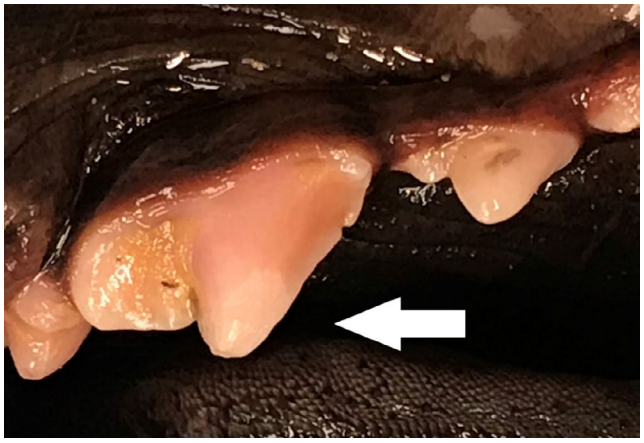

FIG 69. Right maxillary fourth premolar of a dog with an enamel fracture (white arrow). Note that the dentin is not directly exposed. (This is a rare finding in veterinary patients).

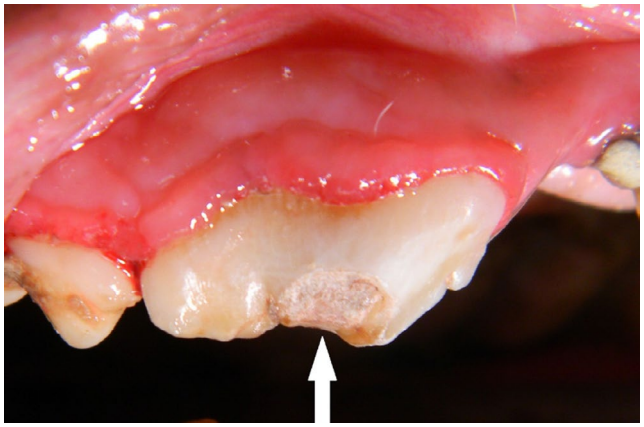

FIG 71. Right maxillary fourth premolar of a dog with an uncomplicated crown fracture (white arrow). Note that the underlying dentin is stained and has a significant amount of dental calculus due to the increased roughness.

to treatment. If the fracture exposes the pulp chamber, the pulp may appear pink if recent or grey/black if old. 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. Pulp tests similar as used in human dentistry were also evaluated in dogs and only the electric pulp test appeared useful to a degree (Proulx et al., 2022).

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 three major radiographic signs of tooth non-vitality – periapical rarefaction, apical root resorption and a larger endodontic system compared to the contralateral teeth (Fiani & Arzi, 2010). If there is evidence of this on radiology, root canal therapy or extraction is necessary regardless of the integrity of the crown.

- If the defect is confined to the enamel and dentine (an uncomplicated crown fracture), without radiographic signs of periapical pathology, smoothing any sharp edges and restoration is all that is required. Treatment of dentine exposure is always recommended to reduce sensitivity, block off the pathway for infection and smooth the tooth, thus decreasing periodontal disease (Theuns & Niemiec, 2011; Woodward, 2008a).
- Chronic wear results in the production of tertiary 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.
- Any tooth with direct pulp exposure or radiographic signs of endodontic disease requires treatment by extraction or appropri-

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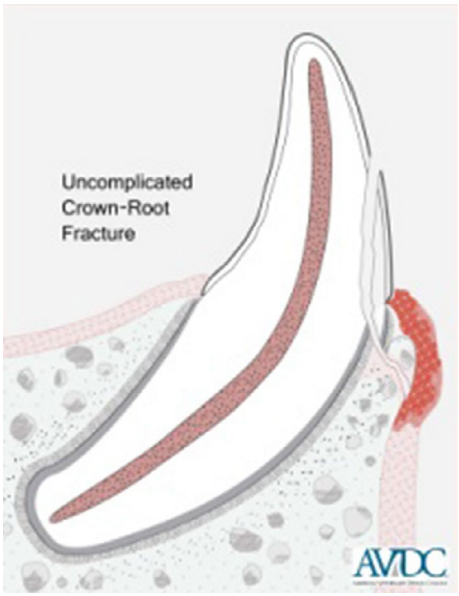

FIG 72. Line drawing of an uncomplicated crown/root fracture.

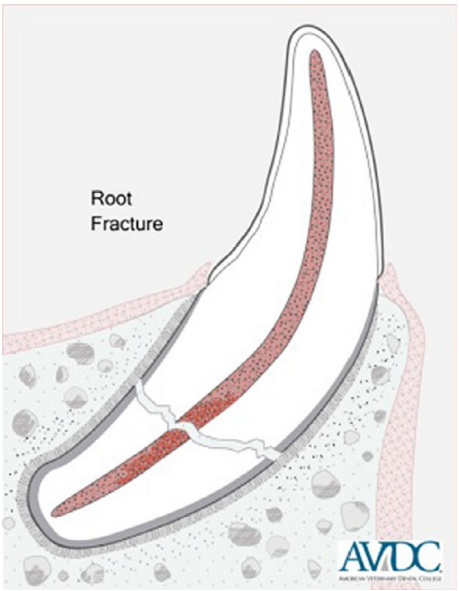

FIG 74. Line drawing of a root fracture.

FIG 73. Right maxillary fourth premolar 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.

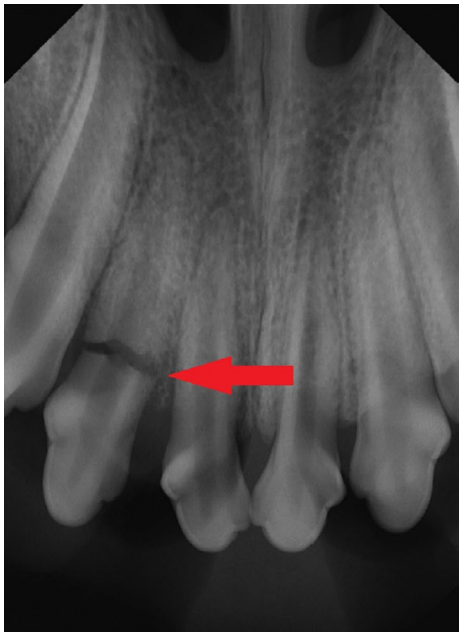

FIG 75. Intraoral dental radiograph of the maxillary incisors of a dog. The right second incisor has a root fracture (red arrow).

ate endodontic therapy to prevent further periapical pathology and subsequent osteomyelitis (Dupont, 2010; Clarke, 2001a; Moore, 2011).

- Vital teeth with direct pulp exposure are quite 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 (Luotonen et al., 2014; Niemiec, 2012b).

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), but possibly depending on the type of the sealer used (Thorne et al., 2020).

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Key points

- Fractures to the crown and/or root of the tooth are a common finding 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 endodontic therapy.

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

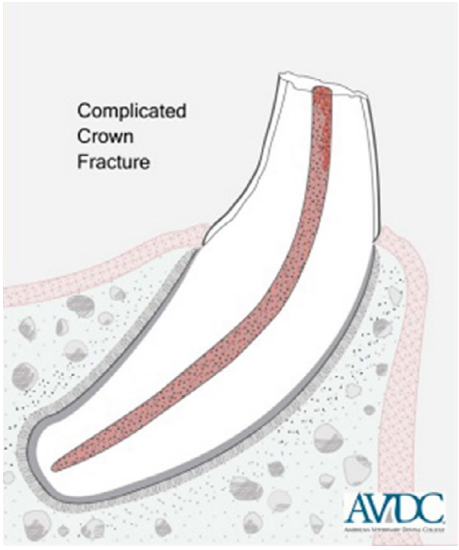

FIG 76. Line drawing of a complicated crown fracture.

Caries

Caries is the loss of dental hard tissue due to acid produced by bacteria. Most dog teeth do not provide a surface for food deposition due to their conical shape and therefore are rarely affected by caries (about 5%). Exceptions to this are the chewing surfaces of the molars in dogs. Four factors are needed for caries to develop: suitable position, bacteria, substrate (carbohydrates) and time (Hale, 1998, 2009). The effect of the acid creates cavities in the dental crown, which can reach the pulp chamber (Fig 81).

Tooth resorption

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

FIG 77. Right mandibular canine 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.

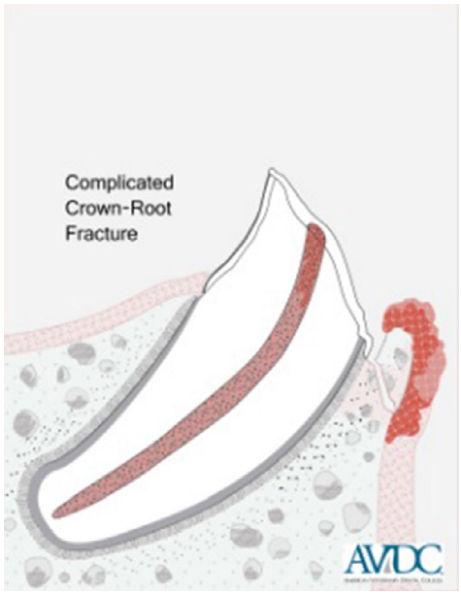

FIG 78. Line drawing of a complicated crown/root fracture.

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TR has been reported in human dentistry (Heithersay, 2004) and various species including the dog (Arnbjerg, 1996; Peralta et al., 2010a, 2010b), feral cat (Verstraete et al., 1996b), chinchilla (Crossley et al., 1997) and horse (James, 2022; Staszyk et al., 2008). In small animal veterinary dentistry, it is most common in the domestic cat where it occurs quite commonly in older cats, and it is increasingly noted in the canine population (Peralta et al., 2010a, 2010b).

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, 2015). Resorption was traditionally considered a disease of modern civilisation but it has also been reported in wild cats (Berger et al., 1996), in a cat from the late medieval era (Berger et al., 2004), and in a dog from the Roman Empire, 3rd century AD (Schernig-Mráz et al., 2023) which directly contradicts that theory.

TR is due to an active process where odontoclasts become activated. The resorption appears to be a progressive process. It generally initiates on the root surface. It then may invade the root and spread within the root dentine up into the coronal dentine, where it may undermine the enamel (Gorrel, 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 (Fig 82).

There appear to be two distinct types of tooth resorption: idiopathic and inflammatory (Eikenberg et al., 1998; Peralta et al., 2010b; Reiter & Mendoza, 2002). The resorption induced by inflammation (periodontal disease or endodontic disease) creates focal or multifocal lesions while the idiopathic variety of resorption results in root replacement by cementum- or bone-like material (DuPont & DeBowes, 2002; Farcas, Arzi, et al., 2014). The pulp resists becoming exposed by the resorption by the creation of tertiary dentine until late in the course of the disease (Gorrel, 2015). Any trauma can create resorption of the root surface; however, some of these defects heal while others do not (Patel et al., 2024).

Above the gingival margin, smaller defects are often covered by a highly vascular granulation tissue, which may be an attempt by the body to cover the exposed dentinal tubules (Fig 83) (DeBowes, 2010).

Classification

A distinction is made depending on the localisation 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

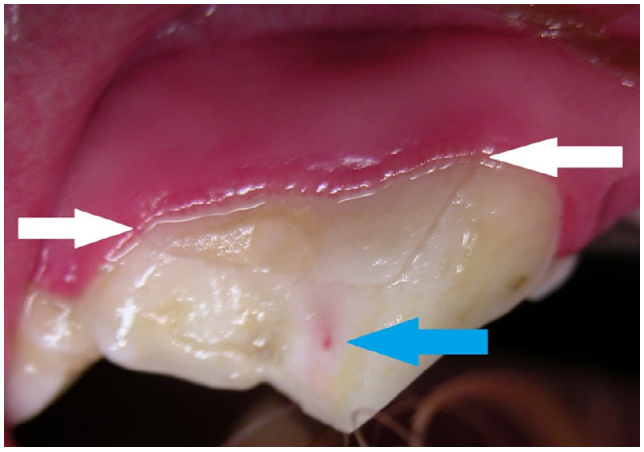

FIG 79. Right maxillary fourth premolar of a dog with a complicated crown/root fracture. Note that the endodontic system (pulp) is directly exposed (blue arrow), and that the fracture extends under the gingival margin (white arrows). Exposed, inflamed pulp is a very painful condition necessitating quick action.

FIG 81. Caries of right mandibular molar.

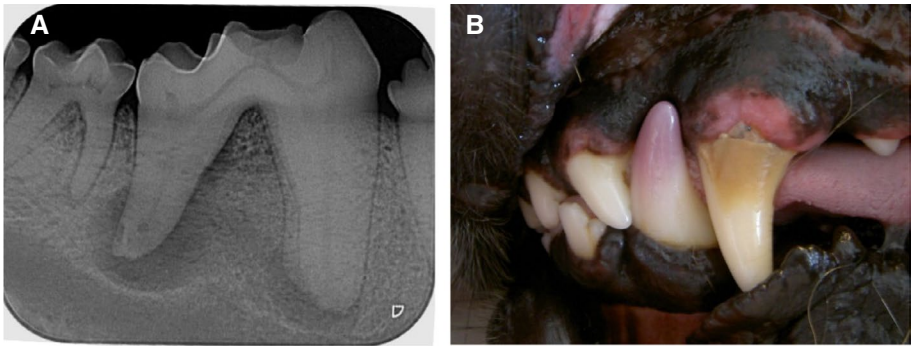

FIG 80. (A) Radiograph of periapical rarefaction. (B) Tooth appears dull or discoloured.

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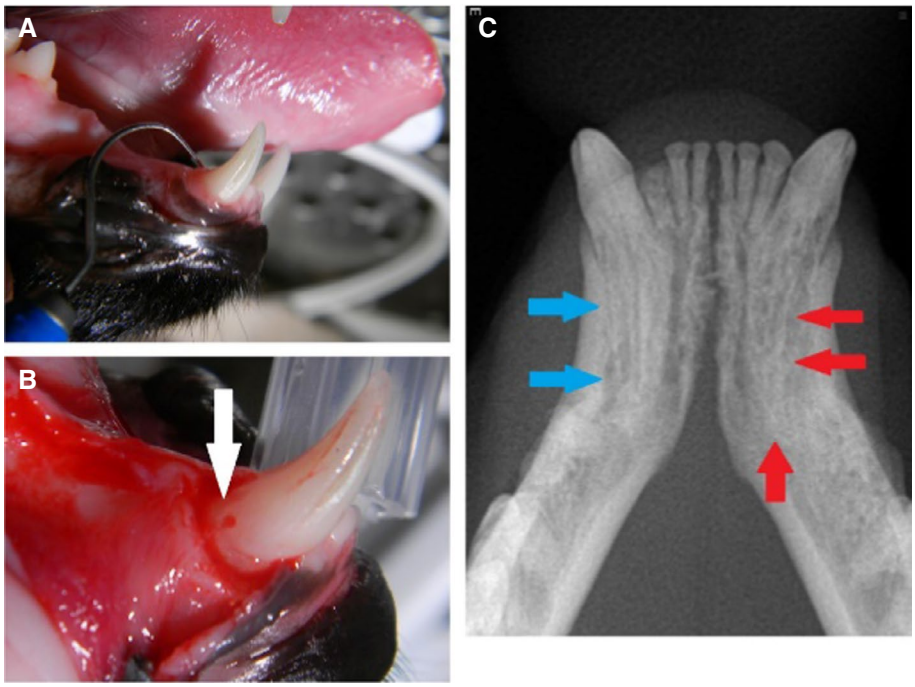

FIG 82. Tooth resorption of the right mandibular canine in a cat with a small external lesion but extensive radiographic changes of root.

FIG 83. Tooth resorptive lesion covered by granulation tissue.

periodontal inflammation being one of them (Farcas, Lommer, et al., 2014; Gorrel, 2015). In an advanced stage, the two forms can hardly be distinguished.

TR is classified based on the severity of the resorption (Stages 1 to 5) and on the radiographic appearance of the resorption. Multiple classifications have been used in animals and humans, all of which are imperfect and not necessarily exclusive to one particular species. The AVDC classification system is typically used for cats, and for dogs, it is Peralta et al. (2010a, 2010b).

Tooth resorption in cats

The AVDC classification defines inflammatory resorption in cats as type 1, idiopathic resorption as type 2 and their combination type 3.

Types of resorption based on radiographic appearance in cats

Type 1 (T1): On a radiograph of a tooth with type 1 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 (Fig 84A).

Type 2 (T2): On a radiograph of a tooth with type 2 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 (Fig 84B).

Type 3 (T3): On a radiograph of a tooth with type 3 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 (Fig 84C).

Stage of resorption based on radiographic appearance in cats (Fig 85)

TR in cats can be further defined by the degree of resorption evident radiographically. One system (AVDC Nomenclature Committee, 2024) is currently acknowledged and accepted.

Stage 1 (TR1): Mild dental hard tissue loss (cementum or cementum and enamel).

Stage 2 (TR2): Moderate dental hard tissue loss (cementum or cementum and enamel with loss of dentine that does not extend to the pulp cavity).

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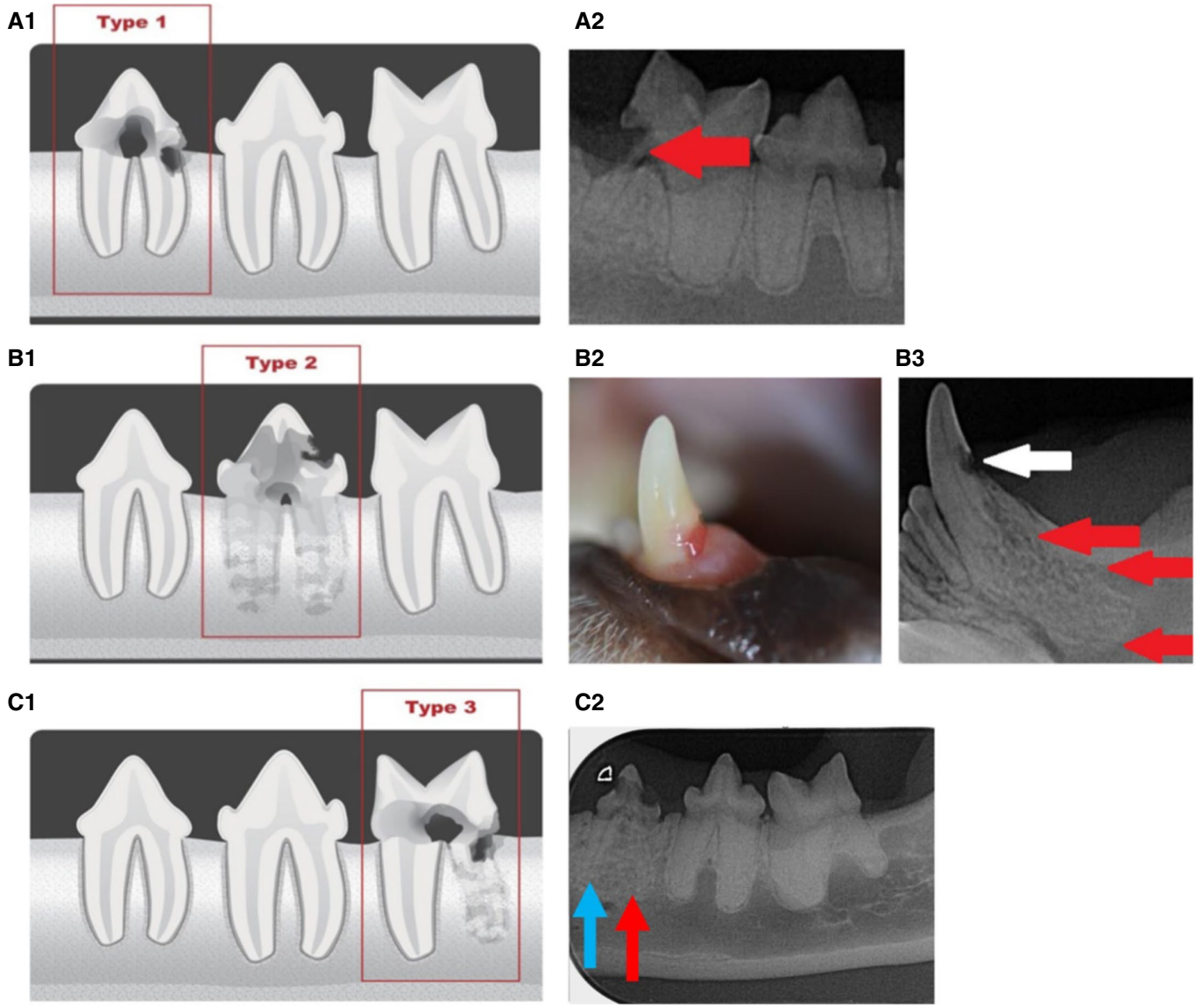

FIG 84. (A) Type 1 TR AVDC illustration and radiograph. (B) Type 2 TR AVDC illustration, image and radiograph. (C) Type 3 TR AVDC illustration and radiograph.

Stage 3 (TR3): Deep dental hard tissue loss (cementum or cementum and enamel with loss of dentine that extends to the pulp cavity); most of the tooth retains its integrity.

Stage 4 (TR4): Extensive dental hard tissue loss (cementum or cementum and enamel with loss of dentine that extends to the pulp cavity); most of the tooth has lost its integrity.

- TR 4a: Crown and root are equally affected.
- TR 4b: Crown is more severely affected than the root.
- TR 4c: Root is more severely affected than the crown.

Stage 5 (TR5): 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.

Tooth resorption in dogs

Idiopathic and inflammatory TR is being seen more commonly in canines currently (Arnbjerg, 1996; Dupont, 2010; Hamp et al., 1984; Peralta et al., 2010a, 2010b; Verstraete et al., 1998a).

Types of resorption based on radiographic appearance in dogs

The radiographic patterns of tooth resorption in dogs are consistent with those previously described in people and include (Peralta et al., 2010a) (Fig 86).

- *External replacement resorption*: This is the most commonly occurring tooth resorption in dogs (34.4%). Radiographs

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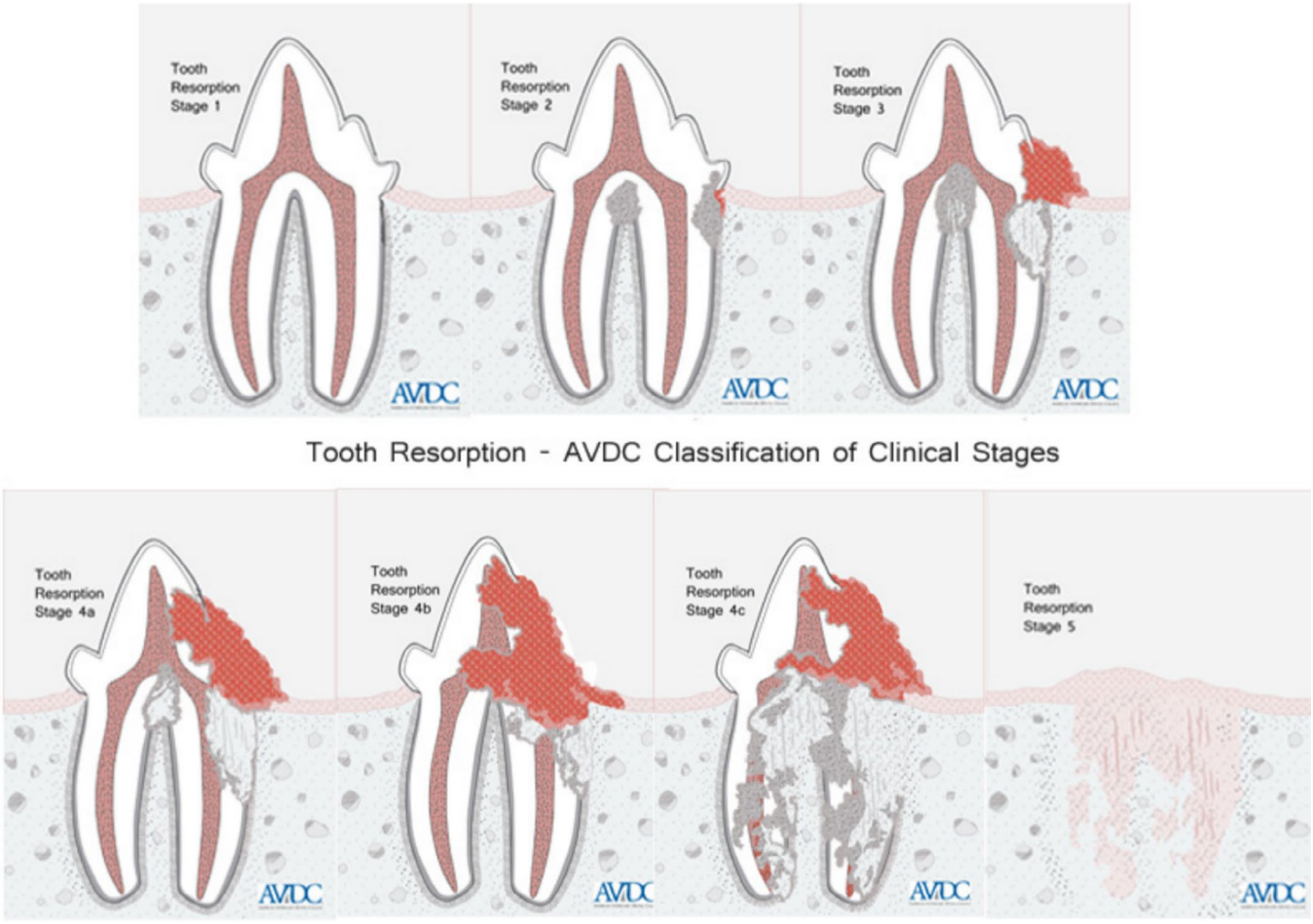

FIG 85. Stages of TR – AVDC.

reveal an indiscernible periodontal ligament space and remodelling of root structure into the alveolar bone.

- *External inflammatory resorption*: Nearly 26% of the studied dogs were found to have external inflammatory resorption, in which inflammation is thought to be the initiating factor. Radiographs reveal tooth resorption associated with surrounding bone loss secondary to periodontitis or apical periodontitis.
- *External cervical root surface resorption*: Just 0.3% of studied dogs fell under this classification. Radiographs show the progression of these lesions beginning at the cervical area of the tooth where cementum meets enamel.
- *External surface resorption*: Only 0.2% of studied teeth were affected by external surface resorption, a condition often unaccompanied by clinical signs and rarely apparent on radiographs. When it is seen on radiographs, it appears as shallow discontinuances of the tooth structure on the lateral edges of the root, and it only involves the cementum and dentine.
- *Internal inflammatory resorption*: This was a very rare finding in studied dogs (0.1%). These oval-shaped enlargements, thought to result from endodontic disease, are often located in the cervical area of the root canal.
- *Internal surface resorption*: This type of resorption was found in only one dog in the study that did not have concurrent periodontal or endodontic disease. Mild trauma may be the initiating factor causing these oval-shaped enlargements found in the apical third of the root canal.
- *Internal replacement resorption*: Not found in any studied dogs, internal replacement resorption is a progressive condition that typically presents as an uneven expansion of tunnel-like areas near the coronal segment of a root fracture.

Clinical significance

TR is very common in domestic cats and dogs. The prevalence of TR in cats is 28.5% to 67% (Clarke & Cameron, 1997; Gorrel, 2015). 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 third premolars were the most commonly affected teeth, and the pattern of TR development was symmetrical in most cats (Ingham et al., 2001), while Pistor et al. (2023) reported affected teeth predominantly in maxillary premolars and mandibular molars. In a clinical study in dogs, 53.6% showed radiographic signs of TR (Peralta et al., 2010b) with external replacement resorption being the most common.

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 cementoenamel

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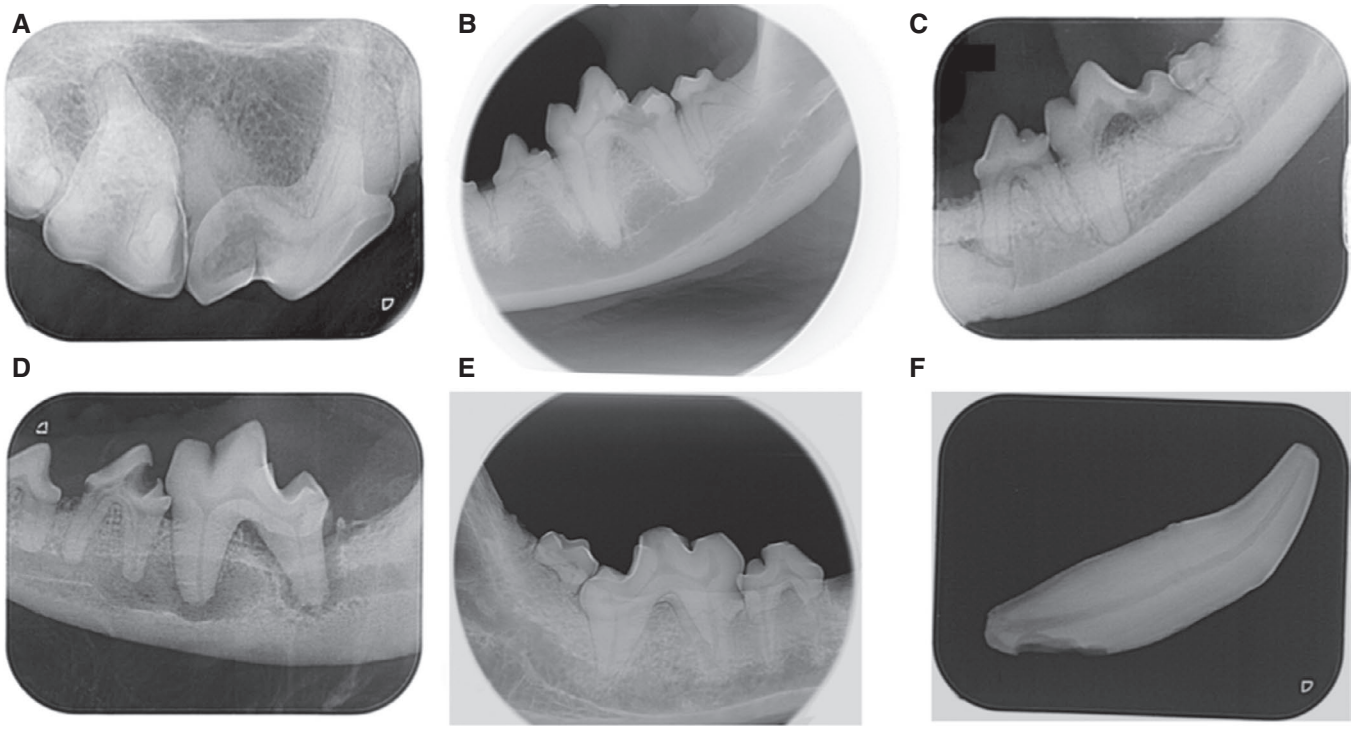

FIG 86. Radiographs of TR patterns in dogs.Canine tooth resorption. a) Internal inflammatory resorption of a maxillary right fourth premolar. b) Internal inflammatory resorption with break through to oral cavity of a left mandibular first molar. c) External cervical surface resorption of a left mandibular first molar. d) Internal inflammatory resorption with break through to oral cavity of the left mandibular fourth premolar and external inflammatory resorption of the left mandibular first molar of the same individual. e) External replacement resorption of the right mandibular fourth premolar, first and second molar of the same patient. f) External root surface resorption of the right mandibular canine.

junction or the enamel collapses over the resorbed space, the dentine – or even the pulp – is exposed, which results in significant pain as well as the possibility of inflammation and/or infection.

Clinical findings

Until the resorptive area is exposed to the oral environment, 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 (Fig 87). With progressive resorption, partial or even complete loss of the crown is possible (Fig 88).

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, hypersalivation.
- Signs of oral discomfort: sticky mucus on the lips, 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 (Cohen & Brown, 2002; Holmstrom et al., 1998d; Le Bars et al., 2001; Niemiec, 2008a; Rollin, 1989). The majority of cats affected by this condition show no outward signs of discomfort.

FIG 87. Early clinical stage of TR.

Examination and diagnosis

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

- Visual examination: the visual examination only allows detection of very late-stage disease, once the crown is involved.
- Tactile exploration: 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

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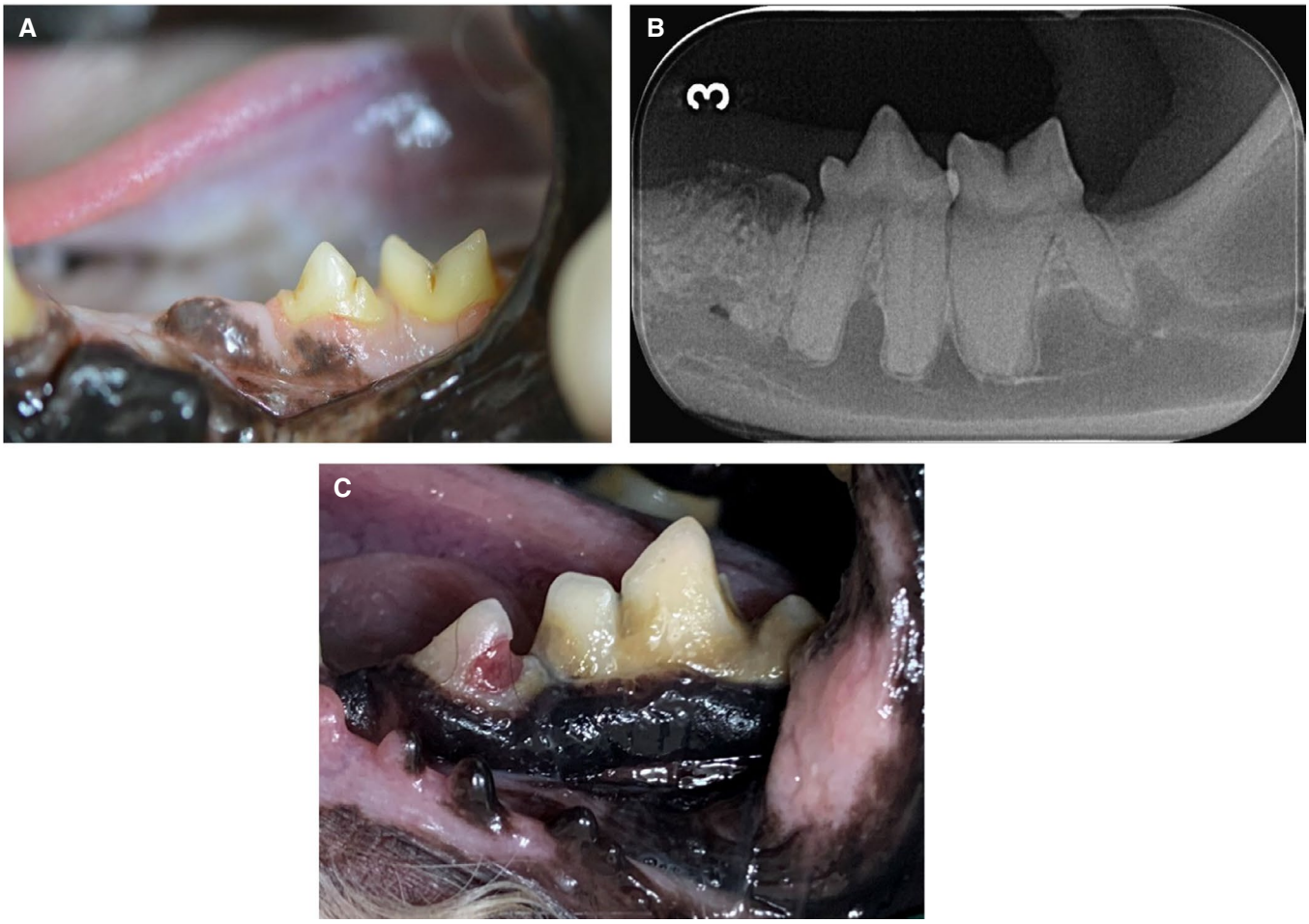

FIG 88. (A–C) Progressive resorption with partial or even complete loss of the crown.

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 reevaluated following scaling.

- Dental radiographs: for a complete staging and treatment planning, dental radiographs are mandatory. It is highly recommended to take a full-mouth radiographic study of all patients presented for dental examination.
- Differential diagnosis: tooth resorption might be mistaken for a tooth fracture, abrasion or furcation exposure. Distinguishing between TR and furcation exposure can be difficult because both lesions have an irregular surface. Furcation exposures are typically smooth and TR is generally rough (DeBowes, 2010). Intraoral radiography is helpful to differentiate them.

Treatment options

The aim of treatment is pain relief. 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 not stop the resorptive process. The treatment will depend on the clinical situation (DuPont, 1995). In case of periodontitis, infection control is indicated to prevent further type 1 TR.

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 can be considered. The monitoring recalls must be performed on a regular basis at the discretion of the clinician (Dupont, 2010; Liang et al., 2003) to ensure that a surgical intervention may be performed expediently. If this is not possible, extraction or crown amputation is indicated.

Extraction

Best practice is the extraction of the affected tooth. Any lesion with oral involvement requires extraction, which is often complicated by significant ankylosis (Dupont, 2010). 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 "atomising" the roots with a bur ("root pulverisation") is strongly discouraged (for more information see the Extraction section).

