Dental Radiography

Introduction

Radiography of the mouth and associated structures can initially be very frustrating. However, once the techniques are mastered, it is possible to produce high quality diagnostic radiographs consistently.

Dental radiography is consistently under-utilised in veterinary practice. In many procedures, diagnostic radiographs are essential for the production of a treatment plan and treatment may be contraindicated without them.

By the end of this chapter you should be able to:

- ✓ Recognise the advantages of using dental equipment for oral techniques
- ✓ Understand the main techniques required for the mouth
- ✓ Be able to interpret dental radiographs.

Film Types

Standard Film

Standard X-ray cassettes with intensifying screens have limited use, as they are too big for most uses except extra-oral views.

Non-Screen Film

These films are useful for both extra-oral and intra-oral views although their intra-oral use is limited, depending on the size of film and the size of the mouth. They provide very good radiographic detail.

Dental Film

Dental film is available in six speeds, labelled A, B, C, D, E and F. Only D, E and F are used in practice with E (or "Ektaspeed") being the preferred speed, in order to reduce radiation exposure to operatives and patient. F speed film (Kodak "Insight") became available in 2000 but is not in common use in veterinary dental practice as yet.

There are also six sizes of film available, with size 4 (57mm x 76mm) and size 2 (31mm x 41mm) being most useful for veterinary work.

Self-Developing Film

Available as ECO 30™ and the Hanshin™ system in periapical (size 2) format only. Size 2 is too small for most dog teeth and, therefore, their use is limited to smaller dogs and cats. The ECO 30 films come ready packed with a monobath containing both developer and fixer, and so do not require a darkroom. The film develops and fixes in 50 seconds. The Hanshin system uses an injector system to run the chemicals into the film envelope. Both systems are expensive, costing more than £1 for each film.

X-ray Units

Veterinary X-ray Unit

Veterinary machines have a limited capability to take dental radiographs, due to the restricted movement of the X-ray head. They are often not conveniently located in the practice for essential intra-operative radiographs.

A general guide to exposure factors is 100*mA* for 0.1 seconds at a *kV* of between 45 and 90, depending on the size of animal. The film focal distance should be around 15cm.

Dental X-ray Unit

This is the machine of choice and can be wall or castor mounted. They are very simple to operate as they have a fixed *kV* and *mA* leaving only the time of exposure to be selected. Also, the head is easy to manipulate. These units can often be bought cheaply second hand.

Processing

Small dental films can be processed manually or automatically.

Standard manual processing tanks for veterinary radiographs need special film hangers for small dental films. A chair-side developer is available, which is a light proofed fibreglass box that enables films to be developed in the operating room. It contains small pots of developer, water and fixer. Results are available in less than one minute. A similar result can be achieved with jam jars in the darkroom.

Many automatic developing machines will not take small dental film. One unit, the VELOPEX EXTRA-X™, uses belts, in addition to rollers, and is suitable for the development of small films.

Accessories

The following accessories are essential:

- Film holders to keep film in position in mouth – swabs, paper towels or foam covered hair rollers
- Bite blocks to keep mouth open – foam rolls/wedges or syringe barrels
- Viewer - Small light box with 2x magnifier on sliding carrier or Plexiglas X-ray magnifier block to magnify image on viewer
- X-ray marker or felt tip pen to identify film
- Dental X-ray envelopes or film mounts.

Intra-oral Parallel Technique – Mandible

Introduction

This technique is commonly used for other parts of the body such as limbs and body cavities.

Principle

The film is located between the tongue and the lingual aspect of the target teeth. The beam is angled at 90 degrees to the film and the target. The target tooth/teeth should be in the middle of the film and the surrounding structures included, when important – for example, the ventral border of the mandible.

Comments

- Very accurate but use is limited to mandibular molars and premolars 2, 3 and 4. An extra-oral technique is possible for the maxillary cheek teeth and mandibular premolar 1.
- If the angle between the tooth and the film is more than 15 degrees, use the bisecting angle technique to prevent gross distortion of the image caused by increasing the Object Film Distance.

Intra-oral Bisecting Angle Technique

Introduction

This technique is used in areas where the parallel technique is impossible due to poor access, making the angle between tooth and film more than 15 degrees. Using this technique, a true image of the tooth length and width is obtained.

