Introduction
The history of musculoskeletal imaging begins with Roentgen’s discovery of X-rays in 1895. Plain radiography has since become the initial, and in many cases, the only imaging modality for the diagnosis and follow up of joint abnormalities. Over the years, however, radiologists and orthopaedic surgeons became aware of the importance of the diagnosis of not only bony conditions but also of a diverse variety of soft tissue conditions. However, we must be on guard against imaging complacency. The ‘perfect’ imaging protocol does not exist because imaging parameters will be both patient and disease specific. When assessing image quality, we must consider both contrast resolution and spatial resolution. Contrast resolution refers to the ability to distinguish different normal tissues and normal from abnormal tissue. Spatial resolution refers to the ability to depict and distinguish small objects that are in close proximity.

In humans, musculoskeletal imaging utilising arthrography, scintigraphy, computerised tomography (CT), magnetic resonance imaging (MRI), ultrasound (US) and arthroscopy are used in clinics. All these imaging techniques have their merits but also their limits (see table 1 at the end of this text).

Weight management is an important component of helping redress mobility problems and the Eukanuba Veterinary Diets® range includes:

- Eukanuba Veterinary Diets® Restricted Calorie Formulas for dogs and cats, available as both dry and canned formulas.
- Iams science shows that the correct choice of carbohydrates in dry diets can affect the glycaemic response favourably and therefore aid with weight loss.
- L-carnitine for fat burning and support of lean muscle
- Animal based protein for support of lean muscle
- Chondroprotective agents (dry dog formula)
- Low level of the fermentable fibre beet pulp
- Omega-6 fatty acid balance for skin & coat health

We sincerely hope that you will find these proceedings, also available at www.eukanuba-scienceonline.com, an excellent addition to your library.

The Iams Company
Geneva, Switzerland / Dayton, USA
Arthrography

Arthrography is seldom used in small animal orthopaedics but is an interesting and simple technique readily available to most veterinarians. Although probably not as accurate as the newer imaging techniques (arthroscopy, MRI, and ultrasound), it provides information on intra-articular structures not seen on survey radiographs. Within the shoulder joint, articular cartilage, biceps tendon, the extent of the joint capsule, and the synovial surface outline can all be roughly visualised on arthrograms. One to 2 ml of preferably a non-ionic, low osmolar contrast medium, has to be injected intra-articularly. Exposures have to be made within 5 minutes post-injection because of the rapid absorption of the contrast medium by the synovial membrane. Cartilage fissuring and fragmentation, such as occurs with osteochondritis dissecans (OCD) can be demonstrated and identified as contrast material infiltrates beneath the articular cartilage (fig 3). A distinction can be made between clinical and non-clinical lesions and this can help in making therapeutic decisions. Synovial proliferation may be demonstrated as a thick, irregular synovial outline or as a small filling defect within the joint capsule. Finally, arthrography can be used to visualise joint mice and can also help in the diagnosis of bicipital tendon problems.

Computerised tomography (CT)

Computerised tomography (CT) has several advantages over plain radiography. It is a cross-sectional imaging technique using x-rays and computers. Better soft-tissue differentiation and absence of superimposition are the major advantages of CT over conventional x-ray techniques. CT enables more detailed and specific morphological diagnosis than radiography. CT greatly facilitates examining complex joint structures like the elbow and tarsus. Another advantage is that the transverse CT images can be reformatted in multiple anatomic planes. Although the spatial resolution of CT images is poorer when compared with classical film-screen radiography, the cross-sectional image display and superior discrimination of tissue attenuation offered by CT can enable differentiation of soft tissue structures that can not be perceived on conventional radiographs. Subtle new bone formation and bone lysis are better identified on CT images when compared with conventional radiography because of their greater physical density discrimination, the ability

Figure 1. Arthrogram of a dog’s shoulder with osteochondritis dissecans (OCD): notice contrast material outlining a cartilage flap (black arrows) which was invisible on the plain radiograph.

Figure 2. Stress radiograph (right image) of a stifle joint with a ruptured cranial cruciate ligament (CCCL; on the plain radiograph bone formation, as there is on the distal end of the patella, is visible (false white arrow); distal gonyoysis can be suspected (black white arrow); on the stress radiograph a caudal displacement of the femur relative to the tibia is seen. Distal displacement of the patellar tendon which an ultrasound (white arrow) is a sign of CCCL disease and can also be seen in this stress view.

