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Originally from rural Argyll, Susan graduated from the University of Aberdeen with a BSc(Hons) in Zoology in 2006, before continuing her studies at Glasgow University Veterinary School where she graduated in 2013. During her university vacations, she visited Africa several times, studying predators ranging from lions to Great White sharks.

After some time in general practice, Susan joined DentalVets in North Berwick on a dentistry and oral surgery residency in 2015, supervised by Dr Norman Johnston.

Her hobbies range from competitive sailing in the summer to skiing in the winter.

*Suggested Personal & Professional Development (PPD)

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DENTISTRY

Dental and oral radiography

Dental radiography is essential for the diagnosis, treatment and planning of canine and feline oral pathology and conditions. It is a core level skill to which all small animal practitioners should have access and be able to operate efficiently.

Approximately 70 per cent of each tooth is embedded root structure. This is invisible during gross dental examination and its condition can only be assessed via dental radiography. Most dental pathology results in radiographic change to the roots and surrounding bone, making a dental examination incomplete without radiography. All veterinary practices performing dentistry should be able to take diagnostic dental radiographs efficiently.

Radiography units

Dental radiography units should be easy to manoeuvre and located next to the dental station. They can be wall-mounted on an arm, on a trolley, or hand-held (**Figures 1** & **2**). When units are located away from the dental area or are cumbersome, they tend to be used less often.

Modern units are easy to operate having fixed kV and mA values, the only variables being exposure time and film/focal distance. Calibration will depend on the age of the machine. Modern machines have the kV set in the range 65-90 with the mA between 7 and 15. The mA regulates the quantity of X-radiation produced while kV indicates the acceleration force of the electrons and, therefore, their penetration potential.

Film focal distance (FFD) is the distance from the tube's focal spot to the film; whereas, object film distance (OFD) is the distance from the object being imaged to the film. The normal rules on radiation physics require as great an FFD as possible with as small an OFD as possible. The FFD used depends on the type of collimation device on the unit and ranges from 15-20cm.

Most units come with a position-indicating device (PID) at the end of the tube head to collimate the beam and protect both operator and patient. This can be a pointed plastic cone (closed-end PID) or a lead-lined tube with an open end (open-ended PID). The open-ended PID provides greater protection against secondary radiation.

Digital processing

Digital processing is the most common method of processing images in veterinary dentistry. There are two main types – direct and indirect.

Direct (DR) digital processing

This uses a CCD or CMOS sensor and is only available in size 2 plates (31mm x 41mm) or less, which is not large enough for dog canines (**Figures 3** & **4**). Images are instant but the sensor in the mouth is vulnerable and very expensive to replace if damaged.

Indirect (CR – computed radiology)

This involves processing using a photostimulable phosphor plate (PSP). Plates are available from size 0 to size 5 and

Figure 1. *Unit wall mounted next to dental table.*

Figure 2. *Remote control panel.*

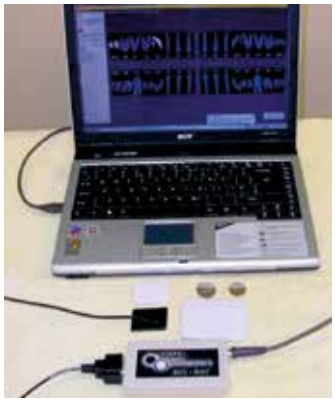

Figure 3. *Direct processing.*

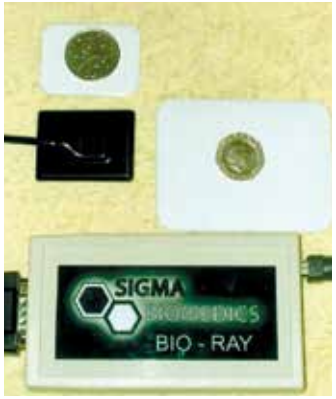

Figure 4. *Size 2 film on the left.*

"It is increasingly popular for practices to perform full-mouth radiographs in all patients at first examination; and then at regular intervals during their life, to monitor for progressive dental pathology"

Figure 5. *Indirect digital processor.*

Figure 6. *Conventional film.*

Figure 7. *Self-developing film.*

Figure 8. *'Chairside' developer.*

require a separate scanner to process (**Figure 5**). This takes longer than direct imaging (20 sec); but the sensors are relatively inexpensive to replace.

