Ultrasonographic Examination of Joints in Horses

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The diagnosis of lesions can be made with ultrasonography in many painful joints with no abnormal radiographic findings. These lesions include ligament, capsule, synovial, and meniscal injuries as well as periarticular injuries. When abnormal radiographic findings are present, complementary ultrasonographic evaluation provides more information concerning the soft tissues and joint surfaces; therefore, a more complete assessment of the joint is achieved. In every clinical case, the ability to diagnose injuries and the reliability of the diagnosis are largely improved when two symmetrical areas are examined; therefore, the homologoid joints of both limbs should always be examined. A systematic approach to every aspect of each joint is necessary to avoid false negative diagnosis. Authors’ address: CIRALE–IPC, Ecole Nationale Vétérinaire d’Alfort, Goustranville RN 175, 14 430 Dozulé, France. © 2001 AAEP.

1. Introduction

Ultrasonography has become an essential procedure for diagnosing joint injuries. With this technique and the new equipment available, noninvasive assessment of most of the soft tissues of every joint in the limbs, back, and pelvis is possible. Ultrasonography also provides useful information for many lesions of the articular surfaces.

The objectives of this presentation are to describe the most interesting anatomical structures that are frequently injured or that present clinical applications in the field of diagnostic ultrasonography; to provide reference anatomical figures to aid in the identification of the most important anatomical structures seen during ultrasonographic examination of joints; and to present the main ultrasonographic abnormal findings of the different joint structures, which will allow the diagnosis and documentation of many joint conditions.

2. Anatomical Basis

Distal Interphalangeal Joint (DIPJ)

This joint presents five ligaments that can be imaged ultrasonographically (Figs. 1 and 2): two short and long collateral ligaments between the middle phalanx (P2) and the distal phalanx (P3), two long and oblique collateral sesamoidean ligaments between the distal sesamoid bone (DSB) and P2 as well as the proximal phalanx (P1), and a short and wide distal impar sesamoidean ligament between the DSB and P3.

The DIPJ presents two main recesses that are accessible with ultrasonography: a dorsal recess between the dorsal digital extensor tendon and P2 and a proximopalmar recess located proximal to the DSB. The dorsal articular margins of P2 and the extensor process of P3 can be seen with a dorsal approach to the joint. With a palmaroproximal approach, the palmar margin of P2 and the proximal border of the DSB can be imaged.
Fetlock Joint

The fetlock joint has a thick dorsal articular capsule (Fig. 3). This joint presents two symmetrical collateral ligaments (Fig. 4) with two layers: a superficial and long as well as a short and oblique layer—except for the suspensory apparatus (third interosseus muscle, proximal sesamoid bones and palmar ligament, sesamoidean ligaments). This joint presents two main recesses: a dorsal recess with little synovial fluid in normal joints and a fibrous proximodorsal synovial fold, and a proximopalmar recess with numerous and high synovial villi.

The dorsal and collateral articular margins are easily accessible and smooth in normal joints. The articular cartilage and subchondral bone surface of the dorsal aspect of the metacarpal (metatarsal) condyle can be imaged on the weight-bearing limb. The distal aspect of this articular surface can be examined on the flexed fetlock. The articular cartilage is thicker dorsally (~1 mm) than it is distally (~0.5 mm).

Shoulder Joint

The scapulohumeral joint is closed by a thin articular capsule and does not present any ligament (Fig. 5). This capsule is better seen with lateral and caudolateral approaches than it is with a cranial approach to the joint. It is covered by the supraspinatus, infraspinatus, and deltoid muscles (Figs. 5 and 6).

There is very little synovial fluid in the articular cavity in sound joints. When present, this fluid is seen on a caudolateral approach below the margin of the humeral head. The articular margins are also more easily imaged with lateral and caudolateral approaches: the glenoid cavity has a sharp articular margin on longitudinal sections whereas the humeral head has very smooth caudolateral articular margins.