Principle

In any 90-degree arc, there is one angle that will allow an x-ray beam to cast an accurate shadow of the tooth on the film. The best analogy is that of a tree in the desert. When the sun rises, the shadow of the tree is longer than the tree. At some point in the morning the shadow and the tree are the same length. This is the bisecting angle. The sun continues to rise until, at its zenith, the shadow is very short. In the afternoon the same sequence occurs in reverse. Therefore in the 180-degree arc of the sun during the day there are two bisecting angles.

For this to work three angles are calculated.

- Angle 1 is the long axis of the tooth
- Angle 2 is the angle of the film.
- Angle 3 is the angle that bisects angle (1) and (2).

The beam is then directed at 90 degrees to angle (3).

Comment - This technique is essential for the incisors and canines in both jaws and preferable, but optional, for the maxillary premolars and molars (see extra-oral near parallel technique).

Example 1– To Radiograph the Mandibular Canines and Incisors

1. Position the dog in dorsal recumbency, with the palate parallel to the tabletop.
2. Place the film carefully in the mouth, so that **all** of the target tooth will show on the film.
3. Hold the film flat with mouth props or swabs.
4. Calculate your angles and direct the beam at approximately 45-degrees to the plate.
5. When taking radiographs of upper canine teeth, angle slightly out to in (i.e. from rostro-lateral to medio-caudal) to avoid superimposing incisors at the apex of the tooth. As with the mandibular canine, a second lateral bisecting angle view will provide information that may not be visible on one view.

Example 2– To Radiograph the Maxillary Canines and Incisors

1. Position the dog in sternal recumbency and place pads below the head, to keep the palate parallel to the table.
2. Place the film in the mouth, so that **all** of the target tooth will show on the film.

3. Hold the film flat, with mouth props or swabs.

4. Calculate your angles and direct the beam at approximately 45 degrees to the plate.

5. When taking radiographs of upper canine teeth, angle slightly out to in (i.e. from rostro-lateral to medio-caudal) to avoid superimposing incisors at the apex of the tooth. As with the mandibular canine, a second lateral bisecting angle view will provide information that may not be visible on one view.

Example 3– To Radiograph the Maxillary Premolar (Carnassial)

1. Position the dog in sternal recumbency and place pads below the head, to keep it stable.

2. Place the film in the mouth, under the carnassial, so that **all** of the target tooth will show on the film.

3. Hold the film flat, with mouth props or swabs.

4. Calculate your angles and direct the beam over the medial canthus of eye onto the target tooth– this should be at approximately 45-degrees to the plate. NB – In cats this angle should be nearer 30 degrees to prevent superimposition of the zygomatic arch over the tooth roots. Near parallel extra-oral may be easier.

5. Take a second, and perhaps a third, radiograph with no change in the vertical beam angle, but move the tube head horizontally (i.e. slightly rostrally or slightly caudally). Multiple views of multi-rooted teeth are often required to limit the effects of superimposition of roots– either by the adjacent teeth or by another root of the same tooth.

Extra-oral Near Parallel Technique

Introduction

This technique is an alternative to the bisecting angle technique , for the maxillary cheek teeth. It is of particular use in cats, where the zygomatic arch superimposes over standard intra-oral bisecting angle views.

Principle

The patient is in lateral recumbency, with the target teeth nearest the table. The long axis of the target teeth is as near parallel to the film as possible and the beam is angled at approximately 70 degrees to the film and the target. The mouth is opened, with a prop, to direct the beam onto the film without superimposing the top cheek teeth on the bottom cheek teeth.

Comments

Accuracy is dependent on the ability to keep teeth as near parallel to film as possible and to prevent superimposing the top cheek teeth on the bottom cheek teeth. An angle greater than 15 degrees from perpendicular requires the bisecting angle technique. Its use is limited to maxillary molars and premolars.

Extra-Oral Standard Views

Introduction

These techniques are an alternative to intra-oral techniques. They are most often indicated for large lesions or when intra-oral techniques are not possible.

Left-Right Lateral or Right-Left Lateral

The patient is in lateral recumbency and the rostral aspect of the head is raised, to create a parallel relationship with the film. This technique is often used for routine surveys, but the diagnostic ability of this technique is limited by superimposition of structures. The open mouth view prevents overlay of the coronoid processes of the mandibles.