Film processing

Conventional films

For conventional dental radiography, small dental films are used (**Figure 6**). In the author's opinion, the most reliable films and the most useful sizes are Ultraspeed Kodak DF58 (31mm x 41mm) and Ultraspeed Kodak DF50 (57mm x 72mm).

Self-developing film

These are expensive, archive poorly, only available in size 2 and, in the author's experience, the film contrast is poor (**Figure 7**).

Analogue film

Analogue film is processed either manually or automatically. Most automatic developers will not take small dental films; so most practices using these films have a small 'chairside' developer (**Figure 8**). This allows films to be developed in the operating room.

Dental radiographic protocol

It is increasingly popular for practices to perform full-mouth radiographs in all patients at first examination; and then at regular intervals during their life, to monitor for progressive dental pathology. Experience with animals has shown that owner history and gross clinical examination is rarely sufficiently accurate to ensure significant pathology is not missed.

Studies have shown that, since 1998, the diagnostic 'harvest' from full-mouth radiographs justifies it. Radiographs of teeth without visible lesions uncovers clinically important findings in 28 per cent of dogs (Kim CG et al, 2012; Verstraete FJ et al, 1998) and 42 per cent of cats (Verstraete FJ et al, 1998).

In the absence of full-mouth radiographs, the following protocol is advised:

All 'missing' teeth

Remember, teeth not present in the mouth may not actually be missing. Examples are retained roots following fracture, resorption or inappropriate extraction. Also embedded or impacted teeth are common, often with an associated odontogenic dentigerous cyst and bone loss. Teeth can also be missing congenitally.

Periodontal pockets over 4mm

Assessment of 'attachment loss' of teeth with periodontal disease, including prognosis of the target and adjacent teeth and their treatment options, is not possible without dental radiographs.

All damaged or abnormal teeth

Trauma to teeth can present in many ways. Fractures of the crown may or may not cause pulp exposure-complicated or uncomplicated crown fractures. Movement of the tooth within the alveolar process during trauma – causing subluxation or intrusion – will often compromise the pulpal blood supply and /or cause haemorrhage in the pulp. In both cases, pulp necrosis follows.

Feline tooth resorption lesions

Full-mouth radiographs of cats should follow any discovery of feline tooth resorption (TR). One study described the mandibular 307/407 to be 'sentinel teeth'. If affected by TR, there is a 93 per cent chance that other teeth in the mouth will have similar pathology (Heaton M et al, 2008). Regular, repeated full-mouth radiographs are advised for cats with TR lesions to monitor progression throughout their life.

Pre-& post-extraction teeth

These should be examined to investigate their morphology and to ensure that complete removal has taken place with no damage to adjacent structures.

Criteria for acceptable radiographs

Radiographs can be considered to be 'acceptable' if they show:

- good contrast of enamel, dentine, cancellous bone and cortical bone
- the target tooth centrally on the radiograph
- a minimum of 2-3mm of bone visible around the root apices
- no superimposition of other structures.

Simplified intra-oral technique

A simplified intra-oral (film in the mouth) technique, after Woodward, describes simply three predetermined angles that are the same for each patient. When learning, it is best to have the patient in dorsal or sternal recumbency. The three angles to remember are: 20°, 45° and 90°.

The starting angle is 0°, when the tube head is aligned vertically and perpendicular to the table surface. If your patient is in true sternal recumbency, the tube head should align with the nasal philtrum (**Figure 9**).

If you can read the angle from your X-ray machine, it should now read 0°. From this angle, you add the set number of degrees depending on which tooth you are imaging.

