The premise for any dental extraction of flap procedure is to appreciate the anatomy as well as the surgical principles necessary for this procedure to be accomplished.

Before any dental extraction should be undertaken, it is ESSENTIAL that a veterinarian has prior appreciation of the root structure of the tooth being removed. The only way this can be accomplished is via dental radiography. While many times complete removal of the affected tooth can be accomplished without radiography, can the veterinarian absolutely claim that there are no tooth shards, bone fragments, or tooth root structures remaining? Failure to completely remove the tooth in entirety without any remnants is tantamount to malpractice. In many clinical situations, existing endodontic disease causing apical periodontitis (abscess) will remain unless the entire tooth root is removed.

The flap procedure is an important consideration, as the veterinarian must choose a flap that allows exposure of the affected tooth and TENSION FREE CLOSURE without disruption of the neurovascular component of the gingiva. The ENVELOPE flap is considered with marginal amount of buccal or labial bone is needed to be removed to accomplish this extraction. This flap, as with others, must extend beyond the mucogingival line to allow for unattached gingiva to be released and facilitate a tension-free closure.

Vertical releasing flaps (single or bilateral) are mucoperiosteal flaps that allow the veterinarian full exposure of the tooth to be removed, thus allowing more buccal bone to be removed to facilitate extraction.

Three (3) Principles of flap surgery are as follows: If a vertical release is to be made, make it on the adjacent tooth at the appropriate LINE ANGLE, not the tooth to be removed. This is important in that you do not want your suture line over the alveolus, but rather over healthy bone (no suture line over a defect). Secondly, preserve blood supply and thirdly, selection of instruments that minimize tissue damage.

**Line angle definition**
This is an imaginary vertical line forming the intersection of two adjacent vertical dental surfaces. This denotes a specific position on a tooth and are important surgical landmarks. (Verstraete F, Lommer M. *Oral and Maxillofacial Surgery in Dogs and Cats.* )

The flap exposure is best accomplished after extraction by excision of the mucoperiosteum. Utilization of a scalpel blade nick followed by sharp dissection of this is made to allow the flap to fully cover the surgical extraction site. Any marginal tissue that looks irregular and inflamed should be removed.

- 4-0 poliglecaprone-25 with a reverse cutting edge needle is chosen as the oral suture material. This suture is rapidly absorbed and the reverse cutting edge is used to minimize inadvertent tissue tears. Since it is a monofilament suture, it pulls freely through tissue, has good knot security, stays in the mouth longer than chronic gut, and does not require removal. Simple interrupted patterns (2-3 mm apart) are needed.

- Scalpel blade selection should be via a #15 or #15C blade. Rarely, a #11 surgical blade is needed. Proper instrumentation is needed to adequately remove large teeth. It is recommended to have a winged elevator kit (2-8), which allows one variability in selection of elevators. Periosteal elevators are ESSENTIAL for adequate flap preparation and a couple of sizes are needed for both the small dog and cat as well as for large breeds.

- In order to facilitate extraction of teeth, a high speed dental unit is a must. One cannot adequately remove large single rooted or multirooted teeth without the benefit of a good high speed unit. BEFORE undertaking any dental extractions, the veterinary would be wise to consult with his/her distributor for a unit. There are many good units in the marketplace, and each has their own benefit or even restriction. It is recommended, however, to go the extra mile and purchase fiberoptics in your high-speed handpiece. Swivel-tip handpiece is also recommended.

- Bone graft materials aid in filling the open socket with bone and connective tissue rather than allowing it to collapse or granulate in with soft tissue. Collapse of the socket can further alter facial features slightly because there is no longer any crown structure to support that portion of the upper lip, which is now vulnerable to trauma by the mandibular canine tooth. (for maxillary canine extraction). If there is marginal amount of ventral cortex remaining from extraction of a mandibular 1st molar tooth, a graft is warranted. Graft of mandibular canine teeth is also recommended if stability of the bone is needed. However, there is no substitute for a good clot formation in the site to help promote new bone formation.
Tips for extractions of the following teeth

Maxillary canine
- Single vertical diverging releasing incision advised (between the maxillary canine tooth and the maxillary lateral incisor tooth (or mesial line angle of the maxillary canine tooth)
- Use larger round bur (#4, #6) to remove buccal bone and DO NOT remove bone mesial or distal to the tooth itself
- Use #170, 701, 699 crosscuts OR #1 round bur to make moat. Make moat only wide enough to accommodate the winged elevators or luxators only.
- Start out by taking buccal bone 2/3 or greater to the apex of the tooth. (remember to follow the contour of the tooth) As you get better at removing teeth, you can take off less buccal bone
- Periosteal release is a MUST and freshen edges prior to closure
- Always perform alveoplasty (football or round diamond)
- If dog or cat has ONF, remove the epithelial downgrowth tissue PRIOR to closure, otherwise the flap will fail
- Tension-free flap (for all extractions)
- Simple interrupted pattern 2-3 mm apart. DO NOT USE PDS
- E-collar may be needed for cases

Maxillary 4th premolar tooth
- Single or bilateral diverging incision. Make sure you DO NOT make incision over tooth you are extracting
- Careful of the parotid papilla if making a bilateral diverging incision
- Remove buccal bone with #4 or #6 round bur
- Moat with same burs you use in canine
- Section all 3 roots prior to removal, regardless if tooth is mobile or not
- Remove caudal crown cusp adjacent to the maxillary 1st molar tooth to facilitate straight-line luxation/elevation. Care needed to avoid contacting the 1st molar tooth
- Remove middle section of tooth if need be to allow straight line removal (OR amputate crowns for better visualization of crowns to facilitate extraction)
- Remove interradicular bone between the mesiobuccal root and the palatal root (after removal of the mesiobuccal root)
- Make a moat around the palatal root carefully with very fine cross cut (#170, 701, or 699) or round (1/4-1/2 round)
- Surgical burs are a must in difficult extractions so keep some on board (#2, #1, #1/2, 701)
- Alveoplasty needed
- Avoid neurovascular bundle at infraorbital foramina

Mandibular 1st molar tooth
- Vertical incision at line angle of the mesial or distal aspect of the 4th premolar tooth, NOT at the mesial aspect of the 1st molar (as roots can diverge)
- Envelope flap if practical
- Amputate mesial and distal cusps of 1st molar to facilitate straight-line access
- Remove middle section of tooth to facilitate extraction if needed
- Alveoplasty after extraction, especially on the lingual mandibular marginal bone

Mandibular canine tooth
- Preservation of labial frenulum advised
- Vertical release from mesial line angle of the canine tooth
- Care with buccal bone removal to avoid the mental foramina (use periosteal elevators to protect this area and avoid the bur macerating/lacerating the vessels/nerve)
- Release of lingual gingiva needed
- Tension-free closure
- E-collar needed

Bone grafts
The most common types of bone grafts in veterinary medicine are osteoinductive and osteoconductive agents. Osteoinduction is a chemical process by which molecules contained in the graft (bone morphogenic proteins) convert the neighboring cells into osteoblasts, which in turn form bone. An example of this is a decalcified freeze-dried bone allograft (DFBDA). Osteoconduction is a physical effect by which the matrix of the graft forms a scaffold that favors outside cells to penetrate the graft and form new bone. In veterinary dentistry, freeze-dried bone allograft (FBDA) or more commonly a synthetic bioactive glass are examples of this type of osteoconductive agent.
Equipment list

