

Tutorial Article

Use of ultrasonography in the evaluation of joint disease in horses. Part 1: Indications, technique and examination of the soft tissues

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Introduction

Ultrasonography has advanced significantly the diagnosis and management of many types of musculoskeletal injuries in performance horses. In particular, diagnostic ultrasound is routinely used for defining and monitoring injuries to the flexor tendons and suspensory apparatus (Rantanen 1985; Genovese *et al.* 1987; Denoix *et al.* 1991; Dik *et al.* 1991). However, it can also be used to evaluate a variety of joint conditions (Denoix 1996).

Joint injury, osteochondrosis and degenerative joint disease are significant causes of lameness in performance horses. Often, a joint is suspected as the cause of lameness but the specific source of pain can be difficult to ascertain (Stashak 1987). Intra-articular anaesthesia often significantly improves the lameness and localises it to a particular joint, but radiography may be inconclusive. In such a case, the cause of lameness is presumed to be soft tissue injury and empirical treatment is instituted. However, examining the joint surfaces and articular supporting structures using ultrasound allows more thorough evaluation of the joint and therefore aids in selection of the most appropriate treatment plan and rehabilitation regimen.

Evaluation of any joint problem should begin with a thorough clinical examination, including detailed history, physical examination, gait evaluation and manipulative tests, as appropriate; and, if necessary, diagnostic regional anaesthesia (nerve and/or joint blocks). Other diagnostic procedures, such as thermography, nuclear imaging, treadmill gait analysis and neurological evaluation, may be warranted in selected cases (Lamb 1991; O'Callaghan 1991; Steckle 1991; Turner 1991). When lameness is localised to a joint, a complete radiographic study should be performed to identify any abnormality in or around the joint. Echographical evaluation of the joint (arthrosonography) and surrounding tissues should also be considered (Benson 1991; Dik 1993; Mack and Scheible 1995; Denoix 1996, 1998).

While radiography has proven to be very effective in imaging the bones of the equine limb, there can be poor correlation between clinical and radiographic findings (O'Callaghan 1991). When used in combination,

radiography and ultrasonography can supply more information about an orthopaedic problem than when each modality is used alone. Diagnostic ultrasound has the added advantage of providing immediate, detailed information about the soft tissues of a joint and the cartilage and subchondral bone surfaces.

In this article, the indicators, technique and examination of the soft tissues using ultrasonography to evaluate joint diseases in horses is discussed.

Indications

Diagnostic ultrasound can be a valuable addition to joint evaluation in any of the following circumstances:

- A joint is enlarged, particularly if synovial effusion and/or joint capsule thickening is present. Examples include synovial effusion associated with traumatic synovitis, and joint capsule thickening accompanying 'green osselets' in the fetlock.
- The source of pain has been localised to a joint by manipulative tests, regional anaesthesia, thermography or scintigraphy.
- Radiography of a joint demonstrates an abnormality, but further evaluation is needed.
- The radiography is inconclusive because the area of interest is difficult to image as a result of swelling or location; for example, certain joints (e.g. shoulder, hip, elbow) and specific areas of a joint can be difficult to image radiographically.
- Preoperative planning, when:
 - (a) the surgical approach involves an area that is not readily imaged radiographically;
 - (b) the approach is close to an important soft tissue structure that must be avoided;
 - (c) a bone fragment must be further assessed to determine whether it is intra- or extra-articular, and if it is fixed or mobile (e.g. an abaxial proximal sesamoid fracture);
 - (d) the joint must be more thoroughly evaluated for coexisting problems before the procedure.
- Information is needed about the joint before radiography is available; for example, field

