DIAGNOSTIC IMAGING OF THE STIFLE JOINT

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Generally, plain radiography has been in many cases the only imaging modality for the diagnosis and follow-up of stifle 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. Besides plain radiography, the veterinary profession nowadays gets access to the following imaging modalities: scintigraphy, computed tomography (CT), magnetic resonance imaging (MRI), and ultrasound (US). Also arthroscopy has moved into the interest of veterinary orthopaedic surgeons for diagnosis and treatment of several stifle diseases and has become a routine procedure in several orthopaedic clinics.

Whereas conventional techniques like radiography are excellent methods to investigate morphologic changes in bones, **scintigraphy** provides information regarding the metabolic function of the skeleton. It is a useful technique to localise the cause of obscure lameness or in case of uncertain radiographic findings. Although it is very sensitive, it is not very specific. Radiography, on the other hand, is less sensitive but more specific.

Conventional radiography is an excellent imaging technique for imaging bony structures but is a poor method for imaging soft tissue structures. It displays a greater spatial resolution than either MRI or CT. The disadvantage is that the two-dimensional display of three-dimensional structures results in superimposition that can obscure important findings. Details that can be derived from plain radiographs include information on the size, contour, density, and location of changes that are present in or around a joint. The areas that can be evaluated include the subchondral bone plate, trabecular subchondral bone, articular margins, and areas where ligaments, tendons, and the joint capsule attach. In people and horses joint space narrowing has been a well-accepted indicator of articular cartilage degeneration and is considered as a cardinal radiographic feature of disease. In small animals the loss of joint space is not a reliable sign as the radiographs are taken non-weight-bearing. Individual soft tissue structures are not visualised as easily as the bony structures unless they are bordered by fat (for example, in facial planes or in the cranial aspect of the stifle). Indirect information on articular soft tissues structures can be present in case of calcification within these structures, mostly a sign of degeneration but can also sometimes be an incidental finding. Also using stress radiographs, an indirect evidence of articular ligament rupture, can be obtained, the most obvious example being a cranial cruciate ligament rupture shown by tibial compression radiographs of the affected knee joint.

Computerised tomography (CT) has been introduced in the seventies in human medicine and has been more readily available to veterinarians over the last decade. 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. 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 enables 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 to manipulate the grey scale of the digital image, and the elimination of overlying structures. While a loss of 30% of bone density is often required for a lesion to be visible on conventional radiographs, CT is able to reliably detect density changes of only 0.5 – 2%. Another advantage is that the transverse CT images can be reformatted in multiple anatomic planes. In the stifle, compared to radiographic examination, CT provides additional useful information in all processes where avulsions or fragmentation are involved. These disorders are not always visible on radiographs. CT proved to be extremely useful in the detection of avulsion fractures of intra-articular ligaments like the cranial cruciate ligament and the tendons of the extensor digitorum longus and the popliteus muscles. In cases of discrete OCD lesions, CT confirmed the diagnosis. Compared to radiography, the use of CT could detect many more intra-articular fragments, which provides important information to the surgeon, especially when arthroscopic treatment is envisaged. The intra-articular administration of iodinated contrast medium (computed tomographic arthrography = CTA) enables the identification of several ligamentous structures within the stifle joint. Although the results for identifying simulated meniscal injury are encouraging, a recent clinical study in dogs reported a limited value of CT arthrography in the detection of naturally occurring meniscal injuries. Although gross meniscal lesions can be evaluated, the problem we experienced with CTA is that in inflamed stifle joints the injected contrast medium is very rapidly absorbed and diluted making an accurate interpretation of possible lesions difficult and in some cases even impossible. Further research on the use of dimeric contrast agents and the admixture of epinephrine with conventional contrast agents in order to slow down resorption should be accomplished.
Degenerative changes can be identified in an earlier stage than on conventional radiographs. 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. In such cases CT guided biopsies can be accurately obtained.

Magnetic resonance imaging (MRI) is an imaging technique superior for the demonstration of soft tissue lesions. With this technique multiplanar reconstructions are possible and by using different sequences differentiation between different structures and pathologic processes is possible. A major advantage of MRI includes its ability to evaluate the various components and surrounding structures of the joint, and not merely the surface visualised by arthroscopy or outlined by arthrography. As in man, also in the dog, MRI has promising capabilities for imaging stifle pathology. Within canine stifle joints, MRI has been valuable for evaluation of the cranial and caudal cruciate ligaments, lateral and medial meniscus, synovium, and the surrounding supportive structures such as the collateral ligaments. Normal cruciate ligaments are hypointense and lack internal signal on common imaging sequences. Complete ligament ruptures are clearly evident by the absence of intact ligaments on selected slices. Partial ruptures of cruciate ligaments are characterized by increased internal signal, roughening of ligament surface and abnormal ligament contour. Partially ruptured cranial cruciate ligament injuries have been diagnosed using MRI when palpable anterior drawer-sign was absent. Reports exist on the use of stress-MRI as a promising tool for the detection of cranial cruciate ligament rupture. The value of MRI in evaluating meniscal tears is controversial. With the use of low-field MRI a high percentage of missed meniscal tears has to be expected. High-field MRI and the use of intra-articular contrast MRI could improve the accuracy. MRI is also 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. Shortcomings of MR imaging include the lack of consensus among radiologists with respect to which protocols best image articular joints.
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 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 (US) is a potential valuable imaging technique of the musculoskeletal system in small animals. Linear transducers with frequencies higher than 7.5 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, meniscus, and capsule) and of the articular cartilage, can be obtained. A drawback of US is that not all joint areas are accessible with the transducer. 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 new bone formation can be picked up as irregularities on the bony surface and can be detected in 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 associated with OCD have irregular borders with pronounced contractions. 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 (distinctly inhomogeneous and has a mixed pattern of hyperechoic and hypoechoic areas). Pathologic changes of the soft tissues (e.g. tumour) can usually be diagnosed.

Radiography, nuclear scintigraphy, ultrasound, CT and MRI each have inherent strengths and weaknesses. Magnetic resonance imaging will likely remain the highest yield diagnostic tool for injury to muscles, tendons and ligaments however other very useful, often more available imaging tests exist. Computed tomography has excellent resolution and has been reported as the diagnostic modality of choice for lesions of bone and with the addition of contrast material, muscle, tendon and ligament injury evaluation has improved. Ultrasound is readily available and relatively inexpensive with excellent soft tissue detail but requires a lot of experience. Nuclear scintigraphy is very sensitive for early bone abnormalities but tends to be non-specific and is often used in conjunction with additional imaging modalities. Imaging modalities should be selected carefully to generate the highest yield for the type of disease process and anatomy being evaluated.

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