Crown amputation

In replacement resorptions, where the root has been fully or partly replaced by bone tissue, extraction can be very difficult if

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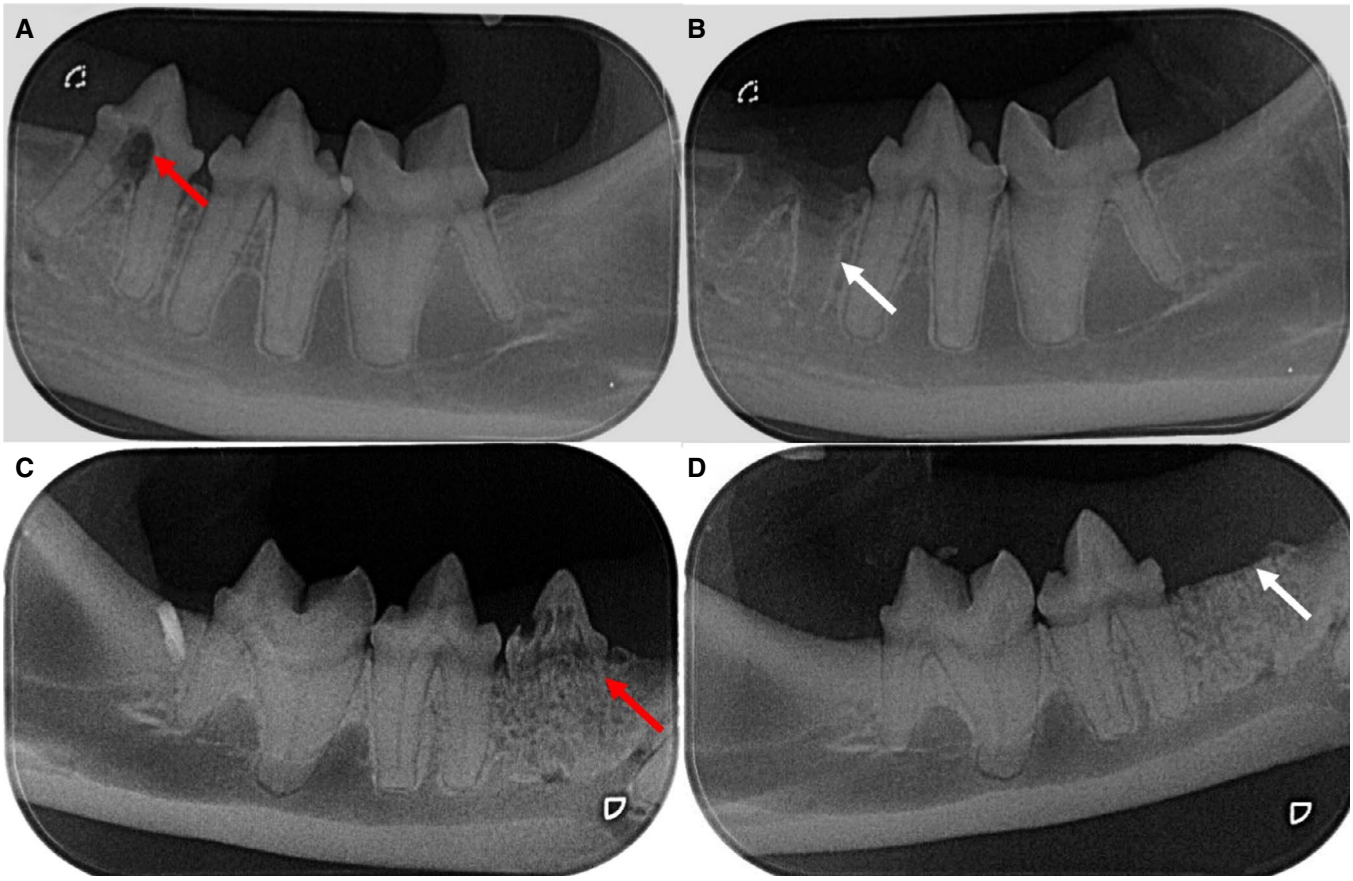

FIG 89. Extraction technique determined by radiographic change. (A) Type 1 inflammatory TR – complete root elevation (B) is needed. (C) Type 2 idiopathic TR – (D) modified extraction/crown amputation appropriate.

not impossible. In such cases, a crown amputation may be indicated (DuPont, 1995) but only when the following criteria are fulfilled (Fig 89):

- No periodontal ligament visible on the dental radiograph.
- No clinical or radiographic signs of endodontic or periodontal pathology.
- No evidence of caudal stomatitis in cats.

Crown amputation (Fig 90) involves the creation of an envelope gingival flap (A), removal of all tooth substance down 1 to 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 may be painful, despite the typical lack of clinical signs.
- Best practice for treatment is extraction.
- Crown amputation is only indicated for advanced replacement resorption under certain conditions.
- Clinical findings (visual or tactile) often represent an advanced stage of the disease.

Feline chronic gingivostomatitis (FCGS)

Feline chronic gingivostomatitis (FCGS) or feline stomatitis (FS) or feline caudal stomatitis as defined in AVDC's Nomenclature is a destructive, ill-defined, painful, severe, immune-mediated, oral mucosal inflammatory disease of cats (AVDC website accessed 1/2024). It is a relatively common disease that affects up to 26% of cats and may be more common in feral cats (Healey et al., 2007; Kim, Yang, et al., 2023; Verhaert & Van Wetter, 2004). The cats typically develop extensive ulcerative and/or proliferative inflammatory lesions throughout the oral cavity, often extending beyond the mucogingival junction and especially the caudal oral cavity and the palatoglossal folds. Cats affected with FCGS may finally be euthanised due to not responding to any treatment or lack of resources (Soltero-Rivera, Goldsmith, et al., 2023).

Aetiology and pathogenesis

Aetiology and pathogenesis are largely unknown, but according to recent literature, FCGS is an immune-mediated disease (Vapniarsky et al., 2020). The disease probably results due to an abnormal immune response to oral antigenic irritation. It has

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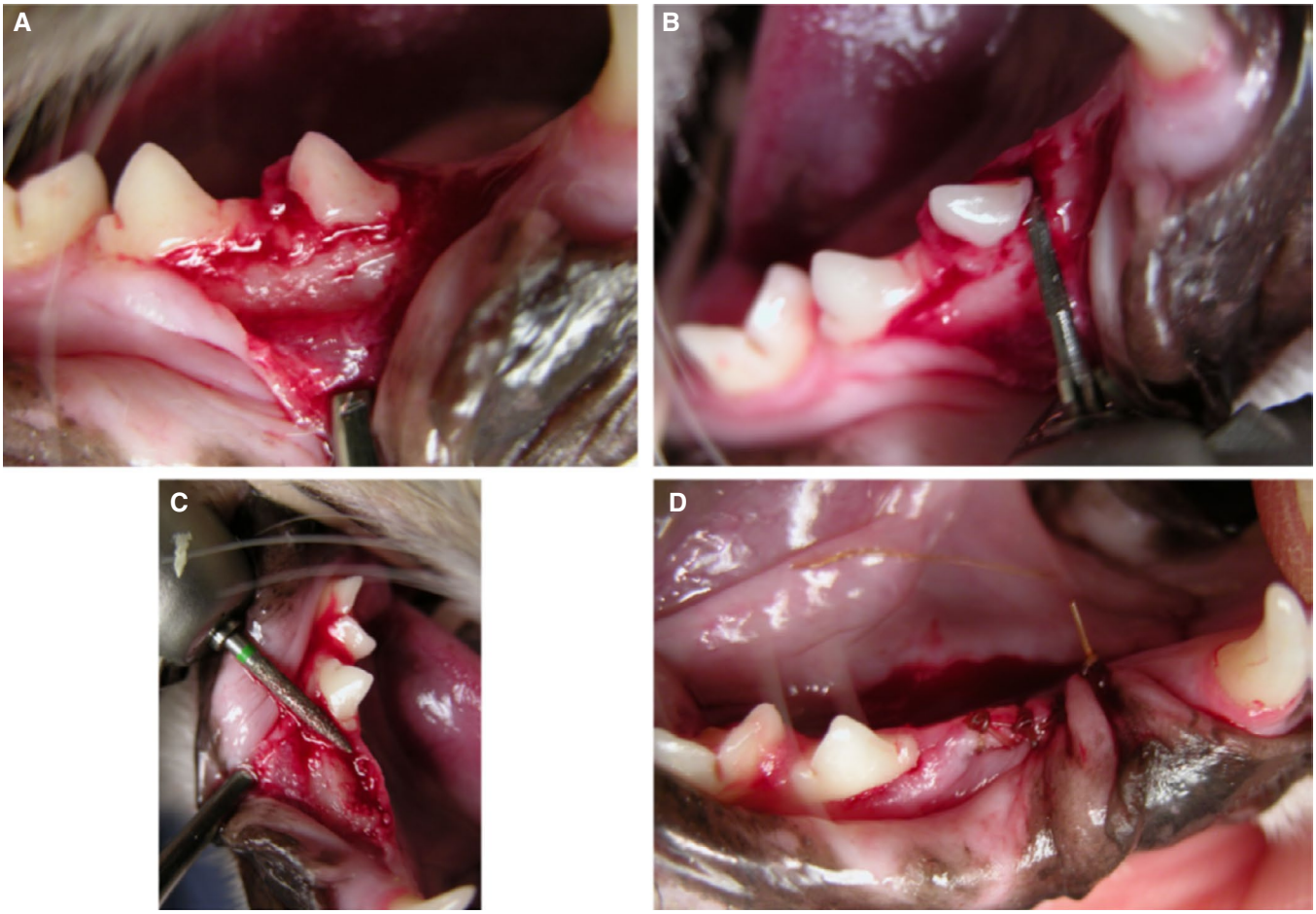

FIG 90. Crown amputation (A) envelope flap; (B) removal of tooth substance; (C) smoothing of remaining bone; (D) gingival closure.

been suggested that systemic pathogens like feline immunodeficiency virus (FIV), feline leukemia virus (FeLV), feline herpes virus (FHV), feline calicivirus (FCV) and *Bartonella* spp., dental diseases (tooth resorption, periodontal disease) and/or hypersensitivity (to microbial plaque or food allergy) are involved (Druet & Hennet, 2017; Knowles et al., 1991; Lommer & Verstraete, 2003; Quimby et al., 2008; Tenorio et al., 1991). However, a common conclusion is that no statistically significant difference was found, between the groups of animals suffering from the disease and controls, for any of the microbial agents except FCV. In fact, it is becoming undisputed that the immune response is somehow related to FCV infection (Fried et al., 2021), although (Druet & Hennet, 2017) suggested that the FCV load in the oral cavity is not related to the severity of the lesions or the prognosis (other than lingual lesions). Puma feline foamy virus was also detected in cats with FCGS (Fried et al., 2021). Another study showed that cats living together with other cats have an increased possibility of developing FCGS and in fact, as the number of animals in household increases the possibility of FCGS increases as well (Peralta & Carney, 2019).

FeLV-positive cats have significantly less proliferative lesions and fewer dental resorptive lesions, though they tend to have more lingual ulcers (Silva et al., 2021). The severity of the disease was significantly associated with tongue lesions (Druet & Hennet, 2017). FCV infection in young cats can also lead to FCGS, but with the proper symptomatic pharmaceutical treatment, the inflammation subsides after a few weeks (Addie et al., 2003; Hofmann-Lehmann et al., 2022; Reubel et al., 1992). Cats with early-onset gingivitis/aggressive periodontitis may also develop stomatitis (Soltero-Rivera, Vapniarsky, et al., 2023). In both earlier and recent studies, it was found that cats suffering from FCGS had oral dysbiosis, with a higher rate of anaerobic and Gram-negative bacteria in their oral cavity than healthy cats (Dolieslager, Bennett, et al., 2013; Dolieslager, Lappin, et al., 2013; Krumbeck et al., 2021; Rodrigues et al., 2019). In conclusion, the role of FCV in FCGS pathogenesis is unquestionable, probably due to dysregulation of the immune system, but there is not enough evidence for FCV to be considered the sole or main causative factor of FCGS.

Dysregulation of the immune system and significant changes in various parameters of this system, like neutrophilia, an increase in T lymphocytes (CD8+) and pro-inflammatory cytokines in the blood circulation were found to play a significant role in the pathogenesis of FCGS (Peralta et al., 2023). In addition, dysregulation of genes associated with cytokine production, T- and B-cell growth, activity and interaction has been mentioned. The

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IL17 gene is found to be dysregulated; this particular gene is associated with viral infections and immune-mediated diseases. An increase in CD8+ lymphocytes in the blood circulation, a decrease in the CD4/CD8+ ratio, CD21 and B lymphocytes was also found. The production of T and B lymphocytes is regulated by CD4+ cells, while the cells infected with intracellular microorganisms are destroyed by CD8 cytotoxic lymphocytes (Vapniarsky et al., 2020).

History and clinical signs

The average age of suffering animals is 7 years, regardless of gender, breed or vaccinations. Inflammatory, ulcerative and/or hyperplastic lesions can be observed in any area of the oral cavity mucosa (Fig 91) especially in the caudal oral cavity and on palatoglossal folds (Fig 92) but also on the lip and buccal area, gingiva, lingual and sublingual tissues (Fig 93), while the soft palate and pharynx can also be affected (Verhaert & Van Wetter, 2004; Winer et al., 2016). Teeth are not affected, but dental (tooth resorption) or periodontal disease can coexist (Farcas, Arzi, et al., 2014).

Typical clinical signs include severe oral pain, oral dysphagia and loss of body weight, reduced grooming behaviour, halitosis and salivation. Behaviour changes such as isolation and aggression can also be observed (Healey et al., 2007; Jennings et al., 2015; Verhaert & Van Wetter, 2004).

As the immune system is dysregulated in FCGS patients, it seems that the disease could affect the body as a whole and not just the oral cavity. Affected cats may have elevated serum and salivary immunoglobulin levels (Harley et al., 1998), elevated values of the parameters related to a systemic inflammatory response (Mestrinho et al., 2020), increased expression of pro-inflammatory serum cytokines, such as interferon-gamma (IFN-γ), tumour necrosis factor-alpha (TNF-α), interleukin-1 beta (IL-1β) and IL-6, as well as blood neutrophil counts (Arzi et al., 2016). The oesophagus is also one of the organs that can be affected (Kouki et al., 2017).

Diagnostic approach

The clinical signs are quite typical and together with history are usually sufficient for the diagnosis. FCGS must be differentiated from gingivitis, early-onset gingivitis and periodontitis as the

FIG 91. Feline chronic gingivostomatitis – inflammatory, ulcerative and/or hyperplastic lesions in any area of oral mucosa.

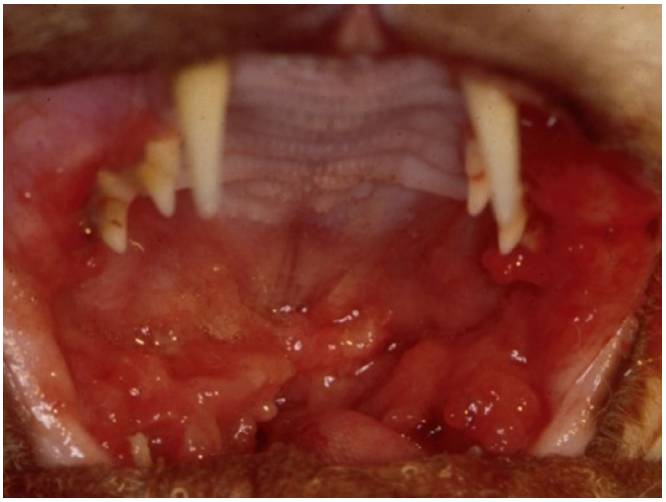

FIG 93. Extensive inflammation on buccal, palatal and sublingual areas.

FIG 92. Caudal oral cavity and palatoglossal folds with inflammation, ulceration and proliferation.

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inflammation extends over the mucogingival junction and affects the oral mucosa (Fig 94), as well as from squamous cell carcinoma and eosinophilic complex of the oral cavity, and from metabolic diseases. In clinically ambiguous cases, biopsy is essential for the diagnosis (Soltero-Rivera, Quinones, et al., 2023; Soltero-Rivera, Vapniarsky, et al., 2023). A viral profile is recommended, although in the case of a positive test for FIV the FCGS prognosis does not change, but FeLV-positive cats show a predisposition to not responding to surgical treatment (Silva et al., 2021). Coinfection with FCV and puma feline foamy virus was also suggested to adversely affect response to treatment (Fried et al., 2021).

Haematological and biochemical profiles are required before general anaesthesia. Detailed oral and dental examination and full-mouth dental radiographs are mandatory (Farcas, Lommer, et al., 2014). In a recent study, the authors performed transcriptomic analysis of FCGS patients and suggested caspase-4 (CASP4), matrix metalloproteinase (MMP8) and prostaglandin-endoperoxide synthase 2 (PTGS2) as potential biomarkers for the prediction of treatment response outcomes (Soltero-Rivera et al., 2024).

Therapeutic approach

A significant number of suffering cats (~30%) do not respond to caudal tooth extraction therapy (refractory FGCS) (Jennings et al., 2015). The goal of the treatment must be the control of the recurrence of the disease, pain management and above all a good quality of life. In general, there are two approaches to the treatment of FCGS: the surgical and the medical one. However, medical treatment on its own usually does not have favourable long-term outcomes, making dental extractions, with or without additional medical management, the current standard of care (Soltero-Rivera, Goldsmith, et al., 2023).

Surgical therapy

Dental extractions are performed with the aim of reducing antigenic irritation and inhibiting or limiting the immune response to the irritation (Bellei et al., 2008; Hennet, 1997). It has been demonstrated that up to 90% of cats with FCGS without retroviral disease will significantly improve following extraction of all premolar and molar teeth (Jennings et al., 2015; Silva et al., 2021; Soltero-Rivera, Goldsmith, et al., 2023; Winer et al., 2016). It seems there is no significant difference between the extraction of molars and premolars compared to the extraction of all teeth if inflammation is not involving rostral oral mucosa (Jennings et al., 2015). Cats that are not responding to dental extractions within a few weeks are considered refractory to surgical treatment, and medical management is necessary. Cautery of proliferative lesions with surgical CO_2 Laser (3 to 4 repetitive sessions with an interval of 2 to 3 weeks) has also been suggested after full-mouth dental extractions as an effective adjunct therapy (Lewis et al., 2007).

Medical management

Crucial for FCGS patients is the pain management at any stage of the disease, when presented, pre and post-operative and in refractory cases (Soltero-Rivera, Goldsmith, et al., 2023). Non-steroidal anti-inflammatory drugs (NSAIDs) are effective in pain management and have an anti-inflammatory action so they are widely used as an adjunct treatment modality for cats with FCGS. Recent studies suggest that NSAIDs may be safe on a long-term basis provided proper monitoring and precautions are taken (Taylor et al., 2024). Buprenorphine seems to be quite effective in managing the pain in cats suffering from FCGS. Stathopoulou et al. (2018) showed that buprenorphine after buccal administration exhibited lower bioavailability and a

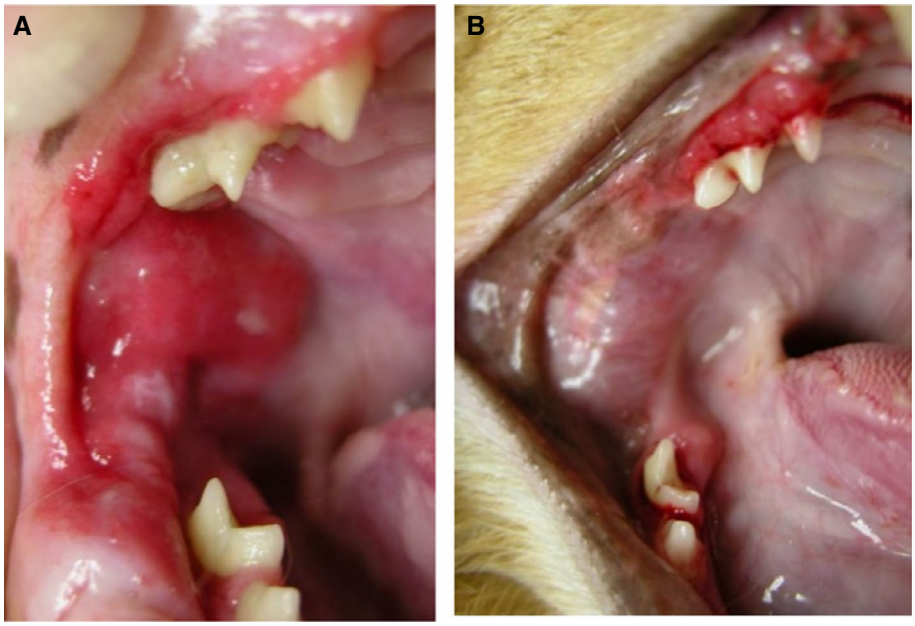

FIG 94. (A, B) FCGS must be differentiated from gingivitis and periodontitis.

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shorter absorption half-life but produced satisfactory analgesic effect. Other agents such as amantadine and gabapentin seem to aid in chronic pain management (Siao et al., 2010; Steagall et al., 2018). Interesting finding is the increase in cannabinoid receptors in the oral mucosa membrane of cats suffering from FCGS (Polidoro et al., 2021). Indeed, cannabidiol-containing food supplement was shown to be safe to use for 15 days in cats with FCGS as an adjunct to other treatments, but the efficacy of it was not clearly demonstrated (Coelho et al., 2023).

Although corticosteroids are initially quite effective (Hennet et al., 2011), their efficiency may be reduced, or they become ineffective over time and may also be associated with several severe side effects. It has not been proven whether their immunosuppressive or anti-inflammatory action is beneficial. Also, longer duration of the oral therapy (months) with very slow tapering of the dose may yield better results (Blank et al., 2019; Mensah-Nyagan et al., 2009).

In a study by Lommer (2013), it was reported that cyclosporine was effective in treating cats with refractory stomatitis after total mouth tooth extractions, specifically 72.3% showed significant improvement after 6 weeks of receiving 2.5 mg/kg cyclosporine orally twice daily. Cyclosporine is effective after about 4 to 6 weeks and side effects can be observed after long-term use, such as renal or hepatic dysfunction, so regular blood tests should be programmed every 6 months or even in shorter periods.

Daily oromucosal treatment with 0.1 MU (1/10 solution) of recombinant feline interferon omega (rFeIFN-ω) seemed to decrease the pain scores in the group of cats receiving rFeIFN-ω, but compared to the group of cats receiving prednisolone, clinical parameters were not significantly different (Hennet et al., 2011). Subcutaneous administration of rFeIFN-ω in 13 FCV-positive cats at a dose of 1 MU/kg, once daily on days 1, 2, 3, 7, 8, 9, 14 and 21 led to a significant decrease of FCV viral load (Matsumoto et al., 2018).

A combination of bovine lactoferrin oral spray and piroxicam was also investigated in a randomised, double-blind clinical trial and clinical signs were significantly improved in 77% of the cats (Hung et al., 2014). However, the results of the study should be seen in the light of the lack of monitoring of these animals and the lack of information on the treatment of their dental diseases.

The efficacy of both autologous and allogeneic, fresh, adipose-derived mesenchymal stem cells (MSCs) administered intravenously has been studied in cats with refractory FCGS. The immunomodulatory action of MSCs has shown up to 57% and 71% of FCGS patients exhibiting clinical improvement or remission after allogeneic and autologous treatments, respectively (Arzi et al., 2016, 2017, 2020; Rivas et al., 2023). No response was seen when treating with MSCs before extraction therapy in a pilot study (Arzi et al., 2021).

Treatment of oesophagitis, especially in persistent cases or if there is a picture of oesophageal dysphagia, has also been suggested (Kouki et al., 2017).

Key points

- The aetiology is currently unknown, but FCV apparently plays a role.
- This is an exceedingly painful and debilitating condition.
- Diagnosis is generally clinical, with severe inflammation caudal to the teeth.
- Treatment can be medical or surgical, but full mouth extractions are generally recommended.
- Stem cell therapy is likely the future for resistant cases.

Maxillofacial trauma

Maxillofacial trauma is a common occurrence and can affect both the soft and hard tissues (typically both). 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 cognisant 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/maxillofacial region.

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 vascularisation. 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 vascularisation in the oral cavity is helpful with healing, which may allow for decreased debridement of diseased tissue (Niemiec, 2012a).

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 with respect to the functionality of oral structures in order to assist with more aesthetic healing. Comfort and function should be the primary aim of reconstruction (Niemiec, 2012a). Prognostic factors associated with head trauma have been studied and it appears that feline patients have an increased risk of craniofacial trauma (Kelley et al., 2023).

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 and vehicular accidents (Fig 95).
- Lip lacerations due to fighting (Fig 96).
- Tongue lacerations/damage due to fighting, car accidents, iatrogenic trauma, epileptic seizures or electrical shock (Fig 97).
- Gingival lacerations (Fig 98) and periodontal trauma.
- Hard palate lesions, also as part of high-rise syndrome (Fig 99).
- Soft tissue trauma from caustic agents or electric shock (Fig 100).

Reparative surgery should be performed expediently for all oral soft tissue lesions, if the patient is stable (see above). Diseased/

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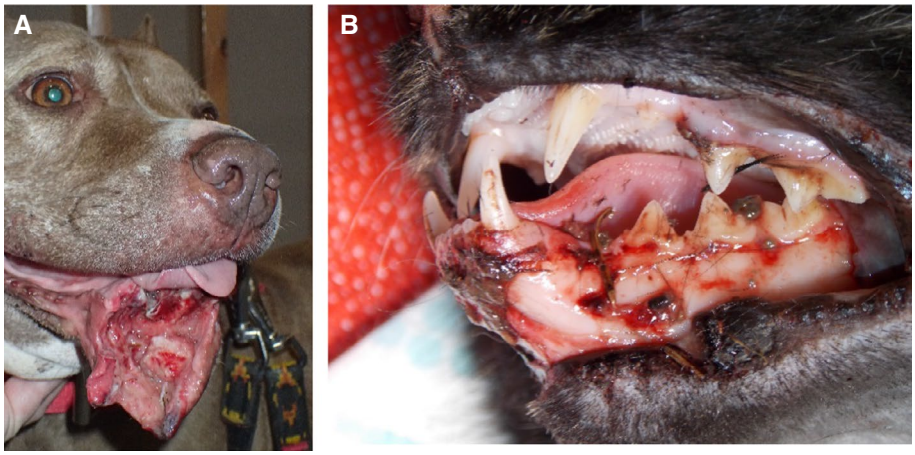

FIG 95. (A, B) Degloving injuries, especially of the lower lip, caused by high-speed traumas and vehicular accidents.

FIG 96. Lip lacerations due to fighting.

FIG 97. Tongue lacerations/damage due to fighting, car accidents, iatrogenic trauma, epileptic seizures or electrical shock.

FIG 98. Gingival lacerations.

FIG 99. Hard palate lesions, also as part of high-rise syndrome.

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FIG 100. Soft tissue trauma from caustic agents or electric shock.

FIG 101. Sutures to repair soft tissue damage should be simple interrupted and placed 2 to 3 mm apart.

FIG 102. Image of maxillofacial fractures – hard tissue trauma.

non-vital tissue should be debrided prior to closure (Saverino & Reiter, 2018; Swaim, 2012). Closure should be delayed if further necrosis is expected (as with injuries due to caustic or electrical shock) (Niemiec, 2012a). 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 be covered by at least 2 mm of gingiva where possible; however, teeth can be healthy despite less coverage (Lewis & Reiter, 2005; Niemiec, 2013e; Takas, 1995; 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 to 3 mm apart (Niemiec, 2008d, 2022) (Fig 101). Absorbable non-braided sutures are preferred on a swedged-on reverse cutting needle and are generally recommended (Silverstein & Kurtzman, 2005), but in general, the suture material should be as strong as the apposed tissues (Tutt, 2006b) (see Equipment chapter).

Hard tissue trauma: The various types of hard tissue trauma include maxillofacial fractures (Fig 102), TMJ fractures and luxations (Fig 103), tooth luxations (Fig 104) and avulsions (Fig 105) (Niemiec, 2012a; Soukup, Mulherin, et al., 2013; Soukup & Snyder, 2014; Taney & Smith, 2010). 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 orthopaedic 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 and neurovascular structures within the mandibular and infraorbital canal. These two structures cannot be injured during therapy (Fig 106). 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, 2001; Taney & Smith, 2010) (Fig 107). Mini bone plates may be useful in certain situations, but care must be taken to ensure atraumatic placement of the screws (Arzi & Verstraete, 2015; Boudrieau, 2012b) (Fig 108).

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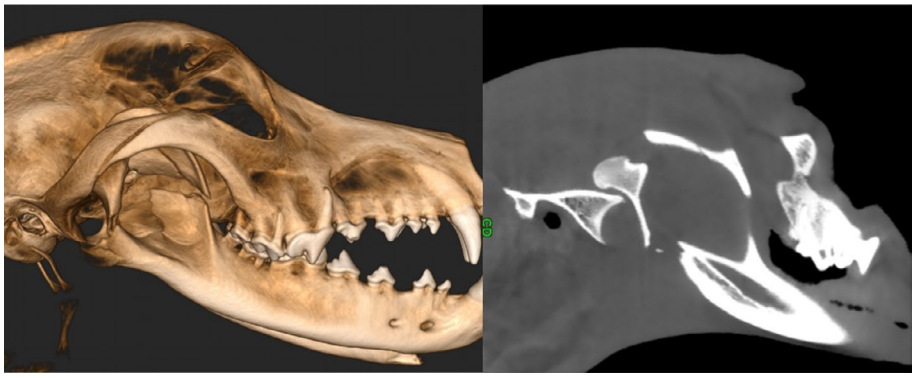

FIG 103. TMJ luxation and coronoid process fracture.

FIG 104. Tooth luxations.

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

An additional difference between appendicular and maxillofacial fractures is the commonality of pathological fracture (Niemiec, 2013b). These may also occur due to a neoplastic or cystic cause (Fig 109), but in the vast majority of cases they are secondary to 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) (Figs 110 and 111). This condition is more common in small breed dogs (Mulligan et al., 1998b), 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 (Figs 112 and 113) (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 generally possible with dental radiography, but the best 3D orientation provides CBCT technique.

Pathological 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 stabilising the caudal mandible (Niemiec, 2012a, 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 (Niemiec, 2012a; Taney & Smith, 2010) (Figs 114 and 115).

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, 2018b) (Fig 116). In tier 1 and some tier 2 countries, they are considered minimally acceptable. However, dental radiographs are recommended whenever possible and are a minimum requirement in tier 3 countries (Fig 117). However, computerised tomography or cone-beam CT (CBCT) scans are ideal for maxillofacial fracture diagnosis and treatment planning and should be considered a requirement for tier 3 countries (Foley et al., 2013; Hirsch et al., 2009; Soukup, Drees, et al., 2015; Tundo et al., 2019; Winer et al., 2018) (Fig 118). CBCT may be also used for 3D printed models (Freeman & Southerden, 2023).

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FIG 105. Tooth avulsions.

Therapeutic measures: There are invasive (insertions into bone) and minimally or non-invasive (intraoral splints, tape muzzle) methods of fracture stabilisation. The invasive methods include interfragmentary wiring (although this may be controversial in cats) (Fig 119), external fixators, mini-plates and microplates (Boudrieau, 2012a, 2012b; Tsugawa & Verstraete, 2012) (Fig 120). Invasive methods should only be used in carefully selected cases taking anatomy and occlusion into account. In addition, invasive methods require future surgery for removal of the implants, unless biocompatible plating material is used (*e.g.* titanium) (Taney & Smith, 2010; Tsugawa & Verstraete, 2012; Wiggs & Lobprise, 1997b).

The non-invasive methods utilise interdental or circummandibular wires (Figs 121 and 122) and/or acrylic resins (Fig 123) for fracture fixation (Guzu & Hennet, 2017; Niemiec, 2003a; Smith & Legendre, 2012; Taney & Smith, 2010). In addition, maxilla-mandibular fixation (MMF) (Fig 124) or labial buttons (Fig 125) can be utilised (Goodman & Carmichael, 2016). These techniques can be cost-effective and easy to learn. A potential drawback with non-invasive fixation is that only the coronal aspect of the jaw is fixated and not as sturdy as invasive methods. The reader is directed to Verstraete & Lommer "Oral and Maxillofacial Surgery in Dogs and Cats" 1st Ed (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) (Fig 126).

Tooth luxation/avulsion

An avulsed tooth has been traumatically torn out of the alveolus (Gracis, 2012; Niemiec, 2012a; Taney & Smith, 2010). A luxated tooth is partially displaced from the alveolus but is still attached. The tooth may be luxated in the buccal direction, which usually involves fracture 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, 1997a). This typically occurs following dog fights but can also result from significant cage chewing or trauma (Gracis & Orsini, 1998; Spodnick, 1992). These conditions may also occur following other forms of trauma like falls and vehicular trauma (Ulbricht et al., 2004). Tooth intrusion (the tooth is traumatically forced apically) 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 (Figs 127 and 128).

Diagnosis: Skull films are useful, however, are typically not detailed enough to diagnose subtle problems such as root fractures (Fig 129), periodontal disease (Fig 130) or small areas of missing bone (Niemiec, 2011). Therefore, dental radiography is recommended prior to fixation (Niemiec, 2012a), and CT should be considered also to rule out other maxillofacial trauma (Soukup, Drees, et al., 2015).

Where possible, these cases should be referred to a veterinary dentist or maxillofacial surgeon as soon as possible for reimplantation and stabilisation. 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 (ideally within 6 hours of the incident). The fixation method is typically a figure-8 wire and acrylic splint (Gracis, 2012; Niemiec, 2012a) (Fig 131). 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/avulsed 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. Great care must be taken not to damage dental structures when the stabilisation implants are applied.

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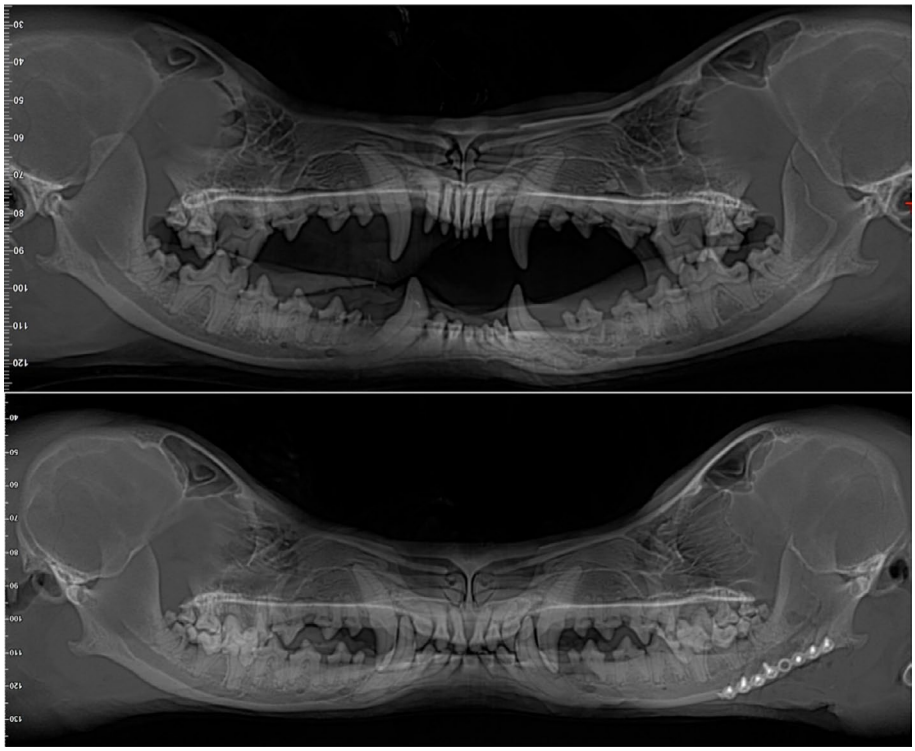

FIG 106. Tooth roots and neurovascular structures within the mandibular and infraorbital canal cannot be injured during therapy.

FIG 107. External fixation is strongly discouraged for maxillofacial fractures because of the risk of traumatic pin placement.

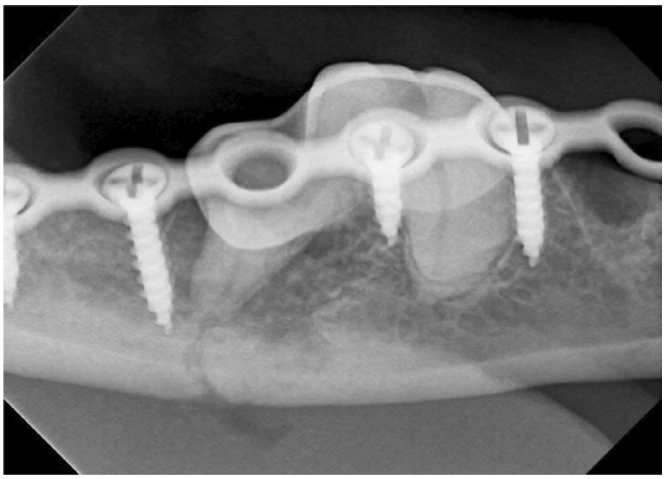

FIG 108. Mini bone plates may be useful in certain situations, but care must be taken to ensure atraumatic placement of the screws.

