VETERINARY
DENTAL
SPECIALTIES

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ORAL PATHOLOGY

Persistent deciduous teeth

Persistent deciduous teeth are very common, especially in small and toy breed dogs. However, they can occur in any breed as well as cats. They create both orthodontic and periodontal problems if not treated promptly. It used to be believed that the persistent deciduous caused the permanent tooth to become malocclused. Studies have shown, however, that it is the permanent tooth erupting incorrectly that causes the deciduous to be persistent.

It has been reported that orthodontic problems begin within two weeks of the permanent canines starting to erupt. This is due to the deciduous tooth being in the place that the adult wishes to occupy.

The periodontal issues occur due to a disruption of the normal maturation of the periodontium. When there is a persistent deciduous tooth, one area of the periodontium is not attaching to the permanent, therefore the periodontal attachment in that location will not be normal. It has been reported that the damage begins within 48 hours of the permanent teeth starting to erupt!

Therefore, the adult tooth does not need to be completely erupted for these problems to occur, and they should be extracted as early as possible, do not wait until six months of age to perform the extractions along with neutering. In fact, we recommend that the owners of breeds prone to retain their teeth be instructed to watch for eruption of the permanent teeth and to present the patient for therapy as soon as this occurs.

Fractured teeth

The two main types of crown fracture seen in veterinary medicine are complicated and uncomplicated. Both types require therapy; however, treatment for each is often different.

All teeth with direct pulp exposure (complicated crown fractures) should be treated with endodontic or exodontic therapy; ignoring them is NOT an option. Prior to tooth necrosis, the viable nerve is excruciatingly painful. Following tooth death, the root canal system will act as a bacterial super-highway creating not only local infection, but also a bacteraemia which has been linked to more serious systemic diseases (see the article on periodontal disease for further information). The owners of these patients will be reluctant to pursue therapy as "It does not seem to bother the dog". Fractured and/or infected teeth do bother the pet and they will act better following therapy. Veterinary patients are known for being stoic, and therefore lack of outward signs of oral pain should not be misinterpreted as a benign state. Therefore, you must be a patient advocate and recommend therapy.

Uncomplicated crown fractures are also a very common finding on oral exam, particularly in large breed dogs. These fractures will result in direct dentinal exposure. The exposed dentinal tubules will create significant pain for the patient. The currently accepted means by which this sensitivity is created is via the theory of fluid dynamics. In addition, some of these teeth will become non-vital due to the traumatic incident, pulpal inflammation, or direct pulpal invasion via the dentinal tubules. For these reasons, it is recommended that these teeth be radiographed to ensure vitality. If the teeth are non-vital (evidenced by periapical rarefaction or a widened root canal) endodontic or exodontic therapy is required. If the teeth appear vital, the application of a bonded composite is recommended to decrease sensitivity (please see the article on composite bonding later in the issue for further information).

Intrinsically stained teeth: Endodontic disease is also manifested by intrinsic staining. This can appear as pink, purple, yellow, or grey. A study by Hale showed that only 40% of intrinsically stained teeth had radiographic signs of endodontic disease, however 92.7% are non-vital. Non-vital teeth lose their natural defence ability and are often infected via the bloodstream, which is known as *anachorisis*. Therefore, do not rely on radiographic appearance to determine vitality; all teeth should be definitively treated via root canal therapy or extraction.

Enamel hypocalcification (hypoplasia)

Enamel is a very thin (<1mm) material on the surface of tooth crowns. It is formed and deposited on the dentin by the enamel forming organ which consists of cells called ameloblasts. Enamel is only formed prior to tooth eruption and cannot be naturally repaired after eruption into the mouth. Hypoplasia/hypocalcification results from disruption of the normal enamel development. Ameloblasts are very sensitive and minor injuries can result in enamel malformation.

Areas of enamel hypocalcification will generally appear stained a tan to dark brown (rarely black) color and may appear pitted and rough. The tooth surface is hard however, as opposed to the soft/sticky surface of a caries lesion. The areas of weakened enamel are easily exfoliated which will expose the underlying dentin, resulting in staining.

Dentin exposure will result in significant discomfort for the patient (see uncomplicated crown fractures above).

The roughness of the teeth will also result in increased plaque and calculus retention, which in turn leads to early onset of periodontal disease. For all these reasons, prompt therapy of these teeth is critical to the health of the patient.

Treatment is aimed at removing sensitivity, avoiding endodontic infection by occluding the dentinal tubules, and smoothing the tooth to decrease plaque accumulation. The most efficient and effective way to accomplish these goals is placement of a bonded sealant. If the damage is severe and the client is interested in a permanent correction, crown therapy can be performed. Alternatively, extraction may be performed; however, this is not the recommended course of therapy if the root structure is normal with no evidence of endodontic infection.

Feline Tooth resorption: TRs are a very common malady. Reports vary as to their incidence, but approximately 60% of cats over 6 years of age have at least one, and those that have one typically have more. These lesions are caused by odontoclasts which are cells that are responsible for the normal remodelling of tooth structure. These cells are activated and do not down regulate, resulting in tooth destruction.

There are currently two recognized forms of resorptive lesions, type 1 and type 2. Clinically, they appear very similar, as dental defects that are first noted at the gingival margin. However, advanced cases will show significant tooth destruction

and may appear to be a fractured tooth. The best diagnostic tool for differentiating between types is dental radiology. With type 1 lesions, there is no replacement of the lost root structure by bone, whereas with type 2 there is generally marked replacement of the lost tooth structure.
Extraction is now the treatment of choice; however, they can be very difficult in these cases due to tooth weakening and ankylosis. Additionally, in some cases, there is little to no tooth structure remaining. In cases with significant weakening and or ankylosis, performing the extractions via a surgical approach is recommended to speed the procedure and decrease the incidence of fractured and retained roots (see extraction article).
Recently, crown amputation has been suggested as an acceptable treatment option for advanced type 2 lesions as it results in significantly less trauma and faster healing than complete extraction. This procedure, although widely accepted, is still controversial. Most veterinary dentists employ this technique, however in widely varying frequency. Veterinary dentists typically employ this treatment option only when there is significant or complete root replacement by bone. Unfortunately, most general practitioners use this technique far too often. Crown amputation should only be performed on teeth with radiographically confirmed advanced type 2 TRs which show no peri-apical or periodontal bone loss. Crown amputation should not be performed on teeth with type 1 TRs, radiographic or clinical evidence of endodontic or periodontal pathology, inflammation, or infection; or in patients with L/P stomatitis. Those practitioners without dental radiology capability SHOULD NOT perform crown amputation. In these cases, the teeth should either be fully extracted, or the patient referred to a facility with dental radiology.

