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Conditions Common in Small and Toy Breed Dogs

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1.1 Periodontal Disease

1.1.1 Periodontal Disease Pathogenesis and Prevalence

Periodontal disease is the most common medical condition in small animal veterinary patients [1, 2]. The classic study from the 1980s reported that by just two years of age, 80% of dogs and 70% of cats have some form of periodontal disease [3]. However, more current studies report that periodontal disease is actually even more common, being diagnosed in 90% of patients by just one year of age [4]. In fact, two studies (one using a sensitive diagnostic test and the other including exam under general anesthesia) revealed that ALL patients in the study were infected [5, 6]. The lack of recognition of the high prevalence of periodontal disease has as much to do with a lack of understanding of the initial signs of disease as it does with the lack of effective diagnostic methods. Part of the issue with diagnosing the early stages of gum disease is that it requires anesthesia (or at least heavy sedation). This is because probing is required (see below) as well as the fact that the earliest signs of disease are typically on the palatal/lingual aspect of the teeth [6].

The earlier onset of periodontal disease is due primarily to the popularity of small and toy breed dogs, who are particularly susceptible [7–11]. The complete reasoning behind this is unknown; however decreased interdental space (crowding) (Figure 1.1) [12], rotation of teeth (Figure 1.2), decreased oral activity (recreational chewing), increased lifespan [13, 14], and shorter tooth roots (Figure 1.3) all likely play a role [15, 16].

There are several additional reasons for the “apparent” increase in incidence. First, the widely known studies from the 1980s were based on erythema of the gingiva being the first sign of gum disease (Figure 1.4). This inflammation is termed “marginal gingivitis” [17, 18], and is created by the proliferation of capillaries and formation of “capillary loops” [19]. While color change is a dependable sign of the presence of gingivitis, it has been established that gingival bleeding on periodontal probing or brushing actually occurs BEFORE any color change [17, 20] (Figure 1.5). Therefore, with new diagnostic tests such as a periodontal diagnostic strip¹, we are finding even more patients affected with periodontal disease. Another reason is the steadily increasing life expectancy in our patients [21, 22]. Small breed dogs are known to live longer than large breeds [13, 14]. This longevity

1 Orastrip, PDX biotech



Figure 1.1 Crowding. The smaller mouths with relatively larger teeth seen in small and toy breed dogs often results in crowding. Crowding hastens periodontal disease by interfering with the patient's natural cleaning ability as well as the loss of the normal gingival collar. This is demonstrated in the incisor region of a Chihuahua (a) and the mandibular premolar region of a pug (b). Note the periodontal loss on the left side of the patient in (a) as opposed to the more normal right side.



Figure 1.2 Rotated teeth. A rotated maxillary left third premolar (207) of a French Bulldog. Note the lack of spacing between the teeth as well as loss of the gingival collar on both the mesial and distal aspects of this tooth.

provides periodontal disease more time to negatively affect the patient, as it is well known that periodontal disease becomes more common with increasing age [9, 23].

The main factor for the increased susceptibility in certain breeds may also be hereditary in nature. A recent study on Labrador Retrievers revealed that in one litter of eight dogs only 12.5% developed periodontitis, whereas in another litter of five dogs, 100% developed periodontitis [6]. Reports on Schnauzers and Yorkshire Terriers confirmed their propensity to this disease process as well [11, 24, 25]. There are other well known “at risk” breeds besides small and toy breeds (e.g. Greyhounds and Cavalier King Charles Spaniels) [26]. Further, there is mounting research on the human side that there is a genetic predisposition to periodontal disease. Studies on twins showed a significant increase in periodontal disease, attachment loss, and plaque accumulation [27, 28]. Early-onset periodontal disease is ten times more likely to occur in African-Americans when

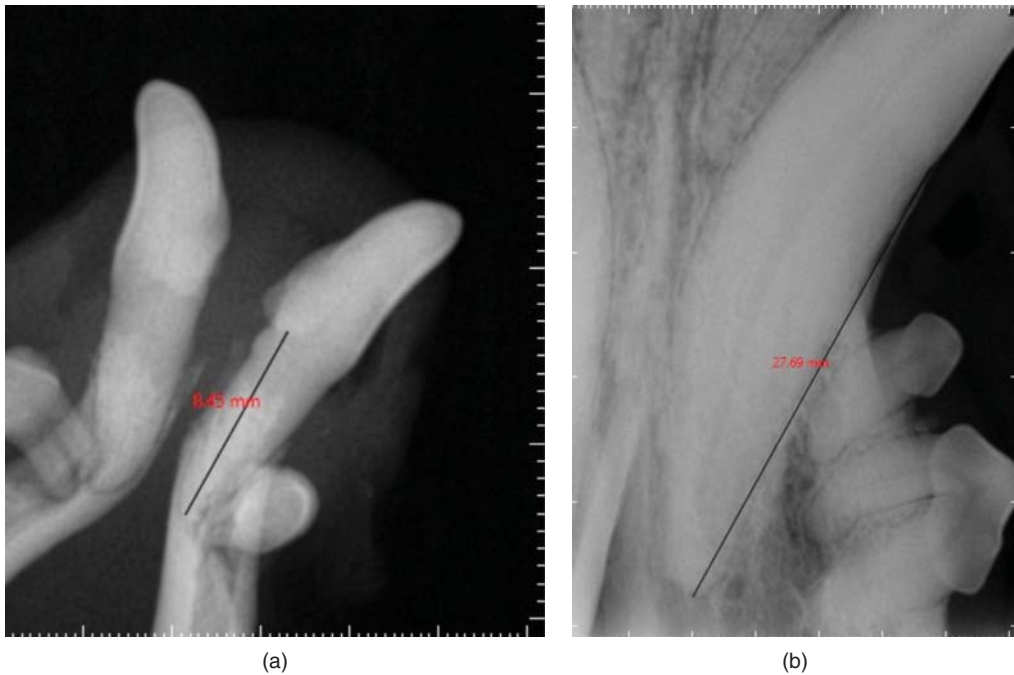


Figure 1.3 Root length is significantly reduced in small breed dogs. (a) An intraoral dental radiograph of the mandibular canines of a 0.9 kg Chihuahua. The root length as measured from the cemento-enamel junction (CEJ) to the apex of the root is 8.45 mm. Note that there is also significant alveolar bone loss. (b) An intraoral dental radiograph of the mandibular canines of a 35 kg Labrador Retriever. The root length as measured from the cemento-enamel junction (CEJ) to the apex of the root is 27.69 mm. This means that the roots of the canines are more than three times the length of the same teeth in a small breed dog, thus providing significantly more attachment that needs to be lost prior to extraction being required and thus the pet has more resistance to tooth loss.

Figure 1.4 Gingivitis. The mild erythema and edema of the gingiva (marginal gingivitis) on this right maxillary fourth premolar (108) is a sure sign of gingival inflammation, and was mistakenly believed to be the first sign of disease. However, it is now known that this is a later sign, as bleeding on probing occurs before a color change (see Figure 1.5).

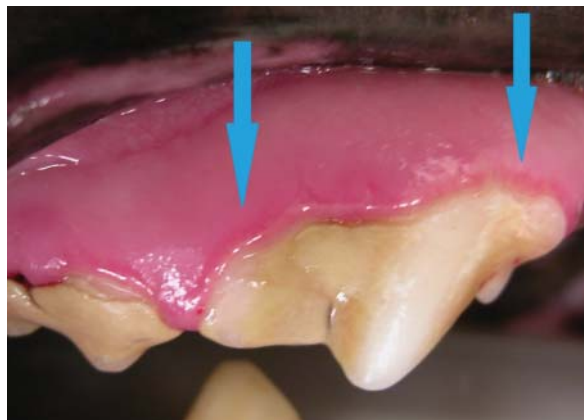




Figure 1.5 Gingivitis. This patient does not have any erythema or edema of the gingiva of this right mandibular canine (404). However, bleeding is provoked with gentle probing due to the fact that the gingiva is mildly inflamed. This is the true first sign of gingivitis, which often cannot be diagnosed without general anesthesia. Thus, gingivitis is severely underdiagnosed, which is why most veterinary dentists recommend annual cleanings regardless of conscious oral exam findings.



Figure 1.6 Normal gingiva. This is a picture of the mandibular left of a dog in good periodontal health. The tissues are coral pink in color and the teeth are clean.

compared to Caucasian patients [29]. Finally, several studies have identified specific genes and genomes that apparently predispose the individual to periodontal disease [30–32]. Localization of the exact genes which are responsible for specific conditions in dogs may be possible in the near future as a canine genome map is currently available [33].

1.1.2 Clinical Signs of Periodontal Disease

Normal gingival tissues are coral pink in color (allowing for normal pigmentation), and possess a smooth/regular texture (Figure 1.6). There should be no visible plaque or calculus on the dentition.

The first *clinical* sign of gingivitis is redness of the gums (see Figure 1.4), followed by edema, (Figure 1.7) and halitosis [18, 19]. However, gingival bleeding during brushing or chewing is usually noted prior to a color change, but this is hard to impossible to evaluate in a conscious patient [16, 19, 34] (see Figure 1.5). In fact, recent studies have proven that general anesthesia is required to diagnose periodontal disease, especially the earliest signs [6].

Gingivitis is typically associated with calculus, but it is caused by plaque and therefore may occur despite the absence of calculus (Figure 1.8). Alternatively, significant supragingival calculus may exist with little to no gingivitis (Figure 1.9). It is critical to understand that calculus in and of itself is essentially non-pathogenic [3, 35, 36]. Therefore, the degree of gingival inflammation should be used to judge the need for professional therapy, not the level of calculus. However, as has been previously noted, periodontal disease (especially the early stages) CANNOT be effectively diagnosed without general anesthesia [6, 9].

Figure 1.7 Gingivitis: Intraoral dental picture of the maxillary left of a canine patient with significant gingival inflammation.