- Dental radiograph system (Progeny generator; digital dental sensor)
- High Speed/low speed dental system
- 4-0 and 5-0 Monocryl (or generic) or Chromic Gut
- #15 or #15c surgical blades
- Winged elevator kit (2-8)
- Periosteal elevators (EX8-108; EX9-108)
- Thumb forceps
- Assorted burs (#1/2, #1, #2, #4, #6 round); 701, 701L Surgical crosscut burs
- Diamond burs (medium grit football)
- Goldman-Fox scissors
- Kelly Straight Scissors
- #100C and 1.3S luxators
- Cawood-Minnesota retractors
- Root tip pick
- Small needle holders (with or without scissors)
- Consil or Oste-Allograph Perio Mix
When a dog has a malocclusion, it can affect that pet throughout their entire lifetime. Left undiagnosed and untreated, these pets suffer unnecessarily. It is the job of the family veterinarian to identify that pathology and recommend treatment options as soon as practical. Malocclusions that do not cause oral pain or discomfort may not need to be corrected, and the scope of this lecture is addressing those occlusion issues that indeed cause oral discomfort. Ethical considerations should be made when altering an abnormal bite for personal gain in the show ring or for masking an underlying genetic defect to further promote the gene pool.

The practitioner must know the dental anatomy of the dog regarding both primary and adult teeth. There are 28 primary and 42 teeth in the dog. **The dental formula is available in many veterinary dental textbooks.

**Eruption location and dates**

**Primary (deciduous teeth)**

- Incisors: 3-4 wks
- Canines: 3 wks
- Premolars: 4-12 wks
- Molars: No primary molars

**Permanent (secondary or adults)**

- Incisors: 3-5 mos
- Canines: 4-6 mos
- Premolars: 4-6 mos
- Molars: 5-7 mos

**Definition of normal occlusion**

An *ideal occlusion* can be described as perfect interdigitation of the upper and lower teeth. In the dog, the ideal tooth positions in the arches are defined by the occlusal, inter-arch and interdental relationships of the teeth of the archetypal dog (i.e. wolf). This ideal relationship with the mouth closed can be defined by the following:

- The maxillary incisor teeth are all positioned rostral to the corresponding mandibular incisor teeth. The crown cusps of the mandibular incisor teeth contact the cingulum of the maxillary incisor teeth. The mandibular canine tooth is inclined labially and bisects the interproximal (interdental) space between the opposing maxillary third incisor tooth and canine tooth. The maxillary premolar teeth do not contact the mandibular premolar teeth. The crown cusps of the mandibular premolar teeth are positioned lingual to the arch of the maxillary premolar teeth. The crown cusps of the mandibular premolar teeth bisect the interproximal (interdental) spaces rostral to the corresponding maxillary premolar teeth. The mesial crown cusp of the maxillary fourth premolar tooth is positioned lateral to the space between the mandibular fourth premolar tooth and the mandibular first molar tooth.

**Types of malocclusions**

Neutroclusion (Class 1 malocclusion; MAL/1): A normal rostral-caudal relationship of the maxillary and mandibular dental arches with malposition of one or more individual teeth. Common abnormalities of MAL/1 include rostral and caudal crossbites, mesioversion, labioversion, lingoverison, distoverison, and buccoverison. (You can also see each of these in other forms of malocclusion)

- Mandibular distoclusion (Class 2 malocclusion; MAL/2): An abnormal rostral-caudal relationship between the dental arches in which the mandibular arch occludes caudal to its normal position relative to the maxillary arch.

- Mandibular mesioclusion (Class 3 malocclusion; MAL/3): An abnormal rostral-caudal relationship between the dental arches in which the mandibular arch occludes rostral to its normal position relative to the maxillary arch.

- Treatment of Malocclusions is based on a single premise…oral pain and discomfort. Orthodontic movement of maloccluded teeth simply for improvement in the show ring is unethical and is not recommended. Orthodontics should therefore be reserved for those patients with attrition (tooth on tooth contact) or oral discomfort due to contact to the mandibular or maxillary gingival mucosa.

Basic tenets of maxillary/mandibular growth and orthodontic treatment in puppies:

1. Growth of mandible and maxilla is under separate genetic control
2. Up to day 50 post partum, the increase in length of mandible occurs as a result of growth in ROSTRAL portion. After day 50, almost all increase in length in mandibular length is a result of growth in the region of the RAMUS. No change in distance b/w tips of central incisors and central cusps of mandibular 1st molar between 3-6 mos of age
3. More time between primary tooth extraction and permanent tooth eruption, better chances of success

Treatment for MAL/1
- **Rostral crossbite**: None if no attrition is present; Maxillary expansion device; Labial arch bar
- **Caudal crossbite**: Extraction of the affected tooth
- **Lingoverversion or linguodisplaced mandibular canines**: Crown reduction/vital pulpotomy; Acrylic incline plane; Crown extension of mandibular canines; Removable orthodontic appliance (aka Kong therapy); Extraction
- **Mesioverted maxillary canine teeth**: Active orthodontic appliance (maisel chain); Extraction

Treatment for MAL/2
- **Puppy or kitten**: Extract mandibular canines and incisors (primary teeth)
- **Adult**: Extraction of the affected tooth
- **Linguoversion or linguodisplaced mandibular canines can occur with this scenario and treatment is the same as MAL/1
- **Crown reduction and dentin bonding of offending mandibular incisors**

Treatment of MAL/3
- **Puppy or kitten**: Extract maxillary canine teeth and incisors (primary teeth)
- **Adult**:
  - Linguoverted or linguodisplaced can still occur with this scenario and treat accordingly
  - Crown reduction and dentin bonding of the maxillary incisors that contact the mandibular gingival mucosa
  - Pay very close attention to the maxillary 3rd incisors to insure no attrition to the mandibular canine teeth. If so, extraction of the 3rd incisor is warranted. (or odontoplasty)

Persistent primary teeth
(Previously called retained deciduous teeth) should be treated immediately. A discussion in this lecture will address the permanent malocclusion ramifications of delayed treatment of persistent primary teeth. The Rule of Dental Succession will be emphasized: No successional and deciduous precursor teeth should be erupted simultaneously or in competition for the same dental arcade space AT ANY TIME.

Other clinical presentations requiring interceptive orthodontics: crowding, rotation, supernumary teeth.
Knowing What’s Abnormal on Dental Radiographs in Dogs and Cats
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When a practitioner opens his/her world to dental radiography, there will become a tremendous amount of pathology that becomes ‘visible’. This new awareness of oral pathology then puts the exclamation point on the ASSESSMENT part of the Oral ATP (Assessment, Treatment, Prevention). Otherwise, the practitioner is thinking their car is in working order by just a simple wash and wax. Neglecting to ‘check under the hood’ not only leaves potential oral pathology to linger causing potential oral pain and discomfort, but also gives the pet owner a false sense of security thinking the mouth is all good as their pet had their ‘dental’.

A benchmark study by Verstraete proved the value of intraoral dental radiography. His findings (226 dogs/116 cats) showed the following: This shows that almost 3/10 dogs and 4/10 cats that only receive a ‘dental’ go out of your door with oral pathology that needs to be identified. This shows that ‘where there’s smoke, there’s fire’ with regard to pathology under the gumline. 50% of both dogs and cats that have radiographically visible pathology have more findings that need attention.