Missing teeth

There are several reasons that teeth may be missing. These reasons include congenitally missing, previously extracted, fractured (or extracted) with retained roots, or impacted. The first two scenarios do not require therapy, whereas the latter two may necessitate intervention. Therefore, dental radiographs are indicated in all cases of "missing teeth".
If dental radiographs reveal retained roots and evidence of inflammation or infection (clinical or radiographic), the teeth should be surgically extracted. If they are "quiet", the owners should be informed and given the option of having the teeth surgically extracted.
On occasion, an unerupted tooth may lead to the development of a dentigerous cyst. The incidence of this is 29% of dogs in one veterinary study. A dentigerous cyst is a fluid filled structure which develops from the enamel forming organ, of an unerupted tooth. Small dentigerous cysts are generally asymptomatic, and often go undiagnosed without dental radiology. If clinical, these cysts will generally be swellings in the area of a missing tooth in a young patient. Dentigerous cysts can become quite large and disfiguring, requiring major surgical correction.
In addition, these cysts may become infected, resulting in acute swelling and pain. Finally, dentigerous cysts have reportedly to undergone neoplastic transformation. Dental radiographs are generally diagnostic, revealing a unilocular radiolucent area that is associated with the crown of an unerupted tooth. An aspirate obtained for fluid analysis and cytology will be supportive of a cyst.
Prognosis for these lesions is excellent if diagnosis and treatment are achieved relatively early in the disease course. Surgical removal of the offending tooth and careful debridement of the cystic lining will prove curative. It is important to avoid leaving any of the cystic lining behind, as this could allow the cyst to reform. Early surgical intervention will result in the least invasive surgery possible.

Oral neoplasia

The oral cavity is the fourth most common place to encounter neoplastic growths. The most common oral growths are the epulids (fibromatous and ossifying). These are benign overgrowths of the periodontal ligament (harmatomas). These can grow very large but are not aggressive. Acanthomatous Ameiloblastomas (epulids) are locally aggressive. They do not metastasize and are mildly aggressive locally. They respond well to local excision with ½ cm margins and enjoy a 90% control rate with radiation therapy.
Benign tumors are exceedingly rare in cats. By far the most common malignant oral tumor in cats is a squamous cell sarcoma. Fibrosarcomas are a distant second. Both tumors are typically seen in older cats, are locally aggressive, and are late to metastasize. The only therapeutic option at this point is early, aggressive surgery (2 cm surgical margins).
The above tumors are also seen in dogs. Their behaviour and therapy are similar to cats, however these tumors respond better to radiation therapy in dogs. In dogs, the most common malignant tumor is a melanoma which is typically seen in older dark pigmented dogs. Melanomas are not only locally aggressive; they also metasitizes very early in the course of the disease. A combination of aggressive surgery, radiation therapy, and chemotherapy is the best way to treat this disease process. In addition, a vaccine has been recently released that shows promise as an adjunct therapy for this disease process.

Caudal Stomatitis

This is another relatively recent disease process in cats that is frustrating us at present. The best description is a severe immune mediated reaction to dental tissues, but we really don't know. Some feel that this may be a group of disease processes that look the same clinically which is why they can be very frustrating to treat.
The history will generally include anorexia, drooling, gagging, and pain during mastication. Physical exam will typically include a thin pet with unkempt fur. The oral exam will reveal severe stomatitis usually over all teeth. The inflammation will most commonly be worse on cheek teeth than canines and incisors. However, faucitis is the key clinical finding. Severe hyperplastic inflammation to the gingiva can result from periodontal disease, however caudal stomatitis will not be present.
Medical Therapy*:* Most medical therapies will work for a while, however in general resistance will start within a year or less. In addition, most therapies have side effects worse than the disease process in and of itself. In general, medical therapy is very frustrating to the practitioner and client.

Corticosteroids are the mainstay of most medical therapy today. It is generally very effective at first and is relatively inexpensive for the client. In my experience, injectable (depomedrol 10 mg IM) is much more effective than oral preparations in my experience. However, they will typically loose effectiveness after a year or so requiring higher and higher doses at shorter increments. This generally results in significant deleterious effects.

***Surgical Therapy**:* Extraction is currently the ONLY effective long-term treatment for this disease process in cats. In our experience, the sooner this is done, the better that cats do both post-operatively as well as long term.

For extractions to be successful, the teeth must be COMPLETELY removed. Therefore, post-operative radiographic confirmation of complete extraction of the tooth roots is recommended. Following the insurance of complete removal of the teeth, perform aveloplasty to remove the periodontal ligament and smooth rough bony edges. This is typically performed do this with a rough diamond bur.

Studies report a 60% success rate when all teeth caudal to the canines are extracted, however our experience has not been as good. However, whole mouth extractions have a success rate of approximately **90-95%** for clinical remission. Slight faucitis may remain, but pets are comfortable. In addition, the rare cases that don't completely respond are generally much more responsive to medical therapy.

If there is NO inflammation to the canines or incisors (which is rare), then the owner is given the option of leaving the canines. However, if these are inflamed, all teeth should be extracted. If the teeth are ankylosed, complete root pulverization may be necessary.

PERIODONTAL DISEASE

Introduction: Periodontal disease is the number one health problem in small animal patients. The classic study reported that by two years of age, 70% of cats and 80% of dogs have some form of periodontal disease. However, more recent studies report that 90% of dogs at just 1 year of age have some form of periodontal disease. However, there are generally little to no outward clinical signs of the disease process, and therefore, therapy typically comes very late in the disease. Consequently, periodontal disease may also the most undertreated disease in our patients. Additionally, unchecked periodontal disease has numerous local as well as systemic consequences. Local consequences include: oronasal fistulas, class II perio-endo lesions, pathologic fractures, ocular problems, osteomyelitis, and increased incidence of oral cancer. Systemic diseases which have been linked to periodontal disease include renal, hepatic, pulmonary, and cardiac diseases; osteoporosis, adverse pregnancy effects, and diabetes mellitus.

Pathogenesis: Periodontal disease is generally described in two stages, gingivitis and periodontitis. Gingivitis is the initial, **reversible** stage in which the inflammation is confined to the gingiva. The gingival inflammation is created by plaque bacteria and may be reversed with a thorough dental prophylaxis and consistent homecare. Periodontitis is the later stage of the disease process and is defined as an inflammatory disease of the deeper supporting structures of the tooth (periodontal ligament and alveolar bone) caused by microorganisms. The inflammation results in the progressive destruction of the periodontal tissues, leading to attachment loss. This can be seen as gingival recession, periodontal pocket formation, or both. Mild to moderate periodontal pockets may be reduced or eliminated by proper plaque and calculus removal. However, periodontal bone loss is **irreversible** (without regenerative surgery). Although bone loss is irreversible, it is possible to arrest its progression. However, it is more difficult to maintain periodontally diseased teeth in comparison to healthy teeth. Additionally, periodontal attachment loss may be present with or without active periodontal inflammation.

Periodontal disease is initiated by oral bacteria which adhere to the teeth in a substance called plaque. Plaque is a biofilm, which is made up almost entirely of oral bacteria, contained in a matrix composed of salivary glycoproteins and extracellular polysaccharides. Calculus (or tartar) is basically plaque which has secondarily become calcified by the minerals in saliva.

Plaque on the tooth surface is known as supragingival plaque. Once it extends under the free gingival margin and into the area known as the gingival sulcus (between the gingiva and the teeth or alveolar bone), it is called subgingival plaque. 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 and calculus is minimal. Therefore, control of supragingival plaque alone is ineffective in controlling the progression of periodontal disease.

The bacteria in the subgingival plaque secrete toxins as well as metabolic products. Also produced are cytotoxins and bacterial endotoxins which can invade tissues on their own, and in turn cause inflammation to the gingival and periodontal tissues. This inflammation causes damage to the gingival tissues and initially results in gingivitis. Eventually, the inflammation can lead to periodontitis, i.e. the destruction of the attachment between the periodontal tissues and the teeth. In addition to directly stimulating inflammation, the bacterial metabolic byproducts also elicit an inflammatory response from the animal.

The inflammation produced by the combination of the subgingival bacteria and the host response damages the soft tissue attachment of the tooth and decreases the bony support via osteoclastic activity. This causes the periodontal attachment of the tooth to move apically (towards the root tip).