The articular surface of the scapula cannot be imaged ultrasonographically. The lateral and caudal parts of the humeral head are the only articular surfaces accessible with this technique. The exposed surface can be expended when the limb is protracted and adducted.

Hock Joint

The crurotarsal joint has two strong and complex collateral ligaments (CL). Each of them presents a long and single CL as well as a short CL (Figs. 7–9) with a calcanean and a talean part. The talean part of the medial CL is divided into superficial and deep fasciculi. These different ligaments do not have the same orientation (Figs. 8 and 9). Therefore, examination of each of them in longitudinal and transverse sections requires specific orientation of the probe.

The articular capsule can easily be imaged at the medial and dorsal aspects of the joint.

The normal crurotarsal joint has a wide dorsomedial recess that is imaged below the medial malleolus of the tibia. The normal synovial fluid is totally anechogenic and the synovial membrane presents distinct villi floating in the synovial fluid. In normal horses, there is very little fluid dorsally and laterally between the talus and the articular capsule or in the plantarolateral andplantaromedial recesses of the tarsocrural joint. The articular margins of the medial malleolus and the medial aspect of the talus are imaged with a medial approach.

The dorsal aspect of the articular surface of the talus is widely exposed, which allows easy imaging of the medial and lateral trochlea ridges of this bone. On the flexed hock, the caudoproximal part of the talus trochlea can also be examined.

The distal tarsus is surrounded by strong ligaments made of the distal part of the CL laterally and medially (Figs. 7–9), the talometatarsal liga-
ment dorsally, and the distal plantar ligament caudally. Very little synovial fluid can be seen at the medial aspect of the distal intertarsal joint or at the plantarolateral aspect of the tarsometatarsal joint. The articular margins of these two joints are regular and sharp; the joint spaces with the articular cartilage are imaged as an anechogenic gap in the hyperechogenic profile of the distal tarsal bones.

Stifle Joint
The three patellar ligaments (PL) of the femoropatellar joint (Fig. 10) can be imaged on the longitudinal and transverses sections. On transverse sections, the medial PL is triangular, the intermediate PL is round, and the lateral PL is flat and wide and is molted over the lateral ridge of the femoral trochlea in its proximal part (Fig. 10). The distal part of these ligaments is extra-articular because the infrapatellar fat pad is between them and the synovial membrane.

On sound stifles, the femoropatellar joints present two recesses with synovial fluid: one medial, caudal to the medial PL, and one lateral, caudal to the lateral PL. High and thick synovial villi are present in the medial femoropatellar recess.

The distal articular margin of the patella is smooth. The articular surface of the femoral trochlea is widely exposed on the weight-bearing limb. The medial trochlea ridge is thick and presents thin articular cartilage (1–2 mm thick), the lateral trochlea ridge is sharp and covered by thick articular cartilage (2–4 mm thick), and the femoral trochlea groove often presents an irregular subchondral bone surface.

The femorotibial joints present two menisci (Figs. 11 and 12), the body and horns of which can be examined on the weight-bearing limb. On longitudinal section, the medial meniscus presents a triangular radial section with a concave proximal border molted over the medial femoral condyle. The body of the lateral meniscus has a trapezoidal shape but its cranial and caudal horns have a triangular radial section. The cranial attachment of each meniscus can be imaged on longitudinal and transverse sections on the flexed limb (Fig. 12). The medial collateral ligament is attached to the medial meniscus (Fig. 10) whereas the lateral collateral ligament is separated from the lateral meniscus by the proximal tendon of the popliteus muscle (Fig. 11).
The insertion surfaces of the cruciate ligaments can be imaged on the flexed stifle with a cranial approach (Fig. 12) and on the weight-bearing limb with a caudal approach but, because of their orientation, the cruciate ligaments themselves are hypoechoic and difficult to differentiate from the surrounding structures.

The femorotibial joint presents two main synovial recesses. On sound joints, the medial femorotibial joint recess contains anechoic synovial fluid and few or no synovial villi. There is no synovial fluid in the subextensorius recess of the lateral femorotibial joint of sound stifles.