Ventro-dorsal Skull

The patient is in dorsal recumbency, with the hard palate parallel to the film. If possible, the endotracheal tube should be removed before exposure.

The diagnostic ability of this technique is limited by superimposition of structures. An intra-oral technique can also be performed with less superimposition.

Dorso-ventral Skull

This technique is similar to the ventro-dorsal technique, but with the patient in sternal recumbency. An intra-oral technique can also be performed with less superimposition.

Extra-oral Supplemental Views

Introduction

Various oblique views are helpful to reduce superimposition produced using extra-oral standard views. The most common of these is the technique detailed below, which can be used for both upper and lower jaws. Standard textbooks also list various other views at different angles.

Open Mouth 45° Lateral Oblique

This technique can be used for both the mandible and the maxilla. The patient is in lateral recumbency and the mouth fully opened with a non radio-opaque gag (foam wedge or syringe barrel). The target area is nearest the film and the sagittal plane is rotated 45° with a wedge.

Temperomandibular Joint Imaging

Introduction

The temperomandibular joints area is challenging for good diagnostic radiographs. It is a common area of injury, particularly in cats. Failure to diagnose luxations or fractures quickly, following trauma, can make treatment very difficult later.

TMJ Dorso-ventral

Place the patient in sternal recumbency and place pads around the head, to keep the hard palate parallel to the table. Place the film on the table for a true D V skull view. There is much superimposition with this view, but both the mandibular condyles can be viewed and their position assessed as normal or not.

TMJ Sagittal Oblique

This is a useful view for the temperomandibular joint spaces. The patient is placed in lateral recumbency with the joint to be examined nearest the table. The rostral aspect of the head is raised so that the sagittal plane is raised rostro-caudally by 25^0 for brachycephalic breeds, 15^0 for mesocephalics and 10^0 for dolicocephalics.

The mouth can be opened to obtain a slightly different view if needed. Use a foam block and have the central beam angled onto the joint to be examined. Try to align the long axis of the mandibular condyle perpendicular to the film for better visualisation of the joint space.

TMJ Lateral Oblique Views- Cat

Due to the prominence of the zygomatic arch in the cat, a slightly different view is employed - the ventro 20° lateral-dorsolateral oblique. The patient is placed in lateral recumbency with the target joint away from the table. The head is tipped up 20^0 from the lateral plane and the beam is directed perpendicularly through the upper TMJ.

CT Scanning

Introduction

Recently, the greater availability of CT scanners has allowed this imaging method to be used, to complement the usual radiographic techniques, for some of the more complex conditions.

Advantages

- Provides powerful images and computer reconstruction of otherwise hard to examine areas, such as TMJ's, caudal mandibular body, coronoid process and zygomatic arch
- Provides a 3D image and reconstruction of neoplasms with likely surgical margins within the cranium, nasal cavity and orbital area
- In time, it may prove more user-friendly than radiographs for imaging the roots of horse and other herbivore teeth.

Disadvantages

- Cost
- Complex machines to use without specialist training
- The image quality is substantially poorer than non-screen and dental radiographs for detail.

Digital Radiography

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Introduction

Digital radiography is currently available to most practices with their current technology – scanners and/or digital cameras. The advantage of digital images is that they can be manipulated on the computer screen to aid diagnosis by changing density, contrast and magnification. These images can also be easily stored and used for client education, referral opinions or letters, etc. The digital files are easily transferred from computer to computer both by disk and via the Internet.

There are four ways that radiographs can be converted to digital images.

Digital Cameras

Digital photography is a cost effective method of converting conventional radiographs to digital images. The radiograph is placed on a view box or window looking into blue sky and the photograph is taken. It can thenbe

transferred to a computer for editing and storage. Generally, the digital image should be converted to black and white format to avoid discoloration caused by artificial lights. Digital photography and scanning (depending on the cost of the scanner or camera) are the least expensive methods of obtaining digital radiographs.

Scanning

This method requires a scanner hooked up to a computer. The scanner must be able to “backlight” the radiograph.