Figure 1.8 Intraoral dental picture of the maxillary right of a dog with advanced gingivitis (blue arrows) despite the fact that the teeth are fairly clean. Thus, a lack of calculus does not signify that there is no infection and the patient does not require professional intervention. This patient is in dire need of a cleaning.

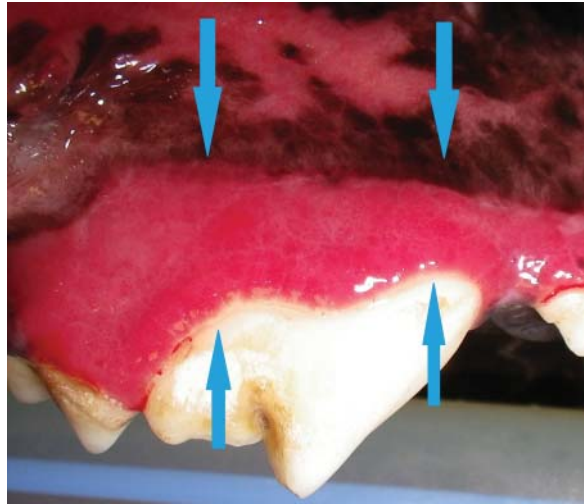


Figure 1.9 Intraoral dental picture of the maxillary right of a dog with significant calculus and minimal gingival inflammation. While this patient does require a cleaning, there is much less infection/inflammation in this case, even though there is significant dental calculus present.



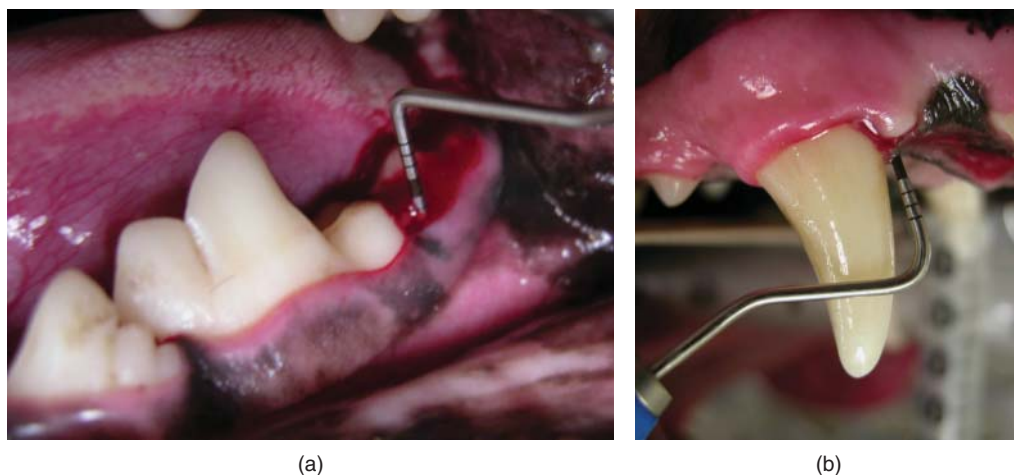


Figure 1.10 Significant attachment loss can be present in patients with clean teeth and no obvious gingival inflammation. (a) Intraoral dental picture of the mandibular left molars (309, 310) of a dog which are clean and demonstrate minimal gingival inflammation. However, periodontal probing reveals a 12-mm pocket. Both of these teeth require extraction despite appearing clean. (b) Intraoral dental picture of the right maxillary canine (104) of a dog which has minimal dental deposits and no evidence of gingivitis. However, periodontal probing reveals a 9-mm pocket. This tooth requires advanced therapy to completely resolve the infection. Ideally this consists of periodontal flap surgery and guided tissue regeneration, however extraction is an acceptable alternative.



Figure 1.11 Gingival recession: Intraoral dental picture of a Yorkshire Terrier with significant gingival recession on the mandibular incisors. This may be diagnosed on conscious oral exam.

As gingivitis progresses to periodontitis (the deeper inflammation of the periodontium resulting in bone loss), the oral inflammatory changes typically intensify (however, advanced periodontal loss can be present despite normal appearing gingiva) (Figure 1.10). The hallmark feature of established periodontitis is attachment loss. There are two common presentations of attachment loss: gingival (gum) recession (Figure 1.11) and periodontal pocket formation (Figure 1.12). When recession occurs, the roots become exposed and may be identified on conscious exam. However, periodontal pockets require general anesthesia for diagnosis.

1.1.3 Onset of Periodontal Disease in Small and Toy Breed Dogs

Periodontal disease is typically thought of as a middle age to older dog problem. This is due to the fact that in most medium and large breed dogs (Cavalier King Charles Spaniels and Greyhounds

Figure 1.12 Periodontal pockets: Intraoral dental picture of the left maxillary third incisor (203) in a miniature Poodle with a deep (7-mm) periodontal pocket on the buccal aspect. Pockets virtually always require general anesthesia for accurate diagnosis.



(a)



(b)

Figure 1.13 Early periodontal loss in a 3-pound poodle. (a) Intraoral dental picture of the left molars (209–10) in a 14-month-old miniature poodle. There is a 4-mm pocket present between the teeth, which in most cases would not be significant. However, the very short roots make this amount of attachment loss enough to create significant mobility and necessitate extraction of the second molar (210). (b) Intraoral dental radiograph of the area demonstrated in (a). There is significant alveolar bone loss (red arrows) between the first and second molars.

being marked exceptions (see below)), periodontal disease does not generally become significant until this time. Therefore, starting professional therapy at four to five years of age has long been an accepted practice in small animal hospitals. However, small dogs typically begin the process of periodontal bone loss very early in life [4, 5]. It has been reported that many dogs less than 10 pounds have demonstrable bone loss at just one year of age [5]. This, in combination with the decreased root length in smaller dogs, creates the need for advanced periodontal therapy (including extractions) much earlier in life. There are numerous reports of extractions being necessary in pets at one year of age (Figure 1.13). In one case treated by this author, 19 extractions were performed in a 19-month-old Pug (Figure 1.14). Furthermore, it is not unusual to perform full mouth extractions in small breed dogs prior to 4 years of age (Figure 1.15). While these are anecdotal reports, most practitioners have similar stories.

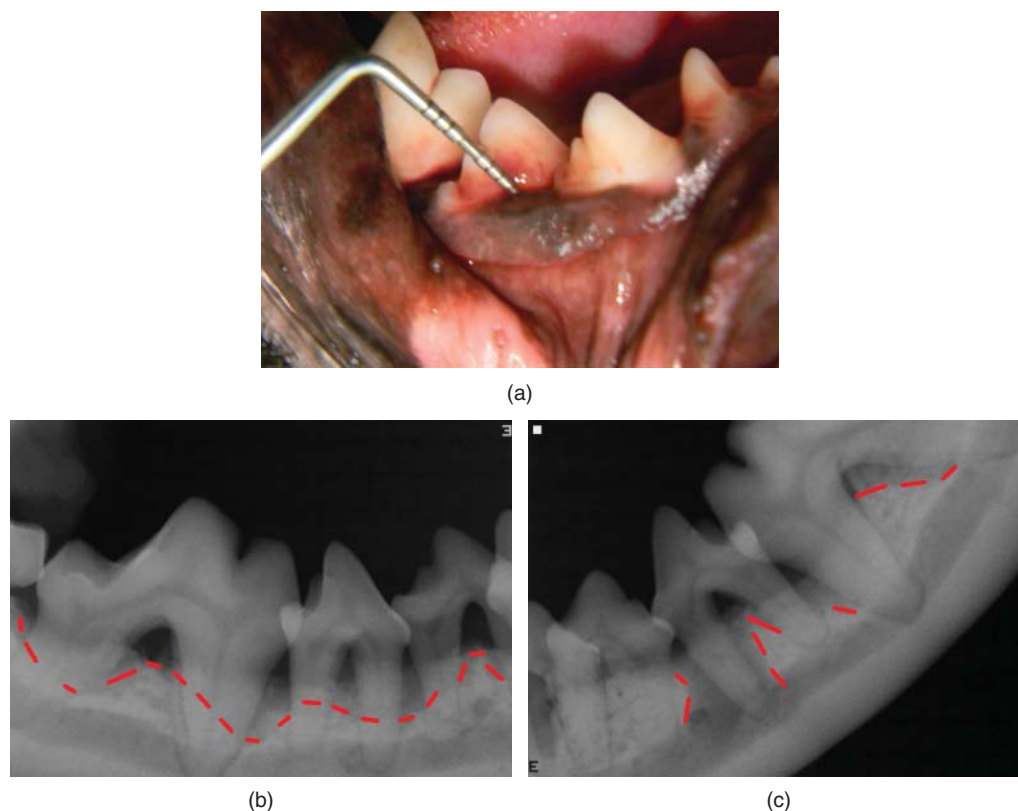


Figure 1.14 Advanced periodontal loss in an 19-month old pug. (a) Intraoral dental picture of the mandibular right premolars demonstrating significant crowding and rotation of the teeth. There is a 6-mm pocket on the fourth premolar (408), despite the fact that the teeth are fairly clean. (b and c) Intraoral dental radiograph of the right (b) and left (c) premolars/first molars of the patient. There is advanced alveolar bone loss (dashed red lines) evident on these images. Most of the imaged teeth required extraction.

1.1.4 Brachycephalic Breeds and Periodontal Disease

In general, these breeds do not appear to be more susceptible to periodontal disease than others of their size (with the exception of Cavalier King Charles Spaniels). For instance, Pugs, as small breeds, tend to suffer from periodontal disease, whereas the larger Boxers tend to be fairly resistant. However, their short maxilla typically creates crowding and rotation of the maxillary premolar teeth [37] (Figure 1.16). Crowding causes a decrease in natural cleaning ability, as well as the lack of a normal gingival collar [12]. These situations markedly increase the incidence of periodontal disease in the affected area. This is of biggest concern when the distal root of the third premolar is crowded between the mesial roots of the fourth premolar [38] (Figure 1.17). When crowding is present (especially involving the fourth premolar), extracting a tooth (the non-strategic tooth if possible) to create room will alleviate much of this issue. (For a complete discussion of rotated and crowded teeth, see below.)

