



**AUSTRALIAN AND NEW ZEALAND  
COLLEGE OF VETERINARY SCIENTISTS**

**MEMBERSHIP GUIDELINES**

*Veterinary Radiology (Small Animal)*

**INTRODUCTION**

These Membership Guidelines should be read in conjunction with the *Membership Candidate Handbook*.

**ELIGIBILITY**

Refer to the *Membership Candidate Handbook*.

**OBJECTIVES**

To demonstrate that the candidate has sufficient knowledge of and experience in small animal veterinary radiology to be recognised as an advanced practitioner. Successful completion of Membership examination represents a middle tier of knowledge, competence and experience in small animal veterinary radiology.

For these guidelines small animal refers to canine and feline species.

**LEARNING OUTCOMES**

**1. Radiation physics as it applies to veterinary radiology**

The candidate should have a **basic**<sup>1</sup> knowledge of:

1.1. electromagnetic spectrum:

1.1.1. elementary general physics as it pertains to radiology

1.1.2. the electro-magnetic spectrum: definition, wave and particle theories

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<sup>1</sup> **Knowledge levels:**

**Sound knowledge** — candidate must know all of the principles of the topic including some of the finer detail, and be able to identify areas where opinions may diverge. A middle level of knowledge.

**Basic knowledge** — candidate must know the main points of the topic and the major literature

- 1.2. generation of x-ray photons:
  - 1.2.1. components of the x-ray tube, types of anodes: rotating and stationary, cathode
  - 1.2.2. thermionic emission, line focus principle, heel effect, heat dissipation, structure of the atom, binding forces
  - 1.2.3. basic generator circuits, rectification, transformers, capacitor discharge equipment
- 1.3. production of the x-ray photon:
  - 1.3.1. interactions at the anode: general radiation / Bremsstrahlung and characteristic radiation
  - 1.3.2. the effect of kV, mA and time on x-ray photon production
- 1.4. the interaction of x-ray photons with matter:
  - 1.4.1. coherent scatter, the photoelectric effect, Compton and the relative frequencies of these interactions
  - 1.4.2. factors affecting attenuation / the inverse square law
  - 1.4.3. scatter radiation – factors affecting the production of and methods to reduce the effects of scatter - grids (types, cut-off), air gap techniques, beam collimation
  - 1.4.4. formation of an image due to differential x-ray absorption
- 1.5. factors affecting image quality:
  - 1.5.1. density, contrast, sharpness
  - 1.5.2. the origin and control of scatter:
    - 1.5.2.1. control of scatter production
    - 1.5.2.2. reduction of the negative impact of scatter on image quality
  - 1.5.3. unsharpness:
    - 1.5.3.1. geometric (magnification, distortion, penumbra effect)
    - 1.5.3.2. motion

## 2. Practice of veterinary radiography

The candidate should have a **basic** knowledge of:

- 2.1. practical radiography:
  - 2.1.1. exposure assessment in digital radiography
  - 2.1.2. factors influencing the choice of kV, mA, time, and grids

- 2.1.3. formation of a technique chart
- 2.1.4. patient positioning and problems in veterinary practice/limitations
- 2.1.5. the need for restraint and suitable methods/advantages and disadvantages of anaesthesia
- 2.2. radiographic anatomy of the appendicular and axial skeleton, thorax and abdomen of dogs and cats
- 2.3. radiographic projections of the different regions of the axial and appendicular skeleton, thorax and abdomen of dogs and cats

### 3. Digital Radiography

Digital radiography encompasses both computed radiography and direct digital systems.

The candidate should have a **basic** knowledge of:

- 3.1. differences in image formation between computed radiography and direct digital systems (both direct and indirect digital systems)
- 3.2. advantages and disadvantages of types of digital radiography including but not limited to latitude, exposure, speed, mobility, portability, workflow.
- 3.3. principles of:
  - 3.3.1. digital imaging and communication in medicine (DICOM)
  - 3.3.2. picture archiving and communications systems (PACS)
- 3.4. common artefacts associated with digital radiography including but not restricted to storage scatter, cracks of imaging plate, phantom image, quantum mottle, planking, grid cut-off, Moire, double exposure, dead pixels, dirty light guide, faulty data transfer, Uberschwinger, clipping/image saturation
- 3.5. factors affecting image quality specific to digital imaging (including system resolution, exposure index, use of grids, algorithms, look-up table)

### 4. Diagnostic ultrasound

The candidate should have a **sound** knowledge of:

- 4.1. generation of the ultrasound image
- 4.2. production of ultrasound – transducer, piezoelectric crystal, frequency, pulse repetition frequency (PRF), power, focal zone
- 4.3. interactions of sound within the patient – acoustic impedance, transmission, absorption, reflection, refraction, scatter
- 4.4. processing the returning signal to generate an image - gain, time gain compensation (TGC), dynamic range.