Figure 3. An example of an arthrogram of a dog’s shoulder with osteochondritis dissecans (OCD); notice contrast material infiltrating beneath the articular cartilage outlining a cartilage flap (black arrow) which was invisible on the plain radiograph.

Figure 4. A CT image of a dog’s elbow with a fragmented coronoid process (FCP) which was not visible on the corresponding radiograph; notice a fracture line (black arrow) and subchondral sclerosis in the area of the coronoid process. The fragment is squeezed in between the radius (R) and the ulna (U).
In tarsocrural OCD, CT is superior in the diagnosis of lateral ridge involvement. In medial tarsocrural OCD, CT allows to assess the exact localization, and the size and number of the fragments. It helps in decision making when using minimal surgical exposure techniques to treat these lesions. In the treatment of hip dysplasia it can be used to check the status of the dorsal acetabular rim which is an important criterion when triple pelvic osteotomy (TPO) is considered.

In cases where treatment of bone tumours is considered, CT enables a more exact demarcation of the affected tissue and helps to decide to what extent the tumour has to be excised. And finally, degenerative joint changes can be identified at an earlier stage than on conventional radiographs.

The disadvantages of CT are the need for general anaesthesia and the cost for maintaining the equipment.

**Magnetic resonance imaging (MRI)**

MRI has definite advantages over CT in delineating peri-articular and intra-articular soft tissue structures. When a patient is placed in a strong magnetic field and subjected to short pulses of radio frequency energy, radio signals can be elicited from the patient’s body. These signals can be compiled into images that reveal certain characteristics of body tissues. MRI is a very useful imaging method because it can detect several tissue characteristics and combine the resulting signals in different ways to yield images with a variety of appearances. Unlike other imaging modalities such as radiography, arthrography, CT and scintigraphy, MRI is capable of directly visualising all components of the joint simultaneously and can detect a wide variety of joint abnormalities. A major advantage includes its ability to evaluate the various components and surrounding structures of the joint, and not merely the surface as visualised by arthroscopy or outlined by arthrography.

With this technique multplanar reconstructions are possible and by using different sequences, differentiation between different structures and pathologic processes, is possible. MRI is especially sensitive to bone marrow alterations. In people, the current status of MRI suggests that it allows an evaluation of the appearance of normal and abnormal articular cartilage, although the optimal sequencing for the detection of cartilage lesions still is undefined. Considering the plethora of imaging protocols, joint-specific orientations, and potential artefacts, the design and interpretation of MRI imaging examination is difficult.

Shortcomings of MR imaging include the lack of consensus among radiologists with respect to which protocols best image articular joints. Musculoskeletal MR specialists are also looking forward to specific improvements that the 3 Tesla will bring to orthopaedic imaging, including better visualisation of articular cartilage. The visualisation of cartilage and its lesions seems to be even more difficult in the dog probably because articular cartilage in dogs is very thin. The distinction between cartilage and synovial fluid is not obvious, at least not in young dogs because the amount of contrast between the joint fluid and articular cartilage is not enough. Also the intra-articular administration of Gadolinium-containing agents is not helpful. The intravenous injection of such contrast agents can be useful in the detection of inflammatory processes.

MRI can be of use in the diagnosis of bicipital pathology and other shoulder lameness. It is also a useful technique to reveal subchondral lesions like inflammatory changes in cases of OCD (fig 5). In humans it is also used to check stability of osteochondral fragments, which influences the therapeutic regime. In the detection of a fragmented coronoid process in the elbow joint, the technique could be helpful in detecting non-mineralised cartilaginous fragments not to be seen on CT. As with man, in the dog MRI has promising capabilities for imaging stifle pathology.

The disadvantages are the same as with CT, the high cost of the equipment and its high maintenance cost. Also the full understanding of the physics behind this imaging technique is not obvious.