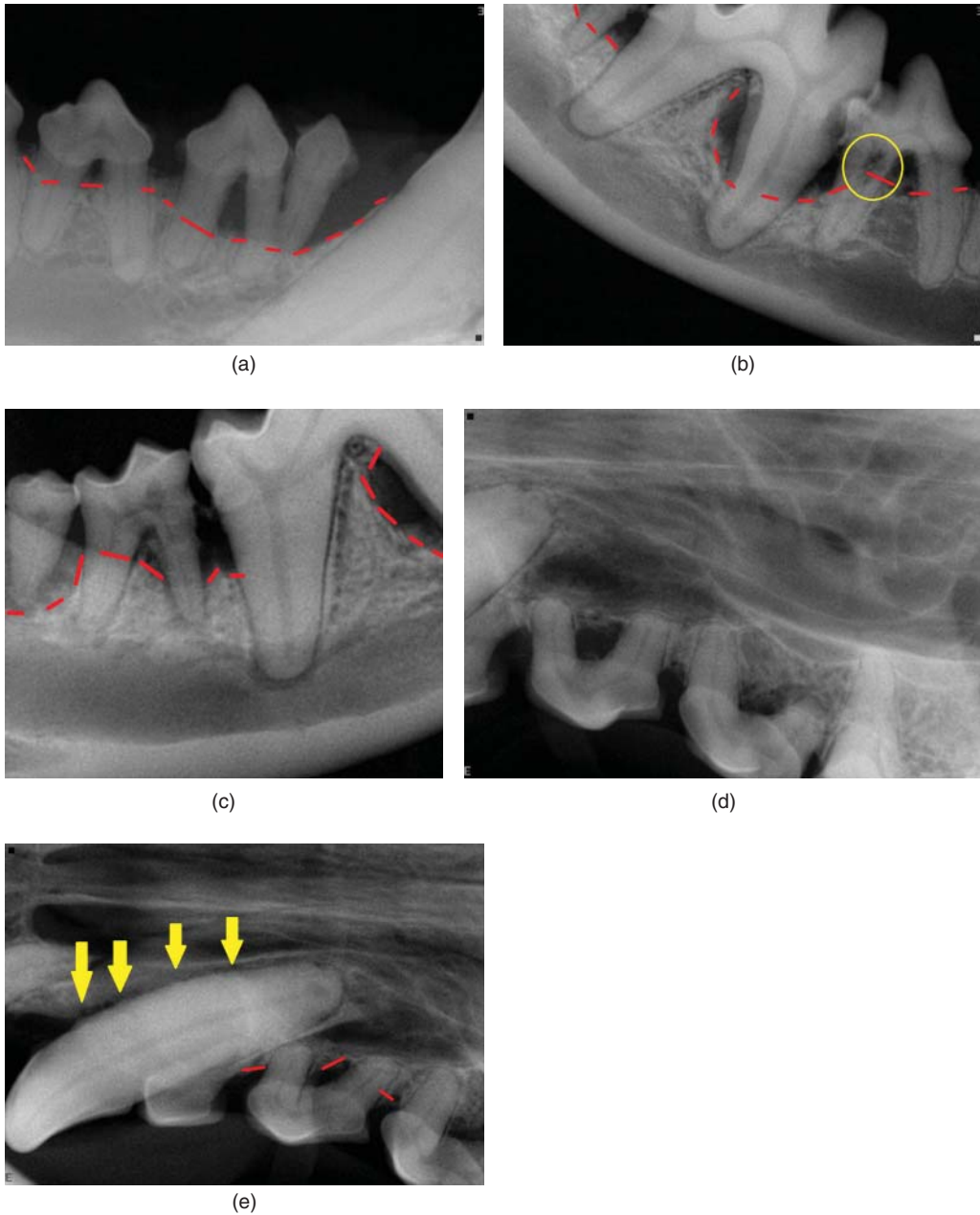


Figure 1.15 Significant periodontal bone loss in a 4-year-old miniature poodle. Dental radiographs of the mandibular right (a, b, c) and maxillary left (d & e) of the patient demonstrating significant alveolar bone loss (dashed red lines). The mandibular fourth premolar (408) already has an evident tooth resorption lesion in the distal root (yellow circle). The maxillary canine (204) has developed an oronasal fistula (yellow arrows).



Figure 1.16 Crowding. Intraoral dental picture of a Pug with significant crowding and rotation of the left maxillary premolar teeth. This patient is less than two years old and already has gingival recession as well as a pathologic periodontal pocket.



Figure 1.17 Intraoral dental picture of the right maxillary arcade in a French Bulldog with significant crowding and rotation of the maxillary premolar teeth. The distal root of the third premolar is between the mesial roots of the fourth premolar. Note the gingival recession and foreign bodies (hair) between the crowded second and third premolars.

1.1.5 Other Predisposed Breeds

Cavalier King Charles Spaniels (CKCS) and Greyhounds are well known for significant periodontal disease [26, 39]. CKCS suffer from early onset periodontal disease, especially in the maxillary premolars (as they are similar to other brachycephalic breeds). There is quite often furcation exposure of these teeth as early as two years of age. Interestingly, it is quite common for them to have advanced periodontal loss with minimal calculus and gingivitis (Figure 1.18).

Greyhounds have a different pattern of attachment loss, in that they quickly develop advanced gingival recession (Figure 1.19). This situation creates early furcational involvement as well as exposing the rougher root surfaces, both of which facilitate plaque accumulation and makes home-care more challenging. Therefore, greyhound owners must start homecare early, which is often not possible as they have often been rescued from a racetrack later in life.

Both of these breeds are very difficult to manage due to the high genetic potential for the disease. They typically suffer from significant gingivitis and early bone loss with only minimal calculus.

Figure 1.18 Intraoral dental picture of the right mandibular first molar (409) in a CKCS. The periodontal probe is demonstrating a 12-mm periodontal pocket, despite the lack of gingivitis and dental calculus. This presentation is not unusual in this breed, and therefore regular cleanings should be performed regardless of clinical signs. This tooth should be extracted to resolve the infection.

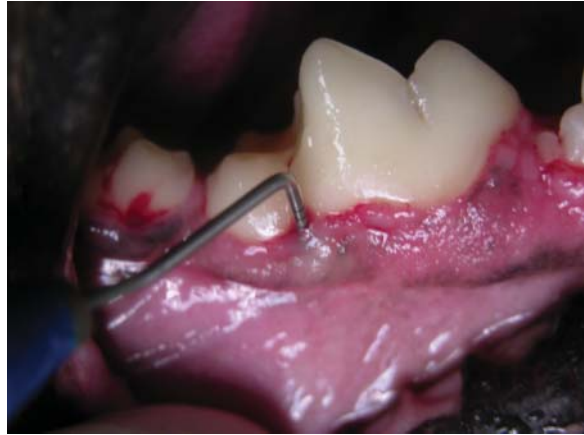


Figure 1.19 Intraoral dental picture of the right maxillary third and fourth premolars (107, 108) in a greyhound. Note that there is advanced gingival recession with minimal inflammation or dental calculus. This is a common pattern of loss in this breed, and the exposure of the cementum, which is much rougher than the enamel, leads to faster plaque accumulation and hastens the recurrence of periodontal disease following professional care. These teeth should be extracted to resolve the infection.



Thus, early initiation of effective and consistent homecare along with regular professional cleanings is critical to maintaining periodontal health.

1.1.6 Significant Local Ramifications of Periodontal Disease

There are several well-established local ramifications of periodontal disease [36, 40]. These include: oronasal fistulas (ONFs) [41], class II perio-endo lesions [42, 43], pathologic mandibular fractures [18, 44], ocular problems (including eye loss) [45, 46], osteomyelitis [47, 48], and an increased risk of oral cancer [49–52]. There does not appear to be a breed predilection to the latter two, but the others are seen with much higher frequency in small breed dogs, and will be detailed below. However, the higher incidence and increased severity of periodontal disease in these breeds likely increases the frequency of neoplastic change and osteomyelitis as well.

1.1.7 Oronasal Fistulas (ONFs)

ONFs are the most common significant local consequence of periodontal disease [40, 53]. This problem is generally seen in older, small breed dogs (especially chondrodystrophic breeds such as Dachshunds and Basset Hounds), but can occur in any breed [41, 54]. ONFs are typically created by the apical progression of periodontal disease on the palatal surface of a maxillary canine [54, 55];

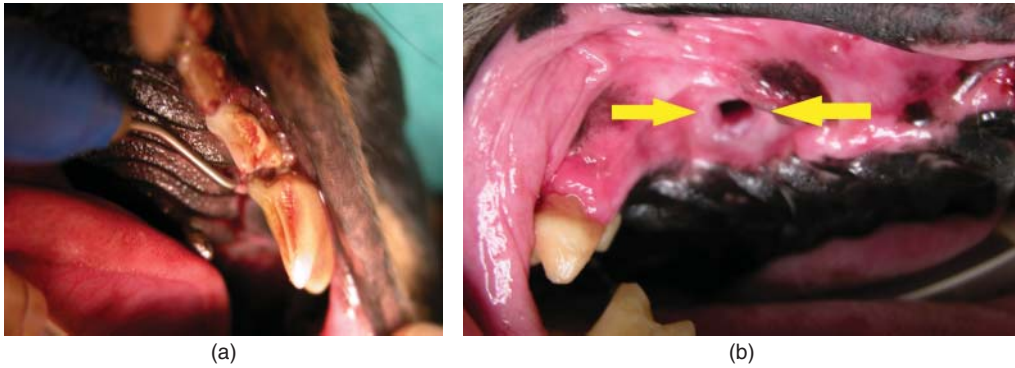


Figure 1.20 Oronasal fistulas can occur on any maxillary tooth. (The examples below actually demonstrate oroantral fistulas as the communication is caudal to the second premolar). (a) Intraoral dental picture of a fistula on the palatine surface of the left maxillary fourth premolar (208) of a Chihuahua. (b) Intraoral dental picture of a fistula from the extraction site of the right maxillary fourth premolar (108) of a miniature poodle (yellow arrows).