Phosphorus Sensor

This technique utilises an image plate, which can be reused. The size of the plate can vary from small periapical films to larger panoramic sizes. After exposure with a conventional dental radiographic unit, the plate is placed in a scanner and transmitted to a computer. The image can be manipulated, is easily transferred, and has less radiation per image than conventional radiology. The disadvantages are that the image is not instant and must be scanned to view. It requires more steps than CCD/CMOS technology. Initial cost is in the range of £5,000 to £10,000.

CCD/CMOS Sensor

This technique uses a sensor plate attached to a computer. The advantage is that the image is immediately displayed on the computer. The disadvantage is that the sensors are expensive and, at this time, only come in periapical film size 2.

Techniques Summary

Intra-oral Parallel

- Similar to conventional radiography
- Target teeth situated parallel to film with x-ray beam at 90 degrees to film.
- Film focal distance 15-20 mm
- Used for mandibular cheek teeth.

Intra-oral Bisecting Angle

- Requires three angles
- Angle of film
- Angle of long axis of tooth
- Angle that bisects a) and b) = Bisecting Angle
- Used for all incisors, canines and maxillary cheek teeth.

Extra-oral Near Parallel Technique

- Techniques with the film outside the mouth as close to parallel to the target teeth as possible
- Beam direction aims to be close to vertical, but to avoid superimposition of upper tooth roots and zygomatic arch.

Other Extra-oral Techniques

- Uses either DV, VD or lateral oblique views with mouth held open and head held at approximately 45 degrees to film

- Used when large lesions require to be imaged
- Useful to image TMJ's.

Common Indications

This section outlines some common indications for oral radiographs.

Trauma and Exodontia

- Radiography is invaluable for diagnosing and planning the treatment of fractured teeth or bones and the surrounding tissues
- Radiographs can be used to distinguish between complicated crown fractures (with the pulp exposed) and uncomplicated crown fractures (pulp not exposed)
- For true representation of root fractures, radiographs should be taken with the primary beam parallel to the angle of fracture. This will allow visualisation of the beginning and end of the fracture line
- Pre extraction radiographs ensure that a procedure can be properly planned and that no developmental abnormalities, resorptive lesions or ankylosis will surprise the operator
- Post extraction radiographs ensure that all root fragments are removed and that no collateral damage has been caused.

Periodontal Disease

Loss of attachment is crucial in the treatment planning of periodontal disease. Significant features to look for are:

- Receding bone height relative to the cemento-enamel junction (CEJ)
- Loss of bone at interproximal space or at furcation
- Widening of the periodontal space (this is highly significant)
- Loss of integrity of lamina dura. The lamina dura is a thin white line around the root. It represents dense cortical bone and is **not** a structure in its own right. A complete lamina dura is suggestive of good periodontal health. The lamina dura is separated from the tooth by the periodontal ligament (PL), which is relatively radiolucent. The jawbone is trabecular in pattern and varies in densit, with age and location. A lack of visible space in the area of the PL may indicate ankylosis of the root
- Apical rarefaction, halo or lucency is strongly suggestive of endodontic and/or periodontal pathology. These lesions can be combined and are classified as:
    - class 1 (primarily endodontic pathology leading to periodontal pathology)
    - class 2 (primarily periodontal pathology leading to endodontic pathology)
    - class 3 (combined lesion with endodontic and periodontal lesion occurring independently).

Defects and Variations in Tooth Density

- Caries usually affect the molar teeth of dogs. Loss of normal contour and density will only be visible on a radiograph if pathology is advanced. Therefore, assess grossly and radiographically whether the pulp canal is affected by loss of dentine. Look for apical root pathology or other signs of endodontic disease
- Feline Odontoclastic Resorptive Lesions. Treatment planning of these lesions must involve radiography

- Internal or external root resorption. This is often secondary to periodontal or endodontic disease.

Endodontic Treatment of Teeth

Good quality radiographs from more than one angle are required for a true representation of pulp canal length, width and lack of long axis fracture.

- Intra operative and postoperative radiographs are required to demonstrate the file or gutta percha point position within the canal and adequate filling of the apical third
- Pulpitis will not show on a radiograph but internal root resorption will be seen as an irregular widening of the pulp chamber
- Apical rarefaction or "halo". Apical rarefaction, halo or lucency is strongly suggestive of endodontic and/or periodontal pathology. These lesions can be combined and are classified as:
  - Class 1 (primarily endodontic pathology leading to periodontal pathology)
  - Class 2 (primarily periodontal pathology leading to endodontic pathology)
  - Class 3 (combined lesion with endodontic and periodontal lesion occurring independently).