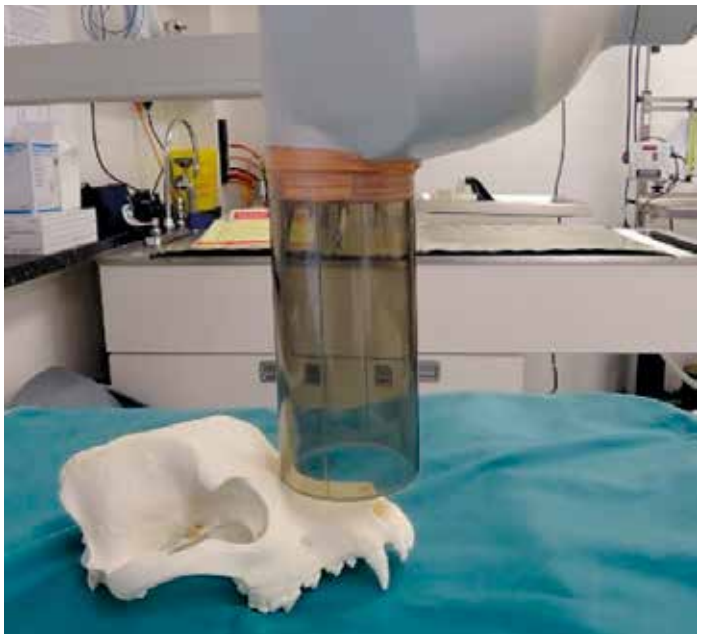

Figure 9. *Intra-oral positioning.*

Angles and positions: dogs

For dogs, size 2 plates can be used for the incisors and mandibular third molars. Use size 4 or 5 plates for all other teeth.

Maxillary and mandibular incisors

The film should be placed perpendicular to the nasal philtrum and flat against the incisors and palate. Aim the beam at 0°, roughly perpendicular to the table top and aligned with the philtrum of the patient's nose. Rotate the tube head 20° rostrocaudally, from the vertical over the target teeth and film.

For the mandibular incisors, the principle is the same, except the patient is in dorsal recumbency (**Figure 10**).

Maxillary canines

The film should be placed in the mouth, under the canine and against the palate. Aim the beam initially at 0° to the table top and along the philtrum of the patient's nose. Then tip the beam so it is angled between 20° and 45° towards the midline and over the canine. The canine imaging angle varies between 20°-45° depending on the width of the maxilla. This is breed dependent; so use a smaller angle for a narrower maxilla (**Figure 11**).

Mandibular canines

Initially start in dorsal recumbency for simplicity. Place the film and angle the beam as for the maxillary canines. When in its final position, turn the tube head in a rostrocaudal direction. As the mandibular teeth are closer to the contra-lateral teeth than in the maxilla, this angulation will stop superimposition of teeth from the opposite side (**Figure 12**).

Maxillary and mandibular premolars

The film should be placed perpendicular to the nasal philtrum, flat against – and covering – the maxillary or mandibular premolars. Tip the beam to 45° and aim over the premolars onto the film/plate.

Maxillary fourth premolar and molars (3 roots)

In sternal recumbency, the film should be placed perpendicular to the nasal philtrum, flat against and covering the maxillary fourth premolar and molars. The film must be as far back in the