- 4.5. factors that influence ultrasound image quality, including but not limited to:
  - 4.5.1. resolution – spatial resolution (axial, lateral, and slice thickness/elevational), and temporal resolution
  - 4.5.2. artefacts
- 4.6. functions of the ultrasound machine used in image optimisation, including but not limited to depth, focal zone, gain, time gain compensation (TGC), dynamic range, persistence/frame averaging

## 5. Radiation safety

The candidate should have a **sound** knowledge of:

- 5.1. Code of Practice and Legislation:
  - 5.1.1. radiation monitoring, safety equipment and regulations
  - 5.1.2. relevant Australian and New Zealand laws and Codes of Practice as they apply to the use of ionising radiation
- 5.2. biologic effects of radiation:
  - 5.2.1. direct and indirect effects
  - 5.2.2. stochastic and deterministic effects
- 5.3. practical applications of the principles of radiation safety, including:
  - 5.3.1. practical applications of a Radiation Management Plan (Australia) or Radiation Safety Plan (New Zealand)
  - 5.3.2. principles of radiation protection: risks involved in the use of radiographic procedures/methods to minimise this risk
  - 5.3.3. basic radiation protection rules for a small animal practice
  - 5.3.4. maximum permissible dose (MPD)
  - 5.3.5. the ALARA principle (As Low As Reasonably Achievable)
- 5.4. monitoring radiation exposure:
  - 5.4.1. units of dose and exposure: Gray, Sievert.
  - 5.4.2. devices, monitoring bodies

## 6. Other imaging

The candidate should have a **basic** knowledge of:

- 6.1. production of a computed tomography (CT) and magnetic resonance imaging (MRI) image

- 6.2. clinical applications of computed tomography (CT) and magnetic resonance imaging (MRI) in veterinary practice.

## 7. Contrast agents and radiographic contrast procedures (contrast studies)

The candidate will be able to with **sound**<sup>2</sup> expertise:

- 7.1. describe how common radiographic contrast procedures in dogs and cats of the gastrointestinal system are performed: oesophagram, upper gastrointestinal barium series, colonogram
- 7.2. describe how common radiographic contrast procedures on dogs and cats of the urinary system are performed: excretory urogram, retrograde cystogram (positive, negative, double contrast), retrograde urethrogram and vaginourethrogram.

The candidate should have a **sound** knowledge of:

- 7.3. Barium sulphate in its different formulations
- 7.4. Iodinated contrast agents and its formulations including the difference between ionic and non-ionic formations.

The candidate should have a **basic** knowledge of:

- 7.5. the pharmacology of radiographic contrast agents including: mechanism of action, indications, contraindication, common side effects and dose rates
- 7.6. the myelographic procedure.

## 8. General radiological interpretation of dogs and cats

The candidate will have a **sound** knowledge of:

- 8.1. radiographic appearance of the normal structure and function of the various organ systems investigated in small animal practice
- 8.2. radiographic pathology, and associated pathophysiology, of the various organ systems commonly investigated in small animal practice

The candidate will be able to with **sound** expertise:

- 8.3. demonstrate a systematic approach to radiographic interpretation
- 8.4. determine which radiographic projection is presented from the radiographic anatomy
- 8.5. recognise, describe and interpret (including formulation of ranked order list of differential diagnoses for) radiographic and sonographic abnormalities in dogs and cats

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<sup>2</sup> **Skill levels:**

**Sound expertise** – the candidate must be able to perform the technique with a moderate degree of skill, and have moderate experience in its application. A middle level of proficiency.