Figure 1.21 An oronasal fistula on the right maxillary canine (104) of a Chihuahua. Periodontal probing has created epistaxis from the ipsilateral nares.

(however, any maxillary tooth is a candidate) (Figure 1.20) [41]. This will eventually result in the destruction of the maxillary bone, causing a communication between the oral and nasal cavities and chronic infection (sinusitis) [40, 41, 56].

Clinical signs of an ONF include chronic nasal discharge (often hemorrhagic) (Figure 1.21), sneezing, and occasionally anorexia and halitosis [18, 41]. Occasionally, a large fistula may be noted on conscious exam (especially one that has resulted from an extraction), (Figure 1.22 and see Figure 1.20b) but definitive diagnosis of an oronasal fistula typically requires general anesthesia [41]. The diagnosis is made by introducing a periodontal probe into the periodontal space on the palatal surface of the tooth [40] (see Figure 1.21 and Figure 1.23). ONFs can occur even when the remainder of the patient's periodontal tissues are relatively healthy, including other surfaces of the affected tooth [36] (Figure 1.24 and see Figure 1.21).

Figure 1.22 Large oronasal fistula following extraction of the left maxillary canine (204) on a Dachshund (white arrows). Due to the chronic nature of the fistula, calculus has formed on the root of the third incisor (yellow arrow).

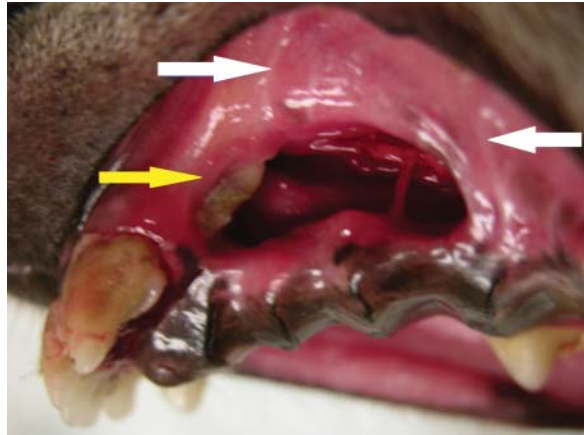


Figure 1.23 Intraoral dental picture of a periodontal probe inserted into the nasal cavity along the palatal aspect of the left maxillary canine (204) of a Basset Hound. This confirms the diagnosis of an oronasal fistula.



Figure 1.24 Intraoral dental picture of an oronasal fistula on the left maxillary canine (204) of a dog. There is dental calculus on the palatal aspect of the tooth, but the remainder of the tooth as well as the rest of the oral cavity is relatively healthy.





Figure 1.25 Post-operative dental picture of a single layer buccal mucosal flap created to close a chronic oronasal fistula. Lack of tension was confirmed prior to suturing.



Figure 1.26 Intraoral dental picture demonstrating a 9-mm periodontal pocket on the mesio-palatine aspect of the left maxillary canine (204) in a dachshund. A fistula has not yet formed, but therapy beyond just a cleaning or closed root planning is required to remove the infection from the root surface. Periodontal flap surgery with guided tissue regeneration (preferred) or extraction is indicated.

Treatment of an ONF involves extracting the tooth (if present) and closing the defect with a *tension free* mucoperiosteal flap [41, 55, 57] (Figure 1.25). Alternatively, if a deep periodontal pocket is discovered prior to creating a communication with the nasal cavity (Figure 1.26), periodontal surgery with guided tissue regeneration may be performed to save the tooth [3, 36, 41].

1.1.8 Class II Perio-Endo Lesion

These endodontic infections are a consequence of advanced periodontal disease, and can occur in any multi-rooted tooth [18, 36, 43, 58]. They occur when the attachment loss progresses apically up the entire root, finally gaining access to the endodontic system via the apical blood supply, causing tooth death via bacterial contamination (similar to a complicated crown fracture) [18, 42, 43] (Figure 1.27). Due to the relative rarity of non-apical ramifications (blood supply other than at the apex) in veterinary patients [59], these infections do not typically occur before the infection reaches the apex. The endodontic infection subsequently spreads through the tooth via the common pulp chamber, creating periapical ramifications on the other root(s) [42, 43]. However, the infected tooth may be retained by the significant surface area of the other root(s) for an extended period of time [43].

Figure 1.27 Class II perio-endo lesion on the left mandibular second molar (310) of a dog. The periodontal loss has extended all the way to the apex of the distal root (blue arrows), allowing the oral bacteria access to the endodontic system via the previous entry point for the blood and nervous supply. This has resulted in the death of the tooth and endodontic infection which spread through the common pulp chamber and created a lesion of endodontic origin (periapical lucency) on the mesial root (red arrow).

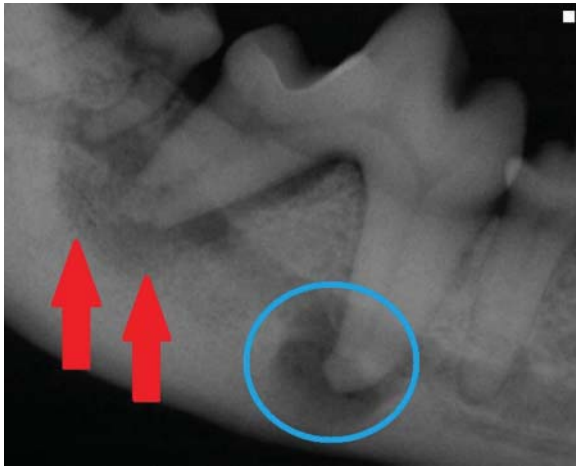
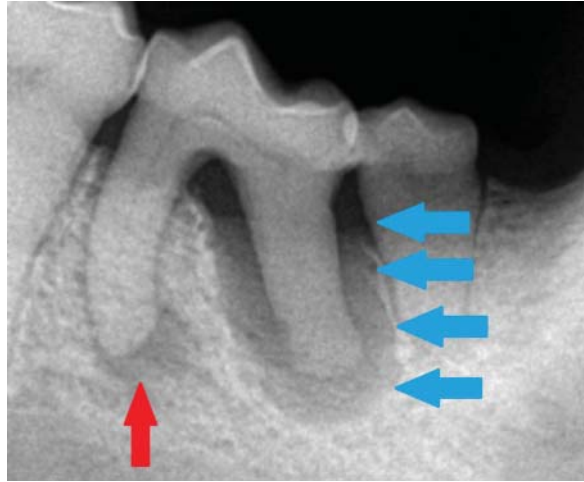


Figure 1.28 Class II perio-endo lesion on the right mandibular first molar (409) of a dog. The periodontal loss has extended all the way to the apex of the distal root (red arrows), allowing the oral bacteria access to the endodontic system via the previous entry point for the blood and nervous supply. This has resulted in the death of the tooth and endodontic infection which spread through the common pulp chamber and created a periapical lucency on the mesial root (blue circle). There is only a small amount of bone apical to the mesial root, increasing the chances of a pathologic fracture during extraction. Extreme care must be taken during the extraction attempt. Finally, note the root resorption of the distal root as well as the fact that the mesial root of the second molar is also affected.

The most common site for periodontal disease to become advanced enough without exfoliation and result in a class II perio-endo lesion is the distal root of the mandibular first molar (Figure 1.28). However, it should be noted that they can occur in any multi-rooted tooth [36, 40].

This condition is most common in older small and toy breed dogs for several reasons, most of which are detailed above [40]. First, these patients have shorter roots compared to their larger counterparts, allowing periodontal infection to reach the blood supply more readily. Second, they tend to develop periodontal disease earlier. Finally, they tend to be longer living, allowing more time for bone loss to occur.

The typical treatment for class II perio-endo lesions is extraction, especially for smaller/non-strategic teeth. However, when one root of a multi-rooted tooth is significantly diseased and the other is healthy, removal of that diseased root while maintaining the healthy/healthier root/s via endodontic therapy may be desirable [42, 43].

The most common indication for root resection in veterinary dentistry is the mandibular first molar of small and toy breed dogs [60]. There is often significant disease associated with the distal root, while the mesial root is spared (Figure 1.29). There are several advantages to root resection in this presentation [61]. First, much of the crown is maintained for mastication. Second, because the distal root is often significantly diseased, its extraction is relatively atraumatic and is therefore less invasive than extracting the mesial root. Similarly, another advantage of tooth resection vs. full extraction of the mandibular first molar is the decreased risk of iatrogenic fracture [40]. With minimal bone apical to the roots in this area which has been further weakened by the periodontally induced endodontic disease, the increased force needed to extract the periodontally healthy mesial root could result in a pathologic fracture (see below).

1.1.9 Pathologic Fracture

One of the most significant local consequences of periodontal disease is a pathologic jaw fracture [18, 40, 44, 62]. These fractures typically occur in the mandible, due to chronic periodontal loss which weakens the bone in affected areas [36, 63–65] (Figure 1.30). Neoplasia and cysts (see impacted teeth below) are a possible but exceedingly rare cause of these fractures as well (Figure 1.31). These fractures can occur in any area of the mandible, but are especially common near the canines and first molars [40]. This condition is significantly more common in small breed dogs [66], 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 [67] (Figure 1.32). Therefore, small breed dogs have a very minimal amount of bone apical to the mandibular first molar roots (especially the mesial), putting this area at high risk of fracture when apical bone loss occurs [67].