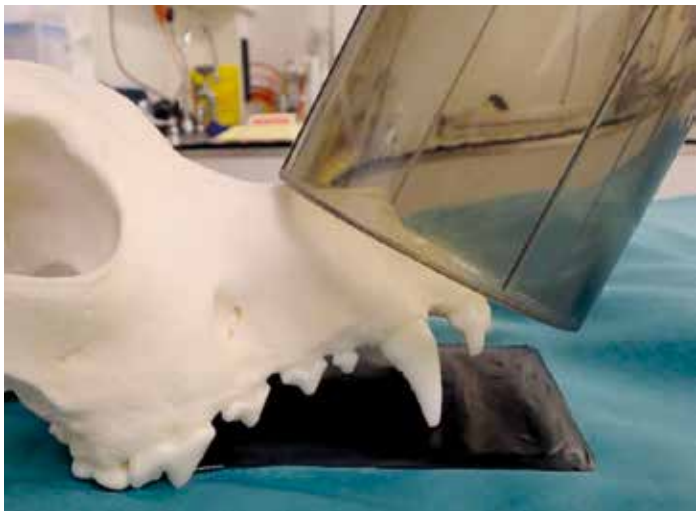

Figure 10. *Incisor view.*

Figure 11. *Maxillary canine view.*

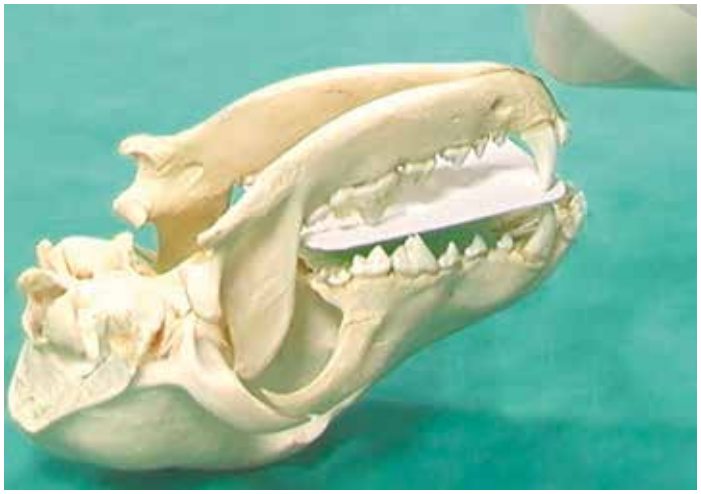

Figure 12. *Mandibular canine view.*

"Most dental pathology results in radiographic change to the roots and surrounding bone, making a dental examination incomplete without radiography"