In a recent JAAHA article, 16 predetermined categories of abnormal radiographic findings in 233 small breed dogs found almost 30% had abnormal findings. The most common tooth identified with pathology was the mandibular 1st molar (70%) followed by the maxillary 4th premolar (40%). Bone loss was noted in 15% of all findings. The conclusion was “full mouth radiographic evaluation should be performed to obtain important information for making accurate diagnoses”.

The indications for dental radiography are:
- Before and after extractions
- Periodontal disease
- Mobile teeth
- Discolored teeth
- Fractured teeth
- Gingival ulcers
- Missing teeth
- Malocclusions causing trauma
- Malformed teeth
- Gingival mass/bone swelling/soft tissue swelling
- Tooth Resorptions/root resorptions
- Pet dropping food
- Foul odor in mouth
- Reluctance to eat
- Reluctance to eat chews
- Nasal discharge

**Before and after extractions**

How would you know if the root has a curved apex or that there is indeed a root fracture? What if the mandibular 1st molar you plan to remove has its apex 1 mm from the ventral cortex of the mandible? A good dentist always knows the lay of the land before undertaking any procedure. As a radiograph is a legal document, this is the ONLY confirmation that the procedure you charged for was done to completion. Tooth root fragments/remnants are quite commonly left in the mouth with extractions.

**Periodontal disease (PD)**

Probing is the gold standard to assess bone loss and periodontal pockets. Radiography compliments this. There has to be 40% cortical bone loss for radiographic evidence of PD to be visible. The earliest sign of periodontal disease is the irregular alveolar margin between teeth. This should give the practitioner a sign that the periodontium is undergoing stress and needs treatment.

**Discolored teeth**

There is a 93% chance that discolored teeth are non-vital, but only 57% of those teeth will show evidence of premature maturation (tooth death). Regardless, it is important to radiograph all discolored teeth for evidence of apical periodontitis. Radiography will aid in deciding if this tooth is a candidate for endodontic therapy or extraction. Leaving a discolored tooth in the mouth without treatment is unwarranted and can be considered malpractice.
Fractured teeth
Even uncomplicated crown fractures (dentin exposure with no pulp exposure) can cause kill a tooth and cause apical periodontitis. Dentin is microscopically porous and bacteria can ingress through these pores and cause premature maturation (tooth death). Treatment options depend on the radiographic structures of the pulp cavity and the surrounding periapical tissue. Uncomplicated crown fractures can be restored with a composite restoration, or with evidence of tooth death, extracted or root canalized. Complicated crown fractures (and crown-root or even root fractures), which are fractures extending into the pulp cavity, must be radiographed prior to treatment as mentioned above. Treatment options for this type of fracture is either extraction (exodontia) or root canal therapy.

**Strategic teeth such as maxillary/mandibular canines, maxillary 4th premolars, 1st mandibular molars and even maxillary 3rd incisors should be endodontically treated if at all possible. Just because one knows how to extract a tooth doesn’t mean it’s the best option for this pet. Endodontic therapy saves the tooth and allows a pet to have a functional tooth for the lifetime of the pet**

Missing teeth/embedded teeth
The only way you can legally document a tooth is not present is by a dental radiograph. Once it is confirmed, it is noted on the dental record as a permanent document. However, many teeth do not erupt and become entrapped under the gumline. A bone-destroying cyst (dentigerous cyst) can occur from any tooth that has not erupted. The reason is enamel does not belong below the gumline. It becomes a foreign body causing an osmotic gradient which leads to bone destruction. Therefore, all missing teeth should be radiographed to either A) confirm they are absent, B) identify tooth root remnants that may need to be removed, or C) identify embedded teeth that need to be removed.

Malocclusions
When a tooth contacts another tooth (attrition) due to a malocclusion, those teeth can die due to the continued trauma occurring. Direct contact (as in maxillary and mandibular incisors traumatizing each other or the maxillary lateral incisor traumatizing a mandibular canine tooth due to a Class III malocclusion) should not occur and in most cases, bad things happen. Dental radiography is needed to assess if the attrition has caused premature maturation (tooth death). Regardless, it is advised to remove those teeth that are traumatizing another tooth due to a malocclusion.

Malformed teeth
Enamel defects (enamel hypocalcification or enamel hypoplasia) not only cause visible crown pathology, but also can cause root developmental pathology. Depending on what caused the enamel defect (localized trauma versus systemic disease), all teeth with enamel defects should be radiographed.

Any tooth that has any visible malformation of the crown should be radiographed. Dens invaginatus is a condition where the dentin is involutes into the pulp cavity and the tooth is endodontically compromised. In many instances, the crown has a lobular appearance and is not smooth.

Gingival mass/soft tissue swelling/bone swelling
In many instances, radiography assists the practitioner in discerning whether a mass is malignant or not. While histopathology is needed for definitive identification of any soft tissue mass, radiography can be a vital aid. If a destructive mass is present but the teeth are not deviated from their normal anatomical position(s), one can assume this is a malignant mass. Odontogenic tumors tend to ‘move’ teeth as they grow.

All areas where an oral mass occurs should be radiographed. The pathology group this author uses request radiographs and clinical images with each sample to provide the most accurate clinical and histopathological diagnosis available.

There is no radiographic difference in many instances between a neoplasia and osteomyelitis. Therefore, histopathology is the only way to confirm this.

Tooth resorptions (TR) and root resorptions
The AVDC (avdc.org) has a very good description of the different types of tooth resorption and the radiographic difference between them. It is beyond the scope of this lecture to discuss them in detail but a very important detail must be discussed:

- Type I TR has a visible periodontal ligament space around the tooth root. Therefore, the tooth MUST be removed.
- Type II TR does not have a visible periodontal ligament space around the tooth root and the root is being remodeled into the alveolar bone. Extraction (if practical and the practitioner follows the principles of exodontia with resorbing roots) is recommended, but crown amputation is allowed. HOWEVER, this must be recorded on the dental/medical record and should be radiographed at least every 6-12 months.
- Type III TR is a tooth that has 1 root as Type I and another as Type II Treatment as above.
Root resorptions pose an interesting conundrum as to what therapy should be performed. A recent article was written describing each type of resorptions (external replacement resorptions, inflammatory root resorptions, etc…) While this is a human classification; it has relevance with dogs and cats. The practitioner should have a basic understanding among them all. The more common one seen is external replacement resorption. “This finding is the gradual disappearance of the periodontal ligament (PDL) with progressive replacement of root tissue by surrounding alveolar bone. The long term prognosis for this tooth is not good. In many instances, the crown fractures and the owner or the practitioner notices a tooth missing.

Internal root resorptions involve the pulp cavity. Treatment is either exodontia (extraction) or root canal therapy. External root resorptions involve the surrounding dentin and the pulp cavity is not involved. The way one differentiates between the two is by adjusting the tube head of your dental radiographic machine. If the lesion remains in the pulp cavity, it is internal root resorption. If the lesion moves with the movement of the tube head, then external root resorptions is present. With external root resorption, if there is no co-existing endodontic or apical pathology, and the lesion is below the alveolar margin, the tooth can remain and be monitored every 6-12 months. Any crown resorption should be treated either via restoration or extraction.
Normal Dental Radiography…
You Must Know this Before Knowing Abnormal
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Congratulations on the addition of dental radiography to your dental services! Without it, you are basically going to the moon without a navigation system, as almost 100% of all dental work requires radiography to assess the visible tooth and the underlying root structures. Utilization of conventional radiography falls considerably short in diagnostics and is truly wasting client’s money.