Pathologic jaw fractures typically occur as a result of mild trauma such as falling off the couch and dog fights, however some dogs have suffered fractures while simply eating [40]. Furthermore, they often happen during dental extraction procedures (see below) [40]. This is typically considered a disease of older patients, but this author has treated several cases in dogs less than three years of age.

Pathologic fractures always carry a guarded prognosis for several reasons [40, 47, 68]. Healing is impaired by the lack of remaining bone as well as the decreased oxygen tension in the fracture site, and rigidly fixating the caudal mandible is exceedingly challenging [36, 54]. There are numerous options for fixation, but the use of wires, pins or plates is often required [40, 64]. This is because there are often no teeth caudal to the fracture for application of interdental wires or an acrylic splint. Regardless of the method of fixation, the periodontally diseased root(s) must be extracted for healing to occur [36, 47, 68] (Figure 1.33).

Awareness of the potential of pathologic fractures can aid the veterinarian during extractions in at-risk patients [40]. If one root of an affected multi-rooted tooth is periodontally healthy, there is an even greater chance of mandibular fracture due to the increased force needed to extract the healthy root [36, 43] (see Figures 1.28 and 1.29). An alternate form of treatment for these cases is to section the tooth, extract the periodontally diseased root, and perform root canal therapy on the healthy root [42, 43, 69, 70] (see Figure 1.29). In cases where severe alveolar bone loss is noted (especially if the mandibular canine or first molar is affected), it is recommended to inform the owners of

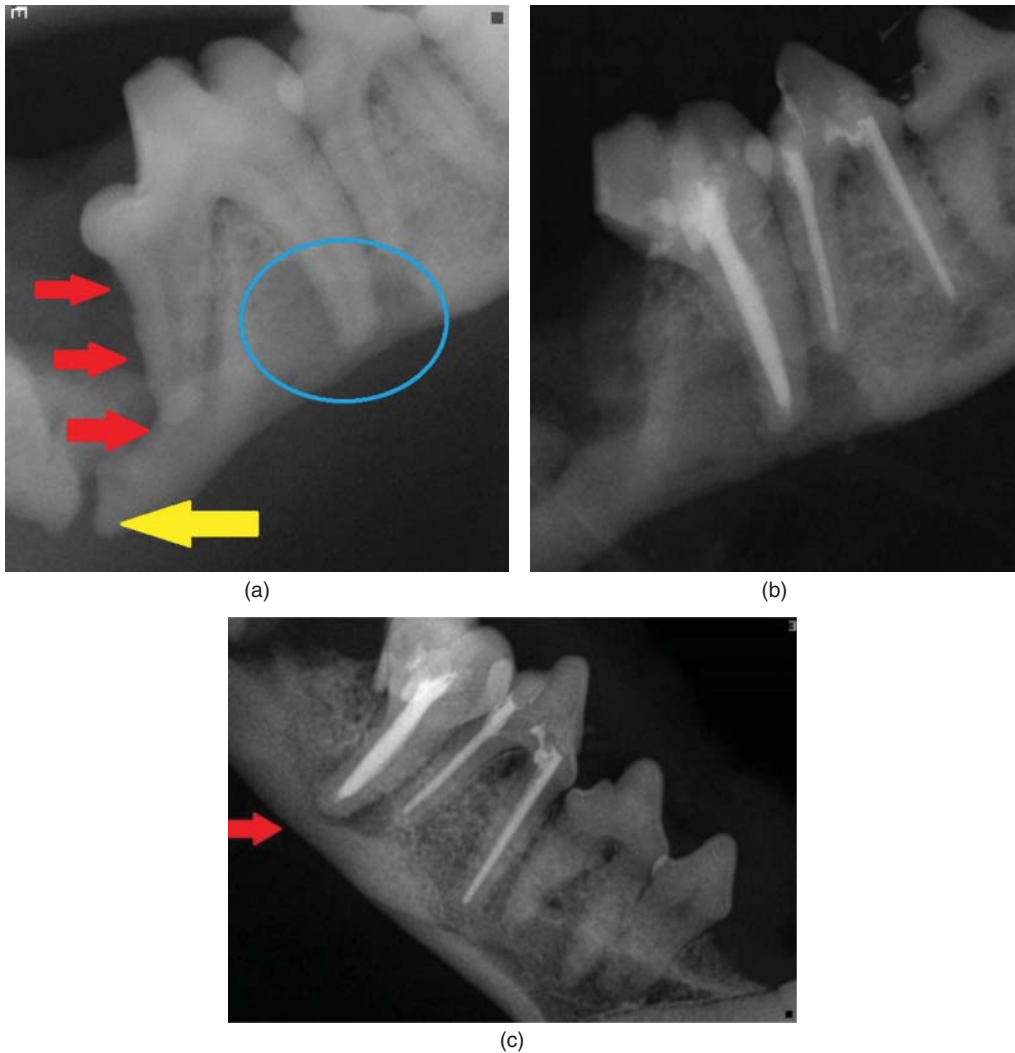


Figure 1.29 A safer option for treating severely periodontally diseased mandibular first molar. (a) Pre-operative dental radiographs revealing extreme weakening of the mandibular bone in the apical area of the right mandibular first molar (409) in a dog. The periodontal loss has extended all the way to the apex of the distal root (red arrows), allowing the oral bacteria access to the endodontic system via the previous entry point for the blood and nervous supply. This has not only resulted in no attachment for the root, but also in the death of the tooth and endodontic infection which spread through the common pulp chamber and created a periapical lucency on the mesial root (blue circle). The bone at the apex of the mesial root is almost non-existent, and there is only a fibrous union in the area just distal to the distal root (yellow arrow). These two factors greatly increase the chances of a fracture during an extraction attempt. (b) Post-operative dental radiograph of the patient in (a). The distal root was sectioned and easily extracted. The mesial root was treated with a root canal to avoid placing pressure on the weakened bone. Note that the fourth premolar was also non-vital and treated with root canal therapy as well. (c) 6-month recheck dental radiographs of the patient in (a & b). There is significant new bone formation in the area of the extraction, as well as almost complete resolution of the periapical lucency (red arrow). This confirmed a successful endodontic therapy and resolution of the weakened mandible.

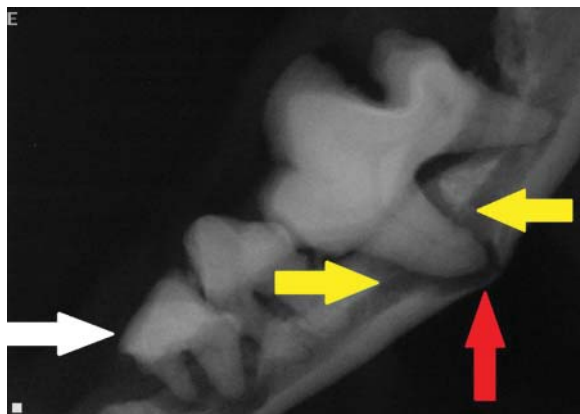


Figure 1.30 Intraoral dental radiograph of the left mandible of a 1.5 kg Yorkshire Terrier with advanced periodontal disease. This has created a complete lack of attachment on the mesial root of the first molar (309) (yellow arrows). This has resulted in a minimal amount of bone (0.3 mm) in the area (red arrow), which significantly predisposes the area to fracture (with mild trauma or during an extraction attempt). Note the complete lack of periodontal attachment of the third premolar (307) (white arrow), resulting in a “floating tooth.”

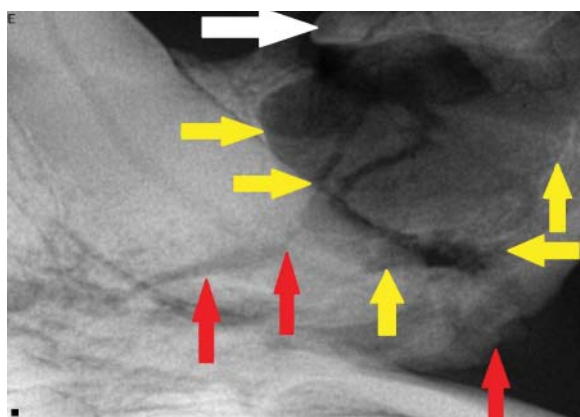


Figure 1.31 Pathologic mandibular fracture in a Boxer secondary to a dentigerous cyst. The patient had an impacted first premolar (white arrow), which has resulted in a larger dentigerous cyst (yellow arrows). The large cyst eventually weakened the jaw sufficiently to cause it to fracture (red arrows) during mild trauma (tugging on a rope).



(a)



(b)

Figure 1.32 Comparison of the root anatomy of small vs. large breed dogs. (a) Normal intra-oral dental radiograph of the right mandibular first molar (409) in a 1.4 kg Maltipoo. The mesial root extends to within 0.5 mm of the ventral cortex of the mandible (yellow arrow). In addition, the root has a significant distal curve (red arrow). Both of these findings greatly increase the chances of fracture should extraction become necessary. (b) Intraoral dental radiograph of the mandibular right first molar (409) of a 37 kg German Shepherd Dog. There is significant (2.5 cm) of bone apical to the tooth roots of the first molar (blue arrows). Thus, there would be plenty of strength left in the jaw even if the periodontal bone was completely lost. Mandibular fracture should not occur in these patients. Note the incidental finding of tooth resorption on the roots of the fourth premolar (408) (yellow arrow). There is no clinical evidence of the resorption, and therefore radiographic monitoring is sufficient.