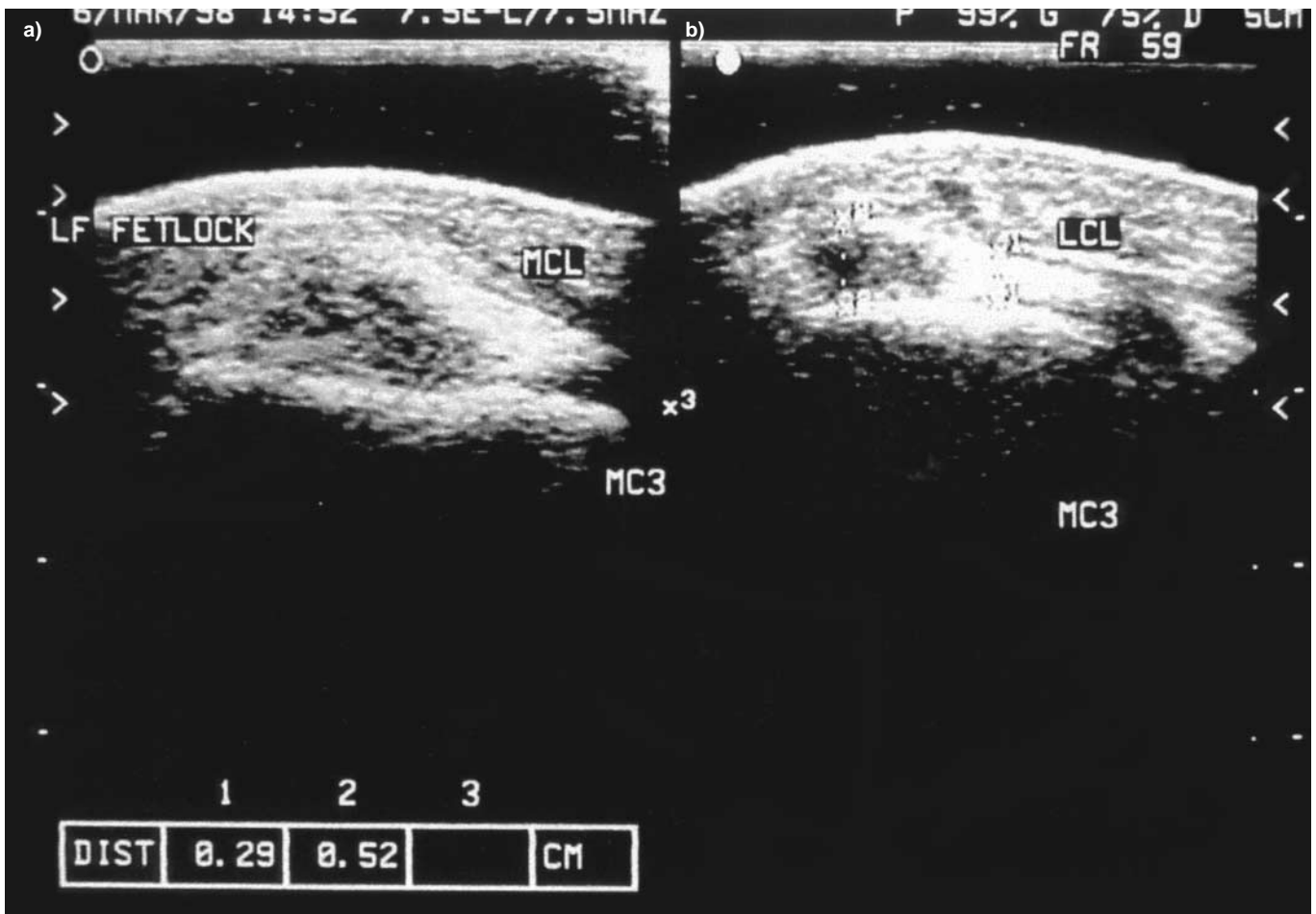


Fig 1: Echogram showing the collateral ligaments of the fetlock joint, viewed in the transverse plane. **a)** The medial collateral ligament (MCL) is grossly thickened and the normally uniform fibre pattern is disrupted by hypoechoic areas which indicate damaged fibres, haemorrhage and oedema. **b)** The lateral collateral ligament (LCL) is of normal size and fibre pattern. Both images are taken at the proximal aspect of the collateral ligaments just distal to the origin on the metacarpus. The cross-sectional area was measured but not used in this photograph to allow a better appreciation of the ligaments.

assessment of a variety of problems, especially septic arthritis or incomplete cuboidal bone ossification in a neonatal foal.

- Earlier diagnostic workup has identified a particular joint to be a problem, but treatment has failed to improve the lameness. In this instance, more detailed evaluation of the structures surrounding the joint is in order. For example, when intra-articular anaesthesia of the distal interphalangeal (coffin) joint improves the lameness but treatment is ineffective, the clinician should carefully evaluate other structures, such as the collateral ligaments of the coffin joint.

Equipment and technique

Transducer

When examining joints using ultrasonography, the superficial location and relatively shallow depth of the

articular structures necessitate a high-frequency transducer. Transducers of 7.5–10 MHz are preferable, although lower frequency transducers (5 or 3.5 MHz) may be required for imaging deeper structures such as those at the caudal aspect of the stifle. Mechanical sector scanners can produce high-quality images, but are limited by suboptimal superficial resolution; they are also prone to producing artefacts. **Higher resolution linear array transducers are best for musculoskeletal examinations.** They have superior near-field resolution and a broad superficial field of view that is helpful in evaluating superficial structures.

With either type of transducer, it is usually necessary to place a stand-off pad between the probe and the skin. The stand-off moves the superficial structures of the joint into the focal zone and away from the near-field artefact, and it increases the 'footprint' or image field of the scanhead. Structures which, by virtue of their deeper location or overlying soft tissues, are already within the focal zone need not be imaged with a stand-off.