The femoral and tibial articular margins of the femorotibial joint are smooth and regular (Fig. 10). The distal articular surfaces of the femoral condyles can be imaged on parasagittal and transverse sections of the flexed limb (Fig. 12). The caudal articular surfaces of these condyles can be imaged with a caudal approach to the joint.

3. General Approach to Diagnostic Ultrasonography of Joint Lesions

Synovial Fluid

Technique

When the synovial fluid and membrane are examined, pressure on the probe should be limited to prevent collapse of the recesses. Pressure on the other recesses of the joint is useful for evaluating intra-articular pressure and synovial fluid. Mobilizing the joint just before examination is useful for assessing the presence of echogenic material in the fluid.

Normal Appearance and Ultrasonographic Findings

Normal synovial fluid is totally anechoic. In normal joints, the amount of synovial fluid is limited. The presence of synovial fluid is abnormal in the dorsal recess of the proximal interphalangeal joint.
A homogeneous echogenic appearance is suggestive of septic arthritis. A heterogeneous echogenic appearance is found after hemarthrosis. Echogenic spots floating in anechogenic synovial fluid are compatible with meniscal debris, cartilaginous debris, or fibrine clots. Hyperechogenic material casting acoustic shadow is indicative of osteochondral fragments. These fragments are usually found in contact with the synovial membrane.

Thickening of the synovial membrane and lengthening of the synovial plica are indicative of synovitis. Hypertrophy of the proximodorsal plica at the dorsal aspect of the fetlock is found in proliferative synovitis. Recent and inflammatory lesions have a hypoechogetic appearance whereas echogenic lesions with or without bone metaplasia are indicative of a chronic process.

Clinical Significance
Synovial fluid distension and synovial membrane thickening or proliferation are indications of recent or chronic arthritis. They can be found without other radiographic or ultrasonographic findings but, in every clinical case, they are sufficient to incite the clinician to look for a causative pathologic process in the joint.

In the majority of clinical cases, synovial lesions are observed with lesions of the other components of the joint.

Ligaments and Capsule

Technique
Examination of the dorsal capsule of the fetlock, as well as of the superficial and collateral ligaments, can be adequately performed with linear probes of 7.5–13 MHz. For special indications such as the collateral sesamoidean and distal impar sasa-
moidean ligaments, convex probes are required. For every clinical indication, lesions must be documented on transverse and longitudinal sections. Because the ligament fasciculi are echogenic only if the ultrasound beam is perpendicular to the fiber interfaces, care should be taken to orient the ultrasound beam to avoid interpreting hypoechoic areas as being indicative of lesions.

Normal Appearance
Normal ligaments have an echogenic appearance. In some of them, several fascicules have different orientations, which induces variations in echogenicity on the same cross-section (e.g., lateral collateral ligament of the femorotibial and carpal joints). Other ligaments, such as the collateral ligaments of the hock, present different distinct parts that must be examined separately.

Ultrasonographic Findings
Complete rupture with lack of continuity of the ligament has been observed in the medial collateral ligament of the stifle. In these patients, thickening of the injured ligament and hypoechogenicity were limited. In acute desmopathy, the ligament is thickened and presents anechogenic areas with alterations of the fiber pattern. Swelling around the injured ligament is often observed. Avulsion fracture at the site of insertion can be seen, especially for the short collateral ligaments of the hock and the collateral ligaments of the fetlock, as well as in the interphalangeal joints. Thickening, heterogenous echogenicity, and fiber pattern alteration are observed in chronic desmopathy. In insertion desmopathies (enthesopathies), these findings are accompanied by bony lesions such as irregular bone surfaces, osteolysis with areas of echogenic bone, and osteophyte production (enthesophytes) at the insertion site. In our patients, the most common sites of enthesopathy are the distal attachment of the dorsal capsule of the fetlock on the proximal...
phalanx (PI), the insertions of the collateral ligaments of the distal interphalangeal joint on the middle and/or distal phalanxes, the insertions of the collateral sesamoidean ligaments and the distal impar sesamoidean ligament, and the distal insertion of the long collateral ligaments of the hock.