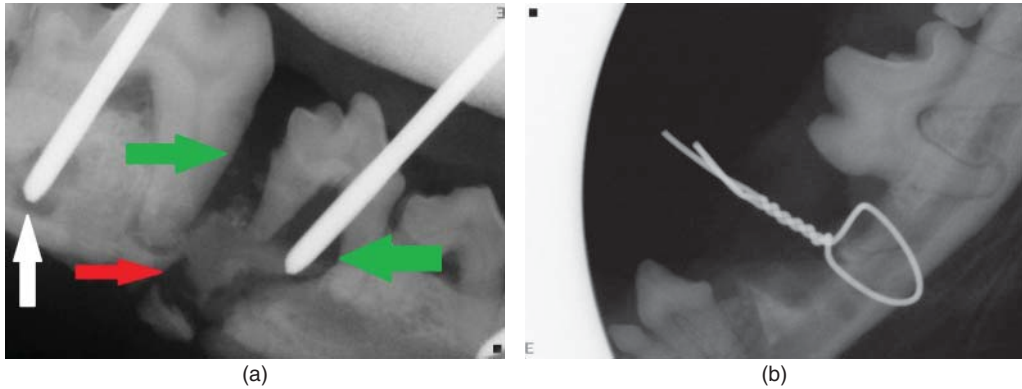


Figure 1.33 Improper treatment of pathologic mandibular fractures resulted in non-union and continued infection vs, proper therapy resulting in a healed fracture site. (a) Intraoral dental radiograph of the right mandible of a Dachshund with a non-healing fracture. The patient has been repeatedly (three times) treated with an external fixator without the benefit of intraoral dental radiographs. This has resulted in failure of fixation and non-union (red arrow). The dental radiographs revealed that there was advanced periodontal disease affecting the fourth premolar and first molar (408 & 409), which was not allowing the bone to heal. Finally, there was damage to and infection of the teeth by poorly placed pins (white arrows). Removal of the appliance and extraction of the infected teeth allowed healing with minimally invasive interfragmentary wires. (b) Intraoral dental radiograph of a pathologic fracture of the mandibular left of a Miniature Poodle. The infected third and fourth premolars (307 and 308) were extracted, and then the fracture reduced and fixed with a single circum-mandibular wire.

the possibility of an iatrogenic jaw fracture prior to attempting extraction of the offending tooth [36, 40]. Referral to a veterinary dentist for extraction of these teeth is strongly encouraged.

1.1.10 Ocular Damage

Another local ramification of advanced periodontal disease results from inflammation close to the orbit which can potentially lead to ocular inflammation, nasolacrimal disease, retrobulbar abscesses, and potentially blindness [36, 40, 45, 46] (Figure 1.34). The proximity of the tooth root

Figure 1.34 Chronic right eye infection in a 5 kg mixed breed brachycephalic dog.



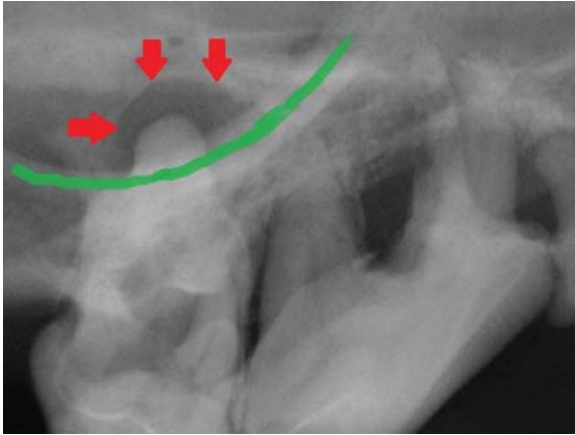


Figure 1.35 Intraoral dental radiograph of the right maxillary first molar (109) in the patient in Figure 1.34. The globe is outlined by the green line. The tooth has a large periapical lucency affecting the palatal root, which resides very close to the globe. The chronic infection almost resulted in enucleation, but was resolved with extraction of the tooth.

apices of the maxillary molars and fourth premolars to the orbit places the delicate optic tissues in jeopardy [46, 71], (Figure 1.35).

1.1.11 Systemic Consequences of Periodontal Disease [72]

While no current research supports that systemic effects of periodontal disease are increased in small and toy breed dogs, there are two facts that may lead to intensification of systemic effects in these breeds. First, as discussed, they typically suffer from a more significant level of disease. Secondly, their larger proportional periodontal surface area provides increased systemic spread compared to body size of larger breeds or human beings.

Systemic ramifications of periodontal disease have been extensively studied over the last few decades, which has resulted in a plethora of publications in peer-reviewed journals. While most of the research has been performed on humans, there is an increasing number of veterinary papers. In addition, while there is currently no proof of cause and effect, there is mounting evidence of the negative consequences of periodontal disease on the systemic health of human and animal patients.

The pathogenesis of the systemic affects is based on the inflammatory cascade. In response to the bacterial infection, the patient creates inflammation within the gingival/periodontal tissues to allow the body's defenses to attack the subgingival bacteria. However, this inflammation not only further inflames the periodontal tissues, it also allows bacteria to gain ready access to the bloodstream and thus to the entire body [73–75]. This is due to enlarged space between the crevicular epithelial cells and increased vascular permeability.

Not only do the bacteria cross the gingival barrier, but also the inflammatory mediators they produce, such as lipopolysaccharides (LPS). The bacteria and their noxious byproducts can create significant deleterious effects throughout the entire body [76]. In addition to the bacteria themselves and their toxic byproducts, systemic effects are also driven by the patient's activation of its own inflammatory mediators such as cytokines (TNF, PGE₂, IL-1, and 6) [77–79]. The effect of these pro-inflammatories on the systemic health of the patient is demonstrated by numerous studies on inflammatory markers in periodontal disease and their response to therapy in both human and veterinary patients [77, 80–82].

Periodontal disease has been linked to numerous systemic problems such as cardiovascular (Figure 1.36), hepatic (Figure 1.37), and renal (Figure 1.38) dysfunction and disease in both veterinary and human studies [7, 77, 80, 83–90]. In addition, human research has revealed associations

Figure 1.36 Post-mortem picture of valvular endocarditis in a miniature Poodle. The patient died of congestive heart failure and had significant periodontal disease. Source: Photo courtesy of Dr. Joao Orvahlo and was previously published in “Veterinary Dental Applications in Emergency Medicine and Critical or Compromised Patients.” Used with permission from Practical Veterinary Publishing.

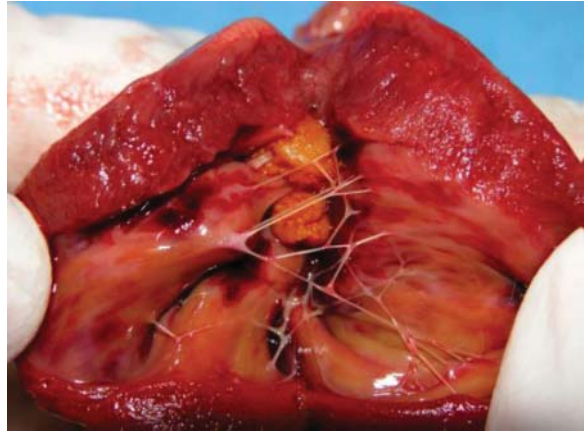


Figure 1.37 Post-mortem picture of areas of abscessation on the liver of a canine patient with multiple organ failure. Source: Images courtesy of Dr. Jerzy Gawor and was previously published in “Veterinary Dental Applications in Emergency Medicine and Critical or Compromised Patients.” Used with permission from Practical Veterinary Publishing.



with cardiac disease, strokes, arthritis, diabetes, pulmonary disease, adverse pregnancy affects, and anemia of chronic disease [75, 91–104].

Recent studies also propose a link between periodontal disease and distant neoplasia such as gastrointestinal, kidney, pancreatic, and hematological cancers [105–109]. Further papers show that human patients affected with periodontal disease are four times more likely to have multiple (three or more) systemic issues than those with good periodontal health [110]. A striking indicator of the degree that periodontal disease negatively affects overall health is established in mortality studies. In several peer-reviewed studies, periodontal disease has been shown to be a significant predictor of hastened mortality in humans [111–113]. One study from Scandinavia reported that severe periodontal disease is actually a higher risk factor for early death than smoking [114].

1.1.12 Systemic Benefits of Periodontal Therapy

It is quite common for canine pet parents whose dogs develop comorbidities (systemic health issues) to express their desire to avoid anesthesia. In addition, many veterinarians are reluctant to anesthetize these patients. These pervasive fears emanate from the myths that anesthesia carries



Figure 1.38 Gross necropsy picture of kidneys with severe glomerulonephritis from a patient who died of renal failure. The patient also had severe periodontal disease which may have contributed to the systemic infection and organ dysfunction. Previously published in “Veterinary Dental Applications in Emergency Medicine and Critical or Compromised Patients.” Source: Used with permission from Practical Veterinary Publishing.

excessive risk as comorbidities develop, or that morbidity and/or mortality increases significantly with age. Further, there has been no perception of significant benefit of dental care and thus those perceived risks are not balanced by the potential benefits derived from proper dental care.

However, it has been shown that age in and of itself has minimal effect on anesthetic morbidity and mortality, other than being clearly associated with comorbidities which do increase anesthetic risk [115, 116]. Further, most comorbidities (even heart disease) carry minimal additional anesthetic risk and the vast majority of pets can still undergo anesthesia, provided it is properly performed and monitored [117]. Finally, recent studies have proven that treating periodontal disease in these patients will improve their overall health (see below).

By far the best studied conditions are diabetes and heart disease in humans. Proper therapy of periodontal disease has been shown to improve glycemic control as well as decrease insulin requirements [118–120]. Conversely, periodontal health is improved in patients with good diabetic control [121, 122]. There is also evidence to suggest that periodontal therapy improves renal function [123, 124]. Furthermore, periodontal therapy has been shown to improve liver values and increase lifespan in patients with cirrhosis [118, 125–127]. Periodontal therapy also has been shown to decrease the level of circulating inflammatory products and improve endothelial function in people [128, 129]. Further studies in the veterinary literature indicate that systemic inflammatory markers and oxidative stress were decreased following periodontal therapy [80, 130].