- External fixators should only be used in carefully selected cases.
- Properly adapted mini-plates or micro-plates may be indicated but require advanced equipment and training.
- Dental radiographs provide critical information in oral trauma cases, but advanced imaging is superior.
- Pathological 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 entirely or partially extracted from fracture sites.
- Reimplanted avulsed and luxated teeth require endodontic therapy and appropriate follow-ups.

Oral tumours

Tumour means "swelling" or an abnormal growth. When considering tissue of origin, oral tumours are either odontogenic or non-odontogenic. However, by their biological behaviour, tumours of the oral cavity can be described as malignant, benign but locally aggressive and benign. The term "epulis" has been misused for decades as the description of a benign oral

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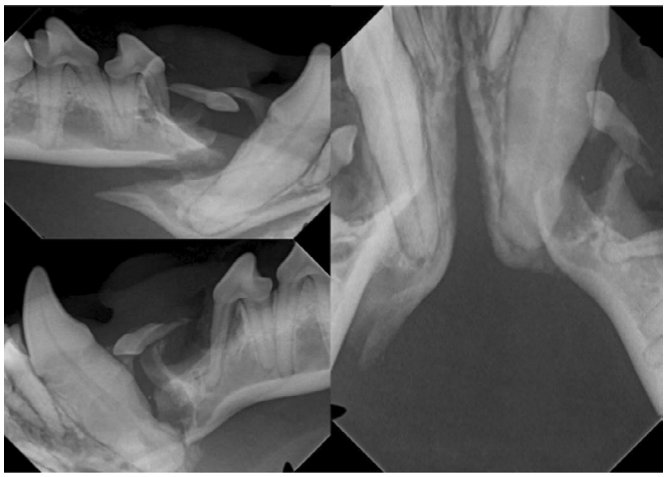

FIG 109. Pathological fracture may occur due to periodontal, neoplastic or cystic bone loss.

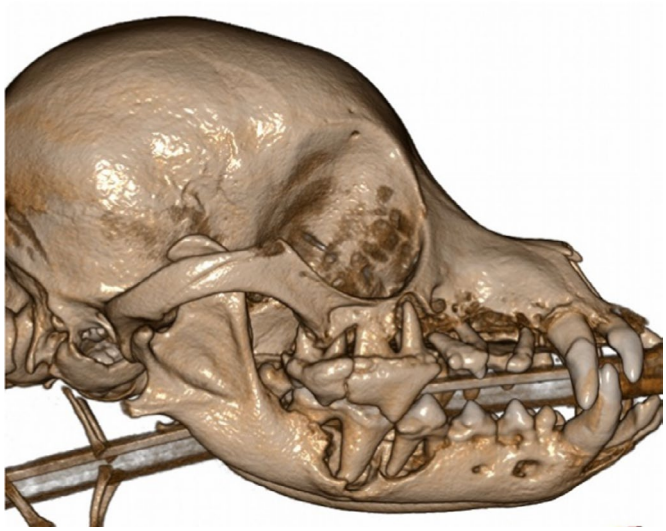

FIG 110. Extensive periodontal bone loss can weaken the bone in affected areas.

FIG 111. Pathological fractures due to periodontal bone loss are more common in small breed dogs, owing mostly to the fact that their teeth (especially the mandibular first molar) are larger in proportion to their mandible in comparison to large breeds.

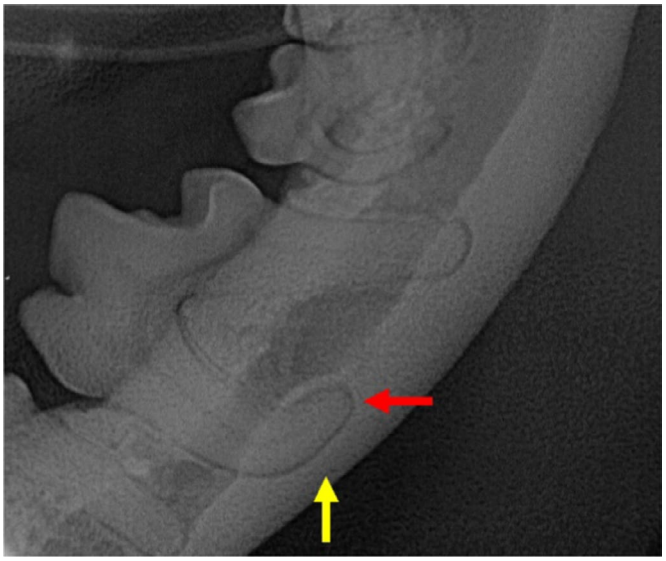

FIG 112. The roots of mandibular teeth in small dogs are positioned close to the ventral border; periodontally diseased root(s) must be extracted for healing to occur.

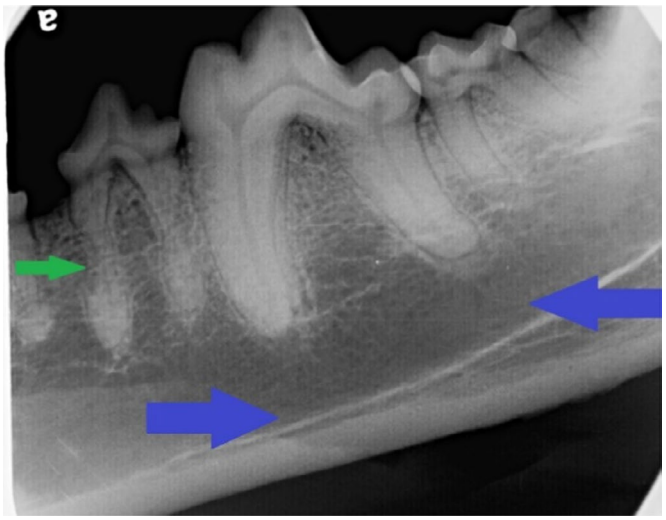

FIG 113. The roots of mandibular teeth in large dogs have more bone proportionally than small dogs.

growth. In actuality, an epulis is any abnormal growth arising from the gingiva, which may include malignant tumours (Fiani et al., 2020; Gieger & McEntee, 2020; Verstraete et al., 1992). The incidence of oral tumours in dogs was recently reported to be 0.5%, with most oral tumours being malignant (Cray et al., 2020).

Staging of patients with oral tumours

Before any oral tumour treatment is attempted, a patient with an oral tumour needs to be properly staged – we need to know what the tumour is, how extensive it is, what the biological behaviour is, and if there is any metastatic disease.

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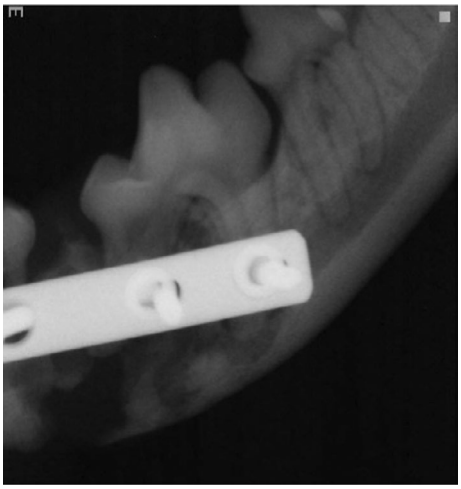

FIG 114. The periodontally diseased roots not extracted prior to fixation prevent healing to occur.

FIG 116. Standard medical radiographs are not optimal, but may be used if other means of imaging are not available.

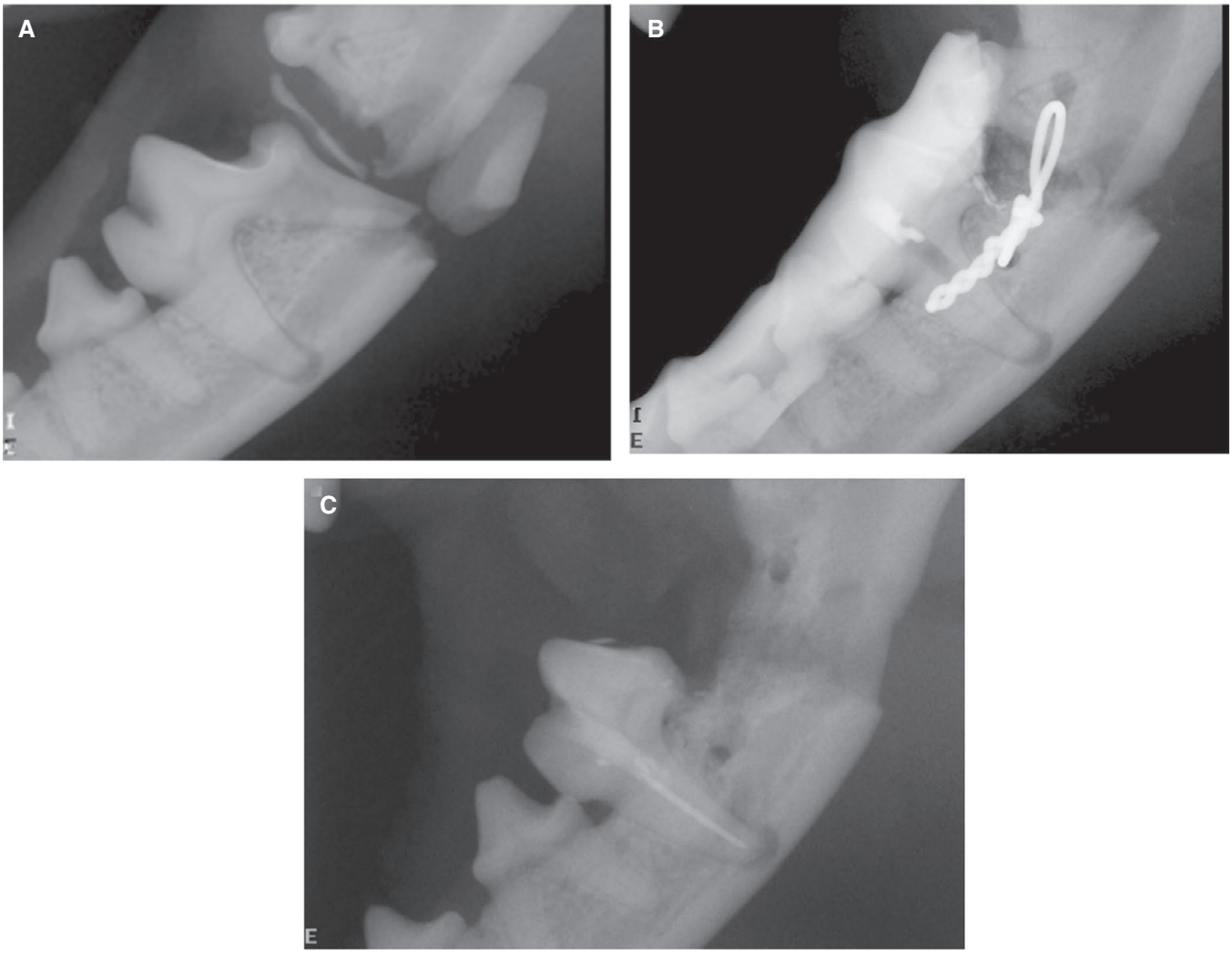

FIG 115. A) Pre-operative dental radiograh of a pathologic mandibular fracture at the distal root of the first molar. B) The tooth was sectioned and the diseased root extracted and the mesial root treated with endodontic therapy (medicated) and the jaw fixated with interfragmentary wires and acrylic splint. C) Recheck radiograph after splint removal and the root canal finished.

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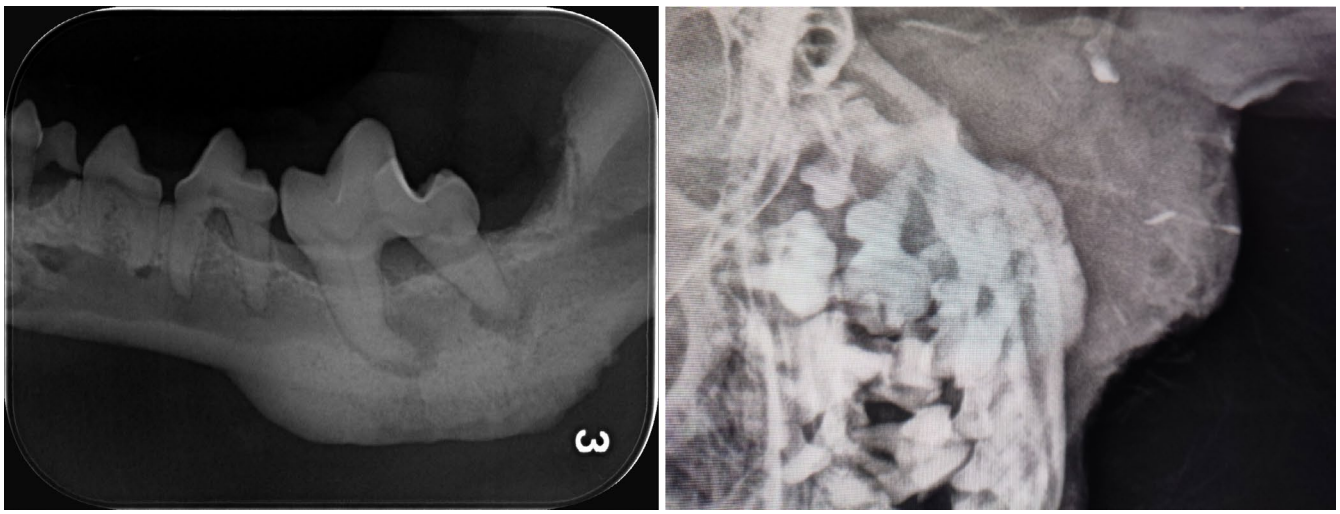

FIG 117. Dental radiographs are superior to skull radiographs.

FIG 118. Advanced imaging such as cone beam CT is optimal for maxillofacial trauma.

Local disease

To determine the type of the tumour, either cytology or histopathology are performed. Fine needle aspiration (FNA), fine needle insertion (FNI) or impression smear (IS) are the options to harvest tumour cells for a reliable cytological evaluation (Bonfanti et al., 2015), that may be combined with immunocytochemistry (Przeździecki et al., 2015). As some tumours may provide poor-quality samples and since general anaesthesia is most likely needed to obtain these samples, biopsy is still the gold standard of diagnosing oral tumours. Biopsy is ideally taken following computed tomography (CT) to best plan the biopsy area, to avoid superficial inflammation and any areas of necrosis. Most commonly an open incisional biopsy is performed. The biopsy is ideally undertaken by the surgeon who plans to carry out the definitive treatment, otherwise the biopsy site/track must be well documented in order to be later included in the surgical or irradiation field (Arzi & Verstraete, 2020).

To further evaluate local disease, tumour location is noted (photographed) and the lesion measured. Diagnostic imaging of the local lesion should include pre- and post-contrast CT of the head (Arzi & Verstraete, 2020). Skull radiographs and/or intraoral dental radiographs will underestimate the extent of the lesion, especially the invasion of maxillary tumours into adjacent structures. For example, in dogs with maxillary tumours, invasion of adjacent structures is identified in 30% of cases with (standard) radiographs, while CT reveals it in 90.4% of cases (Ghirelli et al., 2013). Magnetic resonance imaging (MRI) can also be considered, especially for oral tumours located in the caudal oral cavity and/or oropharynx (Kafka et al., 2004), and PET/CT is becoming available in veterinary medicine as well (Randall et al., 2016).

Regional lymph nodes

Evaluation of regional lymph nodes may be challenging and recommendations on staging vary (Congiusta et al., 2020). Although palpation of the mandibular lymph nodes should be routinely performed, it is unreliable to detect metastatic disease (Williams & Packer, 2003). FNA of the regional lymph nodes may be helpful, but reaching the main draining centre of the head – retropharyngeal lymph nodes – requires an ultrasound-guided approach. Generally, a negative FNA result does not rule out metastases and lymph node metastases should neither be regarded as governors of survival (Arzi & Verstraete, 2020). Evaluation of size and contrast-enhancement pattern on post-contrast CT images may be helpful in evaluating regional lymph nodes for metastases (Arzi & Verstraete, 2020; Menghini et al., 2023), and PET/CT is also very promising (Willcox et al., 2021). Excisional biopsy of the lymph nodes is debatable, as complete staging requires removal of all lymph nodes of the head and neck as the pathways of lymphatic drainage may be unpredictable. Nowadays, preoperative or intraoperative techniques to determine the sentinel lymph node are being developed and optimised to enable targeted excisional biopsy of the lymph node(s) most likely first affected by metastases (Goldschmidt, Stewart, et al., 2023).

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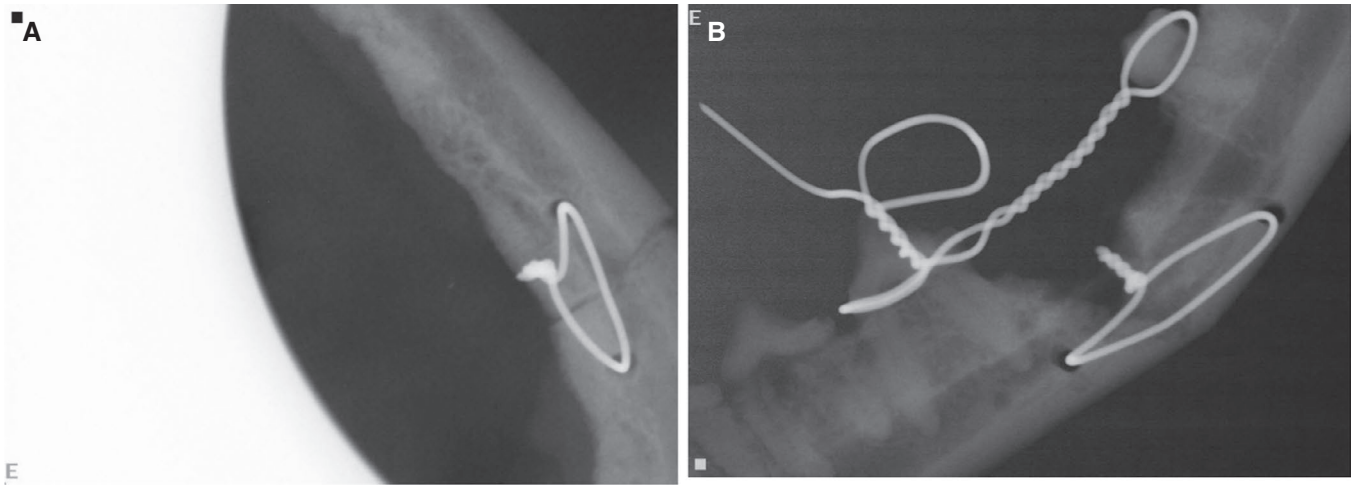

FIG 119. (A, B) Interfragmentary wiring to reduce fractures.

FIG 120. Mini and micro plates for fracture reduction: Mini-plates, micro plates.

FIG 121. Circumferential wiring for mandibular symphyseal separation/ fracture.

Distant organs

Staging is completed with evaluation of distant organs for possible metastatic disease, where chest CT is more sensitive to diagnose pulmonary metastasis compared to (three-view) thoracic radiographs (Armbrust et al., 2012). Abdominal ultrasound or full body CT may be warranted to fully evaluate the patient's health status regardless of the tumour type (Goldschmidt, Soltero-Rivera, et al., 2023; Hansen & Kent, 2019).

Treatment options overview

Only once the patient is fully staged and the disease properly classified using the TNM classification (Arzi & Verstraete, 2020), the prognosis and treatment plan can be discussed with the client. When creating the optimal treatment plan, a team approach should ideally be employed, with an (oral) surgeon, dentist, radiation oncologist, medical oncologist, imaging specialist and pathologist consulted. With the development of telemedicine, a team approach is becoming widely available.

Surgical removal of oral tumours is still considered the gold standard of the treatment for operable tumours, but can be employed in any situation (*e.g.* surgery for palliation for inoperable tumours), as long as the surgical goal is clearly communicated to the client. Function and cosmesis should also be discussed (Boston et al., 2020; Lommer et al., 2020; Sarowitz et al., 2017).

Radiotherapy is another commonly employed treatment modality for oral tumours, either alone or as a part of a multimodal treatment approach. Radiotherapy is quite effective

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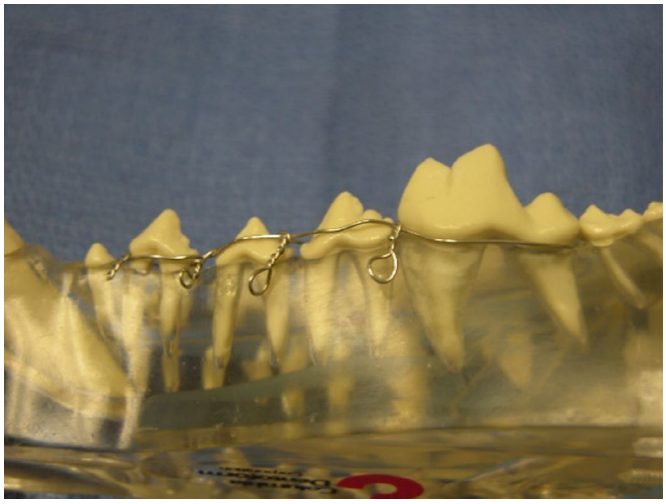

FIG 122. Interdental wiring technique for fracture reduction.

FIG 123. Acrylics resins used for splinting.

FIG 124. Maxilla-mandibular fixation with composite bridge across canine teeth.

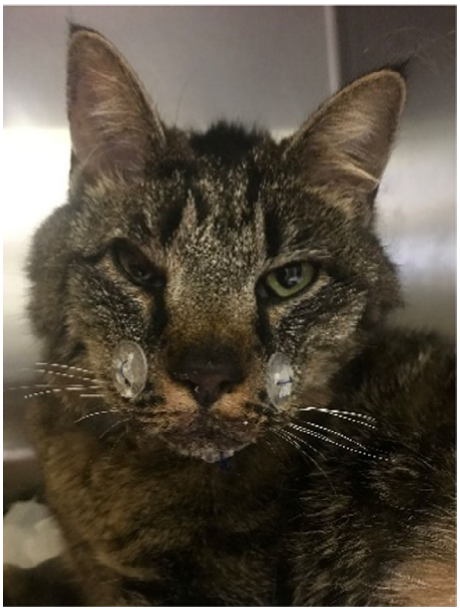

FIG 125. Maxilla-mandibular fixation with labial buttons.

for e.g., oral plasmacytomas or canine acanthomatous ameloblastoma (CAA), with a palliative effect on several other canine malignancies (Evenhuis et al., 2023; Thrall, 1984). Contemporary radiation therapy is heavily reliant on imaging for treatment planning to identify and map out target volumes and critical normal structures to maximise dose to the tumour and minimise dose to the surrounding normal structures (Hansen & Kent, 2019). With radiation therapy, early (*e.g.*, mucositis) and late (e.g., radiation-related osteonecrosis of the jaw, secondary tumours) side effects need to be considered (McEntee et al., 2004; Mosca et al., 2021; Nemec et al., 2015). In addition, guidelines on oral health management in veterinary patients undergoing radiation therapy of the oral cavity and head need to be established following the recommendations in human oral oncology.

Oral tumours are generally poorly responsive to chemotherapy, but metronomic chemotherapy can be beneficial as palliative treatment (Milevoj et al., 2022). NSAIDs can be used to provide analgesia, but piroxicam alone may have some beneficial therapeutic effect in oral squamous cell carcinoma (SCC) cases (Schmidt et al., 2001). Electrochemotherapy (ECT) and gene-electrotransfer therapy (GET) are beneficial especially for small SCC and malignant melanoma (MM) not involving the bone, and protocols are still being developed (Nemec et al., 2020), as are several immunotherapy approaches (especially for canine oral malignant melanoma) (Almela & Ansón, 2019) and photodynamic therapy (McCaw et al., 2000).

Odontogenic tumours

Peripheral odontogenic fibroma (POF)/Fibromatous epulis of periodontal ligament origin (FEPLO) is a common

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FIG 126. Emergency use of a muzzle or elastic face mask.

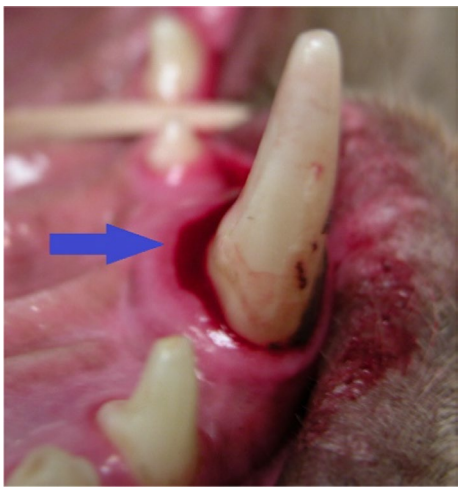

FIG 127. Clinical presentation of tooth luxation – displaced tooth in the alveolus.

FIG 128. Clinica and radiographic presentation of tooth avulsion – displaced tooth and an empty alveolus.

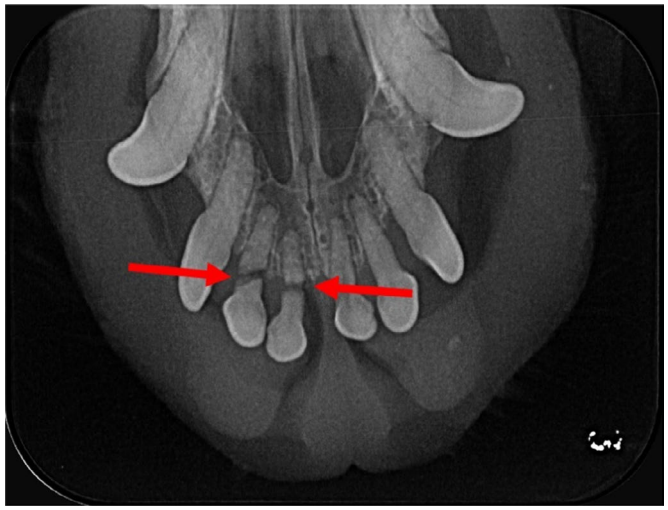

FIG 129. Dental radiograph of maxillary incisor tooth root fractures; skull fractures may not be detailed enough.

mesenchymal odontogenic oral tumour in dogs and rare in cats (Fiani et al., 2020). Some authors consider POF/FEPLO a tumour-like proliferative lesion of the tooth-bearing regions of the jaw (Murphy et al., 2020) and some newest reports suggest additional variants (Kim et al., 2024). It is slowly growing and benign, with minimal osseous destruction (Fig 132); therefore, prognosis is excellent with complete surgical removal (*i.e.*, including some underlying bone), while recurrence is possible with marginal excision (Fiani et al., 2020).

Canine acanthomatous ameloblastoma (CAA) is an epithelial tumour that commonly affects rostral mandibles of adult dogs and commonly presents as an exophytic gingival mass (Fiani et al., 2020; Goldschmidt et al., 2017) (Figs 133 and 134). Although CAA is highly uniform and predictable with the histological pattern, Ki67 labelling index is a useful differential marker of CAA from oral squamous cell carcinoma when distinction between the two entities is difficult (Peralta et al., 2019). Additionally, CT may reveal two different types of CAA lesions – extraosseous or intraosseous (the later with an extensive osteolysis, bone expansion, cortical bone lysis). Reliance on diagnostic imaging as a measure of biological behaviour is recommended (and may potentially lead to a

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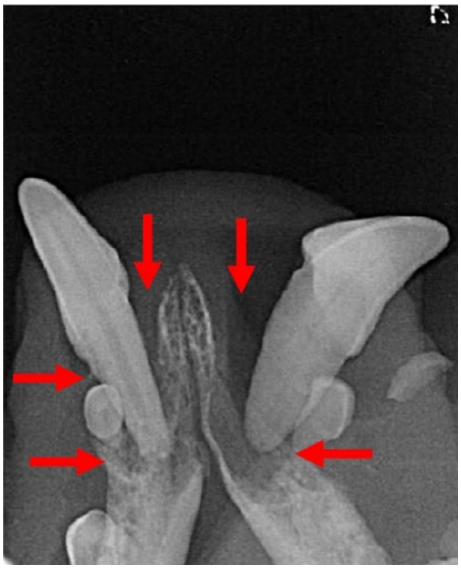

FIG 130. Dental radiograph of mandibular canine periodontal disease with subluxation; skull fractures may not be detailed enough.

FIG 131. Figure 8 wire and acrylic splint to stabilise maxillary canines.

creation of a variant/grading scheme) and needs to be considered when planning the treatment (Goldschmidt et al., 2020). CAA is locally invasive, but it does not seem to metastasise, so prognosis is excellent with complete surgical removal (Fiani et al., 2020). However, a recent study also reported, that no local recurrence was noted on oral examination in any patient regardless of post-surgical histopathological margins, including margins that were incomplete (*i.e.*, with complete margins (>5 mm) there was 0% to 40% chance of local recurrence, with narrow margins (1 to 5 mm) 0% to 34.4% chance of local recurrence, and with incomplete margins (<1 mm), there was 0% to 54% chance of local recurrence) (Goldschmidt et al., 2017). CAA is also radiosensitive, but due to expected long survival post radiation, radiation therapy should be carefully recommended in young dogs as they may develop detrimental late side effects of radiation therapy (development of secondary tumours or osteoradionecrosis) (Fiani et al., 2020). Intralesional bleomycin and feline interleukin-12 DNA injection combined with translesional electroporation, as well as intralesional bleomycin alone have also been used successfully in two reports (Kelly et al., 2010; Reed et al., 2010).

Conventional ameloblastoma (central, intraosseous ameloblastoma) (CA) is a relatively uncommon epithelial odontogenic tumour and commonly presents as a painless swelling of the dentate jaws in dogs and cats. Radiographically, osteolytic cyst-like lesion can be observed (Clayton et al., 2023; Fiani et al., 2020). Histology is usually predictable and most commonly there is no aggressive infiltration of adjacent tissues (Fiani et al., 2020). In cats, two histological variants have been described (a follicular pattern and a keratinising pattern). Wide surgical excision is recommended and will most likely result in cure (Fiani et al., 2020), although no recurrence was observed even in patients with narrow surgical margins or treatment by cyst enucleation (Tjepkema et al., 2020).

Other odontogenic tumours can be occasionally diagnosed in dogs and cats (*e.g.*, odontoma, feline inductive odontogenic tumour, amyloid-producing odontogenic). Malignant odontogenic tumours are extremely rare, but ameloblastic

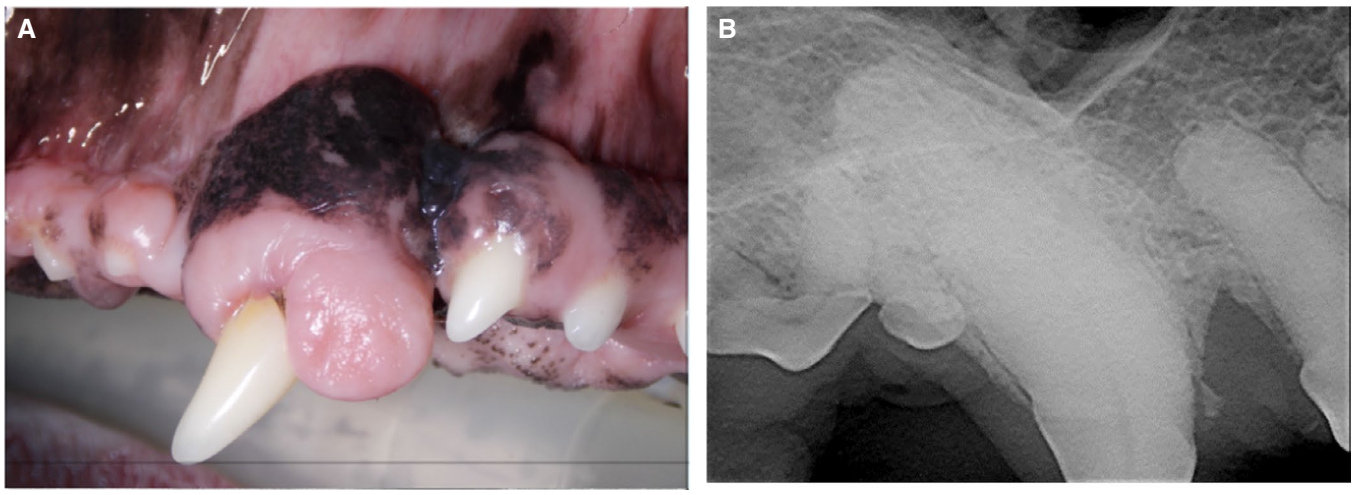

FIG 132. (A, B) POF/FEPLO and radiograph.

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fibro-odontoma, odontogenic myxoma and ameloblastic carcinoma have been described in dogs (Fiani et al., 2020). Recently, primary intraosseous squamous cell carcinoma was described as an entity in cats (Pavlin et al., 2018). Due to low number of cases described in the literature, prognosis is mostly unknown.

FIG 133. Canine acanthomatous ameloblastoma.

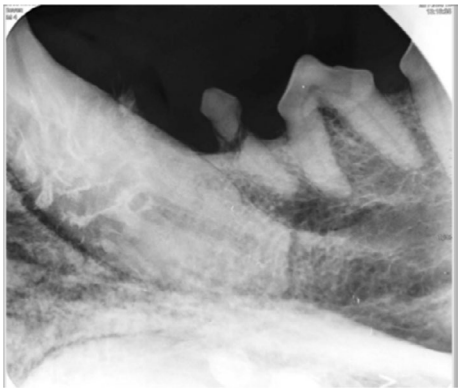

FIG 134. Dental radiograph of the left rostral mandible of the dog form Fig. 133.

FIG 135. Feline squamous cell carcinoma.

Non-odontogenic tumours

Squamous cell carcinoma (SCC) (Figs 135 and 136) is the second most common oral tumour in dogs (or the second most common, if cases of tonsillar SCC are excluded). In majority of the cases, the lesion arises from the dentate jaws of older dogs, but oral SCC may also affect puppies. It is an invasive epithelial tumour with different histological subtypes (Nemec et al., 2012) which metastasises relatively rarely and late. Prognosis is very good, if the diagnosis is established early and the treatment is radical (Fulton, Fiani, et al., 2013; Fulton, Nemec, et al., 2013) (Figs 137 and 138). However, lingual and tonsillar SCC have worse prognosis. Surgery (including glossectomy in dogs) is the main treatment, and it may be combined with radiation therapy, if the margins of the resection are not clean (Gieger & McEntee, 2020; Riggs

FIG 136. Feline squamous cell carcinoma on CT imaging.

FIG 137. Papillary squamous cell carcinoma in a puppy.

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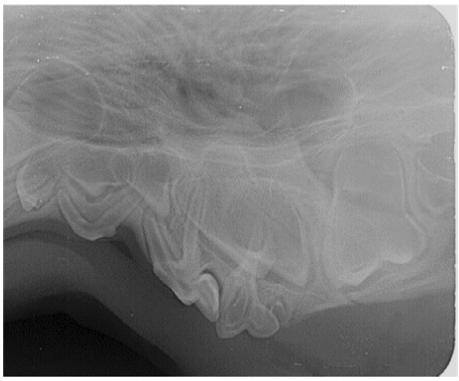

FIG 138. Dental radiograph of the left caudal maxilla of the dog from figure 139 with a papillary SCC.

et al., 2018). Radiation therapy may also be used as a monotherapy and is the other most common treatment applied (Mosca et al., 2021; van der Steen & Zandvliet, 2021). Cyclooxygenase 1 and 2 overexpression has been demonstrated in oral SCC; therefore, piroxicam was suggested to be added in the treatment protocol (Schmidt et al., 2001). Small non-tonsillar SCC tumours not involving the bone are also well responsive to ECT (Simčič et al., 2019).

Squamous cell carcinoma is the most common oral tumour in cats (Bilgic et al., 2015). It is an invasive epithelial tumour with moderate metastatic potential that bears, as opposite to dogs, a guarded prognosis, especially for lingual, sublingual and tonsillar SCC (Gieger & McEntee, 2020). There is still limited evidence on the involvement of papilomaviruses and environmental factors in the pathogenesis of SCC (Noall et al., 2023; Sequeira et al., 2022; Zaccone et al., 2022).

Due to lesions being many times detected late, the treatment is usually palliative in intent with appropriate pain control and feeding support. If lesions are detected in early stages, surgery is the main treatment approach (Gieger & McEntee, 2020). Anecdotally, cats do not tolerate jaw surgery as good as dogs, but this has not been confirmed – although most cats experience hyporexia after extensive maxillofacial surgery, most of them will return to function with an appropriate post-operative management (Boston et al., 2020; Liptak et al., 2021). SCC in cats is also relatively radiosensitive, and radiation therapy has been shown to at least improve quality of life in cats affected by oral SCC. Although a protocol combining medical anti-angiogenic chemotherapy and radiation therapy was shown to result in significantly longer median progression-free interval and median overall survival time, almost a third of cats experienced severe toxicity and the authors concluded, that the protocol cannot be routinely recommended (Marconato et al., 2020). New immunotherapy approaches are also emerging to combat SCC in cats (Giuliano, 2021).