Types of radiology generators and sensors
For those still considering dental radiography for their practice, there are two radiographic generator options. Wall mounted/floor units provide the DVM the ability to retake less than perfect radiographs by adjusting the tube head direction or distance. That tube head isn’t moving unless you move it yourself. This is unlike the hand held dental radiography generators that are quite useful in tight quarters, providing your state allows these systems to be used. A disadvantage to this system is the tube head placement is hard to reproduce or adjust, but many overcome this issue quite easily. Most systems have set kVp and milliamperage (mA) values, while others allow the operator to select mA between 7-15 mA and kVP between 60-90 kVp. Remember from radiography that the higher the kVp and lower mA makes fewer X-rays with higher penetration. Low kVp and high mA produces images using more x-rays but with less penetrating ability. Exposure time may be in fractions of seconds as with digital systems or pulses. A pulse is 1/60th of a second.

Conventional film used to be the gold standard of dental radiography. However, digital radiography affords the DVM images that are easily manipulated, catalogued, and visualized, and in many instances, superior to film. There is direct digital (computer generated) or indirect digital (utilization of phosphor plate to transfer image to computer). Size 2 direct digital sensors are available. Indirect digital utilizes size 1, 2, 3, 4 and even 6 sensor plates.


Tooth root maturation
A recent study evaluated apical closure of mandibular 1st molar teeth (10 months) and canine (7 months) in the cats. Canine teeth apical closure is approximately the same. This is important to know with regard to tooth fractures of young dogs and cats concerning which endodontic therapy to choose. It is also important with regard to orthodontic movement. Orthodontic movement is easier with an immature tooth than with a mature tooth (sound familiar?).

Pulp continues to mature throughout the life of a pet. Therefore, narrow dentin walls/wider pulp cavities are younger pets. As the tooth ages, the dentin wall gets thicker and the pulp canal gets narrower. One way to assess the vitality of a tooth is to radiograph the contralateral tooth to assess pulp cavity width. Premature maturation (tooth death) results in a static pulp canal width.

Q: What is the earliest age you can you radiographically identify adult precursors? 8-12 weeks

Radiographic positioning
Maxillary radiographs are positioned with the crowns facing DOWN. Mandibular views have crowns facing UPWARDS. View images as you are looking at the patient face-on. Right maxillary views have molars to the left and the canine to the right as you are viewing. For left maxillary, molars on the right and canines to the left. Mandibular views are the same (right arch has molars to left and canine to the right and left arch has molars to right and canines to the left). Digital software packages have templates to allow images to be placed in their normal position. If you take an image and the template is set for a different quadrant, the image may be inverted or backwards, this telling you your image is in the wrong quadrant. (pretty cool!)

Maxillary 4th Premolar Teeth…how do I know which tooth root is the mesiobuccal and which is the mesiopalatal? There is a phrase, “Same Lingual, Opposite Buccal” or the SLOB rule that may be a bit confusing to some. What is a bit more understandable is this: The PALATAL ROOT of the 4th PREMOLAR is closest to the tube head (either from the mesial direction to the distal direction; or the distal direction to the mesial direction). Therefore, if you are taking an image of the caudal maxilla and the tube is facing slightly distally, the most forward (mesial) root is the mesiopalatal root. If your tubehead is slightly facing mesial (towards to nose), then when looking at the two mesial roots, the mesiopalatal root is the one closest to the tube head direction.

For maxillary and mandibular canine teeth, a rostral oblique radiograph provides the best view for potential vertical bone loss. An occlusal view or lateral view may not show bone loss due to the superimposition of the tooth over the alveolar bone.
Nomenclature to understand and use
This section will review common radiographic terms that are essential in understanding whether a patient has normal or abnormal radiographic pathology. Here are some terms one may not be as familiar with:

- Mesial, Distal, Apical, Coronal
- Dentin, Pulp chamber
- Cementoenamel junction
- Periodontal ligament space
- Lamina dura
- Interradicular space
- Alveolar margin (marginal bone)
- Furcation
- Mandibular canal
- Palatal fissures
- Mandibular symphysis

Anomalies
- Chevron effect
- 3-rooted maxillary premolars (2nd and 3rd) and 2nd molars
- Gemination tooth
- Fusion tooth
- Curved root tips
- Microdontia
- Fusion
- Supernumerary teeth
- Twining
- Missing teeth

A study was performed evaluating the variations in the dentition of the domestic cat. The following was noted from this study:

- Maxillary 2nd premolar absent 7.9%; single rooted 27%; partly fused 55%; 2 fully formed roots 9%
- Maxillary 1st molar absent 2%; single rooted 35%; partly fused 34%, and 2 rooted 28%
- Maxillary 3rd premolar had supernumary roots in 10% of cases

Radiographic technical errors
Foreshortening and elongation are two common errors that can give the interpreter difficulty in adequately interpreting images. This is especially true with addressing endodontic disease, as foreshortened images make visualization of the apices more difficult.

Over and underexposing images are also quite common for the novice dental radiographer. Many times, increased contrast can be more appealing to the eyes, but at a cost. Septal bone may not be visualized with high contrast, therefore, a lower contrast which may be a bit less clear is preferred in many instances.

Overlapping roots is very common in the caudal maxilla, especially the distal root of the maxillary 4th premolar tooth overlapping the maxillary 1st molar. This non-diagnostic view needs to be modified by adjusting the tube head positioning (previously discussed). However, the two mesial roots of the 4th premolar tooth (mesiobuccal and mesiopalatal roots) may be visualized well, so keeping this image in the template may be worth while. But a disto-mesial tube head angulation must be used to adequately visualize the distal root of the 4th premolar tooth.

In brachycephalics, this can be very difficult, if not impossible due to rotated and crowded teeth. Probing should compliment this closely as sometime radiographic pathology may not be as prominent due to this process.
Oral tumors compromise 5.3% of all neoplasia in the dogs and 6.7% in cats. Therefore, it is necessary for the clinician to be diligent in oral examinations and diagnostics. This lecture will review the most common oral tumors in dogs and cats, and treatment plans for each.

The most common oral malignancies in dogs in order of occurrence: Malignant melanoma, squamous cell carcinoma, fibrosarcoma. In the cat, squamous cell carcinoma

Malignant versus benign tumors
Malignant tumors tend to destroy bone and soft tissue, while leaving teeth in their normal arcade positions. This gives the impression of teeth being suspended in soft tissue with marginal bone. Benign tumors can move teeth due to the soft tissue expansion, thereby redirecting teeth.

Malignant melanoma (MM)
This is the most common oral tumor in the dog. Sex predilection: Males with a male-to-female ration of 1.4-6.0:1. Typically occurs in older dogs (mean 11 years). Cocker spaniels, Labrador retrievers, Golden retrievers and German Shepherds and dogs with heavily pigmented oral mucosa may be predisposed. Non-pigmented (amelanotic) tumors do occur as well (33%). Melanomas are rare in cats. Otherwise, dark pigmented raised masses are noted.