These studies demonstrate the value of periodontal care in patients with comorbidities as well as the minimal anesthetic risk associated with them. Therefore, clients should be *encouraged* to pursue therapy in all but cases of severe systemic disease. If the practitioner is concerned about the anesthesia risk, referral to a veterinary dentist is recommended. This is because they can typically perform the procedure faster, often practice within a large referral clinic, and may have access to an anesthesiologist. For a list of Board-Certified Veterinary Dentists visit www.AVDC.org.

Conclusions

Periodontal disease is almost ubiquitous in small and toy breed dogs, starting well before one year of age. In addition, the shorter roots often make extractions necessary very early in life. The small, fragile jaws result in numerous significant local ramifications such as oronasal fistulas and pathologic fractures, which are almost unheard of in larger dogs. These situations, in combination with the severe systemic effects represent a significant animal welfare concern (see Chapter 3). Therefore, early and regular intervention is mandated for the long-term health of these patients. For information on therapy of periodontal disease in small and toy breed dogs, please see Chapter 10.

◀ **Editor's note:** This was a brief synopsis of periodontal disease and mostly specific to small breed dogs. Practitioners should not rely on this text as sufficient for a complete understanding of periodontal disease. For more information on this disease process and its treatment the reader is directed to the Wiley text "Veterinary Periodontology" by Dr. Brook A. Niemiec.

1.2 Persistent Deciduous (PD) Teeth

A deciduous tooth is considered persistent as soon as the permanent tooth begins to erupt into the mouth [131]. This means that the permanent tooth does not need to be fully erupted for the deciduous to be considered persistent [132, 133]. This condition is far more common in toy and small breed dogs, and Yorkshire Terriers appear particularly predisposed [131, 134]. This is likely due to the change in the facial structures created by specialized line breeding [135].

The most common cause for a deciduous tooth to be persistent is an incorrect eruption path of the permanent tooth [131, 135]. When the permanent tooth erupts along its natural path, it places pressure on the apex of the deciduous tooth resulting in apical resorption in the deciduous tooth [48, 136]. The steady coronal advancement of the permanent tooth will result in continued resorption of the deciduous. This progresses until the deciduous root is sufficiently resorbed, at which point it exfoliates, and the permanent tooth assumes its normal position in the mouth [137].

When a permanent tooth follows an unnatural path, there will be no impetus for the root of the deciduous tooth to resorb [138]. This results in the deciduous tooth remaining in the arcade with the permanent tooth erupting alongside. This improper path is currently considered to be genetic because of the pattern of occurrence within specific breeds and skull types [135].

Persistent deciduous dentition is typically bilateral. The most common teeth to be persistent are the canines, the incisors are next most common, and finally premolars [135]. Oral exam will reveal extra teeth in the arcades, giving the appearance of crowding (Figure 1.39). In addition, the adult dentition may be in an abnormal position [131] (Figure 1.40). This unnatural position may cause tooth, gingival, or palatine trauma [131, 135]. This may also result in traumatic pulpitis in the permanent dentition [37]. Studies have shown these orthodontic problems can occur within 2 weeks of the permanent tooth starting to erupt [132, 135].

In addition to orthodontic consequences, periodontal problems are a potential sequela of persistent deciduous teeth [16]. The most obvious reason is that the retained deciduous teeth typically create crowding. Crowding decreases the natural cleaning ability derived from chewing, thus hastening the formation of plaque and thus promoting periodontal inflammation [12, 18, 37, 139].

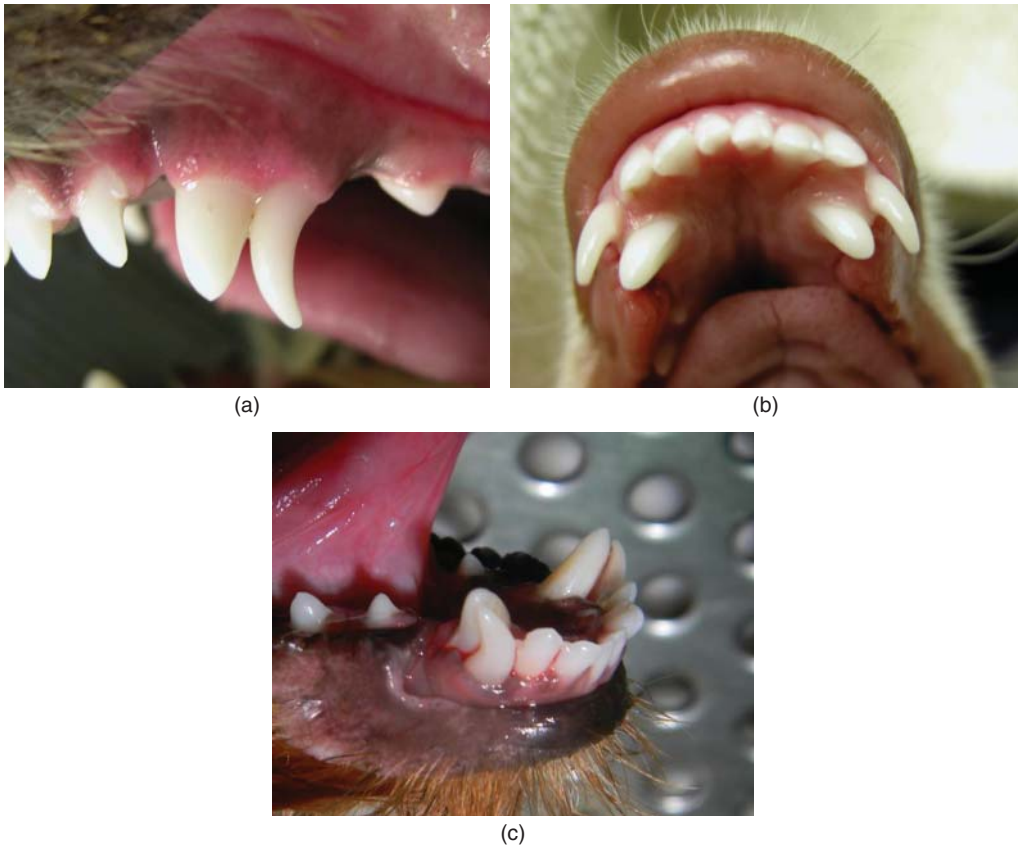


Figure 1.39 Persistent deciduous teeth. The most common appearance of persistent deciduous teeth is the appearance of an “extra” crowded tooth. Examples of a left maxillary canine (604) (a), mandibular canines (704 & 804) (b) and right mandibular canine (804) (c). Note that in a & c, there is no gingival collar between the teeth and in (b) that the permanent canines are linguoclused.



Figure 1.40 Deviation of the permanent teeth into abnormal and potentially traumatic positions by the persistent deciduous teeth. (a) The persistent deciduous right mandibular canine (804) is keeping/deflecting the permanent canine (404) lingually resulting in palatine trauma from the permanent. (b) The persistent deciduous left maxillary fourth premolar (608) is keeping/deflecting the permanent fourth premolar (208) buccally resulting in trauma to the buccal mucosa from the permanent as well as loss of normal chewing ability.



Figure 1.41 Persistent deciduous teeth hasten the onset of periodontal disease in the corresponding permanent tooth due to crowding. (a) Intraoral dental picture of a 9-month-old Yorkshire Terrier with persistent deciduous canines. The crowding has led to an early accumulation of plaque and calculus along with associated gingivitis (blue arrow). (b) Intraoral dental picture of the mandibular incisors and canines in a 12-month-old miniature Poodle. All 6 deciduous incisors and both canines are persistent. The crowding has resulted in significant accumulation of foreign bodies (hair) as well as significant inflammation and infection.

Figure 1.42 Persistent teeth do not allow for normal maturation of the gingiva, resulting in early periodontal attachment loss. This is an intraoral dental picture of the right mandibular canines (804 and 404) in a 16-month-old Yorkshire Terrier. The crowding has resulted in a rapid loss of periodontal attachment, creating a 9-mm pocket in a very young dog. Advanced therapy (periodontal flap surgery and guided tissue regeneration) was required along with extraction of the deciduous tooth. Alternatively, the permanent canine could also have been extracted.



(Figure 1.41). A hidden, but perhaps even more important situation comes from the fact that the deciduous and permanent teeth share the same gingival collar [132]. The lack of a maturation of the gingiva with the permanent tooth results in a weakened periodontal attachment and thus increased susceptibility to periodontal disease [131, 135] (Figure 1.42). Human studies report that this periodontal damage starts *within 48 hours* of the permanent tooth *starting* to erupt [131, 132]. These findings mean that retained deciduous teeth in small and toy breed dogs are even more concerning because as previously discussed, these patients are also more prone to periodontal disease.



Figure 1.43 The permanent tooth does not need to be fully erupted for the deciduous to be considered persistent. As soon as any part of the permanent tooth is visible, it is considered persistent and extraction is indicated.

These significant ramifications make prompt therapy of PD teeth a medical priority. Remember, the permanent tooth does not need to be completely erupted for these problems to occur [132]. In fact, problems begin as soon as the permanent tooth starts to erupt (Figure 1.43). Therefore, timely extraction of these teeth is of vital importance, especially in small and toy breeds. *There should never be two teeth of the same type in the same place at the same time* [132].

In the past, these teeth would be dealt with at the time of neutering. However, given that the canine teeth erupt at four to five months of age and neutering rarely occurs prior to six months of age, the delay can create significant damage. Furthermore, there is a trend towards delaying or completely avoiding neutering, thus making this no longer an acceptable practice.