Malignant melanoma (MM) is a malignant invasive tumour that metastasises early, mostly into the regional lymph nodes and lungs (Proulx et al., 2003). Clinically, MM may present as a pigmented mass (Fig 139), but other clinical presentations (*e.g.* pigmented or non-pigmented masses or ulcers) are possible affecting either dentate jaws, tongue or oral mucosa. Pathohistology of MM may be complicated, and immunohistochemistry is often indicated (Gieger & McEntee, 2020; Smedley et al., 2022). Prognosis is guarded, but with multimodal treatment approaches, MM is becoming a relatively chronic disease. Also, dogs with tumours smaller than 8 cm^3, located on the rostral mandible or caudal maxilla, and/or tumours having a mitotic index ≤3 have longer remission duration and survival regardless of the treatment (Gieger & McEntee, 2020) and additional prognostication factors are being researched (Smedley et al., 2022). Curative-intent surgery is the gold standard of local disease control, but surgery may improve survival times regardless of margins, especially if combined with other treatment modalities (Giacobino et al., 2021; Gieger & McEntee, 2020; Pazzi et al., 2022; Raleigh et al., 2021). Surgery may be complemented with radiation therapy or radiation therapy may be used as a sole treatment (Baja et al., 2022; Gieger & McEntee, 2020). Malignant melanoma is considered a very immunogenic neoplasm, and several immunotherapy approaches are being developed, such as canine melanoma vaccine (Gieger & McEntee, 2020; Turek et al., 2020), electrovaccination (Giacobino et al., 2021; Piras et al., 2017) or combination of immunotherapy with radiotherapy for metastatic disease control (Deguchi et al., 2023). Small MM not involving bone in dogs has recently been shown to be well responsive also to ECT (Tellado et al., 2020).

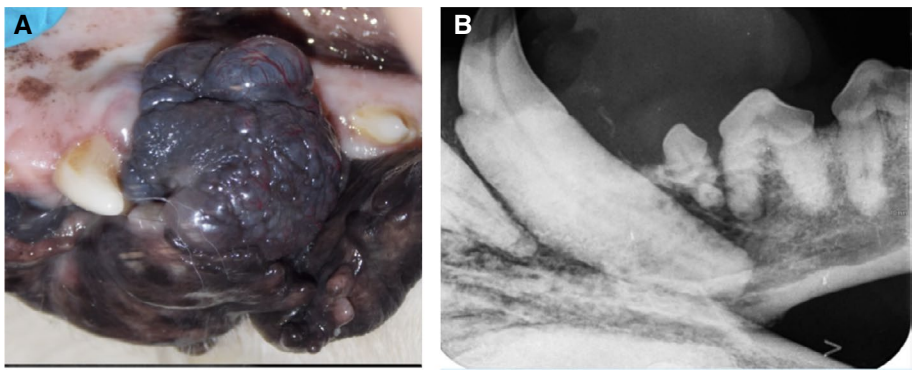

FIG 139. (A, B) Oral melanoma of the left rostral mandible and corresponding dental radiograph in a dog.

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Oral MM is an uncommon malignant tumour in cats and data on the treatment outcomes (which can generally be similar to those used in dogs, including the canine melanoma vaccine) are scarce (Briggs et al., 2023; Farrelly et al., 2004; Sarbu et al., 2017).

Fibrosarcoma (FSA) (Fig 140) is the third most common oral tumour in dogs and may affect puppies, especially of the large breeds. A "high–low" FSA variant may affect certain dogs, especially Golden retrievers. This variant is biologically very aggressive, yet it looks pathohistologically benign (benign fibrous connective tissue). FSA is locally highly invasive; hence, local disease control is difficult, which makes the prognosis guarded. Metastases are relatively rare (Gieger & McEntee, 2020). Dogs with FSA of the maxilla/mandible not involving the palate, stage I FSA, wide resection, clean margins and low-grade FSA have a better prognosis. For FSA, surgery alone results in a relatively high-local recurrence rate and radiation therapy plays a role in FSA management – either as an adjunct treatment to surgery (prolonging survival) or as a monotherapy (Frazier et al., 2012; Gardner et al., 2015; Gieger & McEntee, 2020; Martano et al., 2018).

In cats, FSA is the second most common tumour in the oral cavity and may be difficult to differentiate from other spindle cell neoplasms or even reactive processes (Gieger & McEntee, 2020; Harvey et al., 2022). Similar to FSA in dogs, this is a locally highly invasive neoplasm which metastasises rarely and late in the disease course. Prognosis is guarded due to difficulties in controlling the disease locally, as the required margins for surgical resection should be at least 2 cm, but preferably wider (Gieger & McEntee, 2020; Liptak et al., 2021).

Many other non-odontogenic tumours can affect the oral cavity and maxillofacial region (alone or as a part of systemic disease) such as extramedullary plasmacytoma (Evenhuis et al., 2023), lymphoma (Evans et al., 2023; Nemec et al., 2012), mast cell tumour (Elliott et al., 2016), transmissible venereal tumour of dogs (Bright et al., 1983), osteosarcoma (Farcas et al., 2014), multilobular osteochondrosarcoma (Banks & Straw, 2004; Vedrine, 2023), liposarcoma (Piseddu et al., 2011), hemangiosarcoma (Dennis et al., 2006), osteoma (Fiani et al., 2011; Volker & Luskin, 2014), feline restrictive orbital myofibroblastic sarcoma (Bell et al., 2011), and biopsy is always needed to determine the nature of the lesion.

Similarly, several non-neoplastic and/or proliferative lesions such as gingival enlargement (Fig 141) (Murphy et al., 2020; Roy et al., 2020), early-onset (proliferative) gingivitis (Soltero-Rivera et al., 2023), eosinophilic granuloma complex (Fig 142) (Mendelsohn et al., 2019; Soltero-Rivera et al., 2023), viral papillomatosis and odontogenic cysts can affect the oral cavity and maxillofacial region. Neoplastic and non-neoplastic lesions can clinically appear very similar (Soltero-Rivera et al., 2015). Therefore, biopsy of any newly observed lesion has to be performed as soon as possible and pathohistology results compared with the clinical and imaging appearance of the lesion to reach the final diagnosis (Regezi & Verstraete, 2020).

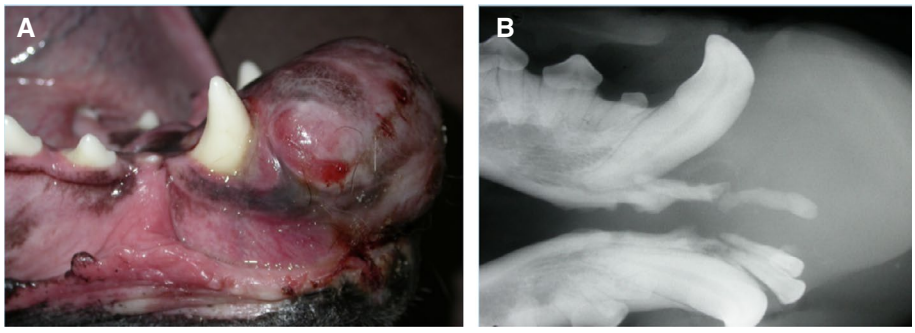

FIG 140. (A, B) Fibrosarcoma of the rostral mandibles and corresponding dental radiograph in a dog.

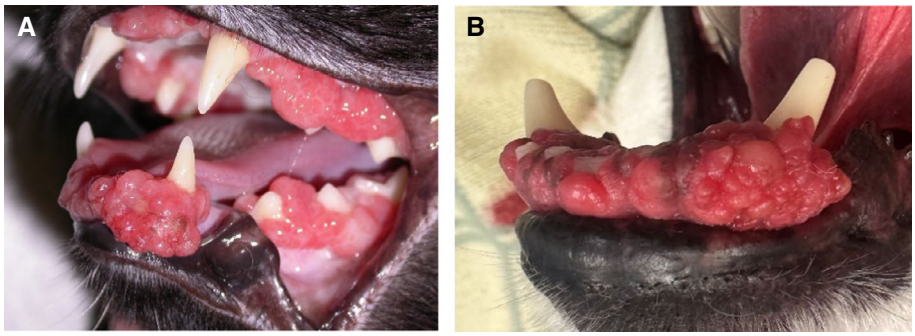

FIG 141. (A, B) Gingival enlargement (GE) in a cat (A) and dog (B).

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FIG 142. Eosinophilic granuloma complex in a cat.

Key points

- Benign and malignant conditions can appear very similar clinically; therefore, biopsy for histopathology is mandatory and clinical-pathological correlations considered.
- The most common oral malignant tumour in the dog is MM followed by SCC.
- The most common feline oral malignancy is SCC followed by FSA.
- Before any treatment is attempted, complete staging of the disease is needed.
- Prompt and aggressive therapy offers the best chance for cure, and therefore, regular oral examinations are necessary.
- Surgical excision is mostly still the primary treatment of choice for most oral tumours, with the surgical margins planned based on the type of the tumour.
- Radiation therapy, immunotherapy, electroporation-based treatments, photodynamic therapy and/or (metronomic) chemotherapy are nowadays also used in the multimodal treatment approach to oral tumours.

SECTION 2: ANIMAL WELFARE ISSUES CONCERNING DENTAL HEALTH

Introduction

Globally, veterinarians take an oath to promote animal health and welfare as a fundamental part of their professional and ethical responsibilities. Central to evaluating animal welfare are five essential principles, commonly referred to as the Five Freedoms. These principles emphasise the importance of minimising an animal's stress, fear, suffering and pain, as well as allowing them to exhibit natural behaviours (Brambell, 1965). Additionally, concerns regarding animals' quality of life arise when they are subjected to stimuli and physiological challenges beyond their coping abilities (Fraser et al., 1997). Providing regular, high-quality dental care is crucial for ensuring optimal health and quality of life in veterinary patients. If dental and oral conditions are not properly treated, they can lead to persistent pain, contribute to severe local or systemic diseases (DeBowes et al., 1996; Finch et al., 2003; Gawor, 2013b; Niemiec, 2013f; Pavlica et al., 2008) and potentially hinder the natural expression of oral and facial behaviours (Palmeira et al., 2017). Neglecting to adequately address these conditions can significantly impair an animal's welfare, which veterinarians must take into account when determining the appropriate level of care for their patients.

Prevalence of dental disease

In the past, it was widely believed that companion animals needed minimal, if any, dental care. It is now recognised that dental disease ranks among the most prevalent medical issues in dogs and cats. Research indicates that more than 80% of dogs and 70% of cats show signs of periodontitis by the age of two (Fernandes et al., 2012; Kortegaard et al., 2008; Lund et al., 1999; Marshall et al., 2014). Additionally, 10% of dogs experience fractured teeth with painful pulp exposure, known as complicated crown fractures (Chidiac et al., 2002; Golden et al., 1982). It is further estimated that 50% of large-breed dogs have minor fractures, termed uncomplicated crown fractures, which expose painful dentine (Hirvonen et al., 1992) (see Tooth fractures section). Bellows (2010b) also found that oral resorptive lesions clinically affect between 20% and 75% of mature cats, depending on the population studied. Within the canine population, prevalence of periodontal disease is increased in certain breeds associated with human created anatomical changes. Notable increased periodontal disease occurs in toy breeds, brachycephalic breeds and Greyhounds (McLeod, 2021; O'Neill et al., 2021; Wallis, Milella, et al., 2021). As a result, a significant number of veterinary patients are suffering from considerable pain, infection or both daily.

Associations with pain and suffering

Pain is a highly individualised experience, and the behaviours associated with pain can vary greatly between species. In humans, it is well documented that dental pain can be severe (Bender, 2000; Hasselgren, 2000; Hargreaves & Kaiser, 2004). Numerous studies have linked dental pain in humans to decreased productivity, disrupted sleep and significant social and psychological impacts (Anil et al., 2002; Choi & Flynn, 2017; Heaivilin et al., 2011; Reisine et al., 1989). While animals may display fewer behaviours directly attributable to oral pain, it is likely that their experience of pain and infection is just as significant (Cohen & Brown, 2002; Holmstrom et al., 1998d; Niemiec, 2005a), considering that pain thresholds in humans and animals are quite similar (Bennett & Xie, 1988; Rollin, 1989).

Non-human mammals have proven to be excellent models for studying dental pain in humans (Le Bars et al., 2001) and have been extensively used in nociception research. In studies of human pulpitis – a condition known to cause severe pain – small rodents have been found to be effective models. Observable and repeatable behavioural changes due to pulpal pain include reduced weight gain, longer meal completion times, shaking, open-mouthed facial grimaces, freezing and decreased activity (Chidiac et al., 2002; Chudler & Byers, 2005). Dogs and cats have also been used to demonstrate behavioural changes associated with both pulpal and non-pulpal pain (Le Bars et al., 2001). Interestingly, despite the common belief among veterinary professionals and pet owners that dental pain would lead to a significant decrease or complete cessation of appetite, this has not been published as of the writing of this paper. Further research

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is strongly encouraged to better understand oral pain and how it should be assessed in companion animals.

There is a strong belief within the veterinary community that, even if it is not always possible to definitively prove that an animal is in pain, we should always aim to alleviate any suspected pain (Matthews et al., 2014). When oral pain is reasonably suspected, it is recommended that effective therapy be administered to relieve this pain. While pharmaceuticals may provide temporary relief, the only definitive way to eliminate pain is to address the underlying issue with appropriate dental treatment.

Behaviour changes noted

Behavioural scoring systems designed to evaluate pain are available for a variety of systems and species (Matthews et al., 2014) and are discussed in more detail in the Anaesthesia section. However, it is crucial to acknowledge that indicators of dental pain are often subtle and nonspecific.

Conditions that may cause oral pain in our patients include periodontal disease, fractures of the teeth and jaw, tooth resorption, caries, traumatic malocclusions, feline orofacial pain syndrome and certain oral neoplasms. It is important for practitioners to recognise that the absence of significant behavioural changes does not equate to the absence of pain, nor does it diminish the potential severity of the condition. Many dogs and cats do not outwardly exhibit the pain they endure daily in ways that are easily noticeable or interpretable by their owners or veterinarians (Merola & Mills, 2016). Behaviours commonly associated with dental pain include pawing at the mouth, rubbing the face, drooling, alterations in mouth movements and a slight decrease in appetite (Rusbridge & Heath, 2015).

Interpreting behavioural signals of oral pain can be challenging, yet it is a simple fact that animals will continue to eat despite experiencing severe and debilitating dental pain. The need for nourishment to survive often outweighs the instinct to avoid pain. It is important to remember that while many animals will still engage in normal oral behaviours, such as playing with toys, marking with facial glands or exploring their environment with their mouths, despite dental pain, some may be hindered from expressing these natural and essential behaviours due to chronic discomfort. Furthermore, clients often report greater satisfaction when they know their pets are not in pain (McElhenny, 2005). Regardless of whether behavioural changes are observed, the underlying pain should never be a condition that animals are expected to endure, either by the veterinary community or by pet owners.

Although a definitive guide for assessing behavioural changes due to oral disease and discomfort is not yet available, the authors strongly recommend that this is an area that warrants further research. On the feline front, a promising opportunity for assessing feline oral pain has emerged with the Feline Grimace Scale, which can be utilised to assist both veterinary teams and pet parents to evaluate post-surgical oral pain and potentially ongoing oral discomfort (Evangelista et al., 2019: Evangelista & Steagall, 2021; Steagall et al., 2023; Watanabe et al., 2020).

Physiological signs of stress

Endodontic and periodontal diseases can impose a significant bacterial burden on the body (DeBowes et al., 1996; Niemiec, 2012b, 2013f). Unchecked pain and infection can trigger the body's natural stress responses, potentially leading to harmful consequences (Broom, 2006). While these stress responses may be adaptive in the short term, chronic stress can have detrimental effects on multiple body systems. The first signs of compromised immune function may manifest as 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 & Zannino, 1997; Karin et al., 2006; Kiank et al., 2006). Untreated dental disease can lead to chronic inflammation and infection of the oral tissues (Niemiec, 2013f). As in other areas of the body, unchecked infection is an ethically unacceptable condition to leave without appropriate therapy.

Client education matters

As veterinarians, we bear the responsibility of actively diagnosing, treating and alleviating pain and suffering in our animal patients. When clients resist our proposed treatment plans, further education may enhance their understanding of the decreased welfare associated with the animal's condition and could improve compliance with our recommendations. Allowing untreated dental disease to persist, causing ongoing pain, without intervention represents a significant concern for animal welfare.

At the practitioner level, a basic questionnaire or discussion with the owner during routine health examinations should address current oral and facial behaviours and any changes observed, with this information documented in the patient's medical records. Although many owners and veterinarians believe that oral pain typically leads to decreased appetite (and its absence might result in misreporting changes), we urge practitioners to adopt a broader perspective on the various changes that can occur as a result of oral disease (Table 1) (DeForge, 2009). When collecting a history from an owner, veterinarians should avoid asking leading or closed-ended questions and instead encourage the owner to reflect on any changes they might have noticed. Equally important is the follow-up on these or any additional changes observed by the owner after professional dental treatment. A follow-up at 2 weeks and again at 2 months is generally recommended to fully assess the improvements following therapy.

Welfare implications of veterinary handling techniques

The welfare needs of our patients begin the moment they enter our practice. Dental procedures must be performed by properly trained veterinary professionals, ensuring gentle and humane handling at all times. Low-stress and feline-friendly handling techniques are recommended during the initial examination and the administration of anaesthetic agents, with established guidelines

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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

available in numerous publications (Carney et al., 2012; Herron & Shreyer, 2014; Rodan et al., 2011; Yin, 2009). The human–animal bond is delicate, and fear experienced during handling for veterinary procedures can quickly disrupt this bond (Knesl et al., 2016). Educating and committing to reducing stress associated with handling during oral examinations and related dental procedures must be prioritised when addressing dental disease in our patients.

All procedures involving the oral cavity, including professional teeth cleaning, should be conducted under general anaesthesia with a secured airway (endotracheal intubation). All safety precautions, monitoring protocols and standards outlined in the Anaesthesia section must be followed.

To prevent excessive pain and swelling post-procedure, gentle, efficient and thoughtful tissue handling (minimally invasive surgery) is recommended. Additionally, the appropriate choice of, or complete avoidance of, mouth gags may help prevent trauma. The use of local and regional anaesthetic blocks, as well as adequate pre- and post-operative pain management, is crucial for controlling pain that may arise from proper dental therapy.

Welfare implications of anaesthesia–free dentistry

Veterinary organisations worldwide agree that performing dental procedures without anaesthesia, referred to here as anaesthesia-free dentistry (AFD), also known as non-anaesthetic dentistry or natural dentistry, offers no medical benefits (Stella et al., 2018). Animal welfare experts assert that preventable and predictable pain, stress and anxiety should be addressed during veterinary care for ethical and moral reasons. Accurate assessment of periodontal health requires thorough periodontal probing, which is difficult to perform on an awake animal, particularly on the caudal teeth and all lingual/palatal surfaces due to challenges such as animal movement, tongue interference and visualisation difficulties. While such a procedure might cause minimal pain and stress in healthy individuals, probing diseased tissues, like resorptive lesions, triggers a significant and predictable pain response. It is rarely possible to accurately predict which animals will experience pain during probing based on visual cues alone, making it difficult for a practitioner to ensure that the process will not be painful or stressful.

Furthermore, those performing dental procedures without anaesthesia cannot carry out a radiological examination of the subgingival anatomy, which is considered essential in Tier Three countries for a comprehensive evaluation. Without proper evaluation of both the supra- and subgingival areas, meaningful treatment cannot be provided, leading to untreated persistent infections, inflammation and pain despite a cosmetically improved oral appearance. This not only renders the procedure ineffective in alleviating pain and infection but also creates a false sense of security for the owner, potentially delaying appropriate professional care.

This directly contradicts the welfare benefits and quality of life improvements central to these guidelines. Additionally, the stress or discomfort associated with this time-consuming cosmetic procedure is entirely avoidable with the use of appropriate anaesthesia, making the practice indefensible from both a medical and ethical perspective. As such, the WSAVA strongly opposes the practice of performing veterinary dental procedures without appropriate anaesthesia, as it is inadequate and fails to meet the standard of care required, potentially misleading pet owners.

Higher education welfare applications

Veterinary dental care is a crucial component of preventive healthcare, yet it remains largely neglected within the veterinary educational system. The majority of veterinarians surveyed from multiple global geographies spanning most continents identified that education in dentistry, from both a technique as well as the effects of dental and oral diseases on an animals' welfare and behavioural health, is grossly underserved (Endenburg et al., 2022; Endenburg & van Lith, 2023). As highlighted in these Guidelines, universities play a vital role in educating and promoting opportunities for learning not only diagnostic and therapeutic techniques in dentistry but also in recognising oral pain and associated behavioural changes. Without educational reform and prioritisation, the welfare and quality of life improvements that could be achieved through enhanced dental care will be hindered.

Conclusions

As advocates for humane animal husbandry and veterinary care, the veterinary profession must strive to continually improve how we safeguard the welfare of our animal patients. We must persist in advocating for optimal oral health in companion animals, promoting proper dental care and educating our clients on the critical importance of dental health for their pets' daily welfare. By adhering to the five tenets of animal welfare, regular dental examinations and appropriate therapy will address infections, control pain, relieve suffering and allow for the return of normal behaviour.

Key points

- Modern animal welfare science expects veterinarians to champion animal health initiatives that reduce pain, stress, suffering

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and fear while allowing our patients to express natural behaviours.
- Dental disease is one of the most common medical conditions in companion animals, with significant welfare implications if left undiagnosed and untreated.
- Untreated dental disease can lead to chronic pain, persistent infections, physiological and immunological stress, severe local and systemic disease and hinder natural behavioural expression.
- Behavioural changes resulting from oral pain can be subtle and nonspecific, often not including appetite loss as commonly believed and should be discussed and evaluated with owners both before and after dental procedures.
- Proper handling techniques before, during and after dental procedures are vital to maintaining the human–animal bond and minimising both physical pain and psychological distress.
- The WSAVA Dental Guidelines Committee strongly opposes anaesthesia-free dentistry, asserting that it provides substandard care that can result in significant welfare and quality of life concerns.
- Veterinarians must change how they discuss dental disease and improve advocacy for patients to help clients understand the welfare issues associated with inadequate dental care, including pain, infection and disease risk in their companion animals.

SECTION 3: ANAESTHESIA AND PAIN MANAGEMENT

Introduction

Dental disease is considered one of the most important sources of chronic pain in dogs (Bell et al., 2014) and cats (Palmeira et al., 2022). 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 the prevention, assessment and treatment of pain in companion animals. This document can be downloaded at https://onlinelibrary.wiley.com/doi/10.1111/jsap.13566 (Monterio et al., 2022) and should be used as supplemental reading material to the WSAVA Dental Standardisation, 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 (Beckman, 2013; de Vries & Putter, 2015; Niemiec et al., 2020; Woodward, 2008b).

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 (https://acvaa.org/wp-content/uploads/2019/05/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 anaesthesia" (https://www.avma.org/resources-tools/avma-policies/veterinary-dentistry). The *Australian Veterinary Association* published a position statement considering AFD 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 Standardisation 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 are 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 the 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 AFD.
- The goal is to provide great quality of care for animals and clients. We can do better as a profession and AFD is not part of this concept.

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- General anaesthesia is required for complete diagnosis and treatment of dental disease (Wallis et al., 2018).
- Senior pets may require general anaesthesia for dental care procedures. Old age alone is not a contraindication of general anaesthesia. If necessary, geriatric pets can safely undergo a variety of anaesthesia events (Dhaliwal et al., 2023).

Patient preparation and assessment

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 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, 2008; Monterio et al., 2022). 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 (Brodbelt et al., 2008). If possible, canine and feline individuals with coexisting disease should be stabilised 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 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). Preoxygenation is recommended for geriatric patients with cardiovascular disease or pulmonary disease (Dhaliwal et al., 2023).

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 (de Miguel Garcia et al., 2013; Stiles et al., 2012). 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 minimised and must be released/removed periodically.

Anaesthetic management

Anaesthetic protocols should be tailored to the patient needs based on individual requirements, risk assessment, coexisting 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 catheterisation.

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 maximising 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 coexisting disease. Suggested indications, advantages and disadvantages of drugs used for sedation and premedication are described in Table 2.

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 3) and drugs should be given "to effect" to minimise 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 (Park et al., 2025). Hypotension can be best avoided with reduced anaesthetic concentrations by using balanced anaesthesia; drugs that decrease volatile anaesthetic requirements and provide good haemodynamic stability and analgesia (*e.g.* opioid infusions or boluses) (Gutierrez-Blanco et al., 2013; Steagall et al., 2015). 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.

In geriatric patients, surgeons are advised to be available during anaesthesia induction to minimise the patient's time under general anaesthesia. Titration of the anaesthetic dose is required when anaesthetising elderly pets because they may require lower doses (Dhaliwal et al., 2023).

Limited drug availability

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

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Table 2. Drugs used for sedation, premedication and chemical restraint in dogs and cats*

Drug	Dosage regimens**	Comments
Acepromazine	0.01 to 0.05 mg/kg im, iv, sc	Mild sedation in cats
Diazepam††	0.2 to 0.5 mg/kg iv	Higher doses will not necessarily increase magnitude of effects; however, duration of action may be increased
Midazolam†† Xylazine	0.2 to 0.5 mg/kg im or iv 0.2 to 0.5 mg/kg im, iv	Poor absorption after IM administration
Dexmedetomidine	1 to 10 µg/kg im, iv 10 to 20 µg/kg (otm) (cats)	Commonly used in combination with ketamine or propofol for anaesthetic induction commonly used in combination with ketamine or propofol for anaesthetic induction Sedation when (dex) medetomidine not available
Medetomidine	6 to 20 µg/kg im, iv	Vomiting and nausea are commonly produced
Ketamine	3 to 10 mg/kg im or po	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
Alfaxalone	0.5 to 1 mg/kg im	Higher doses may be required for chemical restraint of feral dogs and cats see dexmedetomidine
		Half-potency of dexmedetomidine (doses are doubled) Buccal administration produces excessive salivation in cats
		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 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 3. Drugs used for anaesthetic induction and injectable anaesthesia*

Drug	Dosage regimens	Comments
Alfaxalone**	0.5 to 3 mg/kg iv Up to 3 to 5 mg/kg (unpremedicated iv)	Doses are given to effect Cardiorespiratory depression can be observed patients Recoveries can be agitated (see drug's label)
Propofol**	0.5 to 4 mg/kg iv	Higher doses (6 to 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 to 5 mg/kg (induction) iv	Commonly used in combination with diazepam or midazolam for anaesthetic induction 2 to 20 µg/kg/minute (infusion in balanced Should never be administered alone anaesthesia) iv Anti-hyperalgesic effects via N-methyl D-aspartate (NMDA) receptor antagonism Good cardiopulmonary stability Potentially difficult anaesthesia recoveries
Thiopental**	2.5 to 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 to 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

countries. The WSAVA therapeutic guidelines group have published guidelines a global survey on the availability of core essential medicines for cats and dogs with the WSAVA member associations (https://wsava.org/wp-content/uploads/2023/04/A-GLOBAL-SURVEY-ON-THE-AVAILABILITY-OF-CORE-ESSENTIAL-MEDICINES-FOR-CATS-AND-DOGS-WITH-THE-WORLD-SMALL-ANIMAL-VETERINARY-ASSOCIATION-MEMBER-ASSOCIATIONS.pdf).

- 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).
- 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 4).
- NSAIDs are also readily available and play an important role in controlling post-operative 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.

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Table 4. Common local anaesthetics used in veterinary anaesthesia and pain management

Local anaesthetic*	Onset (minute)	Common concentrations (%)	Duration of the block (hour)	Relative potency (lidocaine = 1)	Suggested maximum doses (mg/kg)
Lidocaine	5 to 15	1, 2	1 to 2	1	10 (dogs)
Mepivacaine	5 to 15	1, 2	1.5 to 2.5	1	5 (cats)
Bupivacaine	10 to 20	0.25, 0.5, 0.75	4 to 6	4	4 (dogs)
Ropivacaine	10 to 20	0.5, 0.75	3 to 5	3	2 (cats)
Levobupivacaine	10 to 20	0.5, 0.75	4 to 6	4	4 (dogs)
					2 (cats)
					3 (dogs)
					1.5 (cats) 2 (dogs) 1 (cats)

*Volumes of injection (0.25 to 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 post-operative analgesia and using less than maximum recommended doses (see text)

FIG 143. Cuffed endotracheal tube.

FIG 144. Oropharyngeal packing.

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 (Fig 143).
- Oropharyngeal packing is recommended (Fig 144).
- 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). Use low-pressure cuffs and ideally use a manometer to keep the pressure below 30 cm H_2O.
- Patients should always be 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 2024 AAHA/AAFP fluid therapy guidelines provide comprehensive information on this subject in dogs and cats (Pardo et al., 2024).

- Fluid therapy compensates for ongoing losses, prevents and treats dehydration and hypovolaemia and provides a source of electrolytes.
- Most anaesthetic drugs will cause some level of cardiovascular depression, and the administration of balanced crystalloid solution will optimise hydration status and tissue perfusion during anaesthesia.
- The choice will be based on the patient's needs and requirements. In general, it is accepted that lower (2 to 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 hypovolaemia without concomitant cardiac disease.
- Patients with advanced renal disease may benefit from preoperative fluid administration to establish proper hydration.

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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 the 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 (http://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 (Fig 145).
- Mean blood pressure monitoring should be maintained above 70 mmHg for appropriate tissue perfusion as per commonly applied standards (Fig 146). 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.) (Figure 147A).
- Body temperature should be maintained between 37 and 38°C (98.6 to 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 (Fig 147B). Care needs to be taken with heating pads (especially electric) to avoid thermal burns. Bubble plastic wrap around the extremities can also be used for prevention of hypothermia. This material is cheap and available worldwide.

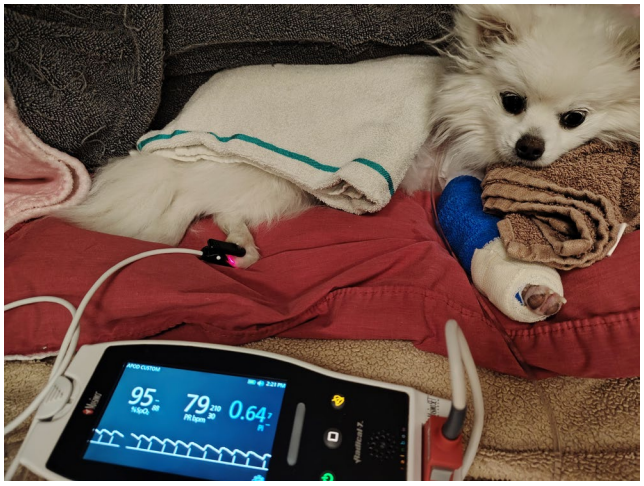

FIG 145. Pulse oximetry.

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 minimise financial costs (Mathis et al., 2025; 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 (https://www.iasp-pain.org/education/curricula/iasp-curriculum-outline-on-pain-for-dentistry-and-oral-health/). A similar outline could be adapted and applied in veterinary medicine for teaching veterinary students. In veterinary dentistry,

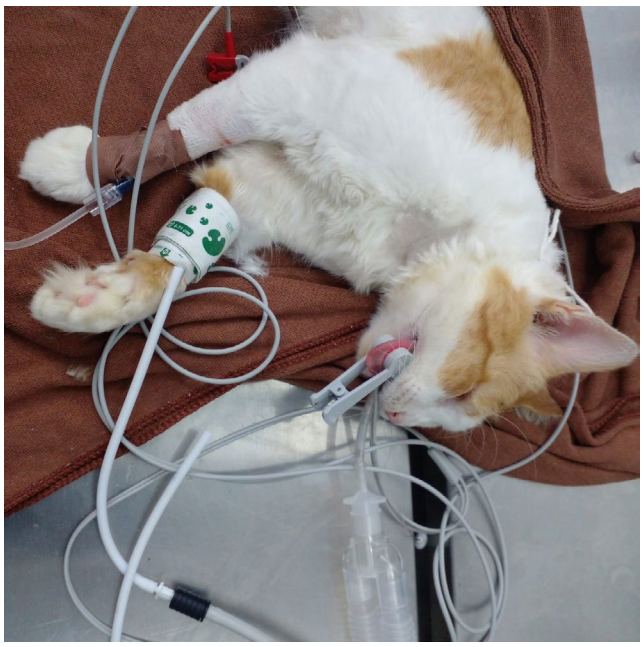

FIG 146. Blood pressure monitoring.

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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 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. Levels of pain and the analgesia plan should be comprehensive and include drugs for post-operative analgesia after patient discharge, taking into consideration drug palatability and frequency of administration for best treatment compliance.
- 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 2).
- The "basic" analgesic protocol includes the administration of opioids, local anaesthetic blocks and NSAIDs (Box 1) unless contraindicated (see Monterio et al., 2022 for drugs, doses and indications).
- The pros and cons of each class of analgesic should be taken into consideration.
- The administration of adjuvant analgesics is recommended in cases of moderate and severe pain and for patient discharge. Hospitalisation is recommended for invasive surgical procedures where a patient requires frequent assessment and treatment with opioid and ketamine infusions.
- While not specifically pain management, decreased surgical trauma will decrease post-op pain.

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 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-Steagall, 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.

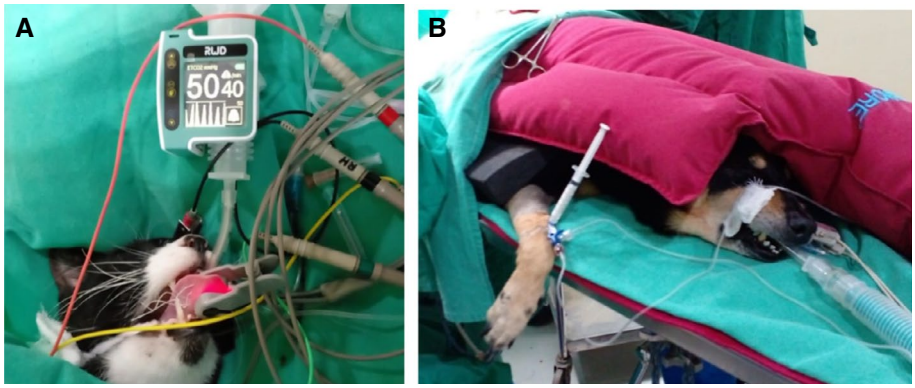

FIG 147. (A, B) Monitoring and maintaining body temperature.

BOX 1. Opioid, dental nerve block, NSAIDs.

1. Preoperative opioid
   - Reduce anaesthetic requirements
   - Produce varying levels of sedation
   - Offer haemodynamic stability

2. Intraoperative dental nerve block
   - Effective analgesic agent
   - Reduce anaesthetic requirements
   - Do not delay recovery from general anaesthesia

3. Post-operative NSAIDs

Pre-anaesthetic assessment

Rule out:
- Coagulopathy, liver dysfunction
- Unstable renal disease
- Hypotension, dehydration
- Gastrointestinal clinical signs

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BOX 2. (a) Preventive analgesia and multimodal analgesia.

Preventive analgesia describes all types of perioperative interventions and efforts to address and minimise post-operative pain. Administration of analgesics is performed at any time and for varying durations in the perioperative period to prevent allodynia and central sensitisation. *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.
(b) Welfare 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 Welfare section).

Perioperative pain control (Table 5)

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

- 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 haemodynamic 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 to 7 days depending on type of oral disease/procedure.
- NSAIDs may also be administered to cats for several days (Monteiro & Steagall, 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

Table 5. 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 3–5 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 to 5 mg/kg), ketamine (5 mg/kg) + diazepam or midazolam (0.25 mg/kg), OR alfaxalone (2 to 5 mg/kg) iv to effect *Maintenance of anaesthesia*: inhalation anaesthesia 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 to 10 mg/kg), alfaxalone (2 to 5 mg/kg) or tiletamine/zolazepam (1 to 2 mg/kg) iv to effect. Induction of anaesthesia can be performed by the intramuscular route of administration when tiletamine/zolazepam is administered as premedication *Maintenance of anaesthesia*: inhalation anaesthesia 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. Metamizole (dipyrone; 25 mg/kg iv every 12 hours) OR acetaminophen (paracetamol; 12.5 mg/kg po every 8 hours) 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 to 5 mg/kg), thiopental (2 to 8 mg/kg), propofol (3 to 5 mg/kg) to effect iv. Tiletamine/Zolazepam iv or im *Post-operative analgesia*: same as suggested protocol without controlled drugs

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pain; they are commonly addressed with balanced anaesthesia/multimodal analgesia (systemic administration of analgesic infusions such as opioids, lidocaine and ketamine) during the early post-operative period (24 to 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 post-operative) analgesia and reduce volatile anaesthetic requirements in a cost-effective manner (Aguiar et al., 2015; Gross et al., 1997, 2000; Snyder & Snyder, 2013). 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 (Monterio et al., 2022). 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- 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 4 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 the procedure/after extubation. Anaesthesia of the lingual and mylohyoid nerves may occur during a mandibular nerve block and result in desensitisation of the rostral two-thirds of the tongue. The idea is to have excellent intraoperative and early post-operative analgesia with local anaesthetics and opioids, whereas post-operative pain relief is achieved with the administration of opioids, NSAIDs and adjuvant analgesics. Some veterinarians combine opioids such as buprenorphine (0.003 to 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 a long-term isoflurane-sparing effect in some individuals (Snyder, Snyder, et al., 2016).