**Ultrasound**

Ultrasound (US) is a potential valuable imaging technique of the musculoskeletal system in small animals. Linear transducers with frequencies higher than 75 MHz are used because of their flat application surface and high resolution power. With this technique imaging of joints, especially of the soft tissues (e.g. ligaments, capsule) and of the articular cartilage, can be obtained. Accurate examination of joints requires substantial ultrasonographic experience and a standardised examination procedure. In most of the joints even small amounts of fluid accumulation (hypo- to anechoic) can be easily demonstrated in the area of the joint pouches. The subchondral bone is visible as a hyperechoic line with a strong acoustic shadow. Arthritic bone formation can be picked up as irregularities on the bony surface and can be detected at an early stage. The surface of normal joint cartilage appears as an anechoic layer and is examined for its integrity. Cartilage defects for example in the lateral femoral condyle or in the humeral head associated with OCD have irregular borders with pronounced contractions. The presence of a second hyperechoic line at the bottom of the subchondral defect seen on US is a pathognomonic sign for the presence of a flap. Synovial proliferation can be evaluated as well. In the stifle joint it is possible to evaluate an old rupture of the cranial cruciate ligament (hyperechoic structures at the ends of the ligament), a meniscal tear or degeneration (seen as distinctively unhomogeneous and with a mixed pattern of hyperechoic and hypoechoic areas). US is only of limited use in the diagnosis of a fragmented coronoid process. Pathologic changes of the soft tissues (e.g. tumour) can usually be diagnosed. Joint effusion in the shoulder joint can be diagnosed easily, and appears as a hypo- to anechoic area around the bony components. Bicipital pathology can be easily evaluated (fig 6). Also Achilles tendon lesions can be evaluated sonographically. Instabilities of the hip joint can be evaluated by dynamic examination. By seeing movement (real-time-system) between the femoral head and the acetabulum it is possible to evaluate laxity of the hip joint. A recent application of ultrasound is the monitoring of fracture healing.

Ultrasound biomicroscopy (UBM) is a new technology that uses very high frequency ultrasound (20-55 MHz or even higher, compared to 3-15 MHz in conventional clinical ultrasound systems). The spatial resolution of a two-dimensional image is up to -50 µm with penetration depth of -20 mm. UBM of articular cartilage reflects histological structure and can accurately detect early changes such as fibrillation. UBM has the potential to be a valuable tool for the in vivo identification of early lesions of osteoarthritits.
As a conclusion we could state that, although a variety of imaging techniques are available nowadays, we should always consider if the results of the intended imaging examination (or examinations) will influence the treatment of the patient and, if so, what is the most direct (i.e. cost effective) way to obtain these results. As in man, the question of over utilisation of high technology imaging techniques can be raised in animals as well.

**Table 1. A quick guide to diagnostic imaging**

<table>
<thead>
<tr>
<th>Technique</th>
<th>Benefit</th>
<th>Specific use</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scintigraphy</td>
<td>High sensitivity for early disease and for surveying the entire skeleton.</td>
<td>Localization of the cause of obscure lameness.</td>
<td>Poor spatial resolution and meaningful interpretation of findings.</td>
</tr>
<tr>
<td>Radiography</td>
<td>Good for bony structures.</td>
<td>Excellent spatial resolution.</td>
<td>Generally poor for soft tissue changes.</td>
</tr>
<tr>
<td>Arthrography</td>
<td>Simple to use.</td>
<td>Cartilage fissuring, joint mice, synovial proliferation, severe bicipital lesions.</td>
<td>Not as accurate as newer techniques like arthroscopy and ultrasound.</td>
</tr>
<tr>
<td>Computed tomography (CT)</td>
<td>Excellent for bony structures and ability to examine complex joint structures.</td>
<td>Detection of subtle new bone formation and bone lysis.</td>
<td>Needs general anaesthesia and cost of maintaining the equipment.</td>
</tr>
<tr>
<td>Magnetic Resonance Imaging (MRI)</td>
<td>Can evaluate the various components and surrounding structures of the joint.</td>
<td>Bone marrow alterations, bicipital pathology, subchondral lesions in OCD.</td>
<td>Needs general anaesthesia and cost of maintaining the equipment.</td>
</tr>
<tr>
<td>Ultrasound</td>
<td>Non-invasive technique.</td>
<td>Good for soft tissue structures like ligaments and joint capsules.</td>
<td>Operator dependent.</td>
</tr>
</tbody>
</table>

**Further reading**


Erickson S. High-resolution imaging of the musculoskeletal system. _Radiology_ 1997;205:613-618.

Gieni I, Van Rijssen B, Buijterls J, et al. Canine elbow incongruity evaluated with computed tomography (CT) and arthroscopy. _Abstracts 8th Annual EAVDI Conference, July 18-21st, 2001_.


van Bree H. Comparison of diagnostic accuracy of positive contrast arthrography and _JAVMA_ 1993;203:84-88.