1.2.1 Treatment

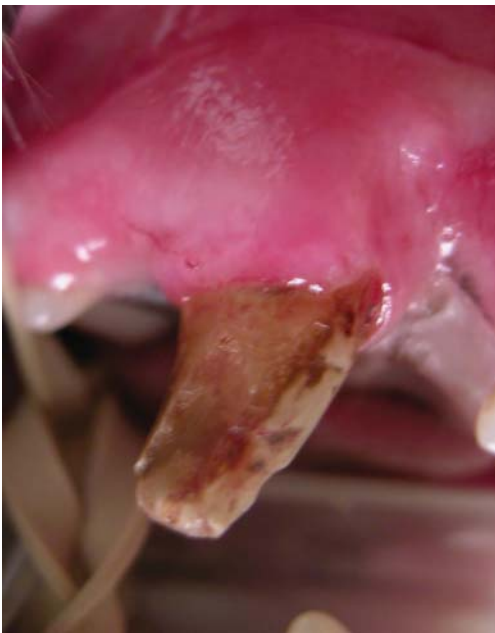
PD teeth should be extracted as expediently as possible to help avoid the periodontal and orthodontic ramifications [140]. For small and toy breed dogs, it is recommended to have the clients monitor the maxillary canines for eruption. As soon as the permanent canines begin erupting, the pet should be presented to a veterinarian for evaluation and extraction if necessary.

Extractions of deciduous teeth can be very difficult as the roots are proportionally much longer and thinner than in the corresponding permanent dentition [141, 142] (Figure 1.44). Deciduous extractions must be performed very carefully and gently with a large amount of patience [141, 143, 144].

Another reason to be cautious during deciduous extractions is to avoid damaging the developing permanent tooth [140, 141]. Prior to eruption, the immature enamel is very susceptible to damage which can easily be caused by an elevator, and once damaged cannot be naturally repaired [145–147]. This can result in enamel hypocalcification, which exposes the dentin and leads to pain and possible infection (Figure 1.45a) [148–152]. In addition, the roughened tooth surface can hasten the accumulation of plaque and calculus and thus speed the development of periodontal disease [18, 146, 153]. If this occurs, the affected teeth should be restored, either with a bonded sealant or composite restoration (Figure 1.45b).

Dental radiographs are absolutely critical to extracting deciduous teeth [138, 154]. Deciduous teeth will often undergo some to significant resorption, typically due to the pressure placed on it

Figure 1.44 Deciduous teeth are much longer and thinner than permanent teeth. This image demonstrates the relative size of the crown (left of the red line) and root (right of the red line) on a deciduous maxillary canine (top) and first incisor (bottom). Client education as to the size of these roots is important for increasing compliance.



(a)



(b)

Figure 1.45 Significant damage can be caused to the permanent tooth during deciduous extractions. (a) The permanent right maxillary canine (104) was severely damaged during extraction of the deciduous tooth. This has created not only significant sensitivity (pain) and potential endodontic infection, but in addition roughness will increase plaque and calculus attachment, hastening periodontal disease. (b) Post-operative image of the tooth imaged in (a) following the application of a composite restoration. The restoration blocks of the pathway for pain and infection, but also smooths the tooth to retard plaque formation. Restorative dentistry is part of a comprehensive periodontal therapy protocol.

by the erupting permanent dentition (Figure 1.46). These teeth are predisposed to fracture, but an intact root canal is often still present. The resorption and potential ankylosis makes extraction very difficult, commonly resulting in a fractured root. Contrary to popular belief, intact/normal deciduous roots do NOT resorb, and will affect the patient regardless of the lack of clinical signs [132, 155] (Figure 1.47).

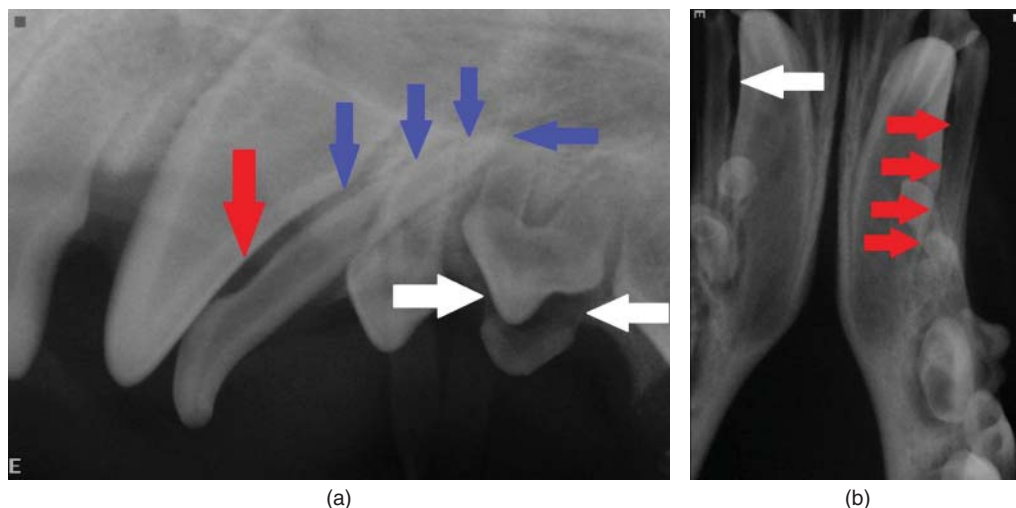


Figure 1.46 Partial resorption of persistent deciduous teeth greatly complicate extraction attempts. (a) Intraoral dental radiograph of the maxillary left of a 5-month-old dog. The permanent second premolar (206) is correctly erupting just under the deciduous causing it to be appropriately resorbed (white arrows). However, the permanent canine (204), is erupting mesial to the corresponding deciduous, thus no eruptive pressure is being applied, resulting in a normal root remaining (blue arrows). However, the lateral pressure at the gingival margin created a area of resorption at the neck of the deciduous tooth (red arrow). This cervical resorption often causes fracture of the root at the gumline. Knowledge of this situation will smooth the extraction. (b) Intraoral dental picture of the mandibular canines of a 7-month-old dog. On the right side, there is a small area of resorption at the gingival margin (white arrow), with normal roots apical to that point. The root is very weak at this point, so extreme care must be taken to avoid a root fracture. The left deciduous canine has significant resorption of the root (red arrows), but enough remaining root to require complete extraction. A surgical (open) extraction is strongly recommended from the beginning to improve the chances of successful extraction.

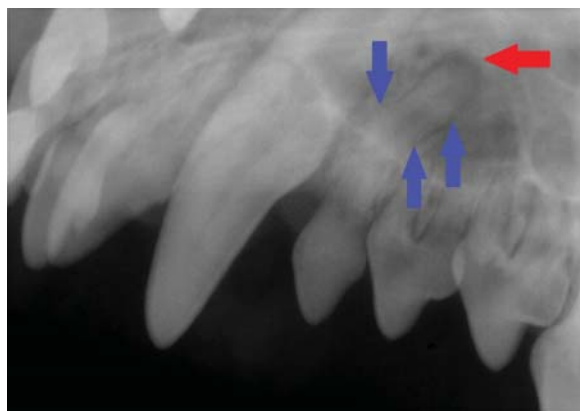


Figure 1.47 Intraoral dental radiograph of the maxillary left in a 14-year-old Maltese. This patient had been suffering from long term ocular infections. Dental radiographs revealed a retained root of the deciduous canine (604) (blue arrows). The tooth also was infected as evidenced by the periapical lucency (red arrows). Extraction of the deciduous tooth resulted in resolution of the infection. This case demonstrates the importance of complete extraction of deciduous teeth as well as dental radiography as a critical diagnostic modality for maxillofacial disease.

However, on occasion, the root of the deciduous tooth may have already been almost completely resorbed [138] (Figure 1.48). In this situation, only the crown and the very small retaining root segment need to be extracted. Having this knowledge initially, saves the practitioner time in searching for the root, avoids undue stress and worry, and avoids unnecessary surgical trauma for the patient.

Some veterinary dentists perform surgical extractions for deciduous canines to decrease the possibility of causing iatrogenic damage [131]. Most veterinary dental texts recommend closed

Figure 1.48 Intraoral dental radiograph of a persistent deciduous right mandibular canine (804). In this case, the root is completely resorbed, and the crown is only held in by the gingival attachment (red arrow). Extraction in this case is simple, and this knowledge avoids unnecessary surgical exploration for a non-existent root.



Figure 1.49 A 1.3 mm luxating elevator is a good choice for deciduous extractions.



Figure 1.50 Fahrenkrug elevator is curved to correctly follow the roots of deciduous canines.

extractions in cases with significant root resorption, while a surgical approach be employed when the root appears normal [141, 148]. However, this author recommends a closed technique for the vast majority of deciduous extractions due to decreased surgical time and trauma of the surrounding tissues [141, 148]. A very small (1–2 mm) and sharp luxating elevator (Figure 1.49) used in a “rock in and twist” motion is best for these teeth [156]. Alternatively, specially designed Fahrenkrug elevators can be utilized (Figure 1.50).

Root fractures are a common complication of extractions, especially of deciduous teeth [157]. If a root breaks, every effort should be made to remove the retained piece(s) [131, 140, 148, 158]. Despite the common thought that roots of deciduous teeth resorb on their own, it is simply not true. Resorption of deciduous teeth occurs most commonly due to pressure from the erupting permanent dentition. Once the permanent crown has erupted, little to no resorption pressure will be placed on the deciduous (see above).

A retained root tip may become infected or act as a foreign body, thereby creating significant inflammation [159]. Unfortunately, there are rarely clinical signs associated with this, but retained roots are known to be painful, and often become infected [148]. Complete root tip removal is even more critical when performed for certain interceptive orthodontic purposes (especially linguocluded mandibular canines), because the apex is sufficient to deflect the permanent tooth from its normal location as well as possibly impede eruption of the permanent [148, 160]. Retained roots are best extracted utilizing a surgical (open) approach [141, 148, 156].

Post-operative dental radiographs are strongly recommended following extraction, in order to confirm complete removal of the deciduous tooth as well as the presence and proper condition of the unerupted permanent teeth [132, 157].

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