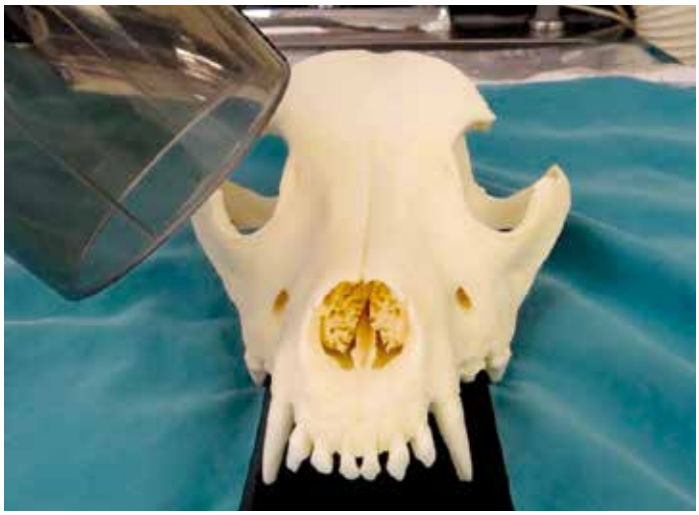

Figure 13. *Maxillary fourth premolar view.*

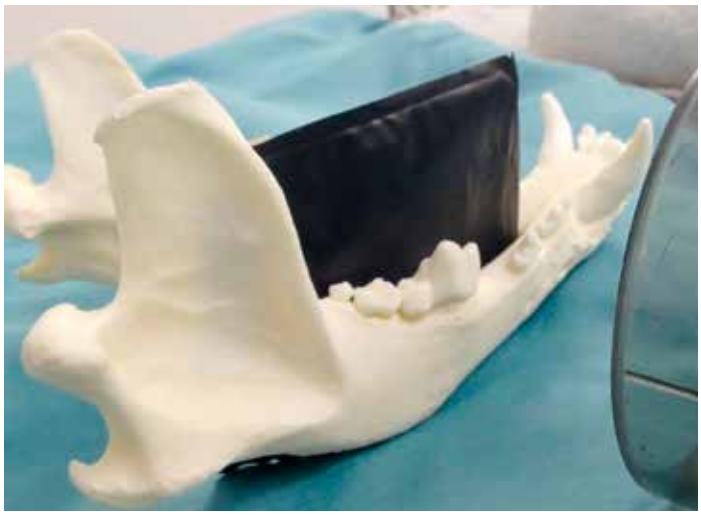

Figure 14. *Mandibular molars.*

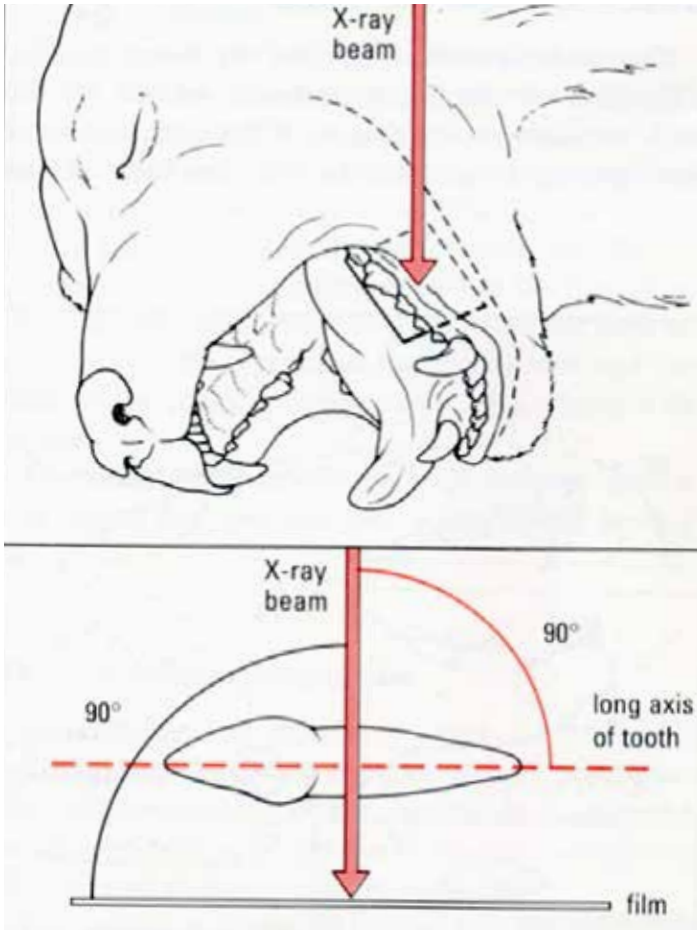

Figure 15. *Small size.*

Figure 16. *Conventional approach.*

mouth as possible to image all three teeth. Tip the cone head so the beam is angled at 45° from the nasal philtrum.

The fourth premolar has two mesial roots and one distal root (**Figure 13**). A true lateral projection will superimpose the two mesial roots. A second – and often third – image is required to separate the two mesial roots and visualise them individually. The beam can be either aimed rostrocaudally or caudorostrally for this image to separate the two mesial roots.

The first projection should be caudorostral as it provides the best chance of capturing all three roots on one image. Usually at least two images will be required of this tooth to fully assess it and to be able to apply Clarke's Rule (aka SLOB) to identify both the mesial roots. Often a dorsoventral (DV) projection is also useful to visualise the mesiopalatal root clearly.

Mandibular premolars/ molars

The film should be placed between the tongue and teeth, parallel to the nasal philtrum. The beam is angled perpendicular to the film at 90°. This technique can often be used for premolars as far rostral as the third premolar, but this is dependent on how far caudal the mandibular symphysis extends (**Figure 14**). The third molar can be a challenge and is often seen as missing in small breeds. A small size 2 film, held in place with a swab, is often best for this tooth (**Figure 15**).

Angles and positions: cats

For feline patients, size 0 or 2 films should be used.