These tumors have focal infiltration, with early metastasis to regional lymph nodes. Metastasis to the lungs and liver are less frequent. Bone destruction is common.

Location – Any part of the oral cavity including the dorsal tongue surface and lips. Encompassing mandibular and maxillary together, 32% were located rostrally and 20% were located caudally.

Diagnostic tests- Intraoral radiographs are needed to assess bone involvement (57%). FNA of mandibular lymph node, incisional biopsy. Once MM has been diagnosed, conventional oncology workup is recommended (CT, CBC, Serum chemistries, UA, 3 view thoracic radiographs and abdominal US).

Treatment options – Curative intent surgery with wide margins (1-2 cm margins), even as a sole treatment often extends PFI (Progression free interval) and ST (Survival times). Metastasis at time of diagnosis carries a poor prognosis and a lower ST. Rostral mandibular and maxillary masses provide the surgeon a more favorable clean tumor-free margin. Also, tumor size directly affects the ability for a surgeon to achieve clean surgical margins. Other therapy: Maximum tolerable dosage (MTD) chemotherapy (Carboplatin), xenogenic canine melanoma vaccine, radiation therapy, metronomic chemotherapy (combination of doxycycline, NSAID, cyclophosphamide), and interferon.

Survival times – The survival time is short, ranging from <4 months to 5.8 months and 8 months in other studies. However, a longer survival time was noted with dogs with histologically well-differentiated melanocytic neoplasms (Mean survival time of 23 months and median survival time of 34 months after surgery)

Squamous cell carcinoma (SCC) – non-papillary / non-tonsillar
This is the most common oral malignancy in the cat and 2nd most common one in the dog (17-25%). This occurs in older dogs (mean 8-10 yrs) with larger dogs overrepresented. The gingiva is the most common site for this neoplasia. The gingiva usually appears ulcerated with secondary bone involvement (77%). Metastasis to regional lymph nodes is rare (<10%) and low to moderate metastasis to the lungs in dogs is noted (3-36%). Some facial changes (exophthalmos) can be noted. These masses are slow growing, locally destructive mostly on the buccal mucosa. (See comparison of this mass with papillary SCC)

Location- In the dog, the gingival mucosa is the most common site. In the cat, premolar / molar area of maxilla, premolar region of the mandible, and sublingual lesion. Metastasis is late to regional lymph nodes and distant organs. SCC is locally aggressive with bone involvement. Tonsillar and lingual SCC are less common but have a higher and earlier metastatic rate.

Diagnostic tests- Incisional biopsy and regional lymph node aspirates are recommended. Once the non-papillary SCC has been diagnosed, conventional oncology workup is recommended.

Treatment options- Wide surgical excision (1-2 cm margins). Rostral mandibular SCC is more favorable with cats but case selection prior to aggressive excisional surgery must be considered. Rostral mandibular provide a more favorable long-term prognosis. SCC is responsive to radiation therapy with a medium survival time (MST) of 16 months. Radiation is radiosensitive but not radiocurative. Cisplatin and piroxicam have been reported to be effective.
Papillary SCC (PSCC)
Previously thought to only occur with young dogs, this form of SCC can occur with middle to older aged dogs as well. The mean age is ~4 years (0.5-9.0 years) in a 9 dog study. CT of these lesions showed bone lysis with our without osteoproliferation. These masses are more infiltrated, rapid growth, and atypical cellularity. PSS do not metastasize.

Location - Most were large breed dogs and the most common location was the rostral maxilla (7/9), however, tumors were noted in the rostral mandible and mid/caudal maxilla.

Diagnostic tests – Same as SCC

Treatment options – Surgical wide margins (1 cm) provide excellent clinical results.

Fibrosarcoma (FSA)
This neoplasia is the 3rd most common neoplasia in dogs (7.5-25%) and 2nd most common malignancy in cats (13%). The median age of 7.3-8.6 years in dogs, and <25% of dogs are <5 years of age. In cats, the average age is 10.3 years. There is a sex predilection of male to female of 1.4-2.8:1. Larger breed animals >50# (Golden Retrievers) have a higher predisposition for FSA. Metastatic potential is low and can occur late in the disease process with lymph nodes (19-22%) and lungs (6-27%) in dogs. The low metastatic potential is the same in cats.

Clinical appearance show a firm, flat, multilobulated and deeply attached to the underlying tissue with rare ulceration noted. Bone lysis occurs in 72% of canine cases.

These tumors are histologically low-grade and biologically high-grade which potentially provides confusion to the DVM when interpreting an aggressive oral tumor. These tumors may be misdiagnosed as benign fibromas or low-grade sarcomas. High grade anaplastic oral FSAs have a more metastatic potential than do low-grade tumors.

Location – The site predilection in dog is maxillary arcade between the canines and carnassial teeth (56-87%), hard palate (7-17%) and buccal or labial mucosa (4-22%). There is no site predilection in the cat.

Diagnostic tests – After initial incisional biopsy, routine staging with FNA of mandibular lymph nodes, 3 view orthogonal thoracic images, serum chemistries/CBC/UA and CT.

Treatment options – Wide surgical excision (2 cm) is warranted. Local recurrence occurs more frequently than metastasis. Radiation therapy post wide excisional surgery, radiation therapy alone, and radiation therapy with local hyperthermia can prolong the survival times.

Survival times- Median survival time (MST) is approximately 11-12 months for both mandibular and maxillary FSA resection with local recurrence rate of 46%. Radiation therapy MST is 6-26 months.

Osteosarcoma (OSA)
Oral osteosarcomas are the 4th most common oral tumor in dogs (6-18%). Feline oral OSAs are much less frequent (2.4%). Medium to large breed dogs that are middle aged to older are mostly represented. Females appear to be more represented.

Location – Most OSAs occur in the maxilla (43%) followed by mandibular (32%) and the calvarium (23%).

Diagnostic tests – After incisional biopsy, regional lymph node aspirates, along with conventional oncological workup.

The metastatic rate of oral OSA is lower than the appendicular counterpart. Occurrence in the mandible and maxilla are noted, with a more unfavorable outcome with OSA in the TM joint and caudal maxilla / mandible.

Treatment options – Wide radical excision (1-2 cm) of the tumor should be performed if possible. Dogs treated with surgical excision had a Median Survival Time (MST) of 329 days. Surgery resulting in complete excision improved prognosis, whereas calvarial tumor location and increased monocyte count were associated with a poorer prognosis. Radiation therapy and chemotherapy have not shown a decrease in hazard of death progression.

Odontogenic tumors
These tumors are derived from ectodermal, ectomesenchymal, or mesenchymal components of the tooth forming apparatus. These include Canine acanthomatous amelolastoma (CAA), peripheral odontogenic fibroma (POF), and focal fibrous hyperplasia (FFH). Of the three, POF and FFH are relegated to the gingiva only.