As periodontal disease progresses over time, the attachment loss continues in a non-linear pattern as active stages of destruction are followed by quiescent phases (burst). The end stage of periodontal disease is tooth loss; however, the disease has created significant problems prior to tooth exfoliation.

Clinical Features:

It is important to be familiar with normal features in order to identify abnormal findings. Normal gingival tissues are coral pink in color (allowing for normal pigmentation), and have a thin, knife-like edge, with a smooth and regular texture. In addition, there should be no demonstrable plaque or calculus on the dentition. Normal sulcal depth in a dog is 0 to 3mm and in a cat is 0 to 0.5mm.

The first clinical sign of gingivitis is erythema of the gingiva. This is followed by edema, gingival bleeding during brushing or after chewing hard/rough toys, and halitosis. Gingivitis is typically associated with calculus on the involved dentition but is primarily elicited by PLAQUE and thus can be seen in the absence of calculus. Alternatively, widespread supragingival calculus may be present with little to no gingivitis. It is critical to remember that calculus itself is essentially non-pathogenic. Therefore, the degree of gingival inflammation (not the amount of calculus) should be used to judge the need for professional therapy. As gingivitis progresses to periodontitis, the oral inflammatory changes intensify.

The hallmark clinical feature of established periodontitis is attachment loss. In other words, the periodontal attachment to the tooth migrates apically. As periodontitis progresses, alveolar bone is also lost. On oral exam, there are two different presentations of attachment loss. In some cases, the apical migration results in gingival recession while the sulcal depth remains the same. Consequently, tooth roots become exposed and the disease process is easily identified on conscious exam. In other cases, the gingiva remains at the same height while the area of attachment moves apically, thus creating a periodontal pocket. This form is typically diagnosed only under general anesthesia with a periodontal probe. It is important to note that both presentations of attachment loss can occur in the same patient, as well as the same tooth. As attachment loss progresses, alveolar bone loss continues, until tooth exfoliation in most cases. After tooth exfoliation occurs, the area generally returns to an uninfected state, but the bone loss is permanent.

Severe local consequences:

In addition to tooth loss, there are six proven local severe sequelae of severe periodontal disease.

The most common of these local consequences is an **oral-nasal fistula (ONF)**. ONFs are typically seen in older, small breed dogs (especially chondrodystrophic breeds); however, they can occur in any breed as well as felines. ONFs are created by the progression of periodontal disease up the palatal surface of the maxillary canines however; any maxillary tooth is a candidate. This results in a communication between the oral and nasal cavities, creating an infection (sinusitis). Clinical signs include chronic nasal discharge, sneezing, and occasionally anorexia and halitosis. Definitive diagnosis of an oronasal fistula often requires general anesthesia. The diagnosis is made by introducing a periodontal probe into the periodontal space on the palatal surface of the tooth. Interestingly, this condition can occur even when the remainder of the patient's periodontal tissues is relatively healthy (including other surfaces of the affected tooth). Appropriate treatment of an ONF requires extraction of the tooth and closure of the defect with a mucogingival flap. However, if a deep periodontal pocket is discovered prior to development of a fistula, periodontal surgery with guided tissue regeneration can be performed to save the tooth.

Another potential severe consequence of periodontal disease can be seen in multi-rooted teeth and is called a **class II perio-endo abscess.** This occurs when the periodontal loss progresses apically and gains access to the endodontic system, thereby causing endodontic disease via bacterial contamination. The endodontic infection subsequently spreads though the tooth via the common pulp chamber and causes periapical ramifications on the other roots.

This condition is also most common in older small and toy breed dogs; however, this author has personally treated a case in a Labrador Retriever. The most common site for a class II perio-endo lesion to occur in small animal patients is the distal root of the mandibular first molars.

The third potential local consequence of severe periodontal disease is a **pathologic fracture.** These fractures typically occur in the mandible (especially the area of the canines and first molars), due to chronic periodontal loss, which weakens the bone in affected areas. This condition is again, most commonly seen in small breed dogs, mostly because their teeth (especially the mandibular first molar) are larger in proportion to their jaws as in comparison to large breed dogs. Pathologic fractures occur most commonly as a result of mild trauma, or during dental extraction procedures. However, some dogs have suffered from fractures while simply eating.

Although this is typically considered a disease of older patients, this author has personally treated three cases in dogs less than three years of age.

Pathologic fractures carry a guarded prognosis for several reasons. Adequate healing is difficult to obtain due to lack of remaining bone, low oxygen tension in the area, and difficulty in rigidly fixating the caudal mandible. There are numerous options for fixation, but the use of wires, pins or plates is generally required. Regardless of the method of fixation, the periodontally diseased root (s) MUST be extracted for healing to occur.

Awareness of the risk of pathologic fractures can help the practitioner to avoid problems in at risk patients during dental procedures. 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. 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 periodontally healthy root. In cases where periodontitis involving a mandibular canine or first molar is identified during a routine prophy, it is best to inform the owners of the possibility of a jaw fracture prior to attempting extraction of the offending tooth.

The fourth local consequence of severe periodontal disease results from inflammation close to the orbit which could potentially lead to **blindness**. The proximity of the tooth root apices of the maxillary molars and fourth premolars, places

the delicate optic tissues in jeopardy. In cats (especially brachycephalic), the apices of the maxillary canines lie in this area and can create similar issues.
The fifth local consequence is described in recent studies which have linked chronic periodontal disease to **oral cancer**. The association in this case is likely due to the chronic inflammatory state that exists with periodontitis.
The final significant local consequence of periodontal disease is chronic **osteomyelitis**, which is an area of dead, infected bone. Dental disease is the number one cause of oral osteomyelitis. Furthermore, once an area of bone is necrotic, it does not respond effectively to antibiotic therapy. Therefore, definitive therapy generally requires aggressive surgical debridement.

Severe systemic manifestations:

Systemic ramifications of periodontal disease are also well documented. The inflammation of the gingiva and periodontal tissues that allows the body's defenses to attack the invaders also allows these bacteria to gain access to the body. Recent animal studies suggest the possibility that these bacteria negatively affect the kidneys and liver, leading to decrease in function of these vital organs over time. Furthermore, it has also been suggested that these bacteria can become attached to previously damaged heart valves (IE valvular dysplasia) and cause endocarditis, which in turn can result in intermittent infections, and potentially thromboembolic disease. Other studies have linked oral bacteremias to cerebral and myocardial infarctions and other histological changes. Additional human studies have linked periodontal disease to an increased incidence of chronic respiratory disease (COPD) as well as pneumonia. There are many studies that strongly link periodontal disease to an increase in insulin resistance, resulting in poor control of diabetes mellitus as well as increased severity of diabetic complications (wound healing, microvascular disease). Additionally, it has been shown that diabetes is also a risk factor for periodontal disease. Periodontal disease and diabetes are currently viewed as having a bidirectional interrelationship where one worsens the other.
Finally, it has been proven in animal studies that periodontal disease can elicit an increase in inflammatory lipids as well as an overall lipidemic state. This is described as a state of overall body inflammation leading to chronic disease processes and an abnormal immune response.
While some of these studies are not definitive, we know that periodontal disease is an infectious process and that affected patients must deal with these bacteria daily, which in turn can lead to a state of chronic disease. Therefore, we must learn to view periodontal disease as not just a dental problem that causes bad breath and tooth loss, but as an initiator of more severe systemic consequences. As one author states, "Periodontal disease is clearly an important and potentially life-threatening condition, often underestimated by health professionals and the general public". Only by thinking in these terms can we fully appreciate the scope of the disease process and discuss the problem with clients so that they can appreciate the depth of the problems their pets face. This information will significantly increase client compliance with homecare and dental prophylaxis, as well as advanced dental procedures.