**Basic expertise** – the candidate must be able to perform the technique competently in uncomplicated circumstances

8.6. select and interpret an appropriate imaging modality (radiography or ultrasound)

The candidate should have a **sound** knowledge of:

8.7. normal sonographic appearance of the following structures in the dog and cat:

8.7.1. abdomen - liver, spleen, kidneys, adrenal glands, urinary bladder, gastrointestinal tract, pancreas, peritoneal cavity, male and female reproductive tract

8.7.2. thorax – heart, pulmonary-pleural interface, cranial mediastinum

## 9. Skeletal abnormalities

9.1. General principles

The candidate will have a **sound** knowledge of:

9.1.1. reaction of bone to disease:

9.1.1.1. bone lysis patterns (geographic, moth-eaten, permeative)

9.1.1.2. periosteal and endosteal new bone patterns

9.1.2. classification of fractures:

9.1.2.1. descriptors of fracture type (e.g. spiral, transverse, incomplete/complete, comminution etc.)

9.1.2.2. location

9.1.2.3. Salter-Harris types

9.1.3. bone healing:

9.1.3.1. radiographic signs of bone healing: primary and secondary intention bone healing

9.1.3.2. radiographic signs of complications of bone healing: delayed union, malunion, non-union

9.1.4. osteoarthritis:

9.1.4.1. radiographic signs of septic and degenerative osteoarthritis

9.1.4.2. radiographic signs of osteoarthritis in all joints, but in particular the shoulder, elbow, carpus, coxofemoral, stifle and hock joints

The candidate will be able to, with **sound** expertise:

9.1.5. classify bony lesions in the spectrum of benign or aggressive

9.1.6. identify changes in soft tissues adjacent to bony lesions (for example joint effusion or soft tissue mass)

## 9.2. Juvenile bone disease

The candidate will have a **sound** knowledge of:

### 9.2.1. osteochondrosis:

9.2.1.1. common signalment in dogs

9.2.1.2. radiographic signs including common locations.

### 9.2.2. hip dysplasia:

9.2.2.1. hip dysplasia schemes available in Australia and New Zealand

9.2.2.2. the method of obtaining studies for each hip dysplasia scheme

9.2.2.3. advantages and disadvantages of the Australian Veterinary Association (AVA) scheme and the PennHIP scheme

### 9.2.3. elbow dysplasia:

9.2.3.1. types of elbow dysplasia in the dog: osteochondrosis, un-united anconeal process, medial coronoid process disease, elbow incongruity

9.2.3.2. radiographic signs of types of elbow dysplasia in the dog

9.2.3.3. radiographic signs of osteoarthritis in the elbow

The candidate will have a **basic** knowledge of:

9.2.3.4. breeds at greatest risk of elbow dysplasia

9.2.3.5. elbow dysplasia schemes available in Australia and New Zealand

9.2.3.6. application of other diagnostic tools in the investigation and diagnosis of elbow dysplasia (including CT scanning and arthroscopy)

The candidate will have a **sound** knowledge of:

9.2.4. radiographic signs of nutritional secondary hyperparathyroidism

9.2.5. radiographic signs of panosteitis

9.2.6. radiographic signs of hypertrophic osteodystrophy (syn. metaphyseal osteopathy)

### 9.3. Vertebrae

The candidate will have a **sound** knowledge of:

- 9.3.1. the radiographic signs and clinical significance of congenital vertebral anomalies
- 9.3.2. the radiographic signs of spinal disease in dogs and cats, including but not limited to intervertebral disc disease, atlanto-axial instability, canine cervical spondylomyelopathy, discospondylitis.

The candidate will have a **basic** knowledge of:

- 9.3.3. the use of myelography in the investigation of spinal disease in dogs and cats
- 9.3.4. indications for advanced spinal imaging (including myelography, CT and MRI)

### 9.4. Head

The candidate will have a **sound** knowledge of:

- 9.4.1. the radiographic signs of nasal cavity disease, including neoplasia and rhinitis (fungal, other infectious, foreign body, allergic, lymphoplasmacytic)
- 9.4.2. the radiographic signs of and differential diagnoses for bony neoplasia of the head
- 9.4.3. the radiographic signs of otitis media
- 9.4.4. the radiographic signs of periodontal disease

The candidate will have a **basic** knowledge of:

- 9.4.5. the radiographic signs of temporomandibular joint disease
- 9.4.6. the radiographic signs of parathyroid disease
- 9.4.7. the indications for CT and MRI of the head