Canine acanthomatous ameloblastoma (CAA)
In a recent study of odontogenic tumors, CAA occurred 45% (68/152). This is an aggressive benign odontogenic tumor that is non-inductive in nature; therefore, the cells of ameloblastic origin do not induce the surrounding mesenchmal cells. Therefore, no dental hard tissues formed and is a soft tissue neoplasia. These raised, lobulated masses also cause local bone infiltration and tooth displacement. Metastasis to regional lymph nodes or distant organs has not been reported. CT is recommended prior to oral surgery to establish bone involvement. 1-2 cm margins are recommended. Intraleisional bleomycin has been documented to resolve this oral mass with no recurrence. Local side effects to bleomycin injections have been documented. Predilection to the rostral mandible is common.
Peripheral odontogenic fibroma (POF)
These are slow growing masses. These benign masses are not locally invasive, and occur in 31% of odontogenic tumors. Clinically, they appear as rough-surfaced masses on the gingiva. Radiographically and histologically, there may be dystrophic calcification within the mass, but no alveolar bone involvement. As with other odontogenic tumors, tooth movement due to expansion of the mass is possible. Regional distribution is mostly the rostral maxilla (47%) and caudal mandible (21%), but these masses may occur anywhere along the gingival margin. There is controversy whether these tumors are actually remnants of the periodontal ligament, and whether removal of the tooth and adjacent periodontal ligament is warranted. Some recommend removal in the reactive zone and the surrounding pseudocapsule. Others recommend a more aggressive approach to remove the tooth and the PDL, which means removal of alveolar bone that supports the tooth, to achieve complete removal.³ ⁷

Focal fibrous hyperplasia (FFH)
This encompasses 16% of odontogenic tumors in the dog. Clinically, these appear raised, smooth and sometimes very firm. Regional distribution of these masses are mostly relegated to the rostral maxilla (57%) as well as rostral (22%) and distal (17%) mandible. Surgical removal is similar with POF.³ ⁷

References
9 Kelly JM, Belding BA, Schaefer AK. Acanthomatous ameloblastoma treated with intralesional bleomycin. Veterinary and Comparative Oncology. Vol 8 (2): 81-86
Clinical presentation
This is a syndrome associated with pain on eating and/or opening the mouth. There is noticeable pawing of the mouth, dysphagia, weight loss, bad general condition, grooming deficiency, ptalysm, and sometimes bleeding from the mouth. There is generally inflammation associated around the teeth, as well as in some cases caudal mucositis (caudal to the dental arch and lateral to the glossopalatine folds). This appears to be a multifactorial process of which the body cannot adequately respond to local inflammation of bacteria or viral pathogens. Calicivirus has been implicated with this disease process. While Bartonella has been discussed as a possible etiology to GS, it has been shown NOT to be involved with this disease process. Clinically, the presentation of gingivostomatitis can be localized or generalized. Periodontitis and tooth resorptions (TR) may present with areas of inflammation so dental radiography is needed to differentiate among the three. Inflammation in the palatoglossal folds is a hallmark sign of generalized feline chronic gingivostomatitis.2

According to Lommer, “While it is believed that feline stomatitis results from an inappropriate immune response to oral antigenic stimulation, the initiating cause is usually not identified, may differ from case to case, and is likely multifactorial”.3 Although underlying immunological abnormalities have not been identified, an increase in mRNA for IL-2, IL-4, IL-6, IL-10, IL-12 and IFN-γ have been identified with chronic stomatitis. Most noticeable in caudal stomatitis are IgG plasma cells and cytotoxic T-cells which could support the possibility of viral etiology in the development of this disease process. Plaque bacteria can stimulate the immune system that appear to contribute to ongoing inflammation. Successful treatment of chronic stomatitis requires minimizing this plaque.3

Initial therapy
Sedation exam with periodontal cleaning, probing, and radiographs is essential. This may have to be done every 3-6 months. Initiation of home care is paramount if the client is going to try a more conservative therapy. Assessment of horizontal bone loss and aggressive gingivitis is needed. Home care should be initiated and clients should be told that this has to be done every day. Therapy is to include the following: daily tooth brushings, chlorhexidine oral rinses bid, VOHC-approved water additives, and a plaque-retarding polymer. However, home care is usually insufficient due to the pain of the inflammation, the unwillingness of the cat to accept therapy, or lack of owner to perform daily.

With most cases, full-mouth or caudal mouth (caudal to the mandibular and maxillary canines) is warranted. It is imperative that dental radiography be utilized with this treatment, as tooth remnants left will not allow proper healing of the gingival and caudal oropharyngeal lesions from healing. Therefore, crown amputation of teeth is not a viable treatment option. The effectiveness of dental extractions has been shown to be: 55% cure, 35% markedly improved, 10% no improvement. Therefore, approx. 90% of cats responds favorably to extractions.1 If the canines do not appear to be involved and the lesions are caudal to them, it is recommended to first consider caudal mouth extractions and spare the canines. However, if the canines and/or incisors have any inflammation present it is recommended removing them and the incisors (full mouth extraction).

Extraction technique is very important as proper flap technique, complete extraction of teeth, alveoplasty of marginal bone with an assortment of diamond burs (round and football), and tension-free closure utilizing 5-0 chromic gut, Poliglecaprone 25, or Polyglactin 910 with a P3 needle. Utilization of assorted winged elevators and small luxators help facilitate complete tooth extraction. Post extraction radiographs are essential to properly confirm complete removal.

Refractory cases (treatment beyond extraction therapy)
No one treatment has shown superiority to another with regard to refractory caudal mucositis. In a recent paper by Hennet at the 2011 Veterinary Dental Forum, he described a study (Harley et all 1999) in that there was a comparison of the effect of methylprednisone, spiramycin-metronidazole, sodium aurothiomalate and chlorhexidine over a 3month treatment showed none of the agents were able to resolve the underlying pathology present in local gingivostomatitis cases at either a clinical or molecular level.

Antibiotics
These should be used sparingly in gingivostomatitis cases as a primary treatment regimen. However, during refractory cases (after extractions) there may be a need for a course (3 weeks) of antibiotics. The most commonly used drugs are clindamycin, amoxicillin-clavulanic acid, doxycycline, and spiramycin-metronidazole. This helps to decrease the oral bacterial load over a significant period of time and there is improvement clinically. While many have chosen Azythromycin in Bartonella-positive cats with GS, a recent study (Dowers et al. 2010) failed to show a correlation between GS and Bartonella.
NSAID’S and opioids

NSAID’s and opioids can certainly be used for pain therapy. With the addition of Robenacoxib, this approved NSAID therapy does have a place in pain management. NSAID’s are better used for inflammatory control of Calicivirus positive cats. Buprenorphine therapy (0.02 mg/kg) sublingually q 8-12 hrs provides analgesia as well.

Glucocorticoids/immune modulating drugs

These can be used but try to avoid high doses in Calicivirus-positive or herpes-positive cases. Taper a 3 week regimen. If cyclosporine therapy is to be initiated, avoidance of steroids is advised.

Immune modulating drugs besides glucocorticoids, aurothiomalate (gold salts), cyclosporine, Omega interferon, and chlorambucil have been used. Feline Recombinant Interferon (Verbagen Omega) has shown promise in some refractory cases.

Cyclosporine inhibits T-cell activation by blocking the transcription certain pro-inflammatory cytokines which include IL-2 and IL-4. Need to evaluate every 2 weeks to identify cyclosporine blood levels. After 6 weeks of therapy, 52.7% improvement SDAI (Stomatitis Disease Activity Index). Establishment of tough levels of Cyclosporine was noted. Whole blood cyclosporine levels >300 ng/ml (72% improvement) while cyclosporine levels <300 ng/ml showed only a 28% improvement. (cat had to have undergone either premolar/molar or full mouth extractions) It is important for tough levels to be done on an empty stomach. It is best to avoid previous corticosteroid usage. Potential side effects include toxoplasmosis for outside cats. Dosage is 2.5 mg/kg of Cyclosporine (Neoral) compounded with 1 ml cod liver oil with tuna base (60 mls). Standard is 1.0 mls po bid x 6 weeks.