BASIC PERIODONTAL THERAPY

The basis of periodontal therapy today is plaque control. This is accomplished via two to four components depending on the stage of the disease. These include a thorough dental prophylaxis, periodontal surgery, homecare, and extraction. There are numerous variations and treatment options for therapy. This lecture will cover the basics and touch on the available options.
The cornerstone of periodontal therapy is a **thorough dental prophylaxis**. This MUST be performed under general anaesthesia including a properly inflated endotracheal tube. The prophylaxis should include the following steps.

Step 1: Pre surgical exam and consultation

This is often a much-neglected step of a professional dental prophylaxis. The veterinarian should perform as complete as possible physical and oral exam. The physical exam (along with pre-operative testing) will help ensure aesthetic safety. The oral examination will identify obvious pathology (fractured, intrinsically stained, or mobile teeth; oral masses; and resorptive lesions) as well as allow for a preliminary assessment of periodontal status. The veterinarian can then discuss the various disease processes found and the various available treatment options. Based on the physical findings, the practitioner can create a more accurate estimate (both financial and time). Both of which will decrease problems with over scheduling and client finances during the anaesthetic event. This small time investment will improve the experience of everyone involved (veterinarian, technician, receptionist, client, and patient).

Step 2: Supragingival cleaning

This can be performed via mechanical or hand scaling. The mechanical scalars decrease anaesthetic time and include both sonic and ultrasonic types. The most common type of mechanical scaler in veterinary dentistry today is the ultrasonic scaler. There are two main types magnetorestrictive and piezoelectric). Both scalers vibrate at approximately 45,000 Hertz. They are very efficient and have an additional benefit of creating an antibacterial effect in the coolant spray (cavitation). They are however can be more damaging to the tooth and may leave some calculus behind. Thus, it has been recommended that hand scaling be performed after ultrasonic scaling to ensure the complete removal of calculus. Sonic scalers run on compressed air and vibrate at 8-18,000 hertz. They are safer, but slower than sonic scalers and do not offer cavitation. The area of maximum vibration is 1-2 mm from the tip. Do not use the tip or back of the instrument as these are not effective for calculus removal and can potentially damage the tooth. The instrument is placed on the tooth and LEFT on the tooth for up to 15 seconds. Once the instrument loses contact with the tooth, the scaler can no longer be

effective. Run the instrument SLOWLY over the tooth surface in wide sweeping motions to cover every mm^2 of every tooth surface.
Hand scaling is performed with a scaler. This is a triangular instrument with e sharp cutting edges. In addition, the tip is very sharp. Scalers are designed for SUPRA-gingival use only. The scalers (as well as curettes below) are held with a modified pencil grip. The instrument is gently held at the gnarled or rubberized end with the thumb and index finger TIPS. 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 surface. Finally, the ring and pinkie fingers are rested on a stable surface.
Hand instruments are used with a gentle touch and are run over the tooth numerous times in overlapping strokes until the tooth feels smooth. This step may be performed with a curette and combined with subgingival scaling (see below).
Step 3: Subgingival plaque and calculus scaling
This step is best performed by hand with a curette. A curette has 2 cutting edges and a blunted toe and bottom. In this way, it will not cut through the delicate periodontal attachment if excess force is not applied. The proper curette is selected based on its angulation. The lower the number (i.e. 1-2) the less the angle and the further rostral in the mouth the instrument is used. The face of the instrument is placed flat against the surface of the tooth and inserted gently to the base of the sulcus or pocket. Once there, the instrument is rotated so that the shaft is parallel to the long axis of the tooth. This will engage the calculus as well as place the instrument in the proper position for root surface and subgingival debridement. This is repeated with numerous overlapping strokes until the root feels smooth. Cleanliness can be further evaluated by gently directing compressed air into the sulcus. Any remaining calculus will appear chalky. This is a very technically demanding procedure and the practitioner is directed to continuing education programs to hone their skills.
Traditional ultrasonic scalers should not be used subgingivally due to thermal damage to the gingiva and pulp. This occurs because the water coolant cannot reach the tip of the instrument. However sonic and ultrasonic scalers with specialized periodontal tips have been developed for subgingival use. These are much easier to use and therefore will likely result in superior cleaning in the hands of novices. Like supragingival scaling, it is recommended to perform mechanical scaling first to remove much of the plaque and calculus first, and then follow up with hand scaling.
Step 4: Polishing
Scaling (especially mechanical) leaves the tooth surface (and especially the root) rough, which increases plaque attachment. Polishing will smooth the surface of the teeth which will retard plaque attachment. Polishing is typically performed with a prophy cup on a slow-speed handpiece with a 90-degree angle. The handpiece should be run at a slow rate and no greater than 3,000 RPM. Ensure that adequate polish is always used. Running the prophy cup dry is not only inefficient, it may also overheat the tooth. Just like with scaling, every mm^2 of tooth surface should be polished. In addition, slight pressure should be placed down onto the tooth to flare the edges of the prophy cup to polish the subgingival areas. One tooth may be polished for a maximum of five seconds at a time to avoid overheating. The tooth can be further polished after a short break (while other teeth are polished).
Step 5: Periodontal probing, oral evaluation, and dental charting
This is a critical, however often poorly performed and underappreciated step. The entire oral cavity must be systematically evaluated using both visual and tactile senses. Careful visual examination should be performed during the periodontal evaluation. The periodontal probe should be inserted at six spots around EVERY tooth to identify periodontal pockets. This is performed by gently inserting the probe into the pocket until it stops and then "walking" the instrument around the tooth. The normal sulcal depth in a dog is 0-3 mm, and a cat is 0-0.5 mm. All abnormal findings must be recorded on the dental chart. Dental charting should be performed 4-handed. This means that one person evaluates the mouth and calls out pathology to the assistant who records it on the chart. Using the modified triadan system will greatly increase efficiency of this step. Dental charts must be of sufficient size to allow for accurate placement of pathology. The minimum size for an acceptable dental chart is 1/3 of a page, however veterinary dentists use full page charts.
Step 6: Dental radiographs:
Dental radiographs should be performed of ANY pathology noted on dental exam. This includes any periodontal pocket which is larger than normal, fractured or chipped teeth, masses, swellings, or missing teeth. Dental radiographs are a critical aid in the evaluation of dental pathology. Help is available for any questionable cases at *www.vetdentalrad.com.*
Step 7: Treatment planning
The practitioner, utilizing all available information (visual, tactile, and radiographic) then decides on appropriate therapy. Additionally, the prudent veterinarian will keep in mind the patient as a whole, the owner's wishes and willingness to perform homecare, and necessary follow-up. Following the creation of a dental plan for the patient, an estimate is created, and the client contacted for consent.
Step 8: Additional therapies: Based on the oral examination and client wishes, any additional therapy is performed. If this is extensive and would result in a long anesthesia or the practitioner to be unduly rushed, rescheduling the remainder of the work **is** an acceptable alternative. There are numerous possibilities for this (including referral).
Home care:
This is a very important part of periodontal therapy. A recent study has shown that periodontal pockets are re-infected within 2 weeks of a prophylaxis if homecare is not performed. Therefore, homecare must be discussed with each client following a prophylaxis.
There are two divisions of homecare active and passive. They both can be effective if performed correctly, however active homecare is still the gold standard in homecare.
Active homecare consists primarily of tooth brushing. There are various veterinary brushes; however, a soft child's toothbrush is also effective. There are numerous veterinary toothpastes available. These increase the palatability of the toothbrush, and many add a cleaning aid. Human toothpastes are generally not recommended. There are also antimicrobial