Mixing local anaesthetics

Historically, lidocaine 2% and bupivacaine 0.5% have been mixed 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 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 and 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) 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:

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- 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, 1991; Woodward, 2008b).
- The administration of lidocaine spray for endotracheal intubation in cats should be taken into 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 not an issue with lidocaine; however, the block may not be effective and haematoma/bleeding may occur (Loughran et al., 2016).
- 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 tongue chewing and 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 (Guerreiro et al., 2014; Smith et al., 2003). Veterinarians should not be afraid to use these techniques; however, they should be used with caution utilising 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.

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 to 5.0). This formulation gives a net prevalence of the ionised form and is thus water soluble. When a local anaesthetic solution is injected into body tissues with a physiological pH (7.4), the non-ionised lipid-soluble form will prevail. This is critical for the drug effect since the non-ionised form crosses biological membranes. In inflamed tissues, the ionised 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 anaesthetise 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 aiming parallel to the palate to slightly 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 to 4 mm into the foramen and the size of the catheter is selected by the veterinarian in advance.
6. Caudal approach to maxillary nerve block (https://wsava.org/committees/global-pain-council/scroll-down-to-anaesthetic-techniques-maxillary-nerve-block).
   To more effectively anaesthetise the maxillary fourth premolar and molars, this approach would be preferred over an infraorbital block, even a "deep" one. While a needle advanced distal to the maxillary molars and directed dorsally may impact the

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maxillary nerve branches to these teeth (before entering the infraorbital canal at the ptyergopalatine fossa), injury to the eye may occur. Instead, a modified caudal approach (percutaneous or mucosal) keeping the needle and syringe parallel to the palate introduces the needle ventral and medial to the junction of the palatine bones and the zygomatic arch. Direct the needle in a rostral-medial direction, towards the opposite nostril. Once the agent is placed at the distal aspect of the infraorbital canal at the fossa, continue to infiltrate the agent as the needle is withdrawn to block the caudal superior alveolar nerve (Grubb & Lobprise, 2020).

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, coexisting 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 allow 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 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 is not always easy, depends on the cooperation of the patient and 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 periodontal examination in the conscious patient 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 Marretta et al., 2012; Queck et al., 2018). 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 lifestyle 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 6).

Occlusion

According to the nomenclature committee of the AVDC (AVDC Nomenclature Committee, 2024), 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, interarch, 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 teeth (see Malocclusions section).

Examination under general anaesthesia

A thorough examination can only be performed under general anaesthesia. Pre-anaesthetic work-up and anaesthesia are described in Anaesthesia section. Following induction of anaesthesia, endotracheal intubation, cuff inflation, securing the airways and

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Table 6. Oral Health Index assessment

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 and/or seldom active	1	
	None	2	2
Scored points results:			5
0–3 points	Prophylactic recommendations		
4–7 points	Radical change required, surgery likely		
8–12 points	Immediate surgery required		

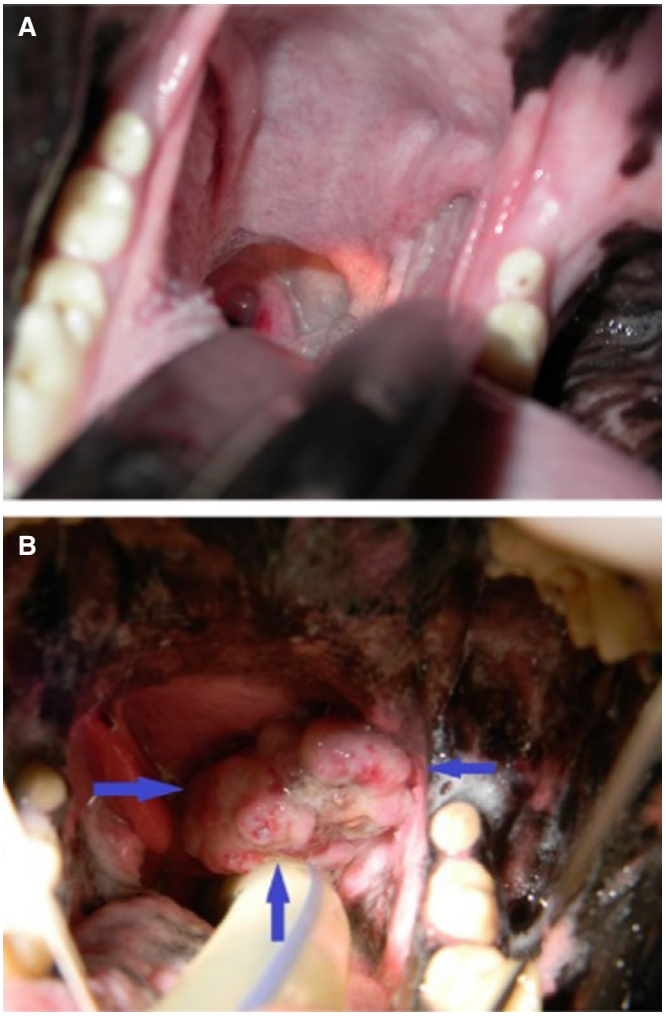

FIG 148. Inspect oropharynx and tonsils before pharyngeal pack; tonsillar mass.

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 utilising the appropriate instruments. First, the crowns are examined for defects such as tooth fractures, tooth wear, resorption, caries, pulp exposure and enamel disease with a dental explorer. Following this, sulcus or pocket depth 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. Inspection of 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 (Fig 148).
2. Inspection of oral cavity
   a. 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 preoperative dental condition as well as provide visual evidence to the owner. It is recommended to use a lip retractor or dental mirror to better visualise the entire dentition and surrounding structures (Fig 149)
   b. Reduction of bacterial load: 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 (Bellows, 2004; Fine et al., 1992). However, the transient nature of the possible bacteraemia makes this step as well as prophylactic antibiotics of dubious value (Blazevich & Miles, 2024). Further, recent studies show that oral bacteria exposed to chlorhexidine may develop resistance and/or tolerance to chlorhexidine and certain antibiotics (Cieplik et al., 2019; Früh et al., 2022). Another option is a solution of 50/50 ppm hypochlorous acid/sodium hypochlorite which takes a very short time to take effect and, above all, does not impair wound healing (Bender & Kramer, 2017). Another option for this step is to use ozonated water which has also shown beneficial results (Failor et al., 2022; Kaur et al., 2014).
   c. Assessment and identification of dentition: primary, permanent or mixed.

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FIG 149. Preoperative photographs.

FIG 150. Intraoperative photographs.

d. Assessment of 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.
e. Initial scaling of the teeth: for better visibility of the tooth surfaces and gingiva and to avoid impaction of debris while probing sulcus/pockets, an initial cleaning with a dental scaler is recommended.
f. Intraoperative photograph: it is advised to take a photograph of any pathology revealed by the scaling (Fig 150)
g. 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 (Fig 151). 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 be explored, especially the area just below the gingival margin to detect resorptive lesions. The examination should note:
h. Presence (or absence) of the teeth: the absence of a tooth can mean hypodontia/oligodontia (congenitally missing teeth), an unerupted (or impacted) tooth, a root remnant or a previously extracted or exfoliated tooth (Niemiec, 2010b). Occasionally, a '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.
i. Tooth surface: any irregularity is suspicious for a pathological process. Differentials for a roughened tooth surface include tooth fracture (uncomplicated/complicated), enamel defect (*e.g.* hypomineralisation), caries (Dupont, 2010) or tooth resorption (see Common Disorders of Teeth section).
j. Colour: Intrinsic staining (a purple, yellow, pink or grey tooth) indicates pulpitis or the use of certain antibiotics during tooth development (Fig 152).

FIG 151. Dental examination with dental explorer.

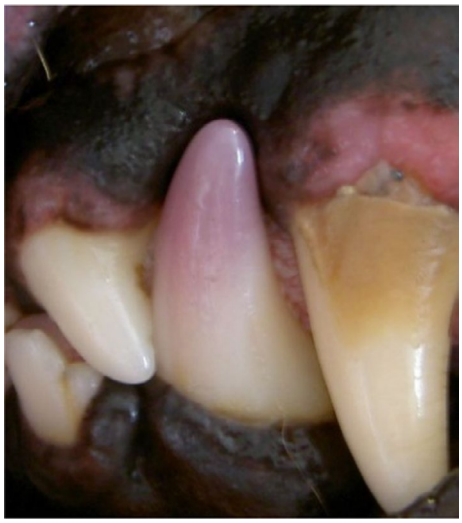

FIG 152. Assess nonvital tooth colour.

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3. Periodontal examination:
   a. Periodontal probing depth (PPD): 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; Niemiec, 2011, 2013c; Tetradis et al., 2006).
   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, 2013c) (Fig 153). 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 (DeBowes, 2010; Stepanuik, 2019). The periodontal probe can also be used to measure any extent of root exposure present due to gingival recession, and any furcation exposure at multirooted teeth. It is important that dental charts be of sufficient size to allow for accurate placement of pathology (see section).
   b. Gingival enlargement: enlargement of the gingiva can lead to pseudo pockets (Fig 154)
   c. Gingival recession is an indication of periodontal disease although the PPD does not necessarily increase (Fig 155)
   d. Furcation involvement: furcation involvement indicates bone loss between the roots of multirooted teeth (Box 3) (Fig 156).
   e. Mobility: the grade of mobility has to be determined (Box 4).
4. Imaging: dental radiographs (and/or CBCT) are a very important part of the dental examination and should be made whenever possible (Niemiec, 2011) (Fig 157) (see Radiology section).
5. Staging of periodontal disease: staging can be performed by combining the clinical findings and the dental radiographs for every tooth (AVDC Nomenclature Committee, 2024) (Box 5) (Fig 158).
6. Definitive cleaning and polishing.
7. Additional therapy: Based on all available information (visual, tactile and radiographic) determine and execute the final treatment plan.
8. Post-operative radiographs and photographs (Fig 159): Post-operative radiographs and pictures should be made of any

FIG 155. Identify gingival recession.

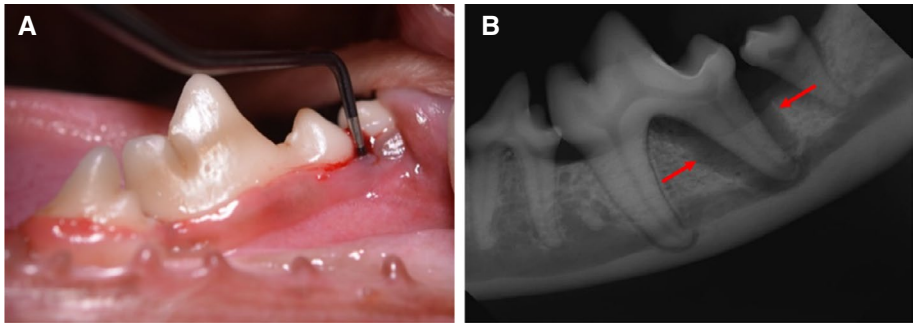

FIG 153. (A, B) Periodontal probing around the tooth; deep pocket distal aspect 309; radiograph shows extensive bone loss.

FIG 154. Identify extent of gingival enlargement to excise excess tissue. (a) Small area of gingival enlargement on the left maxillary canine of a dog, producing a pseudo-pocket (b). (c) Gingivectomy is indicated, and the excised tissue must be submitted for histopathology to rule out neoplasia.

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BOX 3. Furcation index.

Stage 1 (F1): Furcation 1 involvement exists when a periodontal probe extends <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 halfway 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).

BOX 4. Tooth mobility index.

Stage 0 (M0): Physiological 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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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; <25% of attachment loss or, at most, there is a stage 1 furcation involvement in multirooted teeth. There are early radiological signs of periodontitis. The loss of periodontal attachment is <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% to 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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surgical area as well as of the mouth in general to document the quality of cleaning/treatment.

Recording

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 & Caiafa, 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 digit denotes the quadrant, which is numbered clockwise beginning at the right maxillary quadrant and ends at the right mandibular quadrant (1 to 4 for permanent dentition, 5 to 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 (Fig 160).

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

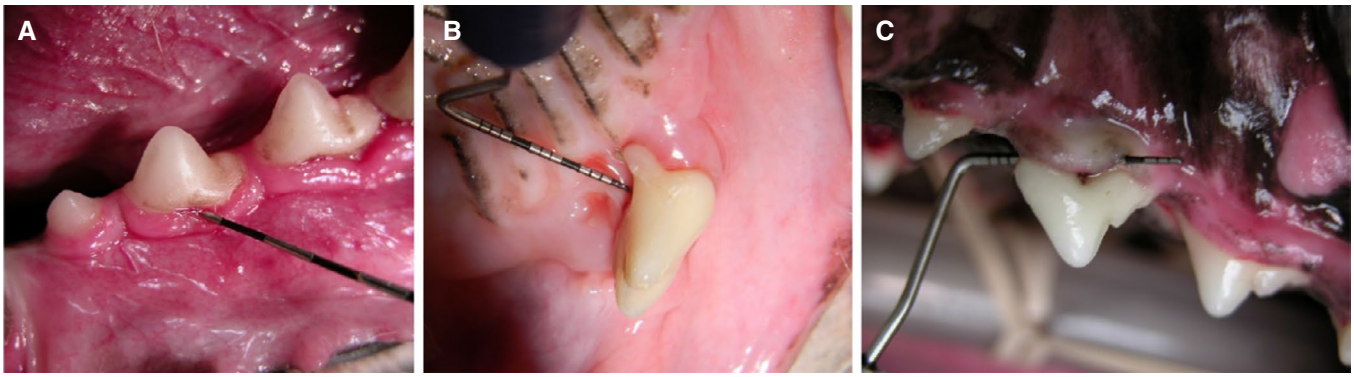

FIG 156. Assess furcation involvement or exposure – stage 1 to 3. (a) Correct use of a periodontal probe to evaluate the level of furcation exposure on the buccal aspect of the left mandibular second premolar of a dog. In this case, there is a grade I furcation, meaning that the probe enters the furcation, but less than one-third of the root width. This level of exposure can be effectively cleaned closed (*i.e.* without a flap). (b) Evaluation of furcation exposure on the palatal surface of the left maxillary fourth premolar of a dog. In this case, there is a grade II furcation, meaning that the probe enters the furcation more than one-third 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 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.

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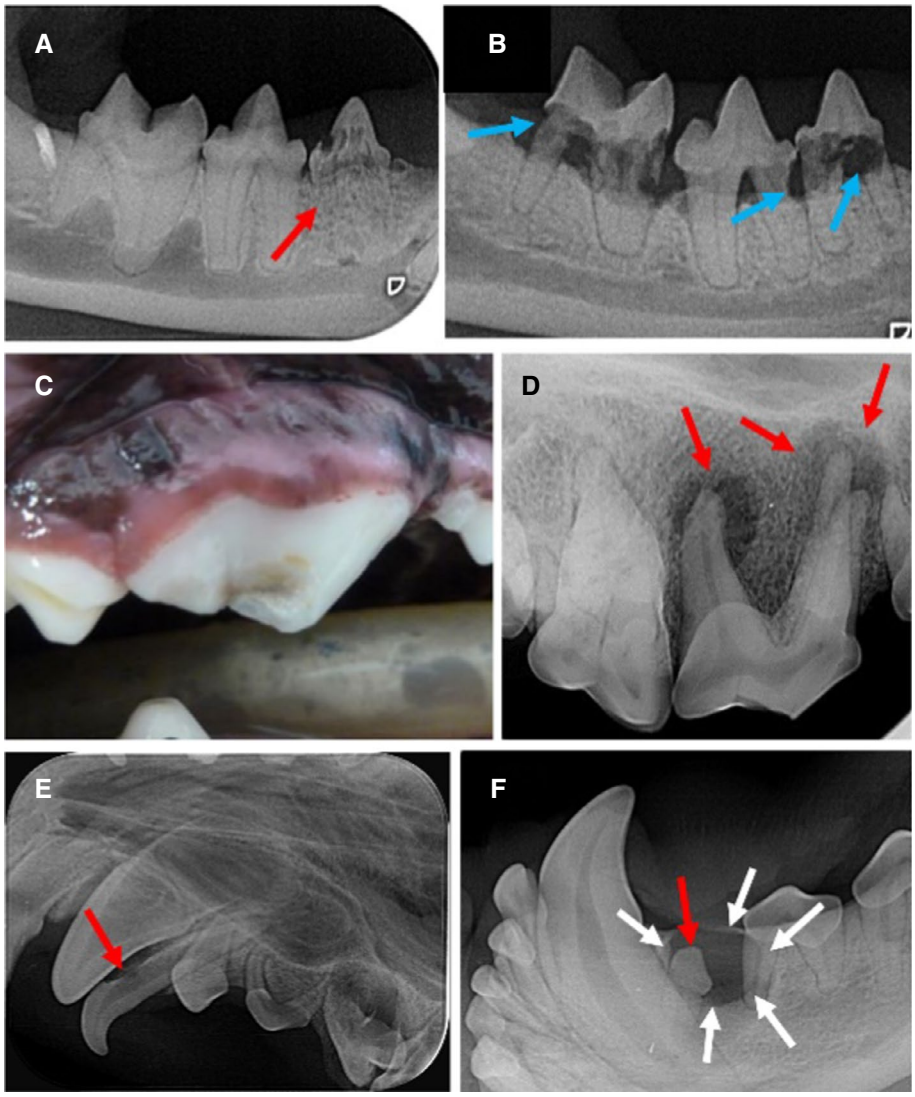

FIG 157. Radiograph to evaluate pathology. (A) TR type 2. (B) TR type1. (C, D) Crown fracture with radiographic evidence of apical bone loss. (E) Persistent deciduous tooth. (F) Unerupted mandibular first premolar with likely dentigerous cyst.

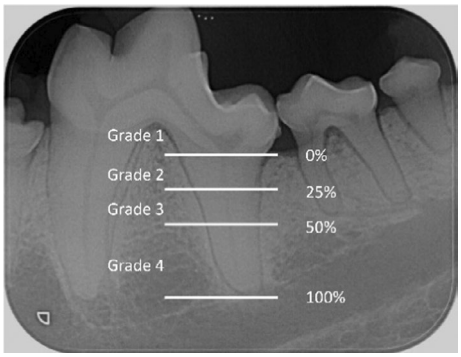

FIG 158. Determine the stage of periodontal disease with clinical findings and dental radiographs for each tooth.

species, faster than writing out the tooth description and ideal for digitalised recording and statistics.

Manual scoring

The clinical findings can be recorded manually (Fig 161). Dental charts for several species are available for free download at (https://bvda.co.uk/index.php/). 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 Electronic Veterinary Dental Scoring (e-VDS) is an online dental charting software, which provides a free basic version available for all veterinarians in nine screen languages (Czech, Dutch, English GB, English

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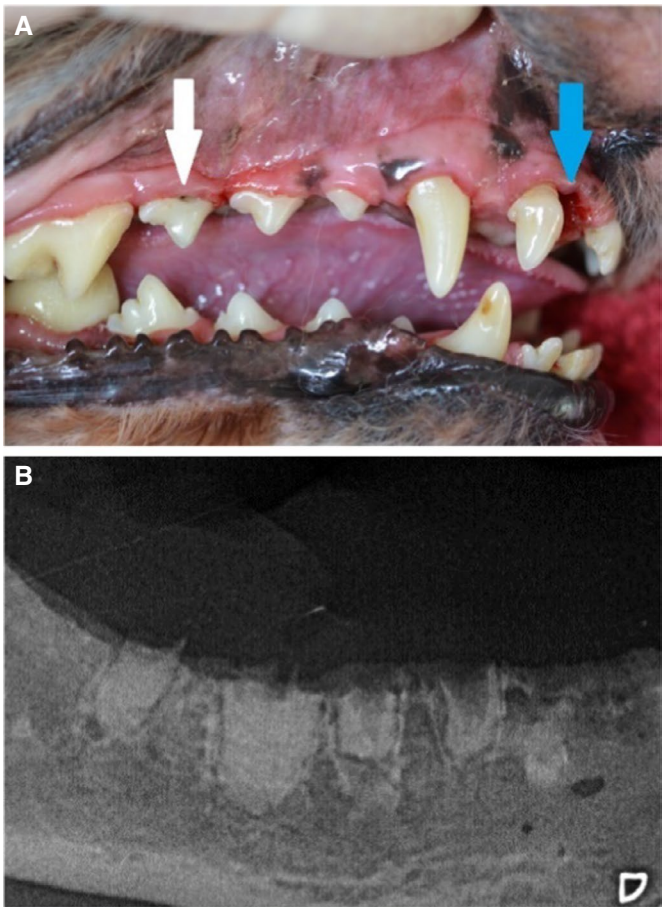

FIG 159. Post-operative radiographs and photos. (a) Post-scaling to demonstrate the clean teeth. Furcation exposure is evident on the third premolar (white arrow) and periodontal loss on the mesial aspect of the third incisor (blue arrow). (b) Intraoral dental radiograph of the right mandible of a cat which was brought in because the wound did not heal after extraction. Post-operative dental radiographs would have revealed the root remnants and saved this patient from unnecessary suffering.

US, French, German, Spanish, Portuguese and Russian). 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 ten common languages (Czech, Dutch, English GB and US, French, German, Italian, Spanish, Portuguese and Russian) 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 (Fig 162). The programme is also equipped with a tutorial which is based on photographs. The feature serves as an educational tool, diagnostic and treatment planning aid, and may be used for illustrating the condition to the client. Access to the programme is via: https://e-vds.vet/.

Tier 2 & 3 are recommended to use a more detailed commercial programme. There are several options available (in alphabetical order: http://animaldentalchart.com; www.accesia.se; www.chartific.com; www.e-vds.vet; www.vetdentalcharts.com).

Key points

- The examination of a conscious patient 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 dentistry without anaesthesia.
- 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

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 et al., 2018).

Plaque removal and control consists of four 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 (Bellows et al., 2019; Niemiec, 2013c). Only when the patient is properly anaesthetised can a safe and effective cleaning and oral examination be performed (Wallis et al., 2018). A recent study proved that non-professional teeth scaling resulted in significantly *worse* periodontal disease (Stella et al., 2018).

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

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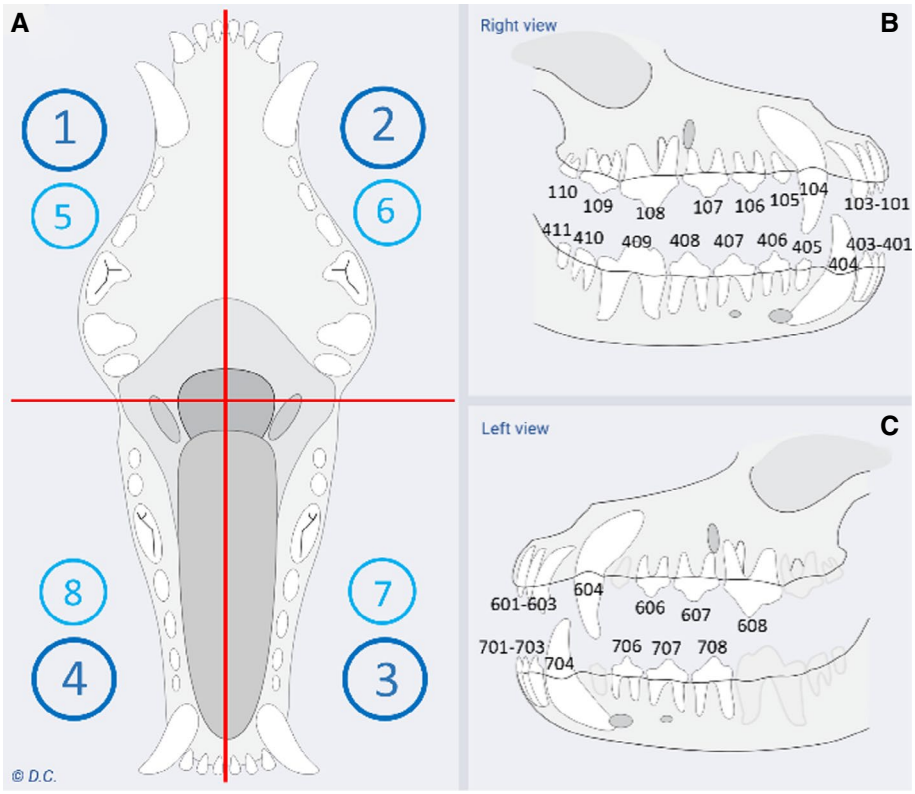

FIG 160. Modified Triadan system. (a) Quadrants one to four for permanent dentition (dark blue), quadrants five to eight for primary dentition (light blue). (b) Numbering of teeth according to Triadan for permanent teeth and for (c) primary dentition (graphics by David Crossley).

Procedure

A professional dental cleaning should include the following minimal steps (Bellows, 2010a; Holmstrom et al., 1998d; Stepaniuk, 2019; Niemiec, 2003b, 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 for thiol detection 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, along with high-speed handpieces create significant bacteria laden aerosols (Harrel, 2004; Pederson et al., 2002; Szymańska, 2007 and to a lesser extent the 3-way Air/Water Syringe Allison et al., 2020). The infectious organisms are not only supplied by the patient's mouth, but also the water lines of the mechanised handpieces (ultrasonic scalers and high-speed handpieces) (Meiller et al., 1999; Shearer, 1996; 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; Holmstrom et al., 1998a; Pattison & Pattison, 2006). Although there are currently no standards set for CFU in dental unit waterlines for veterinary dentistry (they do exist for human dental units in the US), an appropriate disinfection protocol of dental unit waterlines is needed to decrease contamination (Bellows, 2004) or closed system used 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). While controversial, the committee does not recommend dental procedures along with any other surgeries. Dental procedures are best confined to their own designated room (Al Maghlouth et al., 2007; Leggat & Kedjarune, 2001; Legnani et al., 1994; Osorio et al., 1995).

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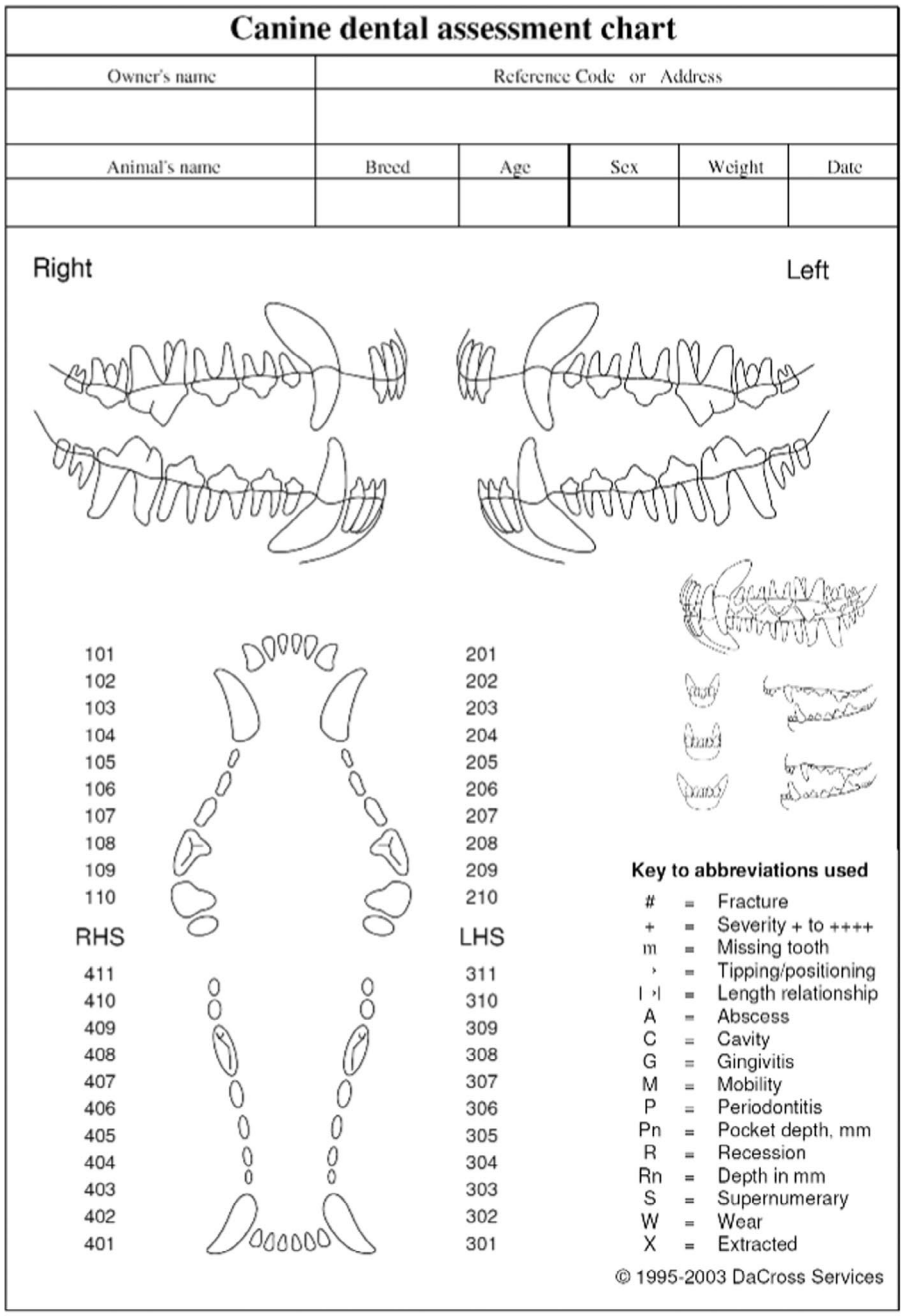

FIG 161. Example of canine dental chart.

Step 2: Decreasing the bacterial load (see examination above)

The oral cavity is a contaminated area, and proper dental cleanings are mildly invasive. This means that dental cleanings may result in a *very* transient bacteraemia, which may be more severe in patients with periodontitis (Daly et al., 2001; Forner et al., 2006; Lafaurie et al., 2007). Dental cleanings cause bacterial aerosolisation 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 (Bellows, 2004; Fine et al., 1992). However, the transient nature of the possible bacteraemia makes this step as well as prophylactic antibiotics of dubious value (Blazevich & Miles, 2024). Further, recent studies show that oral bacteria exposed to chlorhexidine may develop resistance and/or tolerance to chlorhexidine and certain antibiotics (Cieplik et al., 2019; Früh et al., 2022). Another option is a solution of 50/50 ppm hypochlorous acid/sodium hypochlorite which takes a very short

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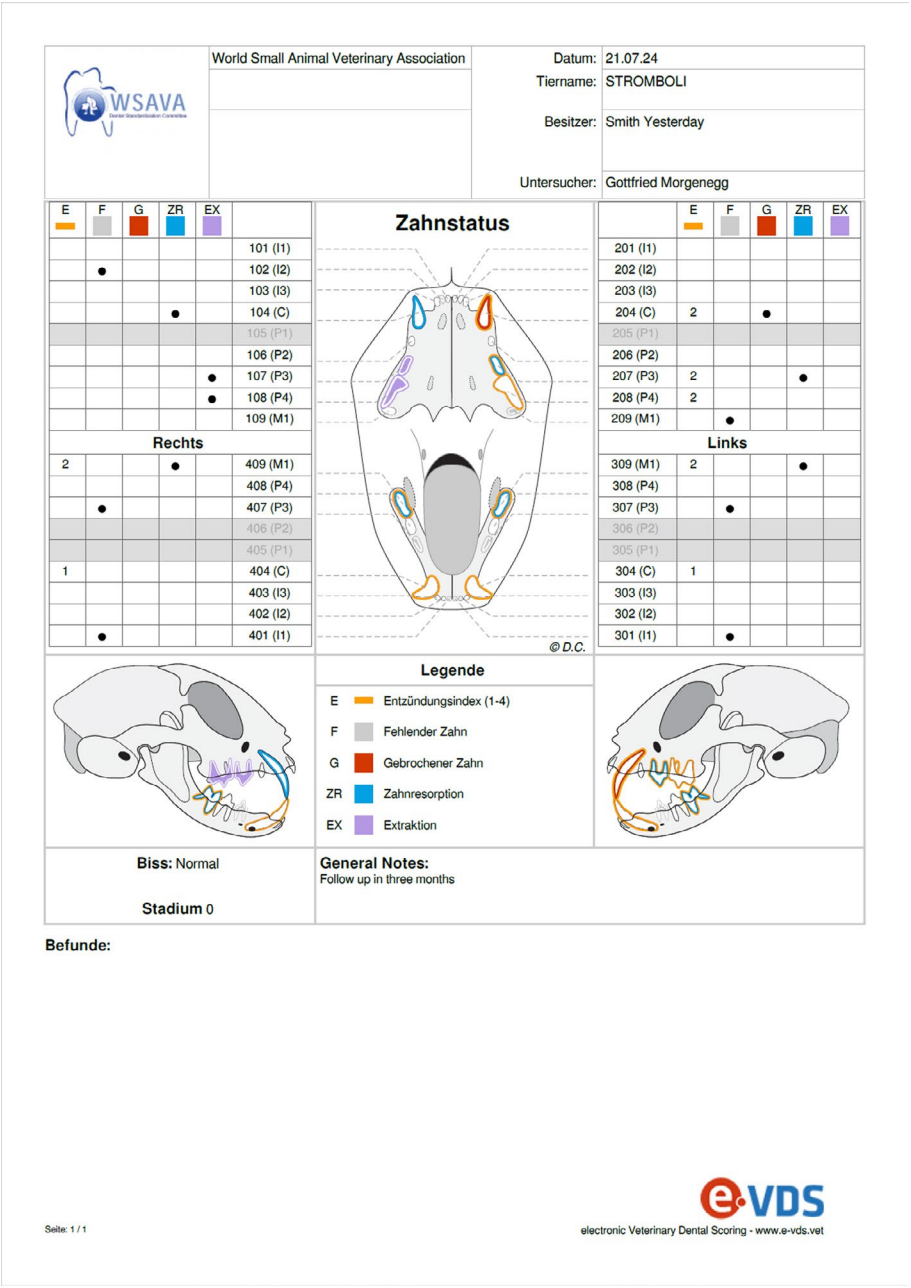

FIG 162. Example of electronic feline dental chart.

time to take effect and, above all, does not impair wound healing (Bender & Kramer, 2017).

Step 3: 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 at various stages of the procedure using both visual and tactile senses (see Oral Examination section).

Step 4: Dental imaging

When available, dental radiographs or CBCT should be taken at a minimum of every area of pathology noted on dental examination and ideally full mouth (see Oral Examination section).

Step 5: 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

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using a combination of the modalities (Bellows, 2004; Pattison & Pattison, 2006).

Mechanical scalers

Mechanical scalers include both sonic and ultrasonic types (Holmstrom 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) (Stepaniuk, 2019). Both ultrasonic scalers vibrate at approximately 25,000 to 45,000 Hz.

Sonic scalers run on compressed air and vibrate at only 2000 to 6500 Hz, although rates of up to 9000 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 to 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 (Fig 163A). Utilising a mechanical scaler without sufficient coolant can cause numerous deleterious effects including tooth death (Nicoll & Peters, 1998). Hand curettes and some water-cooled ultrasonic scalers, with periodontal or universal tips, are used to clean subgingivally (Stepaniuk, 2019). 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 incorrect scaler tips.

Specific low-powered periodontal tips are available for subgingival use, and clinicians and staff should familiarise 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) (Fig 163b). 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. Always keep the instrument in motion to avoid tooth damage. Avoid contacting other mucosal surfaces with the working head of the instrument.

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 the tooth for no more than 6 to 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. Plaque can be microscopically present on all surfaces of the tooth even though the tooth appears clean, and as such, each square mm of every tooth surface should be treated.

Damage or wear 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 because 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, 1997a).

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° to the shaft. Scalers are designed for supragingival use only, as the shape of the

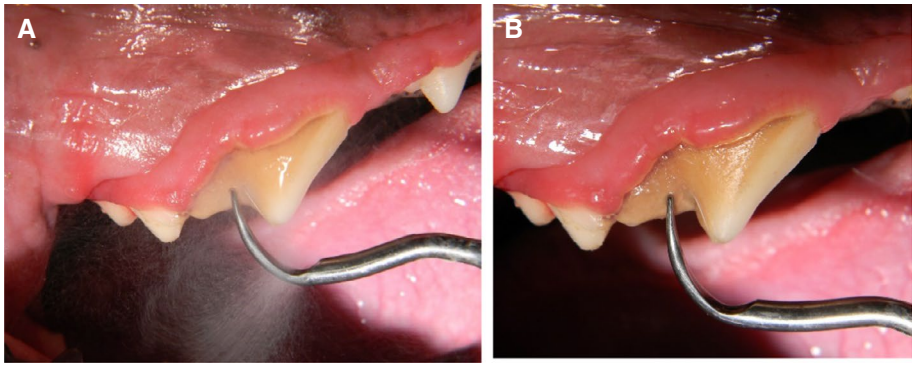

FIG 163. (A, B) Use of ultrasonic scaler.

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instrument as well as the sharp back and tip can easily damage the gingiva (Theuns & Niemiec, 2012) (see 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) and following the manufacturer's instructions.