Stem cell therapy

Current study by UC Davis Dentistry and Oral Surgery Service and the Regenerative Medicine Laboratory: As stem cells are known to have anti-inflammatory and regenerative properties, this may have value going forward. The adipose tissue was harvested from an affected cat with GS and then injected back into the cat (IV) after culture expansion and characterization.

There is a potential side effect of blood clots and transfusion-like reaction so 48-72 hrs of hospitalization/monitoring needed post injection. Two sets of treatment, four weeks apart were performed on cats with non-responsive GS and the cat was rechecked monthly afterwards with ~50% success rate. The clinical trial is still ongoing and the group is investigating the use of an autologous, allogenic and intralesional administration of stem cells.

CO2 laser therapy

This has been written in the J Vet Dent (Lewis et al., 2007). This case required multiple laser therapy and also rescue corticosteroid and IV fluid therapy.

Therapeutic lasers have received attention with regard to healing post surgical tissue, but no information is presently available regarding refractory GS and therapeutic laser tx.

References

3. Lommer MJ. Efficacy of Cyclosporine for Chronic, Refractory Stomatitis in Cats: A Randomized, Placebo-Controlled, Double-Blinded Clinical Study. In J Vet Dent; Spring 2013; Vol 30(1); 8-17.
Why “Let’s Keep an Eye on It” Won’t Work Anymore: Addressing Fractured and Discolored Teeth

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Fractured teeth
In a recent study (Golden, Harvey: A Survey of Oral and Dental Diseases in Dogs Anesthetized at a Veterinary Hospital. JAAHA Nov/Dec 1982; Vol 18: 891-899.) in JAAHA showed that 27% of dogs treated had some form of tooth fracture. That study has been a tested and true evaluation of the % that clinicians see in their general practice. Therefore, if you are not seeing that % of cases, you need to put your ‘diagnostic antenna’ up and start looking…for they are there.

The AVDC has an easy to follow nomenclature regarding tooth fractures in the dog and cat. (http://www.avdc.org/nomenclature.html#toothfracture) This lecture will address uncomplicated crown fractures and the different clinical manifestations presented to you the practitioner.

Enamel fractures (EF) are simply just that…an abrasion or fracture of the outer covering of the tooth. Enamel is the hardest substance in the body. It is also smooth and impervious to bacterial ingress. Enamel wall length is thin in a dog. In an enamel study, canine enamel was noticeable thinner than that of humans, varying from 0.1 mm to 1.0 mm. “A number of teeth showed a difference in enamel thickness between the buccal and lingual/palatal surfaces. This was noted on the carnassial and incisor teeth, with the enamel of some samples being 1.5 X as thick on one side as the other.” “A thick layer of enamel is disadvantageous in teeth that flex even a minute amount during use as they tend to chip and flake, leaving a weakened, rough surface. Therefore, natural selection is likely to favor those carnivores with thin enamel on strategic teeth.” 1

Prior to intubation (either pre-anesthetically or at induction), assess the occlusion of the pet. If there is attrition (tooth on tooth contact) from an opposing tooth, then selective interceptive orthodontics may be warranted to prevent further pathology or failure of any treatment plan.

Treatment of enamel fractures should be performed using an Aluminum Oxide Bur or fine diamond (conical or tapered) on a high-speed delivery system. Care is taken to bevel the edges slightly and remove the loose enamel present. In some instances, a composite restoration can be performed on this.

Uncomplicated crown fracture (UCF) is a bit more complex and there are multiple outcomes regarding tooth vitality with this category. A UCF involves the tooth fracture involving the enamel and the underlying dentin. Dentin, while hard, is not nearly as impervious as enamel. It is softer and is traversed by tubules leading directly to the dental pulp, and has a rougher surface. Exposed dentin wears faster than enamel. Dentin microscopically looks like swiss cheese, and the diameter of it is greater than oral bacteria. (Dentin diameter 0.6-0.8 µm @ DEJ to 3.0 µm @ pulp. Bacteria 0.50-1.0 µm in diameter) Therefore, bacteria could ingress through the dentin tubules, penetrate the pulp cavity, and cause irreversible pulpitis. Naturally occurring processes such as blood pressure and pressure gradients help prevent ingress of bacteria to the pulp cavity. Dentin is sensitive and contains neurofibers, which are directly involved in reacting to hydrostatic pressure gradients. Exposed dentin can respond to the fracture by producing reparative or tertiary dentin. This think thickening of dentin helps to protect the pulp by increasing the thickness of dentin between the fracture site and the pulp cavity. However, even with tertiary dentin, a tooth can become necrotic or infected.2

Use a sharp dental explorer to pass over the fracture site to verify that there is indeed no pulp exposure. If the explorer drops into a hole in the center of the tooth, or if bleeding occurs upon the exploration, then it is a Complicated Crown Fracture requiring either endodontic therapy or extraction.

Treatment of UCF: If you don’t have a dental radiograph unit, you should not be performing treatments for this type of fracture. If you do, then radiograph this tooth and take multiple angulations if need be to make sure no apical or endodontic pathology is present.

1. Unfilled resin only
Clean and polish the tooth. Use flour pumice only for polishing. The oils and fluoride in conventional polish can prevent adequate bone strength or polymerization of the resin. Odontoplasty with an Aluminum oxide bur of fine diamond (cylindrical). Acid etch for 15 seconds, then rinse with water using air/water syringe for 15 seconds. Apply a thin layer of unfilled resin on the tooth and light cure according to manufacturer’s recommendations.

Recheck radiographically in 6-12 months. Discuss with owner lifestyle changes.

**2. Composite restoration**
Clean and polish the tooth (flour pumice only). Prepare the tooth edges and floor to receive the composite restoration. Acid etch bonding agent (unfilled resin) composite restoration (in 2 mm increments) light cure. Then use assorted coarse to fine finishing discs or Aluminum oxide bur. Use explorer to insure no roughened edges, raised composite, and no gaps between prep site and the composite restoration. Re-acid etch and then apply a final application of an unfilled resin and light cure. Recheck radiographically in 6-12 months. Discuss lifestyle changes.

**3. Crown preparation and placement**
With more crown damage or the propensity to have a composite restoration being removed by aggressive chewing, a full coverage or ¾ crown can be fabricated and placed. This entails extensive prosthodontics training and the tooth preparation must be very careful as this is still a vital tooth.

**4. Indirect pulp capping**
If you notice a very thin layer of dentin covering the pulp cavity, a very specific procedure can be performed placing calcium hydroxide or MTA (mineral trioxide aggregate) on the tooth surface followed by the placement of a composite restoration. This procedure entails advanced endodontic training.

**5. Endodontic therapy (root canal) or extraction**
If the tooth is non-vital (diagnosed radiographically) or has visible pulp exposure, root canal therapy or extraction is warranted. If the pulp is entered upon attempting to prepare the tooth for composite restoration, a vital pulpotomy can be performed if the tooth is endodontically sound.