preparations that can be used in certain cases. Technique: Use a circular motion with the brush at a 45-degree angle to the gingival margin.
Frequency: once a day would be ideal, as this is required to stay ahead of plaque formation, but for most owners this is unrealistic. Three days a week is considered the minimum frequency for patients in good oral health. If the patient has periodontal disease, daily brushing is necessary. One other option for active homecare is to rinse with a chlorhexadine solution. This has been shown to decrease gingivitis if done consistently over time. Even though brushing and rinsing greatly improves periodontal health, it does not eliminate the need for professional cleanings.
Passive homecare is the other option for minimizing periodontal disease. Since this requires no work by the owner, compliance is more likely. This is especially important since long term consistency is the most important factor in the effectiveness of dental care. There are currently several diets that decrease tartar and plaque build-up. In addition, tartar control chews and treats have been developed.
All these products have been shown to decrease plaque and calculus, however, they are most effective on plaque and tartar on the cusp tips not at gingival margin. Supragingival plaque and calculus is in general non-pathogenic. Of the available products, only two have been clinically proven to decrease gingivitis.
The downfall of all passive homecare products is that the patient is not likely to chew with the entire mouth; therefore, areas will be missed. Passive homecare is most effective on the carnassial and surrounding teeth, where chewing is concentrated. Active homecare, in contrast, is most effective in controlling plaque and calculus on the incisor and canine teeth, likely due to the ease in accessing these teeth. Therefore, a combination of active and passive homecare is likely ideal.

Periodontal Surgery

Any pockets greater than normal for the species are pathologic and in need of therapy. It is important to note that this is a separate procedure from the prophylaxis and the practitioner should be charging for this. Periodontal therapy is aimed at removing the infection from the root surface (plaque, calculus, and granulation tissue) as well as smoothing the diseased root surface. This will allow for reattachment and decrease in pocket depth.
In the canine patient, pockets between 3 and 5 mm which do not have mobility or other issues are best treated with closed root planing and subgingival curettage. This step is performed in a similar manner to subgingival scaling above, with a combination of mechanical and hand scaling. This should be meticulously performed in order to achieve as clean a tooth as possible to promote healing.
An additional way to promote reattachment is the instillation of a sustained release doxycycline product. This has been shown to temporarily locally control the microorganisms as well as decrease inflammation. It is performed by mixing the product according to package directions and then inserting the product into the pocket until it is just overflowing. The product is then wetted, which will harden it, and tapped gently into the sulcus. If some of the product extrudes from the pocket, it should be rewetted and then placed. This should continue until the pocket is full.
Pockets greater than 5-mm require direct visualization of the root surface for effective cleaning. If the tooth is not effectively cleaned, the infectious agents remain along with the plaque and calculus. Visualization is best accomplished via periodontal flap procedures. These procedures are very effective in animal patients. If the clients are interested in salvaging the teeth, periodontal surgery can be performed. These are advanced procedure but can be learned by general practitioners. However, the reader is encouraged to attend a hands-on wet lab prior to undertaking these surgeries.
The final modality for the therapy of periodontal disease is **extraction**. While extreme, it is the only true cure. Without a commitment to homecare or routine professional cleanings, advanced periodontal surgery should likely not be attempted. Depending on the stage of periodontal disease, the involved teeth should be extracted.

Dental Radiology

Dental Radiograph Units:

Radiographic exposure is controlled by 3 components: kVp (kilovolt peak), MA (milliamperage), and exposure time. KVp controls the "quality" of the x-ray beam. This is the power of each x-ray particle which controls the penetration of the beam through tissues.
The quantity of the exposure is controlled by MA and time of exposure. The higher the MA, the more X-rays produced over the time period. Multiply this number by the exposure time and you will get the total number of x-ray units.
Since there is not a significant amount of variation of tissues in oral radiology, the KVP and MA are set constant on dental radiology units. The only variable factor is time. This is measured in seconds or pulses. One pulse is equal to 1/60 of a second. Most standard (human) dental radiology units have a digital control for the exposure and it is set by the operator based on a technique chart. Recently, however, veterinary specific machines have become available which has a computer that sets the exposure based on the size of the patient, the speed of dental film used, and the object tooth. This can take a lot of the guesswork out of the exposure setting. However, with a little experience and practice, it is easy to figure out a setting.

Digital Dental Radiology: There are numerous human veterinary digital systems. These are excellent means of obtaining dental radiographs. The only major problem currently is the lack of a number 4 sensor. The major advantages to these systems are the decrease in radiation exposure, rapidity of the development, and that you can reposition the sensor if the view is not correct the first time. However, size 4 phosphor plates (CR) are available.

Taking a dental radiograph:

Step 1: Patient positioning

Position the patient so that the area of interest is convenient to the radiographic beam. In general, this is where the object is "up". For mandibular canines and incisors, the pet should be in dorsal recumbency. Finally, for maxillary cheek teeth, the patient should be in lateral recumbency with the affected side up. For maxillary teeth, the patient should be in lateral recumbency with the affected side up. In our practice virtually all radiographs are exposed in lateral recumbency. This takes some getting used to but will decrease the number of times a patient must be rolled when doing surgical or endodontic procedures.

Step 2: Film Placement within the patient's mouth

Place the sensor in the mouth so that the entire tooth (crown and entire root surface) is covered by the radiograph. Remember, the roots of all teeth are very long. This is especially true of canine teeth, which are longer than you think. Always err on the side of having the film too far in the mouth to ensure you do not cut off the root apexes. The sensor/plate should be placed as near as possible to the object (generally touching the tooth and gingiva) to minimize distortion.

Step 3: Positioning the beam head

There are two major techniques for positioning the beam head in veterinary patients. Both techniques are used daily in veterinary practice.

Parallel technique: This is where the film is placed parallel to the object being radiographed and perpendicular to the beam. This is how standard (large) films are taken. This gives the most accurate image. Unfortunately, this is only useful in the lower cheek teeth in the dog and cat. This is because these patients don't have an arched palate. The film cannot be placed parallel to the tooth roots because of the palate's interference. Therefore, this technique is not always possible.

Bisecting Angle Technique: This is the most common type of dental radiograph taken in veterinary patients. This uses the theory of equilateral triangles to create an image that accurately represents the tooth in question. To utilize this technique, the film is placed as parallel as possible to the tooth root. Then the angle between the tooth root and film is measured. This angle is cut in half (bisected) and the beam placed perpendicular to this angle. This gives the most accurate representation of the root.

If this angle is incorrect, the radiographic image will be distorted. This is because the x-ray beam will create an image that is longer or shorter than the object imaged. The best way to visualize this is to think of a building and the sun. The building will create a 90-degree (right) angle to the ground. The bisecting angle in this case is 45 degrees to the ground. Early and late in the day, the sun is at an acute angle to the building and casts a long shadow. In radiology this occurs when the angle of the beam to the object is too small and is known as elongation. At some point in the late morning and early afternoon, the sun is at a 45-degree angle to the building, which is the bisecting angle. This gives an accurate representation of the building height. As the sun continues up in the sky, the shadow shortens. This occurs in veterinary radiology when the angle is too great and is known as foreshortening. Finally, at noon, the sun is straight up from the building, which gives no shadow.