## 10. Thorax abnormalities

### 10.1. Heart and pulmonary vessels

The candidate will have a **sound** knowledge of:

- 10.1.1. radiographic cardiac anatomy (for example, using cardiac clock-face analogy), including the anatomy of pulmonary lobar vessels and differentiation of pulmonary arteries and veins
- 10.1.2. sonographic cardiac anatomy as seen in the right parasternal long axis and short axis views
- 10.1.3. radiographic signs of cardiomegaly, including means to quantify these signs



10.1.4. radiographic signs of left and right chamber enlargement and left and right sided heart failure

10.1.5. differential diagnoses for cardiomegaly, especially as they apply to different species and breeds

## 10.2. Lungs

The candidate will have a **sound** knowledge of:

10.2.1. radiographic anatomy of the canine and feline lung

10.2.2. radiographic classification of pulmonary disease:

10.2.2.1. traditional paradigms of lung pattern (alveolar, bronchial, interstitial patterns)

10.2.2.2. distribution paradigm (cranioventral, caudodorsal, bilateral, unilateral, diffuse)

## 10.3. Pleural space

The candidate will have a **sound** knowledge of:

10.3.1. radiographic anatomy of the pleural space

10.3.2. radiographic signs of pleural space disease, including differential diagnoses for these diseases

## 10.4. Mediastinum/body wall/diaphragm

The candidate will have a **sound** knowledge of:

10.4.1. radiographic anatomy of the mediastinum, including the organs located in each region (cranial, mid, and caudal mediastinum).

10.4.2. radiographic signs of abnormalities of the mediastinum, particularly diseases of the trachea, oesophagus, lymph nodes, thymus

10.4.3. indications for an oesophagram

10.4.4. the methods of performing an oesophagram, including the contrast agents

10.4.5. radiographic anatomy of the body wall

10.4.6. radiographic signs of diseases of the ribs

10.4.7. radiographic features of conditions affecting the diaphragm.

## 10.5. Thoracic ultrasound

The candidate will have a **sound** knowledge of:

- 10.5.1. 'Thoracic Focused Assessment with Sonology for Trauma, Triage and Tracking' (TFAST<sup>3</sup>) ultrasound examination.

## 11. Abdomen (including peritoneal and retroperitoneal space) abnormalities

### 11.1. Gastrointestinal tract

The candidate will have a **sound** knowledge of:

- 11.1.1. radiographic anatomy of the gastrointestinal tract, including the differing location of small and large bowel
- 11.1.2. the variable radiographic appearance of the intestine in dogs and in cats
- 11.1.3. radiographic signs of and differential diagnoses for diseases of the gastrointestinal tract, including but not limited to gastric dilatation and volvulus, and small intestinal obstruction.
- 11.1.4. indications for gastrointestinal contrast studies
- 11.1.5. indications for gastrointestinal ultrasound

The candidate will have a **basic** knowledge of:

- 11.1.6. sonographic signs of small intestinal obstruction

### 11.2. Pancreas

The candidate will have a **sound** knowledge of:

- 11.2.1. the radiographic signs of **and** differential diagnoses for diseases of the pancreas

The candidate will have a **basic** knowledge of:

- 11.2.2. the sonographic signs of pancreatitis

### 11.3. Hepatobiliary system

The candidate will have a **sound** knowledge of:

- 11.3.1. radiographic signs of and differential diagnoses for hepatobiliary disease, including but not limited to those that cause hepatomegaly (focal or generalised), reduction in liver size, and alterations to liver opacity (mineralisation, gas)

The candidate will have a **basic** knowledge of:

- 11.3.2. sonographic signs of and differential diagnoses for hepatic disease including but not limited to nodular hyperplasia, hyperadrenocorticism, diabetes mellitus, diffuse and focal neoplasia, hepatitis, abscess, cirrhosis, congestion

#### 11.4. Spleen

The candidate will have a **sound** knowledge of:

- 11.4.1. radiographic signs of and differential diagnoses for splenic disease such as splenomegaly, splenic mass lesions

The candidate will have a **basic** knowledge of:

- 11.4.2. sonographic signs of and differential diagnoses for splenic disease, including but limited to lymphoid hyperplasia (nodular hyperplasia), extramedullary haematopoiesis, diffuse and focal neoplasia, splenitis, congestion, abscess, myelolipoma