Developmental Defects and Anomalies

- Detection of missing permanent teeth
- Detection and treatment planning of mixed dentition including retained deciduous teeth
- Supernumerary teeth - these can cause crowding problems and are often associated with developmental defects of the crown and/or the root
- Teeth with developmental problems
- Teeth with impacted or delayed eruption.

Swellings, Cysts and Neoplasms

- Cysts present as well demarcated and expansive lytic lesions
- Neoplasms may present as increased or decreased densities. They are often irregular and poorly demarcated, with lysis of bone. Close examination of the periphery of the lesion will help, as this is often the most active zone in a pathological process
- Craniomandibular osteopathy (CMO) is usually a lesion of the mandibular body, occasionally the base of the cranium or TMJ's, and produces a proliferative periosteal reaction
- Osteomyelitis will often present with a proliferative reaction at the periphery, with decreased density at the centre of the lesion.

Metabolic Diseases

Diseases that affect calcium metabolism, such as hyperparathyroidism, present as reduced bone density. Teeth are often quoted as "floating" when the condition is advanced.

Interpretation

Introduction

The interpretation of any radiograph requires time, appropriate equipment and a logical approach in order to avoid missing lesions.

Equipment Viewer

- A magnifying glass or block is very useful, particularly for small lesions
- A hot light within the viewer is helpful, as good contrast exists between hard tissues and air. Enamel, dentine and bone are the three hardest body tissues
- Film quality depends on many variables - exposure, film speed, development quality, positioning etc. It may help to cut a “keyhole” in a card and view the radiograph through the keyhole with the room lights off.

Interpretation Process

1. Evaluate the image quality:
   - Is the image too light or dark?
   - Check the contrast
   - Has the image been processed properly?
   - Is the image distorted or superimposed?
2. Specifically identify the species, location and structures.
3. Examine the whole radiograph from left to right.
4. Teeth – check each tooth for:
   - Changes in contour and/or density of dentine
   - Changes in the bone level around roots (particularly furcation and interproximal)
   - Changes in the pulp chamber or periodontal space
   - Changes in bone density around the root and the integrity of lamina dura.
5. Jaw – examine the lesion in the jaw:
   - Site – location, extent, solitary, multi-focal or generalised
   - Size and shape – measure and describe. This may require one or more views.
   - Symmetry – examine contralateral site. Bilateral symmetry is suggestive of a normal variant
   - Border – sclerosis, resorption, lack of continuity
   - Contents – lucent or opaque. Homogenous or varying density
   - Association with other structures. Teeth displaced or resorbing.
6. Attempt a diagnosis or assess the need for further tests.

Key Points

- ✓ Dental radiography is the number one diagnostic tool in the practice of competent dentistry. Make it available and easy to use during dental procedures by proper provision and location of machine, films and processing equipment.
- ✓ There are two main intra-oral techniques - parallel and bisecting angle. These techniques must be mastered in addition to the extra-oral techniques.
- ✓ Interpretation of dental radiographs requires magnification and a range of lighting facilities. The comparative density of dental structures compared with the contrast of background air assists the clinician considerably.

Further Reading

- Brocklebank L, Dental Radiology, Oxford University Press 1997.
- Deforge DH and Colmery BH, An Atlas of Dental Radiology, Iowa State University Press 2000.
- Mulligan TW, Aller MS and Williams CA, Atlas of Canine & Feline Radiography, Veterinary Learning Systems 1998.
- Owens JM and Biery DN, Radiographic Interpretation for the Small Animal Clinician, 2nd edition, Williams & Wilkins 1999.
- Thrall DE, Textbook of Veterinary Diagnostic Radiology, 2nd edition, Saunders 1994.
- Ticer JW, Radiographic Technique in Veterinary Practice, 2nd edition, Saunders 1984.
- Wiggs RB and Lobprise HB, Veterinary Dentistry - Dental and Oral Radiology, pp140-166, Lippincott 1997.