The **"Simplified Technique"** as developed by Dr. Tony Woodward does not utilize direct measurement of any angle, instead relying on approximate angles to create diagnostic images. There are only 3 angles used for all radiographs in this system 20, 45, and 90.

Mandibular premolars and molars are exposed at a 90-degree angle, maxillary premolars and molars at a 45-degree angle, and incisors and canines at a 20-degree angle.

To initiate any radiograph, place the film in the mouth and set the positioning indication device (PID) perpendicular to the film. For mandibular cheek teeth, this is the correct placement. For the maxillary premolars and molars, rotate the beam to a 45-degree angle. For the incisors and mandibular canines rotate 20 degrees. For the maxillary canines an additional rotation 20 degrees lateral is necessary to avoid superimposition of the first and second premolars.

Step 4: Setting the exposure

If you are using a machine where you set the exposure manually, you will need to set up a technique chart like one for a standard (large) unit. The good news is that there is only one variable that needs to be adjusted. \

If you are utilizing the computer-controlled system, set the buttons for the species, size of the patient, and tooth to be imaged. If you have correctly set the machine and the image is incorrectly exposed, the easiest way to adjust is to change the time setting up or down.

Step 5: Exposing the radiograph

Dental radiograph machines have a handheld switch to expose the radiograph. If it is possible, leave the room prior to exposing the radiograph. If it is not, stand at least 6 feet away at a 90 to 130-degree angle to the primary beam (meaning to the side or back of the tube head, not in front or behind). Once everything is set, press the button. It is important to remember, that these switches are "dead man's". This means if you let up during the exposure, it will stop the production of x-ray beams. On a standard unit, this will make a light radiograph, on a computer controlled one it will give an error message and you will need to start over. Make sure you hold the button down until the machine stops beeping.

DENTAL RADIOGRAPH INTERPRETATION

Interpreting dental radiographs can be daunting, but it is very similar to interpreting a standard boney radiograph. The major difference is that dental radiographic changes are often more subtle. In addition, there are pathologic states that are unique to the oral cavity. Finally, there are several normal anatomic structures that may mimic pathologic changes.
This lecture concentrates on the most common pathologies, which are illustrated by classic examples. Note that in practice, these lesions are often less obvious. The reader is directed to additional continuing education meetings to further their expertise. In addition, **vetdentalrad.com** is an excellent resource for questionable cases.

Determining which teeth were imaged:

The first step in radiographic interpretation is determining which teeth have been imaged. This requires not a firm knowledge of oral anatomy as well as the architecture of dental films. Digital systems with veterinary templates do not require this step if the images are properly placed (DO NOT ASSUME THIS WAS DONE CORRECTLY). If your 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.
The key to properly identifying the imaged teeth is the embossed dot, which is on one corner of the film. When exposing a radiograph, if the film is properly positioned, the convex surface will point 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 side of the film. Therefore, when interpreting the film, the embossed dot is facing out of the mouth.
First, place the dot towards you (this is done for you on most digital systems). This means you are looking at the teeth as if you are the beam.
Next, rotate the film so that the roots are in their natural position (up on maxillary and down on mandibular).
Canines and incisors: This orients the film so the right side of the mouth is on the left, and right side is on the left. This is like a VD abdomen radiograph.
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.

Normal radiographic anatomy:

There are numerous structures within the oral cavity that mimic pathologic states depending on the projection. Knowledge of normal radiographic anatomy will help avoid over interpretation.
Normal alveolar bone will appear gray and relatively uniform throughout the arcade. It is slightly more radiopaque "darker" than 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).The root canals should all be the same width; allowing for differences in the diameters of the root. There should be no radiolucent areas in teeth or bone. A regular thin dark line (periodontal ligament) should be visualized around the roots.
There are several normal anatomic findings that are commonly misinterpreted in dental images as pathologic. On radiographs of the mandibular cheek teeth, a thick, horizontal radiolucent line courses parallel to and just coronal to the ventral cortex of the mandible. This is the mandibular canal. In addition, there are three circular radiolucent areas seen in the area of the apices of the first three premolars, which are the mental foramina (rostral, middle, and caudal). On rostral mandibular views, a radiolucent line will be present between the central incisors. This is the fibrocartilaginous mandibular symphysis. In the rostral maxillary area: there are paired radiolucent areas distal to the intermediate incisors, which are the palatine fissures. Finally, a significant widening of the periodontal ligament at the apex of the cuspid teeth is normal. This may appear to be a periapical lesion but is differentiated from pathology because it is very regular and v-shaped, as opposed to irregular and round.
Any questionable areas should be evaluated by exposing a comparative view.
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 centered on the apex, it is likely real. If the lesion moves off the apex or disappears, it is an artifact. Suspect changes in the diameter of the root canal of a tooth should be compared against surrounding as well as contralateral teeth. Surrounding teeth can be seen on the same film with the "lesion". 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 cuspids). A lateral view may have a much different canal width than a V/D view.

Periodontal disease:

Periodontal bone loss results from the combination of bacterial induced inflammation and host response creating osteoclastic resorption of bone. This resorption will result in crestal bone loss to a level below the cementoenamel junction. This decrease in bone height may also create furcational exposure. Horizontal bone loss is the most common pattern in veterinary patients is horizontal. This appears as generalized bone loss of a similar level across all or part of an arcade. The other pattern is angular (vertical) bone loss. The radiographic appearance of angular bone loss is one area of recession below the surrounding bone. 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.

Bone loss does not become radiographically evident until 30-50% of the mineralization is lost. Therefore, radiographic findings will always *underestimate* bone loss. In addition, bone loss on only on 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 in light of the complete oral examination findings.

Endodontic disease:

Endodontic disease may be demonstrated radiographically in several ways. An individual tooth may have one, some, or all 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. On rare occasions, this may also be seen mid-root, but these will virtually always be associated with periapical disease. Other, more subtle changes include a widened periodontal ligament, a thickened or discontinuous lamina dura, or even periradicular opacities. It is important to be aware of superimposed lucencies which are artifactual. These structures (i.e. mental foramina) can be imaged over an apex and falsely appear as osseous rarefaction. There are several clues that superimposed lucencies are artifactual. First, superimposed artifacts are typically seen on only one root, whereas it is very rare to find a true periapical lesion on only one root of a multi-rooted tooth. In addition, artifacts tend to be regular in appearance, whereas true periapical lesions are ragged.

If any area is in question, it is best to expose an additional film with a slightly different angle. If a periradicular lucency is still centered over the apex, it is likely real and not an artifact.

Tooth changes: The most common change in endodontic disease within the tooth itself is a root canal with a different diameter. As a tooth matures, secondary dentin 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. Conversely, on rare occasions, pulpitis may result in increased dentin 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. Width discrepancy can be compared to any tooth (taking the size of tooth into consideration) but it is most accurate is to compare to the contralateral tooth.

Endodontic disease may also be manifested radiographically as internal resorption. This results from osteoclastic activity within the root canal system due to pulpitis. These changes create an irregular, enlarged region within an area of the root canal system. Finally, external root resorption can be seen with endodontic disease. It will appear as a defect of the external surface of the root, generally accompanied by a loss of bone in the area. External resorption most commonly occurs at the apex in companion animals and is quite common in cats with chronic endodontic disease.