#### 11.5. Adrenal glands

The candidate will have a **sound** knowledge of:

- 11.5.1. normal **retroperitoneal** anatomy
- 11.5.2. radiographic signs of and differential diagnoses for adrenal disease such as adrenomegaly or mineralisation

The candidate will have a **basic** knowledge of:

- 11.5.3. sonographic signs of and differential diagnoses for adrenal disease such as adrenomegaly

#### 11.6. Urinary tract

The candidate will have a **sound** knowledge of:

- 11.6.1. normal radiographic anatomy (including size) of the urinary tract (kidneys, ureters, urinary bladder, urethra (male and female))
- 11.6.2. radiographic signs of and differential diagnoses for urinary tract disease such as renomegaly, alterations in radiographic opacity within the urinary tract
- 11.6.3. indications and techniques for urinary contrast studies

The candidate will have a **basic** knowledge of:

11.6.4. sonographic appearance of renal disease such as acute kidney injury, chronic renal disease, neoplasia, obstruction

11.6.5. sonographic appearance of cystitis, cystolithiasis, and neoplasia of the urinary bladder

11.6.6. contraindications for urinary contrast studies

11.7. Reproductive tract

The candidate will have a **sound** knowledge of:

11.7.1. Normal radiographic anatomy of the prostate, testes, ovaries, uterus and vagina

11.7.2. radiographic signs of and differential diagnoses for reproductive tract disease such as prostatomegaly, uterine enlargement

The candidate will have a **basic** knowledge of:

11.7.3. sonographic appearance of pyometra, benign prostatic hyperplasia

11.7.4. radiographic detection of pregnancy

11.7.5. the use of ultrasound in pregnancy diagnosis

## EXAMINATIONS

For information on both the standard and format of the Written and Practical/Oral examinations, candidates are referred to the *Membership Candidate Handbook*. The Membership examination has **two separate components**:

1. **Written Papers** (*Component 1*)  
**Written paper 1:** Principles of Small Animal Imaging (two hours)  
**Written paper 2:** Applied Aspects of Small Animal Imaging (two hours)
2. **Practical Examination** (*Component 2*)  
**Practical** (two hours forty minutes)

The written examination will comprise two separate two-hour written papers taken on the same day. There will be an additional 15 minutes perusal time for each paper, during which no typing is permitted.

The exam may include a series of short answer questions, multiple-choice questions or may require an essay-type response. The exam is worth a total of 120 marks and all questions must be answered. Allocated marks to each question/sub question will be clearly indicated.

### **Written Paper 1:**

This paper is designed to test the Candidate's knowledge of the principles of Veterinary Radiology as described in the Learning Outcomes. Answers may cite specific examples where general principles apply, but should primarily address the theoretical bases underlying each example. Written Paper 1 will mainly cover the Learning Outcomes 1-7, however material from any learning outcome may be examined. The species examined will be canine and feline.

### **Written Paper 2:**

This paper is designed to (a) test the Candidate's ability to apply the principles of Veterinary Radiology to particular cases/problems or tasks and (b) test the Candidate's familiarity with the current practices and current issues that arise from activities within the discipline of Veterinary Radiology in Australia and New Zealand. Written Paper 2 will mainly cover the Learning Outcomes 8-11, however material from any Learning Outcome may be examined. The species examined will be canine and feline.

### **Practical Examination:**

The practical examination will be 160 minutes in duration and will require written reports on the radiographic digital images of with a number of cases. Images will be provided in Power Point; no image manipulation will be required. Ultrasound images or clips may be included. Each case is of equal value equating to a total of 160 marks. The species examined will be canine and feline.

Each answer might include the following:

- description of the study i.e. list of included views and any techniques used (i.e. contrast studies)
- radiographic description
- conclusions or interpretation, including a ranked differential diagnosis list
- recommendations of further imaging techniques if appropriate

The practical examination may not necessarily be limited to these types of questions.

Examiners are looking for a systematic evaluation of the study. Marks will be awarded for the following areas:

- correct identification of radiographic views
- assessment of radiographic quality only where it impacts interpretation of the image
- description of imaging abnormalities
- radiographic conclusions and differential diagnoses
- recommendations for further imaging procedures

The candidates must demonstrate to the examiners their thought processes, prioritisation and conclusions.