Technique

Hand instruments are typically held with a modified pen grasp (Fig 164) but other grips may be necessary in certain situations. The instrument is gently held at the textured or rubberised 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 (Fig 165). Hand scalers are used in a pull stroke: avoiding gingival damage by pulling away from the soft tissue (Bellows, 2004; Pattison & Pattison, 2006).

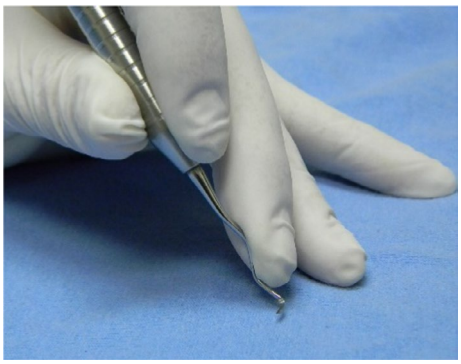

FIG 164. Modified pen grasp of hand instrument (curette).

FIG 165. Use of hand scaler on crown of tooth.

Step 6: Subgingival plaque and calculus scaling

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

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 (Bellows, 2004; Holmstrom et al., 1998a; Pattison & Pattison, 2006).

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 (see Equipment section for more detailed information).

Manual subgingival scaling (root planing and subgingival curettage) is a very technically demanding procedure and although it will be described here, the practitioner is directed to continuing education programmes 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 (Fig 166).
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 (Fig 167)

FIG 166. Place curette blade on tooth just coronal to free gingival margin.

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4. Once the bottom of the pocket is reached, the instrument is rotated to create a 90° working angulation. This is when the terminal portion (or shank) is parallel to the tooth (Fig 168)
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 (Fig 169). This technique is repeated with numerous overlapping strokes in different apical to coronal directions until the tooth/root feels smooth. Note: these photos were taken with the fingers moved away from the Modified Pen Grasp hold for better visualisation of the instrument placement.

Traditional ultrasonic scalers should not be used subgingivally to avoid damage to the gingiva, periodontal tissues and pulp (Jahn, 2006a). Sonic and ultrasonic scalers with specialised 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.

Step 7: 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 utilising a plaque disclosing solution or by gently drying the tooth surfaces with air (residual calculus will appear chalky) (Pattison & Pattison, 2006).

FIG 167. Rotate curette face on tooth surface and insert into pocket.

Step 8: Polishing

Dental scaling (both mechanical and hand) generally results in microabrasion and roughening of the tooth surface, which will result in increased plaque adherence (Berglundh et al., 2007; Silness, 1980). 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

FIG 168. Advance the curette gently to the base of the pocket.

FIG 169. Pull stroke down in a coronal direction.

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shown to leave a very smooth surface (Pattison & Pattison, 2006). However, veterinary dental cleanings are often performed by less experienced operators with inferior 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 (DeBowes, 2010; Fichtel et al., 2008; Niemiec, 2013c). However, care must be taken to only use the finest grit and minimum time to avoid tooth damage.

Practices can choose to use a commercially available polish or make their own slurry of flour of pumice and 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 low-speed handpiece with a 90° angle (prophy angle) (Fichtel et al., 2008). The handpiece should be run at a slow speed, no >3000 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 always use an adequate amount of polish. 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. One tooth may be polished for a maximum of 5 seconds at a time to avoid overheating. Another option for polishing is air abrasive.

Step 9: 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 (Niemiec, 2013e). Sulcal lavage is performed with a small (22 to 25) gauge blunt-ended cannula. The cannula is placed gently into the sulcus and the solution injected while slowly moving along the arches. Sterile saline or lactated ringers are currently favoured.

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, 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 an acceptable alternative. The two parameters which directly affect long-term morbidity and mortality in anaesthetised patients are hypothermia and hypotension (Brodbelt et al., 2008; Torossian, 2008), which become more pronounced with extended anaesthesia time. In fact, anaesthetic length has been shown to increase the complication rate in both humans and animals (Brodbelt et al., 2008; Tiret et al., 1986) (see Anaesthesia section). Patients should be closely monitored in the post-operative period, as morbidity and mortality is increased during this time (Brodbelt et al., 2008).

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 are 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 24 hours of cleaning (Boyce et al., 1995; Holcombe et al., 2014). In addition, without homecare, gingival infection/inflammation quickly returns (Corba et al., 1986; Fiorellini et al., 2006). 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 entire veterinary healthcare team (Wiggs & Lobprise, 1997b). Early institution of homecare not only leads to the greatest benefit, but 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 have little to no effect on periodontal disease. It is the plaque at and below the gumline that creates inflammation and initiates periodontal disease (Niemiec, 2008b, 2013a; Westfelt et al., 1998). Keep this in mind when determining which homecare methods to recommend. Information on the suitability of

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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) and different brushes or cloths can be used, as long as these are used daily (Brissman et al., 2021). Chew-based products can be effective if properly formulated; however, oral sprays, rinses and water additives are generally insufficient (although some products are proven to still be better than nothing – www.vohc.org), 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; Quirynen et al., 2006; Socransky & Haffajee, 2002).

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) (Bjone et al., 2007; Capik, 2007). 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). In one study on 22 dogs, daily tooth brushing was shown to be more than three times as effective at controlling plaque accumulation compared to using a daily dental chew or dental diet (Allan et al., 2019).

Therefore, it should be the goal of all veterinarians to promote tooth brushing for their patients by educating their clients. The ultimate success of a homecare programme depends on owner compliance and the dog or cat's acceptance of the process (Ray & Eubanks, 2009).

Gaining client compliance

Client compliance, or the lack thereof, has been a common challenge in the implementation and continued provision of tooth brushing by pet owners. Client-centred communication may help to increase motivation. Regular veterinary visits, with follow-ups to correct any misunderstandings, could lead to more successful implementation of tooth brushing (Oskarsson et al., 2021; Svärd & Enlund, 2023). A recent study highlighted the multifaceted aspect to non-compliance with toothbrushing and identified areas for improvement in the communication between dog owners and veterinary health practitioners (Enlund et al., 2020).

Materials and methods for tooth brushing

Brushes: The only critical piece of equipment is a toothbrush that has to be used daily. 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 have not been recommended due to their inability to clean below the gumline (Holmstrom et al., 1998a). However, if properly formulated, gloves and wipes can be effective and easier to institute (Olsén et al., 2021).

In addition to veterinary products, soft human toothbrushes 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.

Mechanised (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 mechanised veterinary brush available. The only negative aspect to these brushes is that the movement/vibration is an unusual sensation which may scare the patients (Holmstrom et al., 1998a). Therefore, mechanised brushes should only be used in patients with accepting temperament.

Pastes

There are several 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 (Hennet et al., 2007; Liu et al., 2002). It is important to note, however, that calculus itself is largely non-pathogenic. 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 toothpastes should not be used as they usually contain detergents and fluoride which may cause gastric upset or fluorosis if swallowed, similarly with products such as baking soda (sodium bicarbonate) (Niemiec, 2008c; Wiggs & Lobprise, 1997a).

Antimicrobial preparations are also available, which may 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, although the ideal technique may only be possible in the most tractable patients. A recent study found that dogs showed fewer signs of

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stress after 2 weeks of daily brushing, indicating the potential to train dogs to accept dental home care procedures (Enlund et al., 2023). Clients should be encouraged to work towards 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 (Niemiec, 2013d; Wiggs & Lobprise, 1997b).

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 and routine for the pet.
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° angle to the long axis of the tooth. The brush is then placed at the gingival margin and moved along the arcades utilising 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 non-dominant 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; Gorrel & Rawlings, 1996; Tromp, Jansen, et al., 1986; Tromp, van Rijn, et al., 1986). Equally significant is the aspect of the quality of the brushing to provide effective plaque control. This underscores the importance of proper tooth brushing techniques, highlighting the need for practical teaching in this regard (Svärd & Enlund, 2023). 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).

Additives and rinses

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 (Hennet et al., 2007; White et al., 2002). In one study, adding HMP to a dry diet decreased calculus in dogs by nearly 80% (Stookey et al., 1995), however, tartar is not a major factor in the development of gum disease. Further studies have shown no difference in plaque or calculus when HMP-coated biscuits were fed to dogs for 3 weeks (Logan et al., 2010; Stookey et al., 1996).

The addition of antiseptics to treats is 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; Quirynen et al., 2006; Socransky & Haffajee, 2002). Therefore, while the substance may have a positive effect on singular bacteria at standard concentrations, it may not be 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 it as a rinse. In addition, reports of efficacy are variable (*e.g.* the addition of chlorhexidine to rawhide chews provided a reduction in plaque but had no effect on the degree of gingivitis) (Brown & McGenity, 2005; Rawlings et al., 1998). Along with chlorhexidine, a chew additive anti-plaque agent delmopinol has been shown to decrease plaque and calculus (Claydon et al., 1996); however, not as effectively as chlorhexidine (Reddy et al., 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 antibacterial effects (Hale, 2003). Dextranase enzyme rubbed on the gums and tooth crowns of dogs reduced the average count of bacteria in plaque (Sadighnia et al., 2023).

Antiseptic rinses

The other option for active homecare is the application of antiseptic/anti-plaque solutions. The traditional antiseptic of choice is chlorhexidine. Chlorhexidine has been shown in numerous studies to decrease gingivitis if applied consistently over time (Hamp & Löe, 1973; Hennet, 2002; Tepe et al., 1983). Chlorhexidine reportedly has a quick onset and minimal systemic uptake, making it an excellent choice for oral antisepsis (Salas Campos et al., 2000). One concern with the use of these products is the lack of palatability, which may hinder homecare efforts (Holmstrom et al., 1998a). Further, recent studies show that oral bacteria exposed to chlorhexidine may develop

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resistance and/or tolerance to chlorhexidine and certain antibiotics (Cieplik et al., 2019; Früh et al., 2022).

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 in cats (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 et al., 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, 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 because it is performed (Abrahamsson & Pettersson, 2024; Svärd & Enlund, 2023; 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 (DeBowes, 2010; Niemiec, 2008b; Westfelt et al., 1998). 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 (Clarke & Cameron, 1998; Steenkamp & Gorrel, 1999; Verstraete et al., 1996a). Furthermore, one human study found that the improvement of periodontal health was not related to the degree of residual calculus (Sherman et al., 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, 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 or 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 ask pet food representatives for study information. As this research will take time, a valuable source of information for busy practitioners is the Veterinary Oral Health Council (VOHC) (vohc.org). The VOHC is a non-regulatory agency which includes representatives from professional dental colleges as well as allied veterinary groups. The VOHC consists of nine veterinary dentists and dental scientists with experience of scientific protocols and study design plus a non-voting Director. The VOHC provides an objective means of recognising commercially available products that meet pre-set standards of effectiveness in controlling accumulation of supragingival dental plaque and calculus (tartar) in dogs and cats. If a pet food or treat research is accepted by the VOHC, there is reasonable assurance that the product is effective in preventing or decreasing plaque or calculus; however, published studies and the VOHC only provide whole tooth scoring, which may or may not actually improve periodontal status.

The VOHC does not test products; 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 is 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". This is generally a minimum of a 15% to 20% reduction. Furthermore, to obtain VOHC approval, the product must also have a safe consistency for the patient to chew and not damage the teeth.

Pet food effects on oral health

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

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of contact on the tooth and oral surfaces. A common perception 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. Dry food does leave 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, 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 most matters (Niemiec, 2008c; Westfelt et al., 1998). A study comparing home prepared foods versus commercial wet and/or dry foods showed that feeding a home prepared diet increased the probability of oral health problems. 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 (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 keratinisation 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: It has long been thought that traditional dry dog food is good for oral health, and current studies appear to support these claims (Gawor et al., 2006; Oba et al., 2022). However, another study showed that dry food was not superior to moist foods in regard to improving oral health (Harvey et al., 1996). Several commercial dry diets for adult dogs and cats have been formulated to have 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 maximises contact with the teeth (Larsen, 2010). Foods with the right shape, size and physical structure can provide plaque, stain and calculus control (Hennet et al., 2007; Jensen et al., 1995; Logan, 2006; Vrieling et al., 2005). 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 have a positive effect on gingival inflammation. A 6-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 may not be appropriate to support growth, gestation/lactation or any pet with a high-calorie requirement. The diet's calorie density and nutrient profiles should be assessed to determine if the diet is appropriate for the pet's lifestage and individual requirements. 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 compressed wheat, cellulose incorporated into treats, and rawhide chews have good evidence for efficacy (Beynen et al., 2010; Hennet, 2001; Roudebush et al., 2005; Stookey, 2009). Furthermore, the addition of chlorhexidine has shown benefit in the reduction of plaque in animal studies (Rawlings et al., 1998). Some have received VOHC approval. Of the available products, only a handful have been clinically proven to decrease gingivitis (Brown & McGenity, 2005; Clarke et al., 2011; Crowder et al., 2024; Gorrel & Bierer, 1999; Gorrel et al., 1999; Quest, 2013; Stookey, 2009). A vegetable-based chew has been shown to be effective to reduce plaque and calculus formation and a better efficacy in reducing gingival bleeding compared to other chews (Gawor et al., 2021; Oba et al., 2021). In addition, some have demonstrated halitosis control and/or a shift of the microbiome, which may be indicative of true infection control (Carroll et al., 2020; Oba et al., 2021). It should be noted that canines and incisors are not effectively cleaned by most chew-based products (Bjone et al., 2007; Capik, 2007).

Risks of dental chews: While uncommon, oesophageal foreign body obstruction due to dental chews has been reported in dogs, especially in smaller breeds (Leib & Sartor, 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 considered 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 has noted 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

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tooth" (BVDA, 2017). Recommendations of techniques that can be utilised to evaluate for excessive treat hardness include being able to dent the treat with a fingernail (Hale, 2003).

Water and food 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 et al., 2011). This concern led to a reformulation with pomegranate which was shown to reduce dental plaque and calculus accumulation in dogs (Gawor et al., 2023).

Another option for homecare is a product produced from seaweed which is sprinkled on the food. Supplementation of pet diets with products containing the seaweed, Ascophyllum nodosum, has been shown to reduce both calculus and plaque accumulation after oral administration in both dogs and cats (Gawor et al., 2018). Further, this has been added to a treat, which is also effective.

Vitamin and mineral deficiencies: Deficiencies in vitamins 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 Nutritional 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 practice improves the cleanliness of teeth in pets (Pezzali et al., 2021). 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., 1996a). 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). Some studies show an increased chance of tooth trauma, and there is also the risk of fractured teeth and potentially the spread of zoonotic disease (Furtado et al., 2007; LeJeune & Hancock, 2001; Lenz et al., 2009), although this has not been found consistently (Pinto et al., 2020).

Probiotics

Periodontal disease is now thought to be caused by a *dysbiosis* of bacteria. Thus, probiotics may also improve canine oral health (Bell et al., 2020), for example a study in dogs showed that lactobacillis was beneficial for oral health (You et al., 2022). 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).

Other new potential therapeutic options

Ozone therapy may provide some reduction in periodontal inflammation (Abreu-Villela et al., 2021). Further, beta caryophyllene and nisin have also proven effective in reducing periodontal inflammation (Cunha et al., 2020; Pieri et al., 2016). Finally, oral microbiotia transplant show promise as a future therapy (Beikler et al., 2021).

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 after cleaning.
- Without homecare, the efficacy of professional periodontal therapy is severely limited.
- Tooth brushing is the gold standard and is most effective on rostral teeth.
- Client-centred communication and follow-ups may help to improve compliance.
- 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 only minimally beneficial for oral health.
- A combination of active and passive methods is likely the best choice.

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SECTION 6: DENTAL RADIOLOGY

The importance of dental radiography

Full-mouth dental radiographs are a critical piece of oral diagnostics, 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 greatly facilitate treatment. They are also an important part of the legal record and can be effective client education tools. Full-mouth dental radiographs have been shown to reveal about 40% more pathology than seen on oral examination (Verstraete et al., 1998a, 1998b) (see Oral Pathology section). Due to costs, practitioners may be forced to balance the desire for full-mouth radiographs with their client's financial constraints. However, obtaining dental radiographs of all teeth with clinical evidence of disease is mandatory. In the near future, cone-beam CT (CBCT) will likely become standard of care in many tier 3 countries and advanced imaging (CT, MRI, CBCT) is already considered standard of care for certain conditions (*e.g.* neoplasia, maxillofacial trauma, diseases of the TMJ and retrobulbar space).

Equipment and techniques

Dental radiography requires a dental x-ray unit (wall-mounted, mobile or hand-held) and a detection system (*e.g.* conventional intraoral dental films, "direct" digital radiography (DR) or computed radiography (CR)) (Niemiec, 2010c, 2018c; Niemiec, Gilbert, et al., 2004). However, medical x-ray equipment (full body) with extraoral plates will provide diagnostic information (Gawor, 2018b; Mulligan et al., 1998b) and is acceptable in tier 1 countries (see section on Equipment).

There are two standard techniques for obtaining dental radiographs: parallel technique (for mid to caudal mandibles) and bisecting angle technique for all other areas (Niemiec 2018a, Niemiec & Furman, 2004a, 2004b; Niemiec, Gilbert, et al., 2004; Wiggs & Lobprise, 1997c). In addition, extraoral or near-parallel techniques can be beneficial for the caudal maxillae in cats, dorsoventral technique to search for retained roots on the maxillae and a transorbital projection for maxillary first molar teeth in dogs (Ruhnau, 2023). All radiographs must be obtained with the patient under general anaesthesia (see Anaesthesia section). It is important to note that 3-mm beyond the apex is recommend for accurate assessment. If the entire tooth cannot be imaged due to sensor size, a separate image of the crown may need to be exposed, but it generally does not provide much information.

Parallel technique

Place the film/sensor/phosphor plate intraorally, lingually to the teeth to be radiographed with the film parallel to the long axis of the teeth. 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 (Fig 170A,B). Finally, make sure the area of interest is within the circumference of the tubehead (AVDC, 2025). When imaging smaller films/sensors (*e.g.* sizes 1 and 2) the tubehead should be very close to the object to decrease radiation exposure to the patient as well as scatter radiation. However, with larger size 4 CR plates, the tubehead may need to be moved back to avoid conecut.

Bisecting angle technique

The bisecting angle technique is used when the film cannot be placed parallel to the tooth/roots due to the anatomy of the oral cavity – that is for all maxillary and rostral mandibular teeth. The film is placed in the mouth so that the 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. Visualise the angle formed by the long axis of the tooth to be radiographed and the plane of the film. Then bisect this angle with an imaginary line and position the x-ray tube so that the central x-ray beam is perpendicular to the imaginary bisecting line (Fig 171). 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, 2025). 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, cone cut may occur (part of the plate is not exposed).

The near-parallel techniques are 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 (AVDC, 2025; Niemiec 2018a; Niemiec & Furman, 2004b). Most veterinary dentists feel that with digital systems the interference is minimal and therefore most do not perform these techniques.

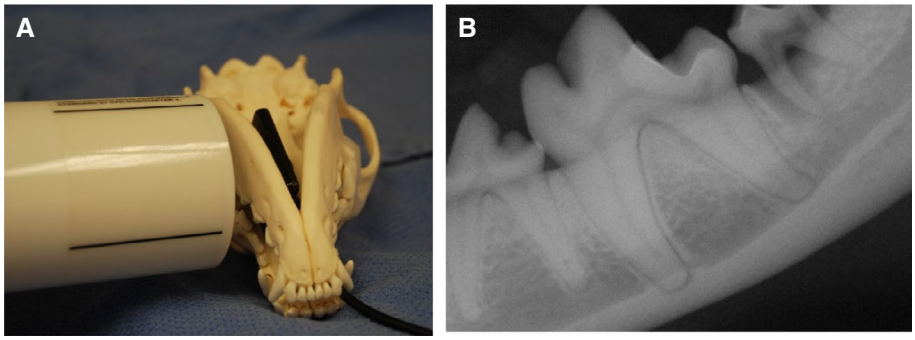

FIG 170. (A, B) Parallel technique for dental radiograph.

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The *simplified approach* to dental radiology was developed by Woodward (2009). This technique does not utilise 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 three angles used for all radiographs in this system: 20°, 45° and 90°. It is important to note that these images are to the sensor/film, NOT the ground or table; thus, this should be used to develop the angle.

The distal mandibular premolars (P4 in cat and P3 and 4 in the dog) and molars are exposed at a 90° angle (see Parallel technique above) (see Fig 170).

The rostral mandibular premolars (P3 in cats and P1 to 2 in dogs) generally cannot be imaged with the parallel technique due to the interference of the mandibular symphysis (Niemiec, 2018a). To image these teeth, place the film/sensor perpendicular to the crown of the teeth (in the correct position to image the mandibular canines). This creates a 90° angle between the sensor/film and the long axis of the tooth. Thus, the correct angle is 45° (Fig 172).

Maxillary premolars and molars also have roots that are approximately vertical from the crowns, and the sensor is positioned essentially flat across the palate, creating a 90° angle. Therefore, the maxillary premolars and molars are imaged with a 45° x-ray sensor bisecting angle (see Fig 171).

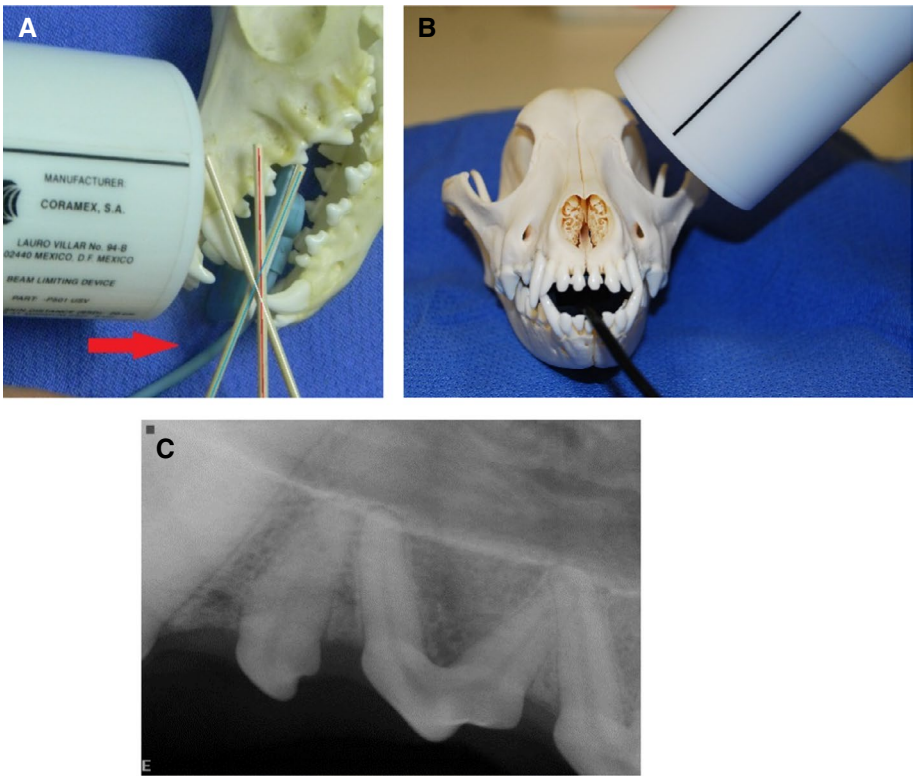

FIG 171. (A–C) Bisecting angle technique; maxillary premolars and molars – angle at 45°.

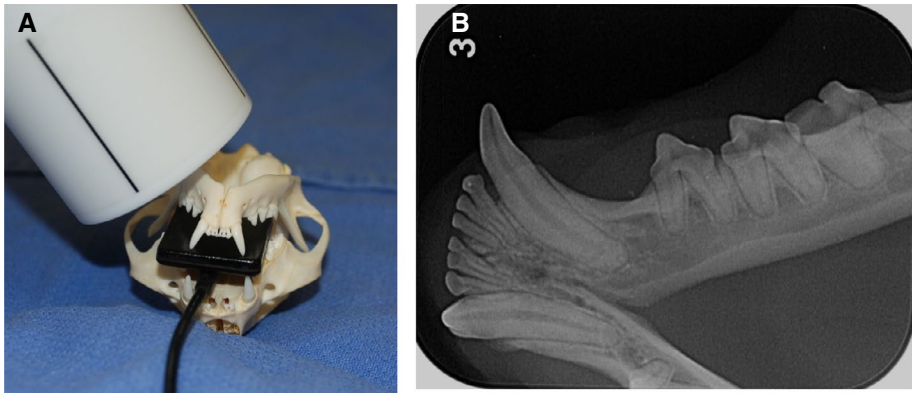

FIG 172. (A, B) Rostral mandibular premolars in cat – angle at 45°.

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The roots of the canines and incisors curve distally to an approximate 40° angle to the palate/mandibular gingiva and therefore are imaged with a 70° angle rostro-caudally (Fig 173). The incisors and mandibular canines can be imaged straight on to the nose/chin. However, because the maxillary canines curve straight back over the maxillary P1-2, an additional angle is needed. By rotating the image 20° laterally, the canine root will be imaged over the nasal cavity, which is mostly air.

Extraoral near-parallel technique

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 mouth prop (only use this for a short period of time – for example 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 (Fig 174).

Intraoral near-parallel technique

To utilise 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, 2009) (Fig 175).

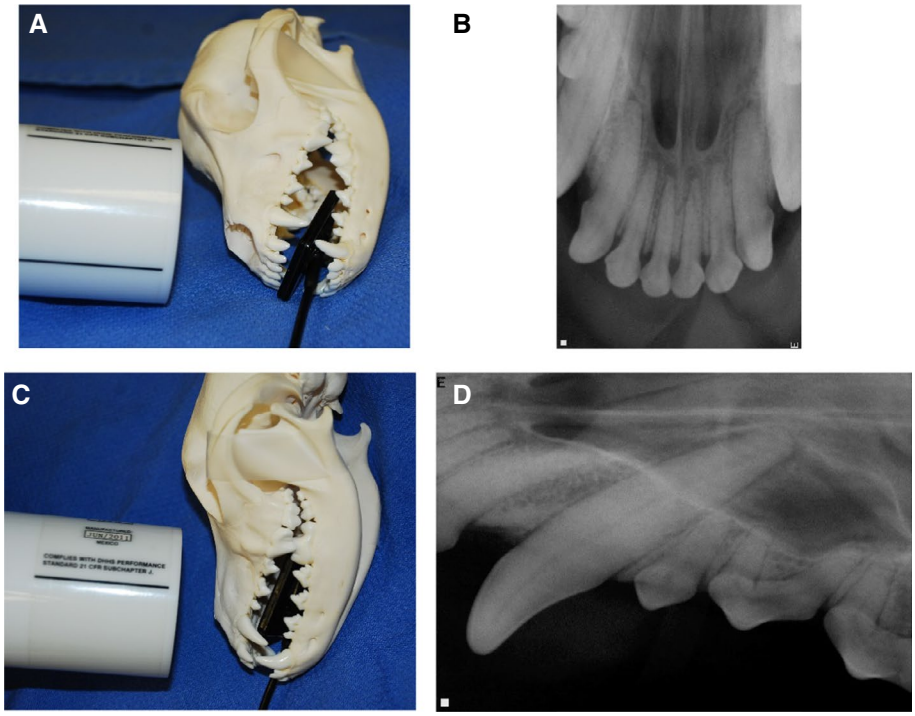

FIG 173. (A–D) Roots of maxillary canines and incisors – angle at 70°.

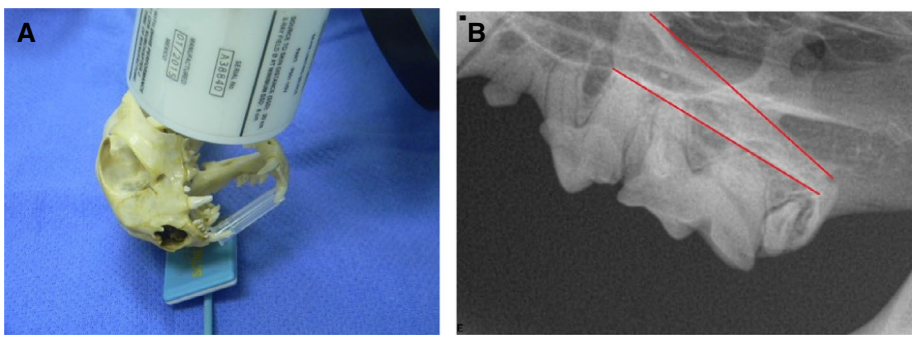

FIG 174. (A, B) Extraoral near-parallel imaging of maxillary premolars in a cat.

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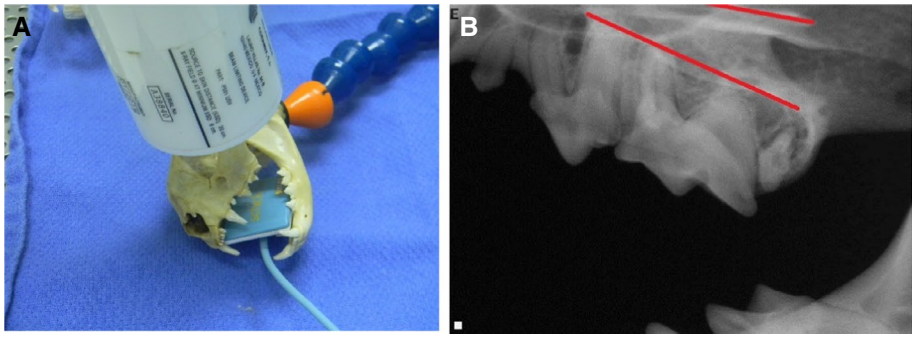

FIG 175. (A, B) Intraoral near-parallel imaging of maxillary premolars in a cat.

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, 2025).

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) extraoral (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 (AVDC, 2025; Niemiec & Furman, 2004a).

Key points

- Dental radiology is critical for proper diagnosis and treatment of oral conditions.
- Standard (analogue) 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.

Dental radiograph interpretation

Determining which teeth were imaged

The first step in interpretation is determining which teeth have been imaged. This requires not a firm knowledge of the anatomy and architecture of dental films. Digital systems with veterinary templates do not require this step if the images are properly placed. If the system does not support a veterinary template, there is a mark on the image which is in a consistent location. Review the owner's manual for instructions on its use.

With standard (analogue) films, the embossed dot on one corner of the film is necessary. When exposing a radiograph, if the film is properly positioned, the convex surface of the dot points towards the radiographic tube head. There is no way to expose a diagnostic radiograph with the film in backwards due to the lead sheet on the back of the film.

First, place the dot towards you (this is done for you on most digital systems). This orients the film as though your eyes are the x-ray generator. Then, determine if the image is maxillary or mandibular. Next, rotate the film so that the roots are in their natural position (up on maxillary and down on mandibular). Do not "flip" the image or film as this will create a mirror image.

Molars and Premolars: Ascertain mesial from distal. If the mesial side is on the left side of the film, it is a radiograph of the left side of the patient and vice versa for the right.

Canines and incisors: This orients the film so the right side of the mouth is on the left, and the right side is on the left. This is like a VD abdomen radiograph.

Normal radiographic anatomy

Normal alveolar bone will appear grey and relatively uniform throughout the dental arch (Niemiec, 2005b). It is slightly less radiodense compared to the tooth roots. In addition, it appears slightly but regularly mottled. Alveolar bone should completely fill the area between the roots (furcation) and end at the cementoenamel junction (CEJ) (Gawor, 2013b). The root canals should all be the same width, allowing for differences in the diameters of the root (Niemiec, 2018d). There should be no radiolucent areas in teeth or bone. A regular thin dark line (periodontal ligament space) should be visualised around the roots, as should be a radiopaque line representing the lamina dura (Fig 176).

There are several normal anatomic findings that are commonly misinterpreted in dental images as pathological. On radiographs of the mandibular premolar and molar teeth, a thick, horizontal radiolucent line courses parallel to and just coronal to the ventral cortex of the mandible. This is the mandibular canal (Fig 177). In addition, there are two circular radiolucent areas seen in the area of the apices of the first three premolars, which are the mental foramina (middle and caudal) (Fig 178) (Niemiec, 2018d). Further, the infraorbital foramina may be seen over the maxillary third premolar. On rostral mandibular views, a radiolucent area will be present between

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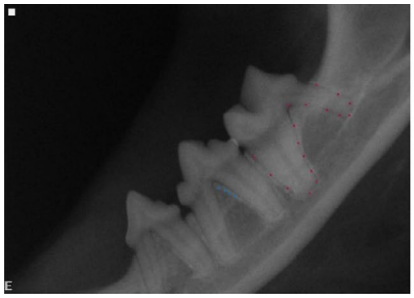

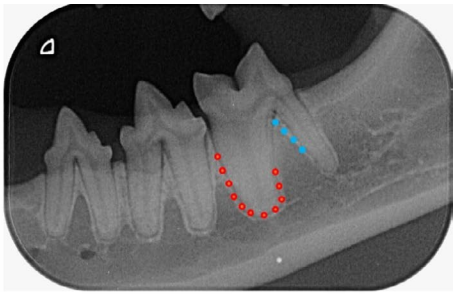

FIG 176. Periodontal ligament line space radiographically.

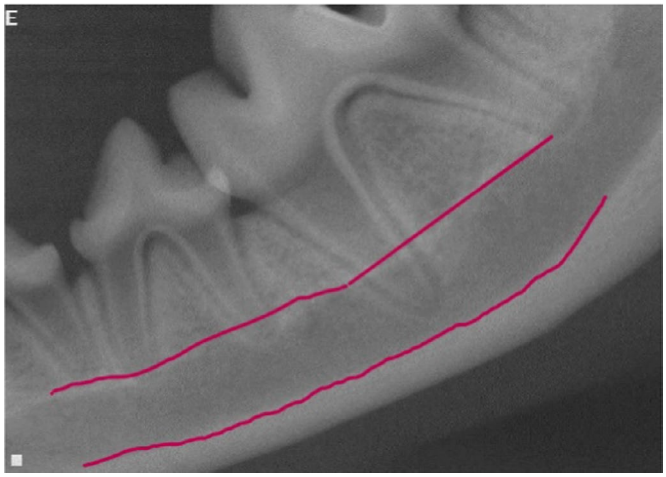

FIG 177. Mandibular canal radiographically.

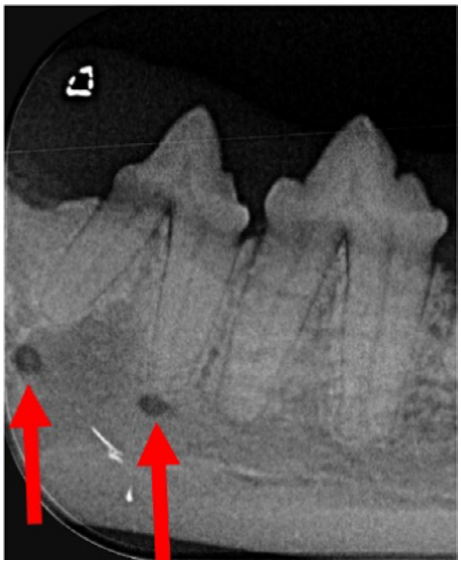

FIG 178. Mental foramina radiographically.

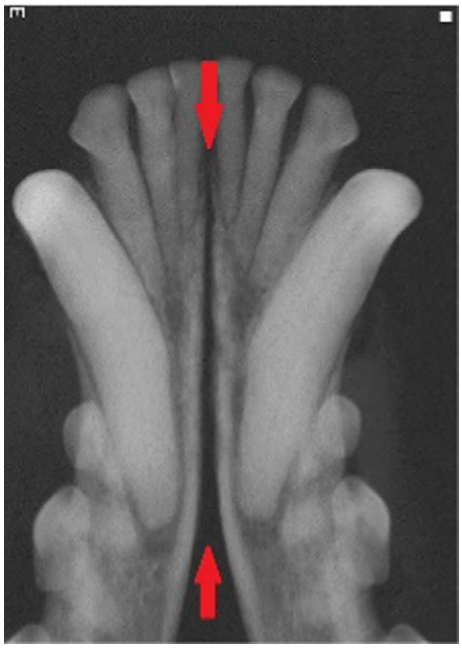

FIG 179. Mandibular symphysis radiographically.