Clinical Significance
Desmopathy is often observed as a primary injury of the joint. In most cases, it is associated with secondary synovitis and degenerative joint disease (DJD). Ligament rupture is always associated with severe DJD, with alteration of the synovial fluid and membrane, periarticular osteophyte proliferation, and cartilage alteration.

Meniscus

Technique
Linear and convex probes of 7.5–13 MHz are adequate for imaging the body (intermediate part) and cranial part (cranial horn and cranial attachment) of the medial and lateral menisci. Convex or sector probes of 3.5–6 MHz are required to image the caudal horns of the menisci. Complete evaluation of these structures requires the realization of radial (proximodistal) and craniocaudal (transverse, horizontal) sections. Because the meniscal fasciculi are echogenic only when the ultrasound beam is perpendicular to the fiber interfaces, the ultrasound beam, on radial cross section of the menisci, should be perpendicular to the abaxial surface of the structure to avoid the creation of hypoechoic artifacts. Flexion of the stifle is required to image the cranial attachment of the menisci.

Normal Appearance
On radial (proximodistal) sections, the menisci appear as triangular echogenic structures limited by the anechogenic cartilage of the femoral and tibial condyles. On craniocaudal (horizontal) sections,
because of the concentric orientation of the fibers, only the intermediate part of the meniscus is echo-

genic. On radial and transverse sections, the cranial attachment of the menisci have the same echogenic appearance as do ligaments.

_Ultrasoundographic Findings_
In our patients, lesions of the medial meniscus have been found four times more frequently than lesions of the lateral meniscus. Several types of meniscal injuries can be observed. Traumatic injuries with hypoechoegenic tears in the meniscal body are always accompanied by secondary DJD. Progressive degenerative injuries are often found to be associated with condylar dysplasia or subchondral bone cysts. Chronic synovitis with synovial membrane and villi proliferation, as well as fluid distension with echogenic spots, are always present. Collapsus and prolapsus of the medial meniscus always accompanies severe degenerative changes of the femorotibial joint. Mineralization of the medial meniscus has been found in the cranial horn, body, and caudal horn of young, adult, and old horses. Thin and horizontal hypoechoegenic images are often found in horses without lameness who have limited synovitis. The clinical significance of these images should not be overestimated.

_Clinical Significance_
Traumatic injuries are quite rare primary lesions that induce secondary DJD with severe synovitis and periarticular osteophyte proliferation. Progressive meniscal degeneration and collapse accompany femoral condylar dysplasia. Severe DJD with extensive periarticular bony proliferation induces secondary trauma on the proximal surface of the medial meniscus.

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_Fig. 11_ Dissected specimen showing the lateral aspect of the stifle. Patella (1), femur (2), tibia (3), lateral collateral ligament (4), lateral patellar ligament (5), lateral meniscus (6), proximal tendon of the peroneus tertius and long digital extensor muscles (7).

_Fig. 12_ Cranial aspect of the flexed femorotibial joint. Femoral trochlea (1), medial femoral condyle (2), lateral femoral condyle (3), tibial tuberosity (4), cranial attachment of the medial meniscus (5), cranial attachment of the lateral meniscus (6), cranial cruciate ligament (7), caudal cruciate ligament (8).
Articular Margins

**Technique**

Articular margins of superficial joints are examined adequately with 7.5–13 MHz linear probes. To examine the margins of the epaxial synovial intervertebral joints, 3.5–6 MHz probes are needed. In some joints, such as the fetlock and the medial femorotibial joints, the displacement of the probe allows complete evaluation of the margins. Therefore, ultrasonography is much more sensitive to any alteration of the articular margins than is radiography.

**Normal Appearance**

Normal articular margins appear as a regular hyperechogenic and smooth bone surface.