Feline Tooth Resorption (TR's)

TRs are the result of odontoclastic destruction of feline teeth and are classified as either type 1 or type 2. In type 1 there is no replacement by bone, whereas in type 2 there is replacement of the lost root structure by bone.

TRs are very common in our feline patients. Studies have reported up to a 70% incidence in felines over 6 years of age! The etiology at this point is unknown. They are not bacterial in nature, although in some cases the inflammation which activated the odontoclasts may have been bacterial in nature. There are numerous theories; however, none have been proven at this time. Osteoclastic resorption will generally begin at the cervical line of the tooth and progress at varying rates until in some cases no identifiable tooth remains.

Type 1 TRs are typically associated with inflammation such as gingivostomatitis or periodontal disease. Thus, they are commonly associated with periodontal bone loss on dental radiographs. In these cases, it is believed that the soft tissue inflammation activated the osteoclasts. The teeth will have normal root density in some areas and a well-defined periodontal space. In addition, there is often a definable root canal in the intact part of the tooth. This type will have significant resorption of the teeth and tooth roots that is *not* replaced by bone.

Type 2 TRs are usually associated with only localized gingivitis on oral exam, in contrast to the more severe inflammation due to periodontal disease or gingivostomatitis seen with type 1. In these cases, the gingival inflammation is secondary to the TR. The radiographic appearance is that of teeth which have a different radiographic density as compared to normal teeth, as they have undergone significant replacement resorption. Findings will include areas with no discernable periodontal ligament space (dentoalveolar ankylosis) or root canal. In the late stages, there will be little to no discernable root structure (ghost roots). In these cases, the lost root structure will be replaced by bone.

The importance of dental radiography in TR cases cannot be overstated. Type 1 lesions typically retain a viable root canal system and will result in pain and endodontic infection if the roots are not completely extracted. However, the concurrent presence of a normal periodontal ligament makes these extractions routine. With type 2 lesions, there are areas lacking a normal periodontal ligament (ankylosis) which also demonstrate varying degrees of root resorption, which makes extraction by conventional elevation difficult to impossible. The continued resorption in type 2 teeth is the basis for crown amputation therapy It is this authors opinion that teeth with an identifiable root canal on dental radiographs MUST be extracted completely, while teeth with no discernable root canal may be treated with crown amputation. If there is any question, always err on the side of complete extraction.

Neoplasia:

Neoplasia is defined as the abnormal growth of cells that is not responsive to normal growth control. Neoplasms can be further classified by their biologic behavior as benign or malignant.

Benign masses: Most benign neoplastic growths will have no boney involvement on dental radiographs. If bone involvement does occur with a benign growth it will be expansive, resulting in the bone "pulling away" from the advancing tumor leaving a decalcified soft tissue filled space in the tumor site. Bony margins are usually distinct. Finally, this expansive growth will typically result in tooth movement.
Cysts: Cystic structures will appear as a radiolucent area with smooth bony edges. Like other benign growths, they grow by expansion and thus displace the other structures (e.g. teeth). Dentigerous cysts are typically seen as a radiolucent structure centered on the crown of an unerupted tooth.
Malignant neoplasia: Malignant oral neoplasms typically invade bone early in the course of disease, resulting in irregular, ragged bone destruction. Initially, the bone will have a mottled "moth eaten" appearance, but radiographs late in the disease course will reveal a complete loss of bone (the teeth will appear to float in space). If the cortex is involved, an irregular periosteal reaction will be seen.
Histopathologic testing is always necessary for accurate diagnosis of oral masses since a variety of benign or malignant tumors appear radiographically similar. In addition, osteomyelitis can create the same radiographic findings as malignant tumors. Finally, aggressive tumors will show no bone involvement early in the course of disease. The prudent practitioner will note the type and extent of bony involvement (if any) on the histopathology request form (and may include copies of the radiographs and pictures) to aid the pathologist. It is key to interpret the histopathology result considering the radiographic findings. A diagnosis of a malignancy without bony involvement should be questioned prior to initiating definitive therapy such as aggressive surgery, radiation therapy, or chemotherapy. Conversely, a benign tumor diagnosis with significant bony reaction should be further investigated prior to assuming that the patient is safe.
Additional diagnostic tests in questionable cases include complete blood panel, urinalysis, bacterial and/or fungal culture, as well as fungal serology.

Retained tooth roots:

Persistent tooth roots following extraction attempts are a common occurrence in veterinary medicine. In most cases, there are no outward clinical signs, however the patient suffers regardless. In rare cases, the retained root may abscess, resulting in significant morbidity to the patient and possible legal action from the client.
Dental radiographs must be exposed following *all* extractions. Regardless of the appearance of complete extraction, there is still a possibility of retained roots or other pathology. Therefore, post-operative radiographs are critical in all cases. In addition, they will serve as a legal document in cases of complications.

EXTRACTION TECHNIQUES

Step 1: **OBTAIN CONSENT**

NEVER extract teeth without owner consent (preferably written), no matter how bad the problem, or how obvious the decision is. Make sure that you have a valid daytime number (or numbers) for the client and inform them they must be available during surgery hours. Consider loaning pagers to clients for the day, as this author has found this to be a very effective means to contact clients. If the client cannot be reached and prior consent was not obtained, DO NOT PULL THE TOOTH. Document the problem, recover the patient, and reschedule the work. Remember, the tooth can always be extracted later, but it cannot be put back in!

Step 2: **DENTAL RADIOGRAPHS**

Dental radiographs should be exposed on all teeth prior to extraction. Dental radiographs are invaluable resources. Radiographs allow the practitioner to determine the amount of disease present, any root abnormalities or ankylosis. Help with radiographic interpretation is available while the patient is under anesthesia at www.vetdentalrad.com. In addition, the radiographs will serve as evidence for the extraction in the medical record. Radiographs should also be exposed post-extraction to document complete removal of the tooth.

Step 3: **OBTAIN PROPER VISABILITY AND ACCESSABILITY**

The patient should be positioned in such a way as to allow maximum visibility of the area as well as make the surgeon most comfortable. Note that during the extraction procedure the ideal position may change, and the patient should be adjusted appropriately. The lighting should be bright and focusable on the surgical field. Suction, air/water syringes, and gauze should be utilized continually to keep the surgical field clear, and mouth gags can be used to hold the mouth in proper position for surgery. Finally, magnification may help the surgeon locate furcations or retained root tips.

Step 4: **PAIN MANAGEMENT**

Extractions are surgical procedures and are moderately to severely painful for the patient. Depending on patient health, a multimodal approach (combination of opioids, NSAIDs, local anesthetics, and dissociative) should be employed, as this provides superior analgesia. Preemptive analgesia is proven to be more effective than post-operative, and it is therefore important to administer the drugs BEFORE the painful procedure.

Step 5: **INCISE THE GINGIVAL ATTACHMENT**

This is accomplished with a scalpel blade (number 11 or 15), elevator, or luxator. The selected instrument is placed into the gingival sulcus with the tip of the blade angled toward the tooth (this will help avoid going outside the bone and creating a defect or cutting through the gingiva). The blade is then advanced apically to the level of the alveolar bone, and the instrument is carefully worked around the entire tooth circumference.