Feline maxillary and mandibular incisors, canines, mandibular premolars and molar

For all these teeth in cats, use the same technique as described for dogs.

Feline maxillary premolars and molar

The feline maxillary premolars and molar are difficult to image as the zygomatic arch superimposes over the tooth roots when standard angles are used. Three different techniques have been developed to overcome this:

1. Conventional approach – place the film perpendicular to the nasal philtrum, flat against the palate to allow imaging of the maxillary premolars and molar. The film must be placed as far back in the mouth as possible to visualise all four teeth. The beam should be angled at 60º from the vertical/nasal philtrum and turned in a rostrocaudal direction (**Figure 16**).

2. Extra-oral technique – position the patient in lateral recumbency, with the target teeth nearest the table. Place the film extra-orally (on the table). The mouth is held open with a radiolucent gag. The beam should be aimed through the open mouth onto the target teeth and film. There is no specific angle for the beam and is positioned by line of sight. This technique pushes the zygomatic arch upwards on the film. Turning the cat skull approximately 20º dorsally will give good access to the target teeth with the beam (**Figure 17**).

3. Intra-oral, near parallel – place the film diagonally across the mouth resting between the lingual aspect ipsilateral mandibular PM3 and PM4 and the palatal aspect of the contralateral maxillary cheek teeth. The beam is angled approximately 70º from the nasal philtrum, which is nearly parallel to the plate (**Figure 18**).

Plate placement

Most plates or films have an embossed dot on a corner. Intra-orally place the dot away from the tooth being imaged to ensure it does not interfere with the image. The dot differentiates between the left and right sides of the image. On images where side needs to be determined, a small paper clip can also be placed on a designated side to assist. Place the film intra-orally so that the entire tooth and its root is covered by the plate – the roots can be longer than you think! Place the tip of the crown at a corner of the film to give the best chance of the entire root being imaged. The film should be placed as close to the tooth as possible, without distortion, to reduce the OFD. Props such as cotton swabs or paper towels will keep the plate or sensor in the correct position.

Conclusion

Mastering dental radiography and applying the outcomes to cases intra-operatively is the single biggest factor that will improve your ability to investigate, diagnose and successfully treat dental cases. ■

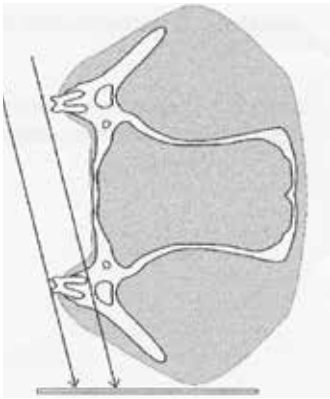

Figure 17. *Extra-oral technique.*

Figure 18. *Intra-oral, near parallel view. (Photo: Dr Tucker)*

PPD Questions

1. What are the two different types of digital film processing available?
2. In the absence of full-mouth radiographs, what pathology should always be radiographed?
3. What main criteria should be present in a diagnostic radiograph?
4. Describe in detail how to radiograph a dog's maxillary canine.
5. Name the three different approaches to radiograph feline maxillary cheek teeth.

Answers

1. direct digital processing (DR) and indirect (CR)
2. all 'missing' teeth; all teeth with periodontal pockets over 4mm; all damaged or abnormal teeth; full-mouth radiographs of cats if feline TR is found in 307, 407; pre- and post-radiographs of any treated or extracted teeth
3. good contrast of four main hard tissues – enamel, dentine, cancellous bone and cortical bone; target tooth should be central and the main focus of the radiograph; minimum of 2-3mm of bone should be visible around the root apices; no superimposition of structures; good handling and developing of the film
4. the film should be placed in the mouth under the canine and against the palate. Aim beam initially at 0° to the table top and along the philtrum of the patient's nose. Then tip the beam so it is angled between 20°- 45° towards the midline and over the canine. The canine imaging angle is between 20°- 45° depending on the width of the maxilla
5. conventional approach; intra-oral, near parallel; extra-oral technique.

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