Normal findings need not be described in detail, but the candidate should indicate they have been evaluated and are normal (for example: ‘there are no skeletal abnormalities’).

Candidates should not comment on artefacts unless they are pertinent to interpretation of the study (i.e. they affect the study outcome).

Both descriptive sentences and dot points may be used for the observation of imaging abnormalities or conclusions.

Candidates must use correct radiographic terminology and avoid colloquial language.

### **RECOMMENDED READING LIST**

The candidate is expected to read widely within the discipline, paying particular attention to areas not part of their normal work experiences. This list of books and journals is intended to guide the candidate to some core references, including comparative texts, and other source material. Candidates also should be guided by their mentor / supervisor. The list is not comprehensive and is not intended as an indicator of the content of the examination.

**Recommended textbooks:<sup>3</sup>**

Thrall DE. (2017) 7<sup>th</sup> ed. “Textbook of Veterinary Radiology”, Saunders Elsevier, Missouri.

Nyland TG, and Mattoon JS. (2015) 3<sup>rd</sup> ed. “Small Animal Diagnostic Ultrasound”, Saunders Elsevier, Philadelphia

Penninck D, and d’Anjou MA. (2015) 2<sup>nd</sup> ed. “Atlas of Small Animal Ultrasonography”, Blackwell Publishing

**Additional reading materials:**

Barr FJ, and Kirberger RM. (2006) “BSAVA Manual of Canine and Feline Musculoskeletal Imaging” BSAVA

Bushong SC. (2012) 10<sup>th</sup> ed. “Radiologic Science for Technologists: Physics, Biology, and Protection” Elsevier

Muhlbauer MC, and Kneller SK. (2013) “Radiography of the dog and cat: guide to making and interpreting radiographs”, Wiley-Blackwell

O’Brien R, and Barr FJ. (2009) “BSAVA Manual of Canine and Feline Abdominal Imaging” BSAVA

Schwarz T, and Johnson V. (2008) “BSAVA Manual of Canine and Feline Thoracic Imaging” BSAVA

Coulson A and Lewis N. (2008) “An Atlas of Interpretative Radiographic Anatomy of the Dog & Cat”, 2<sup>nd</sup> ed, Blackwell Science, Oxford

Thrall D, Robertson I. (2015) “Atlas of normal radiographic anatomy and anatomic variants in the dog and cat”, 2<sup>nd</sup> ed., Saunders.

Lavin LM. (2014) “Radiography in Veterinary Technology”, 5<sup>th</sup> ed. Saunders Elsevier, Philadelphia.

Wallack ST. (2003) “The Handbook of Veterinary Contrast Radiography” San Diego Imaging Inc. CA, USA

Dennis R, Kirberger RM, Barr FB, Wrigley RH. (2010) “Handbook of Small Animal Radiological Differential Diagnoses” 2<sup>nd</sup> ed. Elsevier Health Sciences.

Lisciandro GR. (2014) “Focused Ultrasound Techniques for the Small Animal Practitioner”. Wiley Blackwell.

Nykamp SG, et al. “Radiographic signs of pulmonary disease: An alternative approach” *Compendium on Continuing Education for the Practicing Veterinarian*, 2002; 24(1):25-36 \* *this is the first description of the “location approach” to reading thoracic radiographs and is an excellent description of this approach to the interpretation of thoracic radiographs*

Veterinary Radiology and Ultrasound : 2008; 49 (supplement 1) – digital radiography.

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<sup>3</sup> **Definitions of Textbooks**

**Recommended textbook** – candidates should own or have ready access to a copy of the book and have a sound knowledge of the contents.  
**Additional references** – candidates should have access to the book and have a basic knowledge of the contents.

*Veterinary Radiology (Small Animal) Membership Guidelines 2022\_23*

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Mattoon JS. “Digital Radiography” *Vet Comp Orthop Traumatol*. 2006;19(3):123-32.

Jimenez DA, et al. “Artifacts in digital radiography” *Vet Radiol Ultrasound*. 2008; 49(4):321-332

Drost WM, et al. “Digital radiography artifacts” *Vet Radiol Ultrasound*. 2008; 49(s1):S48-S56

## **FURTHER INFORMATION**

For further information contact the College Office

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