**Discolored tooth**
A study by Fraser Hale in the Journal of Veterinary Dentistry (Hale FA. Localized intrinsic staining of teeth due to pulpitis and pulp necrosis in dogs. J Vet Dent 18[1]:14-20 2001 Mar) showed that over 92% of intrinsically stained teeth were non-vital (partial or total pulp necrosis). Amazingly, only 42.9% of those cases had radiographic evidence of endodontic disease.

Teeth can become non-vital via a variety of ways. The first is obviously via direct pulp exposure as in a complicated crown fracture which if not treated within 48 hours is considered non-vital. Other ways teeth can become non-vital is via trauma as in a subluxation, luxation or even avulsion of a tooth. This interruption of the blood supply can cause premature tooth maturation or tooth death. Finally, blood borne infection called anachoresis can affect a tooth at the apex and kill a tooth.

**Why does a tooth discolor and what does this mean?**
When the blood supply to a tooth is interrupted, either temporarily or permanently, hemoglobin in the pulp cavity is degraded into byproducts (hematoidin, hetoporphyrin, hemosiderin ) and leeches to the dentin wall. This gives a pink/purple hue. If this becomes irreversible pulpitis, the hemocomponents continue to breakdown and the tooth can appear to be blue/grey in appearance.

**Reversible vs. irreversible pulpitis**
*Reversible pulpitis* is pulpal inflammation that over time returns to a viable pulp cavity. It can be caused by inflammation or trauma. The tooth discoloration may lessen with time and return to a normal ivory color. Radiography may not be beneficial with reversible pulpitis until pulp canal or apical lesions occur. Pain, however is very common in humans with acute periapical periodontitis and acute periapical abscess so please consider this the same for dogs and cats.

Ideally, it would be great to know the exact time of trauma or inflammation but usually it is not known. However, if the tooth tip or the coronal ¼ of the crown becomes acutely discolored, aggressive therapy should be performed initially to see if the tooth would indeed revert to a normal, healthy pulp.

*Irreversible pulpitis* can be a sterile event or it can be bacterial related. It can also be acute, subacute or chronic in nature. If bacterial infection combines with the hemoglobin breakdown products, iron sulfide is formed which causes a dark grey or blue color to the tooth. Once that color appearance is noted, it is almost pathognomonic for irreversible pulpitis.

According the Hale study, “Inflammation within the pulp during the period of irreversible pulpitis stimulates nerves within the pulp leading to the perception of pain. Intact teeth undergoing necrosis are often more acutely painful compared with open-chambered, fractured teeth based on increased intra-cranial pressure. Over time, the pain diminishes with the onset of pulp necrosis. However, over time tissue-breakdown products, which include several mediators of inflammation, may extend beyond the apical delta into the LDL space leading to periapical periodontitis which is quite painful (dull pain).” (Hale FA. Localized intrinsic staining of teeth due to pulpitis and pulp necrosis in dogs. J Vet Dent 18[1]:14-21 2001 Mar)

**Radiographic evidence of a non-vital tooth**
Dental radiography plays an important role in identification of irreversible pulpitis, but it is not soley. With regard to the above-mentioned study by Hale, radiographic signs of endodontic disease were not present in 42.4% of these teeth. Therefore, the eyes (seeing intrinsic staining) and radiography do make for a very powerful diagnosis of over 92%.

Radiographic signs: Wide pulp cavity with relation to the contralateral tooth; apical rarefaction (apical lucency); Narrowing of the pulp cavity due to pulp calcification (localized or generalized); and root resorption.

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Treatment for reversible and irreversible pulpitis

Reversible pulpitis: Therapy includes antibiotics (Ampicillin/Clavulinate or Clindamycin) for 7 days plus NSAID therapy for 7 days (providing renal and hepatic function is normal). If the discoloration does not return to normal after 2-3 months, it can be assumed that this tooth now experiencing irreversible pulpitis which requires immediate therapy.

Irreversible pulpitis: Root canal therapy or extraction is the two treatment options for a non-vital tooth.

Root canal therapy is highly recommended for strategic teeth in the mouth (maxillary and mandibular canines; maxillary 4th premolars and mandibular 1st molars) as well as lateral incisors in large breed pets. Root canal therapy removes the necrotic pulp, and hermetically seals the tooth root canal system with materials that allow the tooth to remain in the mouth for the life of the pet. Success rate of root canal therapy is over 90%. In many instances, a full coverage crown is recommended.

Surgical extraction is the other treatment option for an irreversible pulpitis tooth. While the success rate is 100% (provided dental radiography is performed after the procedure to confirm complete extraction), it does have limitations and consequences. Firstly, extractions can cause more pain than endodontic therapy and involve a longer recovery period. If the pet plays and retrieves or likes to chew, removing a strategic tooth may compromise that aspect of the pet’s life. Removing a mandibular canine tooth has its own unique set of risks involved such as mandibular fracture or trauma to adjacent incisors and premolars. The tongue may loll or fall to one side once the canine is removed and this becomes an undesirable side effect of the removal.
The word ‘dental’ by nature is an adjective, not a verb. There is more to a periodontal sedating exam than just cleaning and polishing. Cleaning and polishing alone is defined as a ‘dental prophy’, but 80% of dogs and cats over the age of 3 have some form of periodontal disease. Therefore, some form of additional therapy must be performed. Ergo, this procedure is not defined as a ‘dental prophy’.

Practitioners must be more proactive with oral care to include sedation examination and cleaning with younger pets. Waiting for oral disease to occur allows bone loss to develop unnecessarily. It is recommended to start sedation dentistry at 1-1 ½ years of age. Dental radiography should be performed to assess for any missing teeth or identification of a primary tooth (puppy tooth) with no adult counterpart.

Acceptable probing depths are ≤2 mm in small dogs and ≤3 mm in large breed dogs. The clinician will be introduced to the 3 furcation stages and how each one can be treated.

**Stage 1 periodontal disease (PD1)**
This is defined as gingivitis with no bone loss associated with it. Of the 4 stages of PD, this is only reversible stage. Treatment for gingivitis includes subgingival and supragingival scaling and polishing, along with any gingival curettage. In some instances, gingivoplasty is needed to recontour and smooth the inflamed gingiva.

Home care at this level is vitally important to avoid this progressing to a bone loss stage. These home care products will be discussed in the lecture. Of all stages of PD, this is the one that most practitioners avoid treatment. Going forward, this stage must be treated aggressively.

**Stage 2 periodontal disease (PD2)**
Bone loss of <25% occurs with this level of PD. While this may not be severe for a large breed pet such as a Golden Retriever or Rottweiler, it can be extremely severe in a pet under 5 kg. Treatment plan includes closed root planing, perioecutic application, and home care products.

**Stage 3 periodontal disease (PD3)**
Bone loss of ≥25% and <50%. This stage has a variable treatment plan based on the tooth size and amount of attachment loss. In many instances, open root planing and bone grafting is a possible treatment option. However, in other instances, extractions are necessary.

**Stage 4 periodontal disease (PD4)**
This is the terminal stage of PD (>50% bone loss). Extractions are the only treatment option for this stage.

**Other items**
Antibiotics should only be used in those severely diseased cases that are immunocompromised or have systemic disease. Pulse antibiotic therapy is not advised as a clinically relevant treatment option.