This step is very helpful as the gingival attachment contributes approximately15% of the retentive strength of the periodontal apparatus. More importantly, however, this procedure will keep the gingiva from tearing during the extraction procedure. This is most important with mobile teeth where little elevation is needed, but one edge is still attached. Gingival tearing can cause defects that require closure or can make a planned closure more difficult.

Step 6: **ELEVATE THE TOOTH**

Elevation is the most dangerous step in the extraction procedure. Remember that you are holding a sharp surgical instrument and working in an area of numerous critical and delicate structures. There have been many reports of eyes that have been gouged and lost by extraction instruments as well as at least one confirmed fatality due to an elevator puncturing a patient's brain. The index finger is placed near the tip of the instrument to avoid causing iatrogenic trauma in the event of instrument slippage or encountering diseased bone. In addition, the jaw should be gently held with the opposite hand to provide stability and avoid mandibular fracture.

First, select an instrument which matches the curvature and size of the root. There are numerous instruments available including the classic elevator, the luxating elevator, and the winged elevators. Classic elevators 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 can be GENTLY twisted for elevation, but they are not designed for this and can be easily damaged when used in this manner.

Elevation is initiated by inserting the elevator or luxator firmly yet gently into the periodontal space. The insertion should be performed while keeping the instrument at about a 10 to 20-degree angle toward the tooth, to avoid slippage. Once in the space between the bone and the tooth, the instrument is ***gently*** twisted with two-finger pressure. This is not to say that the instrument should be held with two fingers, rather the entire hand should be used to hold the instrument. Twist only with the force that you could generate when holding with two fingers. Hold the position for 10-30 seconds to fatigue and tear the periodontal ligament.

It is important to note that the periodontal ligament is very effective in resisting intense, short forces. It is only by the exertion of prolonged force (i.e. 10-30 seconds) that the ligament will become weakened. Heavy stresses only serve to put pressure on the alveolar bone and tooth which can result in the fracture of one of these structures, so it is important not to use too much 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 this procedure 360 degrees around the tooth, each time moving the elevator apically as much as possible. Depending on the level of disease and the size of the tooth, a few to several rotations of the tooth may be necessary.

The key point to successful elevation is PATIENCE. Only by slow, consistent elevation will the root loosen without breaking. It is always easier to extract an intact root than to remove fractured root tips.

Step 7: **EXTRACT THE TOOTH**:

Removing the tooth should only be attempted after the tooth is very mobile and loose. This is accomplished by grasping the tooth with the extraction forceps and gently pulling the tooth from the socket. Do NOT apply undue pressure as this may result in root fracture. In many cases, especially with premolars, the roots are round and will respond favorably to *gentle* twisting and holding of the tooth while applying traction. This should not be performed if there are root abnormalities (significant curves, weakening) seen on the pre-operative radiograph.

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.

Step 8: **CLOSURE OF THE EXTRACTION SITE**:

This is a controversial subject among veterinary dentists, and thus some texts recommend suturing only in large extractions, other authors (including this one) recommend suturing almost all extraction sites. Closure of the extraction site promotes hemostasis and improve post-operative discomfort and aesthetics. It is always indicated in cases of larger teeth (e.g. canines, carnassials), or any time that a gingival flap is created to allow for easier extraction. This is best accomplished with size 3/0 to 5/0 absorbable sutures on a reverse cutting needle. Closure is performed with a simple interrupted pattern with sutures placed 2 to 3 mm apart. It is further recommended to utilize one additional throw over manufacturer's recommendations to counteract tongue action.

Regarding flap closure, there are several key points associated with successful healing. The first and most important is that there must be no tension on the incision line. If there is any tension on the suture line, it will not heal. Tension can be removed by extending the gingival incision along the arcade (called an envelope flap) or by creating vertical releasing incisions and fenestrating the periosteum. The periosteum is a very thin fibrous tissue which attaches the buccal mucosa to the underlying bone. Since it is fibrotic, it is inflexible and will interfere with the ability to close the defect without tension. The buccal mucosa is very flexible and therefore will stretch to cover large defects. If there is no tension, the flap should stay in position without sutures.

EXTRACTION OF MULTI ROOTED TEETH

Section all multi-rooted teeth into single rooted pieces. The roots of almost all multi-rooted teeth are divergent and this will cause the root tips to break off if extractions are attempted in one piece. Root fracture can occur even if a tooth is relatively mobile to start with. With mobile teeth, the sectioning step alone often allows for simple extraction.

The best tool for sectioning teeth is a bur on a high-speed air driven hand piece. Besides being the quickest and most efficient tool for the job, it also has air and water coolant that will avoid overheating the tooth. Many different styles of burs are available; however, this author prefers a cross-cut taper fissure bur (699 for cats and small dogs, 701 for medium dogs and 702 for large breeds).

The best way to section the teeth is to start at the furcation and work towards the crown of the tooth. This method is used for two major reasons. First, it avoids the possibility of missing the furcation and cutting down into a root, which subsequently weakens the root and increases the risk of root fracture. In addition, this method avoids the possibility of cutting through the tooth and inadvertently damaging the gingiva or alveolar bone.

After the tooth has been properly sectioned, follow the above steps for each single rooted piece. In some cases, the individual tooth pieces can be carefully elevated against each other to gain purchase.

SURGICAL EXTRACTIONS

The more difficult extractions are best performed via a surgical approach. This includes canine and carnassial (maxillary fourth premolar and mandibular first molar) teeth, as well as teeth with root malformations or pathology, and finally retained roots. A surgical approach allows the practitioner to remove a small amount of buccal cortical bone, promoting an easier extraction process.

A surgical extraction is initiated by creating a gingival flap. This can be a horizontal flap along the arcade (an envelope flap) or a flap with vertical releasing incisions (a full flap). An envelope flap is created by releasing the gingival attachment with a periosteal elevator along the arcade including one to several teeth on either side of the tooth or teeth to be extracted. The gingiva along the arcade is released to or below the level of the mucogingival junction (MGJ) and the flap is connected by incising the gingiva in the interdental spaces. The advantage to this flap is that the blood supply is not interrupted and there is less suturing.

The more commonly used flap includes one or more vertical releasing incisions. This method allows for a much larger flap to be created, which (if handled properly) will increase the defects which can be covered. The vertical incisions are created at the line angle of the target tooth, or one tooth mesial and distal to the target tooth. The incisions should be made slightly apically divergent (wider at the base than at the gingival margin). Furthermore, it is important that the incisions be created full thickness, in one motion (rather than slow and choppy). A full thickness incision is created by incising all the way to the bone, and the periosteum is thus kept with the flap. Once created, the entire flap is *gently* reflected with a periosteal elevator. Care must be taken not to tear the flap, especially at the muco-gingival junction.

Following the flap elevation, a small amount of buccal bone should be removed (approximately 1/3 to ½ of the root length depending on the situation) to the depth of the root. This should only be performed on the buccal side. Next, the teeth should be sectioned if multirooted and the teeth then extracted as described above. After the roots are removed the alveolar bone should be smoothed and the defect closed.

Closure is initiated with a procedure called fenestrating the periosteum. The periosteum is a very thin fibrous tissue which attaches the buccal mucosa to the underlying bone. Since the periosteum is fibrotic, it is inflexible and will interfere with the ability to close the defect without tension. The buccal mucosa, however, is very flexible and will stretch to cover large defects. Consequently, incising the periosteum takes advantage of this attribute. The fenestration should be performed at the base of the flap and must be very shallow as the periosteum is very thin. This step requires careful attention, as to not cut through or cut off the entire flap.

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