**Ultrasonographic Findings**

Periarticular osteophytes appear as an elevation of the profile of the margins. Periarticular bony fragments are easily located with ultrasonography. They show up as isolated hyperechogenic nodules. Abnormal echogenicity of the underlying bone is indicative of periarticular bone lysis.

Osteophyte proliferation and bone remodeling can be found a small distance away from the articular margins. When these conditions are not located in an insertion area, they are often indicative of subchondral bone collapse of the joint with callus formation in the injured area.

**Clinical Significance**

Periarticular changes are indicative of primary or secondary DJD. Periarticular osteophytes are more often located in the side of joints undergoing heavier loads. Periarticular bony fragments can be related to osteochondrosis or acquired chip fractures.

Articular Surfaces

**Technique**

Articular surfaces of superficial joints can be examined adequately with 7.5–13 MHz linear probes. To examine the surfaces of deep joints such as the femoral condyles with a caudal approach, 3.5–6 MHz convex probes are needed.

Several articular surfaces can be examined on the weight-bearing limb. They include those of the dorsal fetlock, the talus, the femoral trochlea, and the caudal aspect of the femoral condyles. Other articular surfaces require flexion of the examined joint. These include the dorsal part of the interphalangeal joints, the distal part of the metacarpal condyle, and the distal aspect of the femoral condyles.

**Normal Appearance**

The articular cartilage appears as a regular hyperechogenic to anechogenic band located between the synovial membrane or fluid and the hyperechogenic subchondral bone. The cartilage surface is imaged as a regular echogenic thin line and the subchondral bone surface appears as a regular hyperechogenic thin line.

**Ultrasonographic Findings**

Thickening of the articular cartilage surface is indicative of cartilage fibrillation. Cartilage degeneration induces local or diffuse thinning of the articular cartilage. Linear cartilaginous erosion, such as in the metacarpal condyle, induces an irregular cartilage surface on transverse sections.

Alteration of the subchondral bone surface induced by subchondral bone cysts is frequently observed in the femoral and metacarpal condyles and, for some small lesions, ultrasonography is more sensitive than radiography. Defect of ossification in the deep layers of the articular cartilage can be seen in the lateral femoral trochlea ridge and the medial ridge of the talus. Subchondral bone lysis with areas of echogenic bone has mainly been documented in the distal tarsal joints as well as in the metacarpal condyle.

**Clinical Significance**

Subchondral lysis is always a significant finding. In the metacarpal condyle, ultrasonography occasionally has been more sensitive than radiography. Ultrasonography is a useful technique for documenting the relations between subchondral bone cysts and the articular surface.

4. Discussion

Ultrasonographic evaluation of the joints is a very informative procedure for diagnosing many joint injuries with or without radiographic manifestations. As a primary step, knowledge of the normal ultrasonographic appearance of each joint structure is essential. Regular training is required as is knowledge of soft-tissue anatomy. Because of their quite simple anatomy, the fetlock and stifle can be used as models for beginners in this diagnostic procedure. In all clinical cases, comparison with the same structure of the contralateral limb improves sensitivity (better identification of lesions) and specificity (limits false interpretation) of the ultrasonographic diagnosis.

Like every imaging technique, ultrasonographic examination of joints has some limitations that are related mainly to anatomical particularities of the joints. For example, in the fetlock joint the main limitation of ultrasonography is the lack of imaging of the proximal articular surface of PI and the palmar (plantar) articular surface of the metacarpal (matatarsal) condyle. In the carpus and tarsus, the intra-articular ligaments and most of the articular surfaces cannot be imaged. In the stifle, the cruciate ligaments cannot be adequately imaged.
represented and the articular surface of the patella is not accessible.

Despite these limitations, ultrasonography provides much diagnostic information through a noninvasive approach to the joints. For the equine practitioner, there is much value in combining systematic radiography and ultrasonography. This complementary approach provides more information concerning the different anatomical components of the joint and aids in interpreting X-rays. With this combination, the limitations of each technique are better identified.

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References