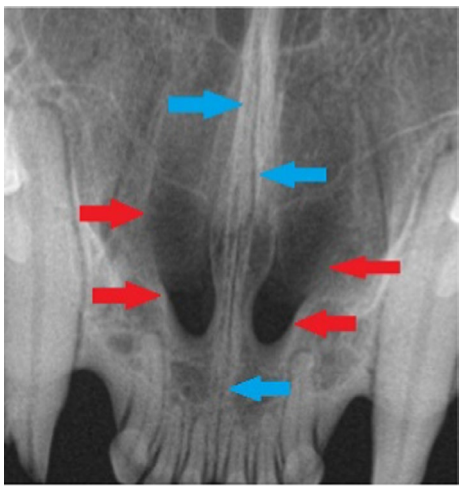

FIG 180. Maxillary palatine fissures (red arrows) and palatine suture (blue arrows) radiographically.

the first incisors (Minei et al., 2023, 2024). This is the fibrocartilagenous mandibular symphysis (Niemiec, 2018d) (Fig 179). In the rostral maxillary area: there are paired radiolucent areas distal to

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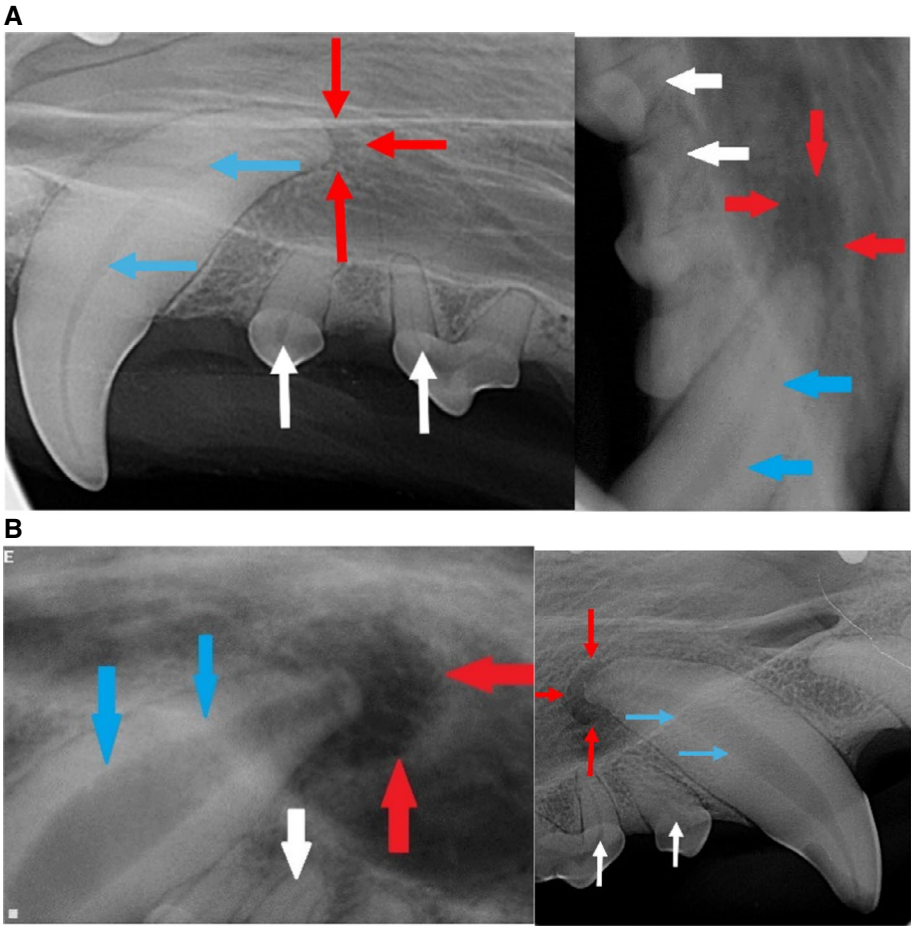

FIG 181. (A) Chevron effect versus (B) apical bone loss radiographically.

the intermediate incisors, which are the palatine fissures (Fig 180). Finally, a widening of the periodontal ligament at the apex of the canine teeth may be normal. This is called a "chevron effect" and can be differentiated from periapical rarefaction because it is very regular and v-shaped, as opposed to irregular and round (Niemiec, 2018d) (Fig 181). This effect may also be seen in the carnassial teeth, especially in large-breed dogs (Stepaniuk & Hinrichs, 2013).

A suspicious periapical lucency (especially in the area of the mandibular premolars) should be evaluated with an additional film exposed at a slightly different angle (in the horizontal or vertical plane). If the lucency is still centred on the apex, it is likely real. If the lesion moves off the apex or disappears, it is an artefact (Niemiec, 2018d).

Suspect changes in the diameter of the root canal of a tooth should be compared against surrounding as well as contralateral teeth. The contralateral view should be taken at the same angle as the original. It is important to note that root canals are not exact cylinders (especially canines) (Niemiec, 2018e; Rochette, 1996). A lateral view may have a much different canal width than a V/D view (Niemiec, 2005b).

Periodontal disease

Horizontal bone loss is the most common pattern in veterinary patients (Gawor, 2013b). This appears as generalised bone loss of a similar level across all or part of an arcade (Fig 182). The other pattern is angular (vertical) bone loss (Niemiec, 2005b). The radiographic appearance of angular bone loss is one area of recession below the surrounding bone (Fig 183). The surrounding bone may be normal or be undergoing horizontal bone loss. Therefore, it is common to have a combination of the two types in the same arcade.

Furcation exposure also appears distinct radiographically. Stage 1 furcation exposure is not evident radiographically. Stage 2 is seen as a darker grey than the surrounding bone (Fig 184). Finally stage 3 will be black (no bone) (Fig 185) (Gawor, 2013c, 2018a; Theuns, 2013).

Bone loss does not become radiographically evident until 30% to 50% of the mineralisation is lost (Verstraete, 1999). Therefore, radiographic findings will always *underestimate* bone loss. In addition, bone loss on only one surface (*i.e.* lingual, palatal or facial) may be hidden by superimposition of bone or tooth. This may result in a non-diagnosed bony pocket. Always interpret radiographs considering the complete oral examination findings (Yun et al., 2005).

Endodontic disease

Endodontic disease may be demonstrated radiographically in several ways (Niemiec, 2018e, 2008a). An individual tooth

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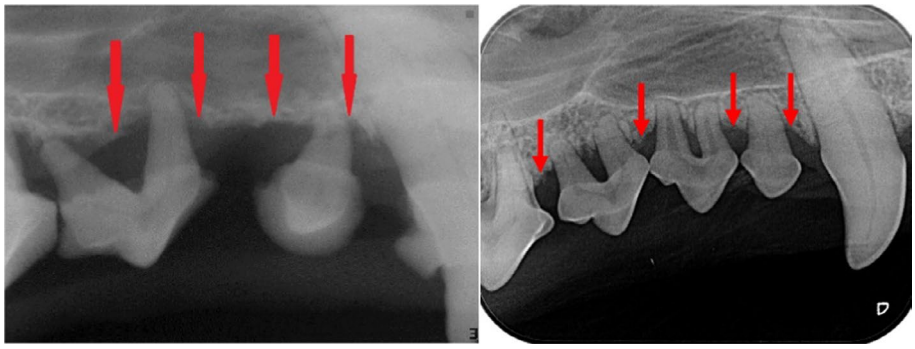

FIG 182. Horizontal bone loss radiographically.

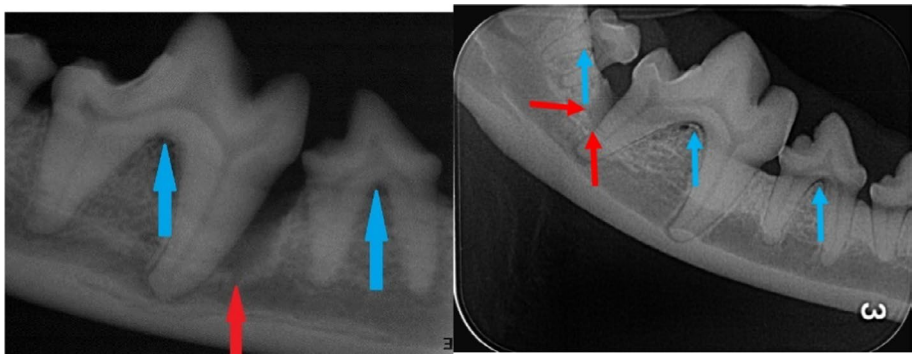

FIG 183. Vertical bone loss radiographically.

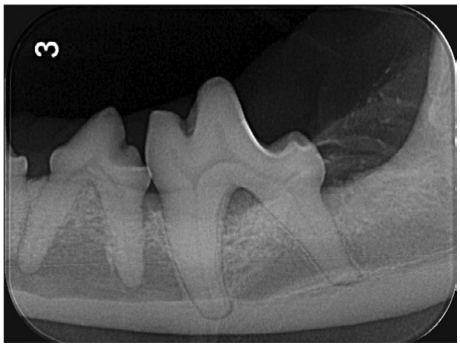

FIG 184. Stage 2 furcation exposure radiographically.

FIG 185. Stage 3 furcation exposure radiographically.

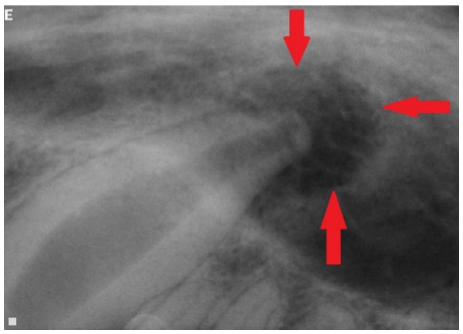

FIG 186. Periapical rarefaction radiographically.

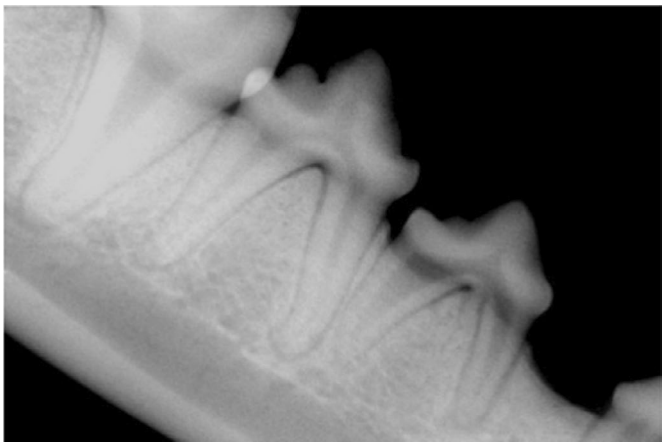

FIG 187. Wide root canal in non-vital tooth radiographically.

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may have one, some or all of the different changes listed below. However, only one need be present to establish a presumptive diagnosis of endodontic disease. Radiographic changes can be broken into two major classifications: (1) changes in the surrounding bone or (2) changes within the tooth itself.

Bony changes: The classic and most obvious finding is periradicular rarefaction. This appears as a radiolucent area surrounding the apex of a root (Fig 186) (Niemiec, 2005a, 2018e).

Tooth changes: The most common change in endodontic disease within the tooth itself is a root canal with a different diameter (Niemiec, 2005b, 2018e). As a tooth matures, secondary dentine production will cause a decrease in canal width. When a tooth becomes non-vital, this development stops secondary to the death of the odontoblasts. Consequently, non-vital teeth have wider root canals than the surrounding vital teeth (Fig 187). On rare occasions, pulpitis may result in increased dentine production and create an endodontically diseased tooth with a smaller root canal. This is especially common in teeth that are also periodontally diseased. This could potentially lead to a misdiagnosis of the endodontically diseased tooth as healthy and vice versa with the contralateral tooth. Hence it is important to evaluate the adjacent teeth as well as the contralateral (Niemiec, 2008b). Width discrepancy can be compared to any tooth (taking the size of tooth into consideration) but it is most accurate to compare to the contralateral tooth. Finally, internal resorption is a rare indication of endodontic disease (Niemiec, 2008b).

Tooth resorption (TR)

The importance of dental radiography in TR cases cannot be overstated. Therapeutic decisions require dental radiographs (see Tooth Resorption section in oral pathology).

Neoplasia

While histopathology is required for definitive diagnosis, dental radiographs can provide insight as to the probable type of tumour. In addition, the radiographic signs can aid the pathologist in diagnosis.

Benign masses: Benign neoplastic growths will have no bony involvement on dental radiographs. These are most commonly fibromas or gingival hyperplasia. However, note that any tumour will have no reaction early in the course of disease.

Locally aggressive masses: These are AA and plasmacytomas. They grow by expansion, resulting in the bone "pulling away" from the advancing tumour leaving a decalcified soft tissue filled space in the tumour site. Bony margins are usually distinct (Sanders & Parsons, 2001). Finally, this expansive growth will typically result in tooth movement (Fig 188).

Cysts: Cystic structures will appear as a radiolucent area with smooth bony edges (Niemiec, 2011). Similar to locally aggressive growths, they grow by expansion and thus displace the other structures (*e.g.*, teeth). Dentigerous cysts are typically seen as a radiolucent structure centred on the crown of an unerupted tooth (Fig 189).

Malignant neoplasia: Malignant oral neoplasms typically invade bone early in the course of disease, resulting in irregular, ragged bone destruction (Mulligan et al., 1998). Initially, the bone will have a mottled "moth eaten" appearance (similar to osteomyelitis), but radiographs late in the disease course will reveal a complete loss of bone. If the cortex is involved, an irregular periosteal reaction will be seen (Fig 190).

SECTION 7: DENTAL EXTRACTIONS

Introduction

Dental extractions are a very common procedure in veterinary medicine, yet they are often 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 intrinsically stained teeth), significant

FIG 188. Expansive growth from oral mass resulting in tooth movement radiographically.

FIG 189. Dentigerous cyst radiographically.

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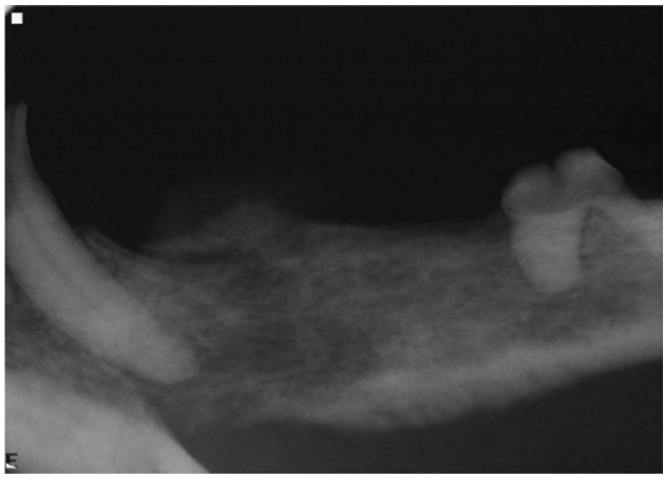

FIG 190. Irregular periosteal reaction to oral mass radiographically.

periodontal disease, traumatic malocclusion, persistent deciduous teeth, tooth resorption, infected teeth, caudal stomatitis and unerupted teeth (Niemiec, 2023a, 2023b). It should be noted, however, that options exist to save many diseased teeth (root canal therapy, orthodontics, periodontal surgery), especially in tier 3 counties and clients should be informed of these options.

Extractions (open or closed) are surgical procedures, which, in some circumstances, can be very delicate. 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 problem. However, even "simple" extractions can have numerous iatrogenic complications, including haemorrhage, osteomyelitis, oronasal fistula, forcing of a root tip into the mandibular canal or nasal cavity, mandibular fracture and ocular damage (Holmstrolm et al., 1998b; Niemiec, 2022; Taylor et al., 2004). However, the most common iatrogenic complication is retained tooth roots (Moore & Niemiec, 2014; Woodward, 2006), which almost invariably results in continued infection (Woodward, 2006).

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

Step 1: Obtain consent

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, 2008b, 2023a, 2023b).

FIG 191. Severe root replacement resorption (type 2) and secondary ankylosis on the mandibular canines of a cat.

Step 2: Obtain preoperative dental radiographs

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, 2018b; Niemiec, 2009, 2022). Radiographs allow the practitioner to determine the amount of disease present, any root abnormalities and/or level of resorption/ankylosis (Blazejewski et al., 2006; Niemiec, 2009). Significant mandibular alveolar bone loss secondary to periodontal disease weakens the bone and predispose to an iatrogenic pathological fracture (Gioso, 2001; Snyder, Soukup, et al., 2016). Dentoalveolar ankylosis (Fig 191) makes extraction by traditional elevation practically impossible. For this reason, crown amputation and intentional root retention *may be* acceptable for advanced Type 2 feline tooth resorption, as determined via dental radiographs (DuPont, 1995). In short, they provide critical information for effective treatment planning and the successful outcome of dental extraction procedures. Finally, radiographs provide solid evidence for the need of extraction as well as potential complications in the medical record (Niemiec, 2009).

Step 3: Ensure proper visibility and accessibility

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 utilised continually to keep the surgical field clear. Finally, magnification (ideally via surgical loupes) is invaluable especially for cats and small breed dogs (Niemiec, 2008d, 2022).

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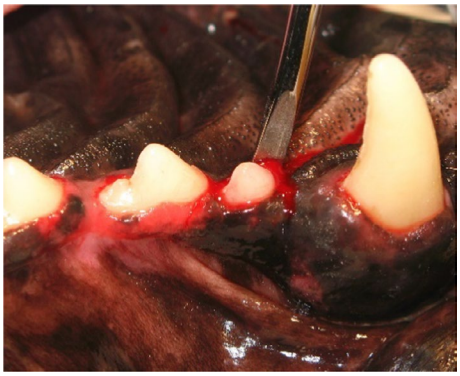

FIG 192. Gingival attachment cut.

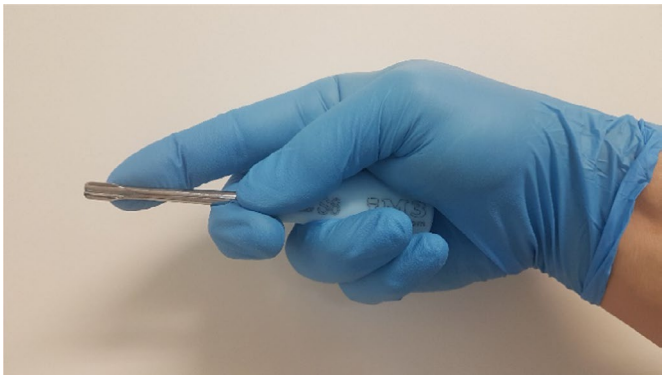

FIG 193. Index finger placed in extracting instrument working part.

Step 4: Pain management

Extractions are surgical procedures and are moderately to severely painful. Depending on patient health, a multimodal analgesic approach should be employed, as this provides superior analgesia (Beckman, 2013; Jones et al., 2025; Kelly et al., 2001; Pavlica et al., 2025) (see Anaesthesia section).

Step 5: Cut the gingival attachment

This can be performed with a scalpel blade, periosteal elevator or dental elevator/luxator. The selected instrument is placed into the gingival sulcus with the tip of the blade angled towards the tooth approximately 20° to the long axis of the tooth. This helps keep the instrument within the periodontal ligament space, slide under the dentinal bulge and catch on the thin ledge of bone. Failure to do this often results 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) (Fig 192).

Step 6: Elevation/luxation

Elevation/luxation is by far 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). It is critical to note that in small breed dogs (and especially small breed brachycephalics), there are only millimetres between the apices of the maxillary molars and the orbit. 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, 2023a, 2023b) (Fig 193).

It is important to select an instrument which matches the curvature and size of the root. If using standard or luxating elevators it is critical to ensure that you can see the tooth on both sides of the instrument (Woodward, 2006). If so, the blade will slide easily into the periodontal ligament space. Winged elevators should fit the circumference of the tooth well.

FIG 194. Insertion of extracting instrument.

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. Luxators may be gently twisted (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 (Niemiec, 2022) (Fig 194). The insertion should be performed while keeping the instrument at an approximate 20° angle towards the tooth to avoid slippage (Harvey & Emily, 1993a; Niemiec, 2023a, 2023b). Once in the space between the bone and the tooth, the instrument is gently twisted (Wiggs & Lobprise, 1997c). When the instrument is twisted, the tooth should move slightly. If it does not, no damage is being done to the periodontal ligament and extraction will not proceed. If after a few attempts the tooth still does not move, likely there is ankylosis present and an open extraction may be required. Once the tooth moves slightly, hold this the position for 10 to 30 seconds to fatigue and tear the periodontal ligament (Holmstrolm et al., 1998b).

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Luxation, in contrast, is performed by gently inserting the luxator into the gingival sulcus and "rocking" the instrument as it is advanced apically. Many veterinary dentists use a combination of luxation and elevation when utilising luxating elevators.

It is important to note that the periodontal ligament is very effective in resisting short, intense forces (Niemiec, 2023a, 2023b). It is only by the exertion of prolonged force (*i.e.* 10 to 30 seconds) that the ligament will become weakened. Increased pressure will transfer 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 to 30 seconds, reposition the instrument about 1/8 of the way around the tooth and repeat the above step. Continue 360° around the tooth, each time moving the elevator apically as much as possible (Holmstrolm et al., 1998b; Niemiec, 2023a, 2023b; Wiggs & Lobprise, 1997b).

The key to successful elevation is patience. Only by slow, consistent elevation will the root loosen without breaking. Remember, it is easier to extract an intact root than to remove fractured root tips (Blazejewski et al., 2006; Niemiec, 2008d, 2022; Woodward, 2006). If the elevation is not resulting 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 (open) approach is necessary.

Step 7: Extract the tooth

Removing the tooth from the alveolus should only be attempted after the tooth is very mobile. Extraction is performed by grasping the tooth with extraction forceps and gently pulling the tooth from the socket (Fig 195). If the root is amenable (meaning round and not significantly curved), gentle rotation is acceptable, providing the torque is maintained for a minimum of 10 seconds. Undue pressure often results in root fracture (Niemiec, 2008d, 2022; Wiggs & Lobprise, 1997a).

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.

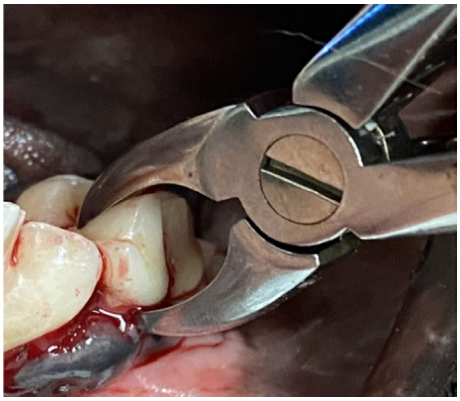

FIG 195. Extracting forceps pulling out the tooth from alveolar socket.

Step 8: Smoothing the bone

If there are jagged edges on the remaining bone, they should be smoothed. This is best performed with a coarse diamond bur on a water-cooled high-speed air driven handpiece (Fitch, 2003;

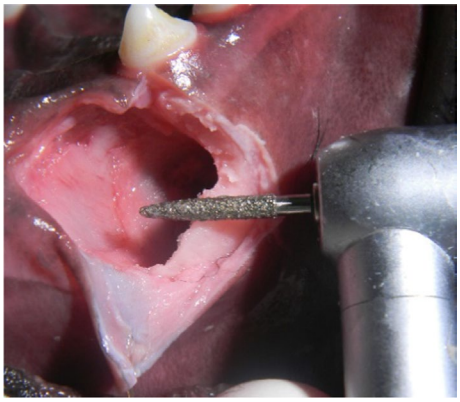

FIG 196. Smoothing the bone.

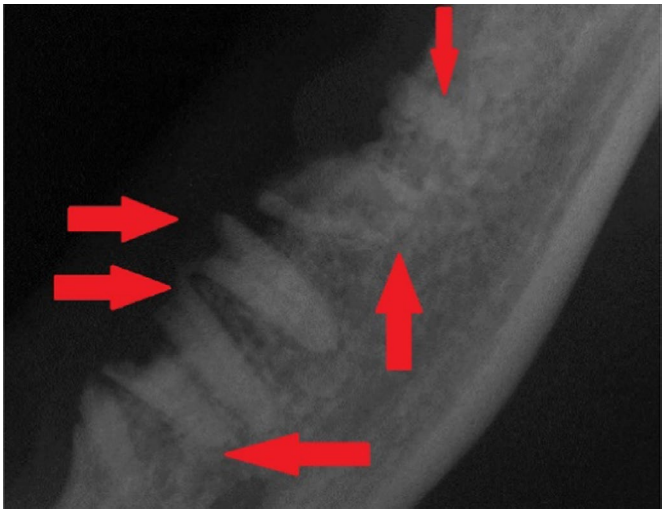

FIG 197. Post-operative radiograph – retained roots in the mandible of a cat.

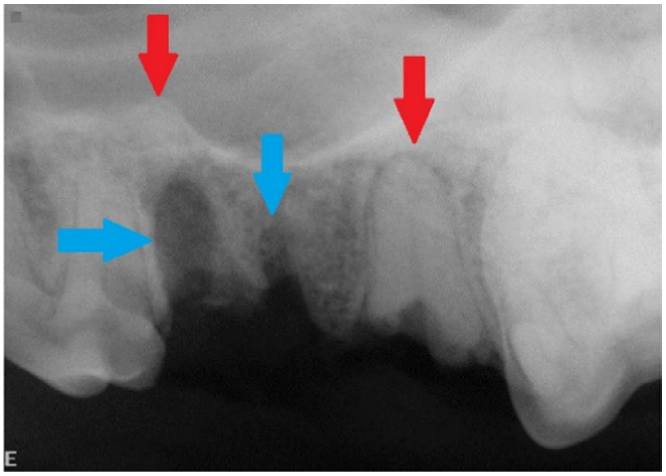

FIG 198. Post-operative radiograph – retained roots in the maxilla of a dog.

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Harvey & Emily, 1993a; Niemiec, 2022; Smith, 1998; Taney & Smith, 2006; Wiggs & Lobprise, 1997b) (Fig 196).

Step 9: Obtain a post-operative dental radiograph

Post-operative dental radiographs should be made to document complete removal of the tooth (Holmstrolm et al., 1998b; Niemiec, 2009). It has been reported that 92% of extracted carnassial teeth in dogs and cats have retained roots (Moore & Niemiec, 2014) (Figs 197 and 198).

A retained root tip may be or become infected (Ulbricht et al., 2003; Wiggs & Lobprise, 1997b). There are rarely any clinical signs observed with this complication, but it is generally painful and/or infected. Occasionally, this results in 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, with some texts recommending suturing only in large extractions. However, most authors recommend suturing almost all extraction sites. Closure of the extraction site promotes haemostasis, maintains the blood clot in the alveolus to speed healing and improves post-operative comfort and aesthetics. This is best accomplished with size 3/0 to 5/0 absorbable sutures on a reverse cutting needle. Closure was classically performed with a simple interrupted pattern with sutures 2 to 3-mm apart (Fig 199). However, recent studies suggest that cruciate or simple continuous patterns are as effective and faster than simple interrupted (Pegg et al., 2021). It is recommended to utilise one additional throw over manufacturer's recommendations for the chosen product to counteract tongue action (Fitch, 2003; Harvey & Emily, 1993a; Niemiec, 2022; Smith, 1998; Taney & Smith, 2006; Wiggs & Lobprise, 1997a). A recent study has shown that buried knots are effective and can create less inflammation (Klim et al., 2025). Primary (tension-free) closure is always indicated in oronasal fistulas or any time that a mucogingival flap is created to allow for easier extraction.

Extraction of multirooted teeth

All multirooted teeth should be sectioned into single-rooted pieces (Charmichael, 2002; Smith, 1998). The roots of multirooted teeth are almost always divergent, which will cause the root tips to break off if extractions are attempted in one piece (Fig 200) (Marretta, 2002; Wiggs & Lobprise, 1997a). When teeth are initially mobile, the sectioning step alone may allow for simple extraction. The best tool for sectioning teeth is a carbide bur on a high-speed air driven handpiece (Blazejewski et al., 2006; Charmichael, 2002; Terpak & Verstraete, 2012). It is not only the most efficient tool, it also has air and water coolant that will avoid overheating the surrounding bone. 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) (Niemiec, 2008d, 2022; Wiggs & Lobprise, 1997c) (see Equipment section).

FIG 199. Closure of the extraction side.

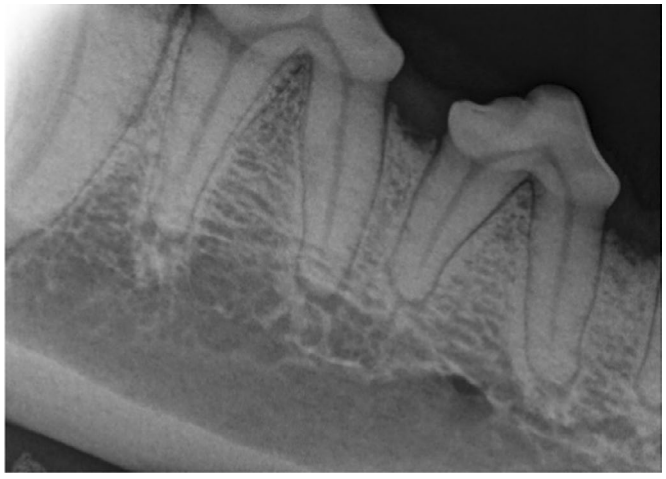

FIG 200. Divergence of multirooted teeth roots.

FIG 201. Sectioning should start at furcation side.

The recommended method to section the teeth is to start at the furcation and work towards the crown of the tooth (Niemiec, 2022) (Fig 201). This avoids the possibility of missing the furcation and cutting down into a root (increasing the risk

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of root fracture) as well as of cutting past the tooth and inadvertently damaging the gingiva or alveolar bone (Smith, 1998).

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 (Bissett & Niemiec, 2021) (Fig 202).

Sectioning results in multiple single-rooted segments. Thus, 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, 2022). This is typically thought of as the canine and carnassial (maxillary fourth premolar and mandibular first molar) teeth. However, some dentists will still attempt to extract these teeth closed. Open extractions are also beneficial for teeth with root malformations or pathology (dilaceration, ankylosis). An open approach allows the practitioner to remove a small amount of buccal cortical bone, promoting an easier extraction process.

Open extractions are initiated by creating a mucogingival flap. There are various flap types. The least invasive is a horizontal flap along the arcade (an envelope flap). More invasively, vertical incisions can be created to increase exposure. One vertical incision creates a triangle flap while incisions on both sides of the tooth create a full or pedical flap (Blazejewski et al., 2006).

An envelope flap is initiated by incising the gingiva in the interdental spaces along the arcade (Fig 203). Next, gingival attachment is released with a periosteal elevator along the arcade including one to several teeth on either side of the tooth or teeth to be extracted (Grant et al., 1998; Niemiec, 2022). Finally, release the tissue apical to the mucogingival junction (MGJ) (Fig 204). The advantages of this type of flap are that the blood supply is not interrupted and there is less suturing (thus decreased surgery time).

FIG 202. Sectioned maxillary molar tooth into three single-rooted fragments.

FIG 203. Envelope flap.

FIG 204. Released flap giving access to entire area of interest.

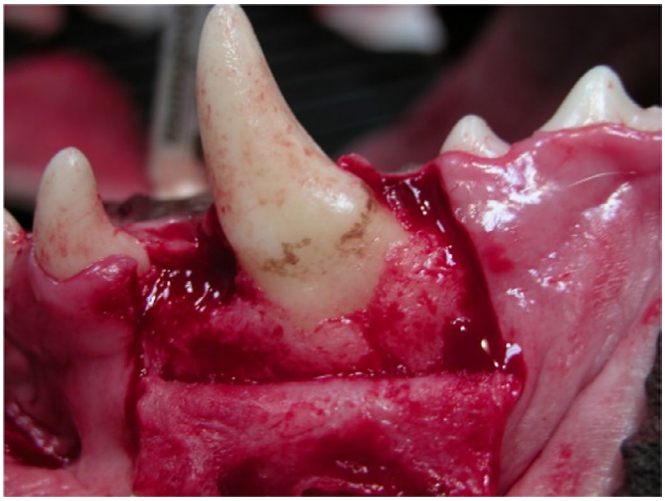

FIG 205. Vertical release incision(s) to release triangle and trapezoid flap.

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Previously, pedicle flaps were favoured for open extractions. This technique allows for a much larger flap to be created, which (if handled properly) will enable closure of larger defects (Holmstrolm et al., 1998b). However, it significantly disrupts the blood supply to the area, takes much longer to suture and has an increased chance of dehiscence (Niemiec, 2023a, 2023b).

Classically, the vertical incisions were created at the line angle of the target tooth, or one tooth mesial and distal to the target tooth (Smith, 2003). However, if there is space between the teeth (a naturally occurring diastema or from previous extraction) the incision can be made in the space rather than extending it to a healthy tooth (Niemiec, 2022).

Vertical incisions should be made slightly apically divergent (wider at the base than at the gingival margin) to maintain blood supply (Carmichael, 2002; Manfra Marretta, 2002). Incisions should be created full thickness and in one motion (rather than slow and choppy) to avoid strands of tissue remaining, which can result in flap tearing. A full thickness incision is created by incising all the way to the bone, and the periosteum is thus kept with the flap (Fitch, 2003; Manfra Marretta, 2002). Once created, the entire flap is *gently* reflected with a periosteal elevator (Fig 205). Care must be taken not to tear the flap, especially at the mucogingival junction.

Following flap creation, buccal bone may be removed with a carbide bur (Niemiec, 2022; Terpak & Verstraete, 2012) (Fig 206). Most dentists recommend an end cutting round bur for this step, but others favour the cross-cut taper fissure variety. The recommended amount of buccal bone to remove is very controversial. Some dentists remove the entire buccal covering and others remove only 1/3 of the root length of bone on the mandible and 1/2 for maxillary teeth (Fitch, 2003; Smith, 1998). The Dental Guidelines Committee supports minimally invasive surgical techniques and thus recommends that the minimally required amount is removed. If this does not allow for an expedient extraction, additional bone can be removed. Ideally, the bone removal is only performed on the buccal side. However, ankylosis may require removing bone on other surfaces.

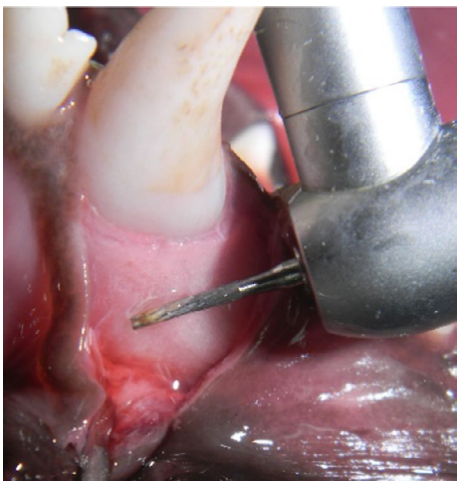

FIG 206. Alveolectomy with cutting bur.

Following bone removal, multirooted teeth should be sectioned (as above). Please note there are some authors that recommend sectioning prior to creating a flap.

Then 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.

There are several key points associated with successful flap healing (Wiggs & Lobprise, 1997a). The first and by far most important is that there can be no tension on the suture line. If tension exists, dehiscence will almost invariably occur. The best way to relieve the tension is fenestrating the periosteum (Blazejewski et al., 2006; Fitch, 2003; Niemiec, 2022) (Fig 207). The periosteum is a very thin fibrous tissue which attaches the buccal mucosa to the underlying bone (Evans and de Lahunta, 2013; Grant et al., 1998). Due to its fibrotic nature, it does not stretch and thus interferes with closing the defect without tension

FIG 207. Fenestration of periosteum to advance the flap for tension-free closure.

FIG 208. Flap stays in place after its advancement in a tension-free manner.

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(Niemiec, 2022). The buccal mucosa is very flexible and once released will stretch to cover large defects. If there is no tension, the flap will stay in place when placed in position. If it pulls back, tension is present and must be released prior to closure. Fenestration may be performed with a scalpel blade; however, LaGrange scissors offer more control.

After fenestration, the flap should stay in the desired position without sutures (Fig 208). 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.

Another key point is that you must ensure that all keratinised 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 but is generally not necessary in most extractions. Most authors recommend this be performed with a coarse diamond bur. Finally, it is ideal (but not required) that the suture line is not over a void (*e.g.* a fistula), but rather it should rest over bone. This is because it may create tension during breathing or eating. This can be achieved by removing a small amount of palatal tissue. However, this should not be performed if it will create tension.

Root fractures

If a root breaks, it is not recommended to attempt to extract it "blind". It is difficult to impossible to elevate a root you cannot see, and this technique greatly increases the risk of displacing the root into the nasal cavity or mandibular canal (Niemiec, 2022).

When this occurs, extract the tooth with an open approach. Make a flap and remove the buccal bone to identify the root and proceed with careful elevation.

Deciduous tooth extractions

The extraction of deciduous teeth can be very difficult due to the considerable length and thin walls of the deciduous tooth (Fig 209). For this reason, very small/sharp luxating elevators should be used for deciduous extractions. If these are not available, a 20 or 22 gauge needle can be an effective tool. Elevation is performed as above; however, even less pressure should be placed on the root due to its fragility. Extraction should only be attempted once the tooth is *very* loose.

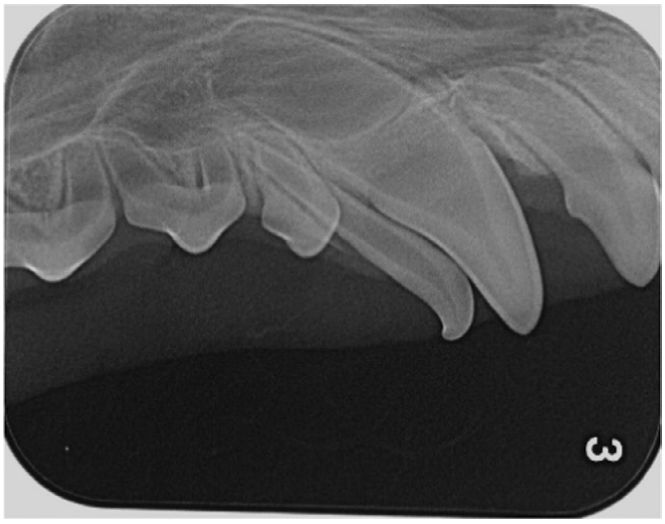

FIG 209. Deciduous teeth have long roots and thin walls.

Some veterinary dentists perform open extractions for deciduous canines; however, most generally perform the less invasive closed technique.

Another difference in extraction of deciduous teeth exists if the permanent tooth has not yet erupted. In this case, the enamel may not have completely formed and thus is at risk for iatrogenic damage (Dupont, 2010) although rare with a careful technique (Felz et al., 2024).

In these cases, it is recommended to take greater care with extractions and avoid the surface where the permanent teeth are erupting. This is the mesial surface of the maxillary canines and the lingual surface of all other teeth.

Dental radiographs are critical for the proper performance of deciduous extractions, because there is often some degree of resorption of the deciduous root (Niemiec, 2011). In some cases, the root may be completely resorbed, making the extraction simple. However, more commonly, there is an area of resorption near the cementoenamel junction. This greatly predisposes the tooth to fracture. This knowledge will aid the practitioner achieve a successful outcome.

While it is a common misconception that fractured and retained deciduous roots will resorb, this is simply not true. A retained root tip typically becomes infected. There are rarely any clinical signs associated with this, but the patient suffers regardless (Niemiec, 2018f). Dental radiographs should be exposed following all deciduous extractions to confirm complete removal.

Conclusion

Extractions are a very common procedure in veterinary medicine but can be very challenging, 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 complications such as fractured root tips and/or more serious iatrogenic problems. By following the steps outlined above, and utilising 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 broken down into simple, single root extraction via sectioning and buccal cortical 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.
- Crown amputation is an accepted method of therapy for advanced type 2 lesions in cats, but only if certain criteria (clinical and radiographic) are met.
- Never extract a tooth without client consent.

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Ergonomics in veterinary dentistry

Proper ergonomics are critical to your long-term health and ability to practice. While this is true in all facets of veterinary medicine, it is particularly important in veterinary dentistry (DeForge, 2002). Being able to safely practice and not be hindered by uncomfortable positions will improve patient care.

It is well established that work related musculoskeletal conditions are a huge issue in human dentistry. Numerous studies have found that most dentists and hygienists develop repetitive motion and posture related injuries (Batham & Yasobant, 2016; Kierklo et al., 2011; Soo et al., 2023; Tirgar et al., 2015).

These issues occur even though human dentists and hygienists are very well trained, have excellent equipment and at least somewhat ergonomically designed workspaces. This is not the case in veterinary medicine. Veterinarians rarely invest in a proper physical plant, quality equipment or even basic training.

FIG 210. Magnification.

FIG 211. Dental loupes encourage good posture.

Unfortunately, to make veterinary dentistry as safe as possible, wholesale changes to the physical plant would be required (Pollack, 1996; Rucker & Sunell, 2002). New tables, chairs, lights and even dental machines would need to be purchased. Further, a commitment to training specialised in maintaining proper ergonomics during dental procedures would need to be completed, which does not currently exist.

However, there are some simple and inexpensive options that can go a long way. One of the best ways to improve ergonomics is magnification (Fig 210) (Lietz et al., 2020; Soo et al., 2023). Dental loupes not only greatly reduce eye strain, but they also force you to sit up straight which is beneficial for your back and neck (Fig 211). Magnification also improves procedure quality and efficiency, the latter of which is of further ergonomic benefit. Further, saddle chairs are highly regarded as very beneficial for the back and neck.

The best way to decrease hand and wrist strain and repetitive motion injuries is to use sharp instruments. This, like many other proper ergonomic investments, will also speed and improve dental procedures, which is good for staff as well as patients. Consider a new set of periodontal hand instruments and/or elevators, or getting your current equipment sharpened.

Finally, hands-on training can have a side effect of improving ergonomics. Learning how to properly use equipment will go a long way to decreasing strain and stress. Further, it reduces the amount of time needed for dental therapy, again, which improves ergonomics.

Utilisation of veterinary support staff in the care of the dental patient

Introduction

Veterinary Dentistry is an area of veterinary medicine where the entire team is utilised to help support and care for the dental patient. Each team member brings their own skillset to educating clients on the importance of good oral health, the provision of support and assistance to the veterinarian during treatment, and maintenance of instruments and equipment. All members of the veterinary staff play an important role in caring for the dental patient.

A cohesive team-based approach leads to an increase in uptake of the treating veterinarian's recommendations for treatment, increased compliance with homecare along with increases in job satisfaction for all and ensures better patient outcomes (Boursiquot et al., 2023). Empowering your team through better utilisation improves team effectiveness in the provision of a high standard of care along with efficiency in workflow. Better utilisation of staff improves job satisfaction and staff retention.

In order to utilise the team to the best of their ability, the veterinarian needs a sound knowledge of the skill level of each team member and assign tasks to suit the skillset and education the team member possesses. Although the diagnosis of disease should be left to the veterinarian, the technician and other staff members can assist the veterinarian by recognising conditions that appear abnormal and alerting the veterinarian to them (Holmstrom, 2013). Conducting a Training Needs Analysis of each staff member will expose any gaps in their knowledge or

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skills, and an appropriate Training Plan can be devised to address these areas. The practitioner should have an understanding of the qualifications of their team members, along with any regulatory restrictions on the tasks they can perform, along with an appreciation of the tasks that can be directed to credentialled and non-credentialled staff members, and which staff members require supervision in the performance of their tasks. This will also help to recognise the important role that the credentialled Veterinary Technician/Nurse plays in the success of your dental practice. Reference should be made to all Acts, Regulations and guidelines appropriate to your Region, State or Country for proper guidance on the delegation of tasks amongst your team.

The following are suggestions for the delegation of tasks in order to better utilise your team in the performance of dental procedures.

Veterinarian

The practitioner's role is within the act of surgery, diagnosis, prescription and prognosis with the support and assistance of their team. One has to remember that all responsibility for the clinical result of the treatment belongs to the operator; therefore, all surgical procedures such as extractions, surgical flaps, suturing in the oral cavity, as well as nerve blocks must be performed by a skilled veterinarian (Gawor, 2008). Developing a Standard Operating Procedure (SOP) around your dental treatments will give structure and guidance to your team in the standard of care expected. It will help to create and set proficiency goals for your team's training and guide the appropriate assignment of tasks.

Credentialled veterinary nurse/technician

The credentialled Veterinary Nurse/Technician (VN/T) has a vital role in advocating for the patient, educating the client and supporting the veterinarian. Their multifaceted contributions enhance the efficiency, safety and overall quality of care provided to animal patients (Clarke, 2024). Understanding their scope of practice, skills and knowledge will help the practitioner to best utilise their skillset.

The VN/T can be utilised from admission to discharge of the dental patient undergoing treatment with tasks including:

- Gathering an accurate patient history
- Patient admission and/or discharge
- Perform an oral examination on the conscious patient, reporting all findings to the veterinarian
- Dental charting and transcription into the patient medical record
- Dental prophylaxis and professional cleaning procedures (refer to "Periodontal Therapy" section)
- Producing dental radiographs (if appropriate following State/Federal legislation)
- Assist in oral surgery & other procedures
- Monitor the vital signs of the anaesthetised patient and perform appropriate interventions under the veterinarian's direction/supervision
- Present the treatment plan and estimate of costs to the client
- Discuss the pathology found and the reason for treatment
- Deliver post-operative instructions to client
- Discuss homecare recommendations with the client and provide instruction of which the VN/T plays a vital role in providing this education (Berg, 2021)
- Ensure dental operatory is stocked & equipment is well maintained
- Conduct follow-up visits with pet owners.

Kennel assistants and other non-credentialled assistants

Kennel Assistants and other non-credentialled assistants can provide valuable assistance to the Veterinarian and/or credentialled VN/T in the efficient performance of dental procedures. However, care should be given to ensure that veterinary assistants are only performing tasks appropriate to their skill level and their State's practice act (Boursiquot et al., 2023). Suggested tasks include:

- Provide pre-, intra- & post-operative assistance
- Clean & fully stock dental suite & set-up ready for patient
- Recognise when instruments require sharpening/replacement including ultrasonic tips, burs & consumables
- Provide four-handed dentistry assistance by recording the findings on the dental chart. Four-handed dentistry increases efficiency and decreases the amount of time under anaesthesia (Lewis, 2016)
- Assist with patient positioning
- Assist with the production of pre- & post-operative radiographs
- Transcribe findings into patient record, upload photos & radiographs, help prepare discharge paperwork
- Post-operative husbandry of the patient ensuring they are made ready for discharge
- Cleaning and care of the dental operatory, instruments and equipment
- Maintenance of dental equipment
- Care of boarding patients – if appropriately trained, perform oral examinations & bring attention to veterinarian of any oral abnormalities, then discuss referral with client for vet consultation
- Carry out established homecare routine while pet is boarding

Receptionist – customer care team

The Receptionist is often the first and last person a client sees during a visit, whether for a consultation or leaving their pet for a procedure. They reflect the clinic and should be friendly and approachable. They should be well-versed in providing accurate information to the client as they are often a vital link in the communication between the client and the veterinarian. Often, they will be confronted with questions from clients with regard to the pet's procedure, the safety of anaesthesia and moreover questions relating to the cost of procedures. They should project a positive attitude towards dentistry and are vital to the success of ongoing homecare compliance. Their training should specifically expose them to dental procedures being performed to better answer client's questions and any concerns they may have. The customer care team should be included in continuing education opportunities on homecare products and the significance of early intervention in the management of periodontal disease. Other tasks performed by the receptionist are:

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- To follow clinic protocols on the day of the dental procedure relating to greeting the client and patient, checking in and admission protocols
- Communication with the veterinary team
- Scheduling of any follow-up appointments and/or procedures
- Processing of payment ensuring a positive experience for the client
- Provide high standards of customer service and communication
- Responsible for communication with referral practice, including compilation of patient documentation, patient history, radiographs, photographs.

The universities role in dental education

The WSAVA Dental guidelines highly encourage Universities' involvement in veterinary dentistry training and make some recommendations for the teaching of veterinary dentistry in the university settings at both undergraduate and graduate levels.

Training in veterinary school

Although oral and dental diseases are common diseases in small animals, veterinary dentistry is still a largely neglected field in the veterinary medicine curriculum in most of the universities. There are currently only a few universities worldwide, which include veterinary dentistry in the regular curriculum. A few additional universities have veterinary dentistry as an elective subject/course, usually offered to a limited number of students (Perry, 2014).

Each DVM programme should include veterinary dentistry in the curriculum, ideally after the students have completed their training in medicine and surgery. Veterinary dentistry training should include at least lectures to cover oral and dental anatomy, physiology, oral/dental examination techniques including dental radiography, and most common oral/dental diseases, hands-on wetlabs on oral/dental examination, radiography, periodontal treatment, regional anaesthesia and basic principles of tooth extractions, and rotation through the dentistry department of the Teaching Hospital (if available). Practice with dental models may also help students with their comfort level before cadaver laboratory (Goldschmidt & Root Kustritz, 2022; Hunt et al., 2021). "Day-1 competence" skills are 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) and core competencies recommended for inclusion in the veterinary curriculum for all veterinary graduates based on the American Association of Veterinary Medical Colleges Competency-Based Veterinary Education document have also been recently published (Harvey et al., 2023).

Hence, to provide the necessary teaching environment with clinical cases for veterinary students, veterinary dentistry as a specialty should be included in clinical activities (Esteghamati et al., 2016). Establishing a veterinary dentistry department requires some basic equipment but is usually a very cost-effective investment. Moreover, Veterinary Teaching Hospitals should strive to provide veterinary dentistry services at a specialist level. This can be achieved through the employment of a Board-certified veterinary dentist (Dipl. AVDC, Dipl. AVDC-Eq, Dipl. EVDC, Dipl. EVDC-Eq), ideally a PhD holder that provides clinical services, training to undergraduate students and postgraduate students – interns and residents, as well as research in veterinary dentistry. Students should be given an option to complete their rotations in veterinary dentistry as externships with specialists in veterinary dentistry in private practice, until the university builds a veterinary dentistry specialty service/programme. If no board-certified veterinary dentist and/or PhD holder with documented advanced training in veterinary dentistry is available in the country, then a veterinarian with special training in the field (MSc or similar) should be included in teaching veterinary dentistry.

Postgraduate training

PhD training

PhD is currently the highest degree possibly achieved in postgraduate training aiming at training in research. An individual with a DVM degree, that is accepted into a PhD training, can focus his/her research on oral/dental health of animals, which is usually related to the main research focus of the Supervisor and/or research group to which she/he is accepted to. Such programmes are currently very rare, but ideally in the future, veterinary dentistry-focused PhD training programmes should be formed and followed by a residency or vice versa to train clinician-scientists (DeLuca et al., 2016). Ideally, PhD holders in veterinary dentistry should also staff Veterinary Faculties worldwide to provide research in the field.

Residency training

Residency in veterinary dentistry can currently be obtained through one of the two registered colleges worldwide – AVDC (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 residency training, a DVM needs to fulfil certain criteria as described by the AVDC or EVDC websites. Usually at least 1-year internship (or the equivalent) is needed after graduation. Once registered and in training, the resident must achieve a high level of knowledge and clinical skills as also described in detail in the AVDC or EVDC documents. It can take between 2.5 and 6 years before the resident completes the training and applies for the entry examination to the College. Only after the candidate successfully passes the practical and written examination, he/she is awarded a Diplomate status. Ideally in the future, residency training is followed by a PhD or combined with a PhD training in a longer time period (Bourgeois et al., 2015; DeLuca et al., 2016; Esteghamati et al., 2016).

Currently, the level of university involvement in veterinary dentistry training is still poor. Establishing veterinary school training and residency programmes in veterinary dentistry should be one of the main priorities of Veterinary Faculties worldwide.

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SECTION 9: NECESSARY EQUIPMENT

Oral examination

Assessment of the conscious patient

The oral examination should be one of the most performed procedures in small animal practice. WSAVA believes that an oral examination must be performed during every physical examination. A systematic approach which identifies both normal and pathological states is important for completeness (Hansen & Goldstein, 2009).

The necessary equipment for a detailed intraoral conscious examination includes adequate room lighting, magnification and a pen light. The veterinarian should wear examination gloves to assess the oral cavity to decrease the risk of infection (Huffman, 2010). While light may seem obvious, many clinicians attempt to perform an examination in a poorly lit room with the unaided eye, to less than satisfactory results. A pen light (or oto/ophthalmoscope) can be used to improve visualisation as well as to transilluminate the tooth to determine vitality (Huffman, 2010).

Proper patient position should provide the mouth at an appropriate level for comfortable evaluation by the inspecting veterinarian (ergonomic positioning is advantageous) (Aller, 2005; DeForge, 2002; Huffman, 2010).

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

1. A good light source
2. Examination gloves

Examination under general anaesthesia

Following general anaesthesia and intubation, a complete and thorough oro-dental examination must be performed (Huffman, 2010; Niemiec, 2013d). All dental procedures must be performed under general anaesthesia (see Anaesthesia and anaesthesia-free sections). Endotracheal intubation is critical for dental procedures. Use of a laryngoscope will aid with intubation and inspection of the oropharyngeal area (Fig 212).

Holding the mouth open and visualisation during the professional dental cleaning and other dental procedures should be accomplished with appropriately sized props rather than spring-loaded gags. This is due to the risk of blindness with extended mouth opening in cats (Barton-Lamb et al., 2013; Martin-Flores et al., 2014; Scrivani et al., 2014).

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 (Huffman, 2010):

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
5. Explorer
6. Dental mirror
7. Lip retractor
8. Mouth gag (properly sized syringe case or plastic gag)
9. Personal protective gear (eyewear, mask and examination gloves).

Periodontal probes are typically a metal or plastic tapered rod with a blunt end attached to a handle, with graduated millimetre markings. There are several types available. The Williams, Marquis, Michigan-O, UNC and Nabors are commonly available (Fig 213).

FIG 212. Use of laryngoscope during intubation.

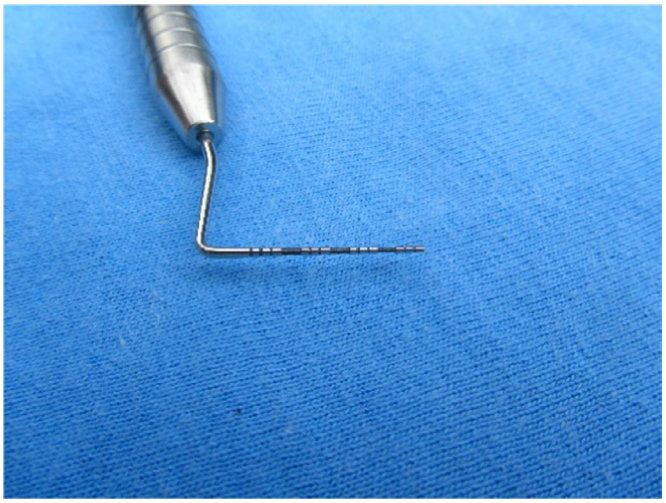

FIG 213. Periodontal probes: The Williams, Marquis, Michigan-O, UNC.

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The probe allows the clinician to measure the depth of the sulcus or pocket, degree of gingival enlargement and/or recession and furcation exposure (in multirooted teeth) (Huffman, 2010; Niemiec, 2013a).

An explorer is typically 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 subgingivally; dental defects such as resorptive lesions, pulp exposure, attrition, abrasion, lost enamel or dentine may also be assessed (Fig 214) (Huffman, 2010; Niemiec, 2013b).

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 (Fig 215).

The lip retractor is used to improve the visualisation of the caudal dentition either for assessment or for photography. It may be used during dental procedures to improve visibility of the surgical area.

Residual plaque can be identified by drying the teeth with compressed air. 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. Fluorescein may also be utilised. Another tool utilises 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 (Marshall-Jones et al., 2017; Wallis et al., 2016).

FIG 214. Explorer.

Patient safety/monitoring

Temperature maintenance equipment:

- Tier 1: hot water warming device
- Tiers 3 & 2: 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

- Tier 1: Dedicated staff member to monitor pulse rate and quality, respiration rate, body temperature, mucous membrane colour and refill time, and depth of anaesthetic plane by assessing eye position and jaw tone.
- Tier 2: Anaesthesia monitoring body temperature, recording of pulse, respiratory rate, recording of blood pressure, measurement of expired CO_2.
- Tier 3: Additional equipment: IV infusion pump.

Radiology/radiography

Oral radiology and radiography are important for adequate diagnosis and therapy. Performing dentistry without radiography greatly increases the likelihood of missed pathology and iatrogenic trauma.

To produce diagnostic radiographs, an x-ray generator, dental film and developer solution, or a digital dental system and a computer with appropriate software. Dental x-ray machines and intraoral film/sensors are always recommended; however, diagnostic images can be obtained with the use of the full body x-ray and dental film/sensors and appropriate techniques. Full body radiographs are of insufficient detail for proper dental diagnosis and are very difficult to expose.

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 intraoral dental film (Tier 2)
   b. Phosphor-stimulable (PSP) plates (CR system)

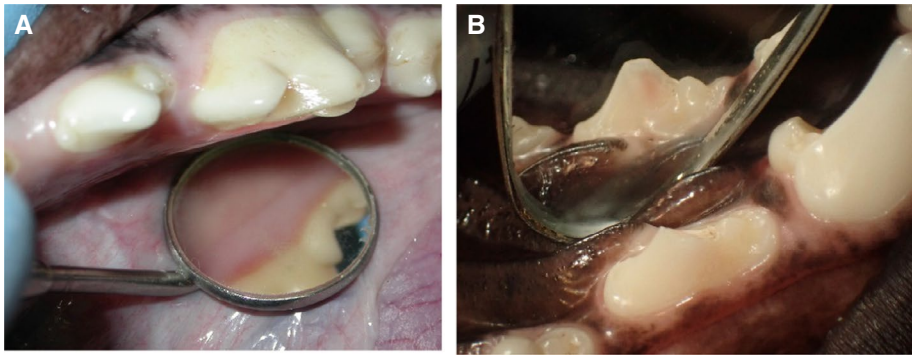

FIG 215. (A, B) Use of dental mirror or dental mirror application.

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FIG 216. Phosphor plates.

FIG 217. Digital sensors.

c. Digital sensors (DR system)

Digital dental radiology should be available in all tier 3 countries.

Manual processing can be performed using wet chemistry in a dark-room or light proof chamber (chairside 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 (Niemiec 2018b; Niemiec, Sabatino, et al., 2004).

Processing can also be performed using a computer software programme that transmits the x-rays detected on a plate or sensor to a radiographic image on a computer screen.

Phosphor plates (CR technology) (Fig 216): 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 centres in the crystal lattice until stimulated by the second illumination. These mobilised 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 4, are reusable and replacement is quite affordable.

Digital sensors (DR technology) (Fig 217): There are numerous human and veterinary direct digital systems. These are excellent means of obtaining dental radiographs. 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.

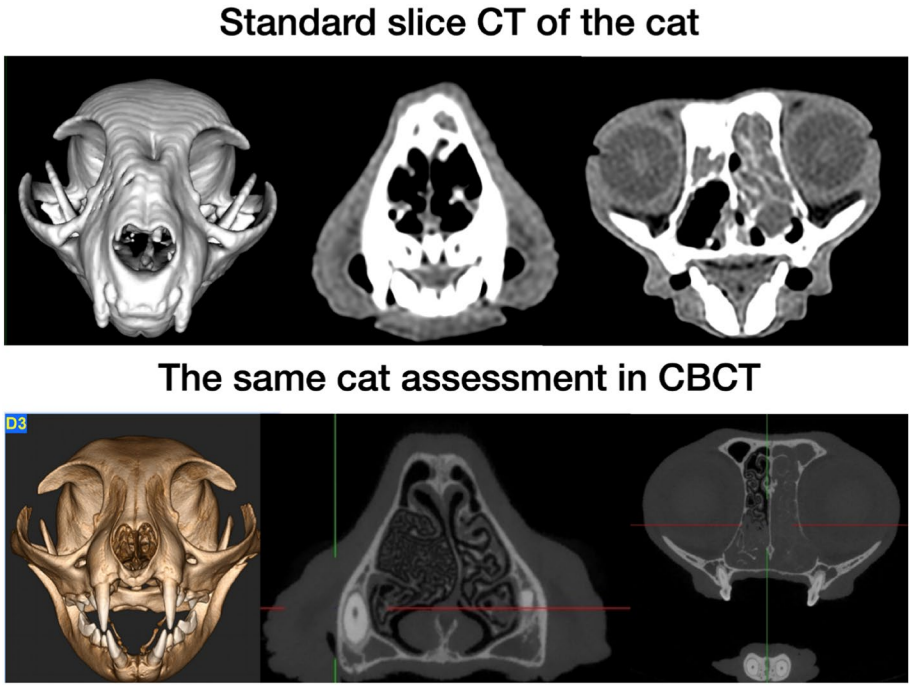

FIG 218. CBCT.

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Cone-beam CT: This technology allows for 3D imaging with good detail and contrast quickly and without the radiation shielding required of a standard CT unit. While it is not as good as standard CT (especially for soft tissue), it provides excellent detail for dental and oral surgical purposes (Fig 218). It has become the standard of care in tier 3 countries.

FIG 219. Tartar removing forceps.

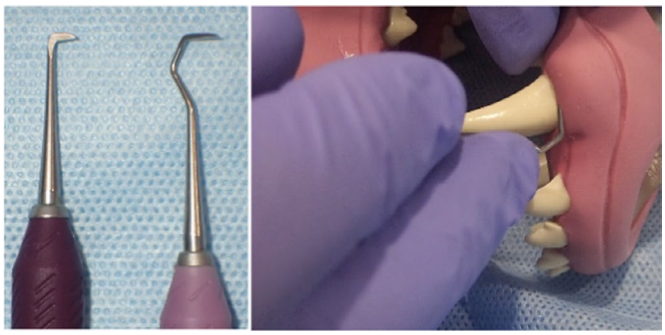

FIG 220. Scaler.

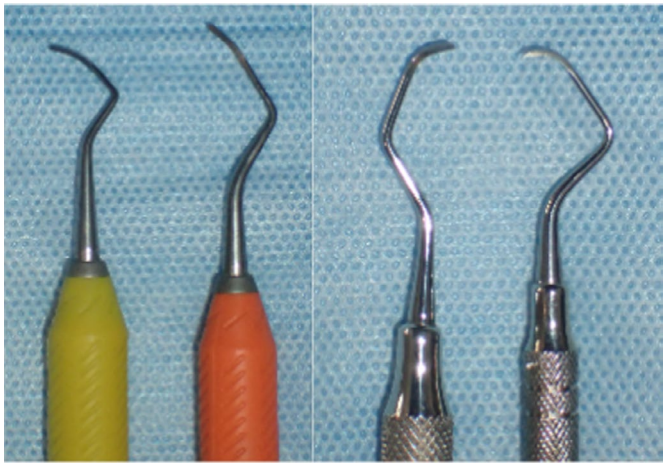

FIG 221. Selection of curettes.

Equipment to clean teeth

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

FIG 222. Sharpening stone and oil.

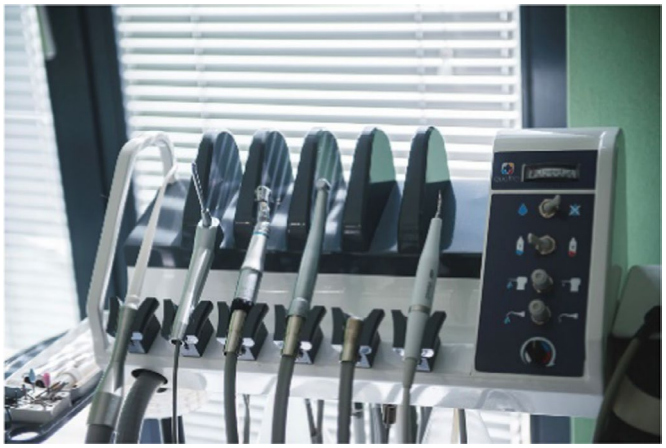

FIG 223. Dental unit.

FIG 224. Mechanical scaling – supra and subgingival tips.

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Diagnostic instrumentation:
See above.
Scaling instrumentation (Niemiec, 2003b, 2018d).
Tier 1:

- Tartar removing forceps (Fig 219)
- A scaler (for supragingival scaling) (Fig 220)
- A selection of curettes (for subgingival scaling) (Fig 221)
- Sharpening stone and oil (Fig 222)

Tiers 2 & 3 should have the above plus:

- A dental unit (high speed and low speed) (Fig 223)
- Mechanical scaling: sonic or ultrasonic (piezoelectric, magnetostrictive)
  - Appropriate supra and subgingival tips (Fig 224)
- Prophy paste/pumice (Fig 225)

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 (Niemiec, 2013c). The blade is triangular in cross section. The sharp blade is used to remove plaque, calculus and other deposits from the supragingival area. Hand scalers come in different patterns including: sickle, Universal (or H6/H7), Jacquette and Morse (Theuns & Niemiec, 2012) (Fig 226).

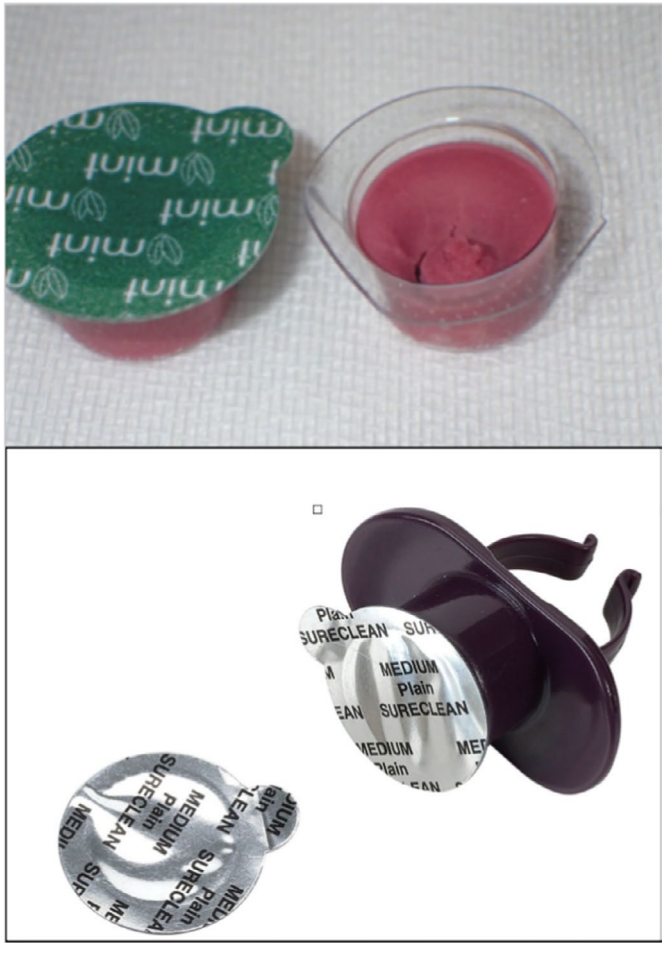

FIG 225. Prophy paste/pumice.

Ultrasonic scalers: Ultrasonic scalers are commonly used for removal of supragingival plaque and calculus. Ultrasonic scalers operate at >25 kHz (Niemiec, 2013c). The principal action of plaque and calculus removal is by a mechanical kick or oscillation. This is achieved by the vibrating tip contacting the calculus and vibrating it off. In addition, ultrasonic scalers create an effect called "cavitation" where the ultrasonic waves derived from physical vibrations of the tip energise the water spray, providing an antibacterial effect (Niemiec 2013).

Ultrasonic scalers run via electricity and the working tip has one of three types of movement. The magnetostrictive type utilises 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 25 kHz, 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 utilise 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 (Fig 227). 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 the visible tooth surface. The tip of the magnetostrictive and piezo scaler becomes very hot with normal use. Coolant is absolutely required to prevent this from overheating the tooth and causing painful pulpitis and possible tooth death (Niemiec 2013). The water spray should be directed at the end of the tip to dissipate heat. Care must always be taken to make sure the coolant is reaching the tip properly, especially if the ultrasonic is used subgingivally. Properly designed subgingival tips will allow the water coolant to get to the tip and be used subgingivally.

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 to 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).

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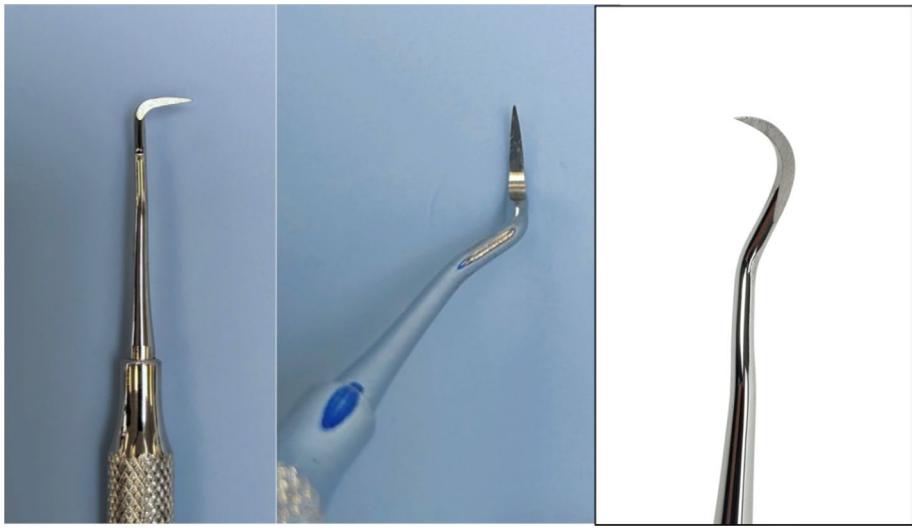

FIG 226. Hand scalers: sickle, Universal (or H6/H7), Jacquette and Morse.

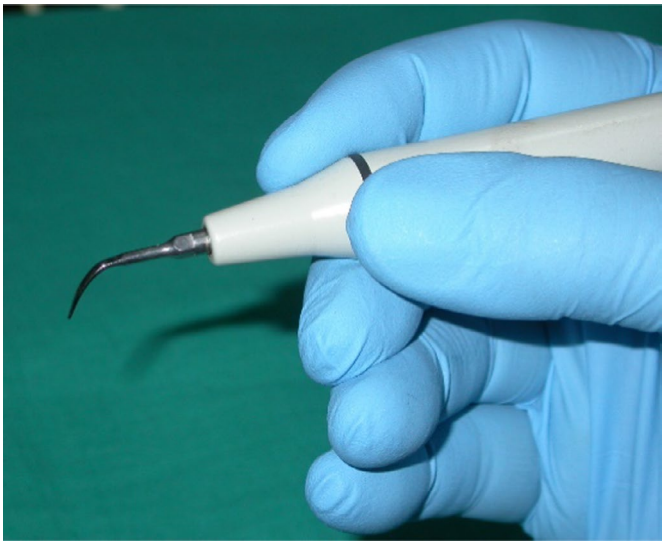

FIG 227. Pen-like grip-handle of ultrasonic scaler.

Subgingival scaling (root planing) and curettage: While supragingival scaling results in an aesthetic result for the owner, it does not provide any medical benefit for the treatment or prevention of periodontal disease. This medical therapy requires subgingival scaling and curettage. Root planing is defined as removal of the necrotic cementum from the root surface while curettage is the debridement of epithelial cells, endotoxins and accumulations from the epithelial wall lining the pocket (Niemiec, 2013e, 2013h). Subgingival debridement and curettage can be performed using ultrasonic and sonic scalers (with proper subgingival tips) or by hand with curettes.

There are two types of curettes, universal and area specific. The universal type, of which Columbia and Barnhart are examples, has two cutting surfaces, a rounded toe and a blade with cutting surfaces angled at 90° to the handle. The area-specific type, of which Gracey is an example, has a rounded toe and a single sided cutting blade which is angled at 70° to the shaft (the instrument between the cutting blade and the handle).

In addition to the 70% 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 to 18. The higher the number, the greater the accessory bend and the further back in the mouth the instrument is designed to be used.

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.

Polishing

Generally speaking, there are two types of polishing actions. The traditional cup, which rotates continuously at 3000 rpm, and the newer type of cup with a reciprocating action, back and forth. Fine grades produce a smoother finish, whereas coarse grades will remove more enamel and produce a rougher surface. The polishing paste can also be created chairside from pumice powder and water. The cups should not be applied to the tooth surface for >3 to 5 seconds duration as the heat generated can cause an increase in dentine temperature and an irreversible pulpitis (Ertugrul et al., 2019). Overpolishing or using abrasive materials can lead to abrasion of enamel, which can lead to sensitivity. Air-polishing systems can also be used with similar abrasive effects and the rubber cup and pumice (Yildirim et al., 2021).

Extractions/oral surgery

Tooth extraction is one of the most common surgical procedures performed by veterinarians in small animal practice. While repair

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of fractured jaws, closure of oronasal fistulas, and removal of oral tumours are generally considered oral surgery, extraction of a tooth is also a surgical treatment and a procedure that should be perfected by all practitioners.

Ideally, extractions result in complete removal of the tooth and 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 (Chengye, 2017; Parmigiani-Izquierdo et al., 2013; Ramfijord & Costich, 1968; Wood et al., 1972).

Tooth extraction requires the veterinarian to have a detailed knowledge of anatomy, wound healing and suturing, proper dental materials and equipment, as well as the technique to accomplish the procedure.

Oral surgery kit (Fig 228)

Extraction instrumentation:

1. An assortment of luxating elevators (luxators) can be used for cutting the periodontal ligament. The luxator consists of a handle, shaft and a working end. The working end typically has a concave surface and opposing convex surface, straight sides and a sharp end perpendicular to the instrument long axis. The blade comes to a fine/sharp tip (Fig 229).
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 rounded tip. The tip may be sharp or blunt (Fig 230).
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) (Fig 231).
4. Periosteal elevators are flattened/sharpened cutting instruments that are round to pear shaped. These are used to carefully raise the mucogingival flaps.

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.

FIG 228. Oral surgery kit.

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FIG 229. Luxators.

FIG 230. Elevators.

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:

- Soft tissue oral surgery kit
- Elevators or luxators
- Extraction forceps
- Some method for sectioning teeth.

Tiers 2 & 3 should have the above plus:

FIG 231. Extraction forceps.

- High-speed dental unit and handpiece with assorted burs for sectioning teeth and cutting dental hard tissue.

All equipment should be sanitised, disinfected and/or sterilised based on the category of each item's intended use (*e.g.* noncritical, semi-critical or critical) (Terpak & Verstraete, 2012) (Fig 232). 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, but there are other options such as polyglactin 910 and chromic gut, where available (Tutt, 2006b).

As far as suture size, in general 4/0 to 5/0 is recommended for cats and 4/0 to 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 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. Two to three mm between the wound edge and the suture entry point and a 2 to 3 mm distance between interrupted sutures is recommended. A single 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

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FIG 232. Sterilisation of dental equipment.

decrease surgical time as well as less knots will decrease inflammation. 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 the dental operatory should be sanitised, disinfected and/or sterilised on a regular basis.
- Dental/oral procedures require the use of specific instruments and equipment.
- The most common dental procedures (diagnostic, prophylaxis and extractions) cannot be properly performed without access to radiographic equipment.

Author contributions

All authors have contributed equally to this work.

Conflict of interest

None of the authors of this article has a financial or personal relationship with other people or organisations that could inappropriately influence or bias the content of the paper.

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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