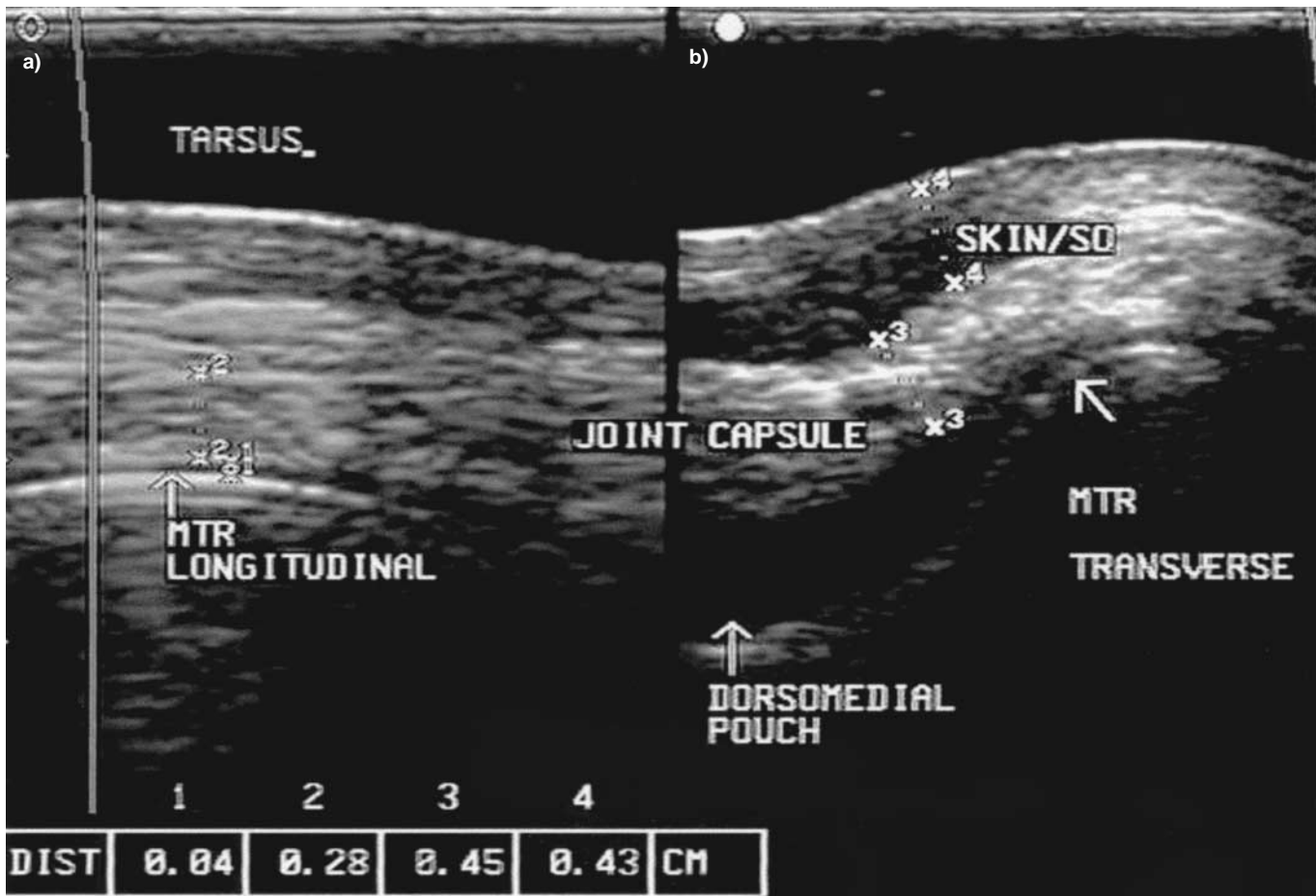


Fig 2: Echogram of a normal medial trochlear ridge of the tarsocrural joint, viewed in (a) longitudinal section directly over the trochlear ridge and (b) transverse section. Proximal is to the left and distal is to the right on the longitudinal section image. Note the appearance of the joint capsule, articular cartilage, and subchondral bone surface. There is little synovial fluid present, so the anechoic area is primarily articular cartilage.

Preparation

The joint should be prepared as is routine for echography of the digital flexor tendons; the site is clipped (and possibly shaved, depending on the operator's preference), cleansed to remove dirt, hair and other surface debris and coated liberally with a conducting gel.

Technique

Echography of structures in real time and in several different planes allows fairly comprehensive evaluation of a joint, including examination through the normal range of joint motion. The nonweightbearing areas can usually be imaged in the standing horse and, by lifting the limb and flexing the joint, at least part of the weightbearing surface can also be evaluated. **Readers unfamiliar with diagnostic ultrasonography** are encouraged to review the basic concepts and techniques before attempting evaluation of a joint.

The procedure and area of interest is, in many cases,

directed by the case details and by any prior radiographic findings. For example, **racehorses have a high incidence of problems involving** the dorsal articular surfaces of the high-motion joints, particularly the fetlock and carpus; **younger horses** may have developmental orthopaedic disease which, when involving a joint, frequently involves the trochlear ridges of the stifle, the distal intermediate ridge of the tibia, or the trochlear ridges of the talus; Warmbloods often have a similar distribution of osteochondrosis lesions and they also tend to develop periarticular changes in the coffin, pastern and fetlock joints.

However, in each case, it is important to perform as complete an examination as possible because many joint conditions involve more than one part of the joint. For example, **osteoarthritis tends to cause cartilage degeneration and thinning in loaded areas of the articular surface.** Along with these cartilage changes, periarticular remodelling occurs in the form of osteophyte and/or enthesophyte formation.

Joint capsule thickening, with or without metaplasia, is also a common feature of osteoarthritis (see below). As

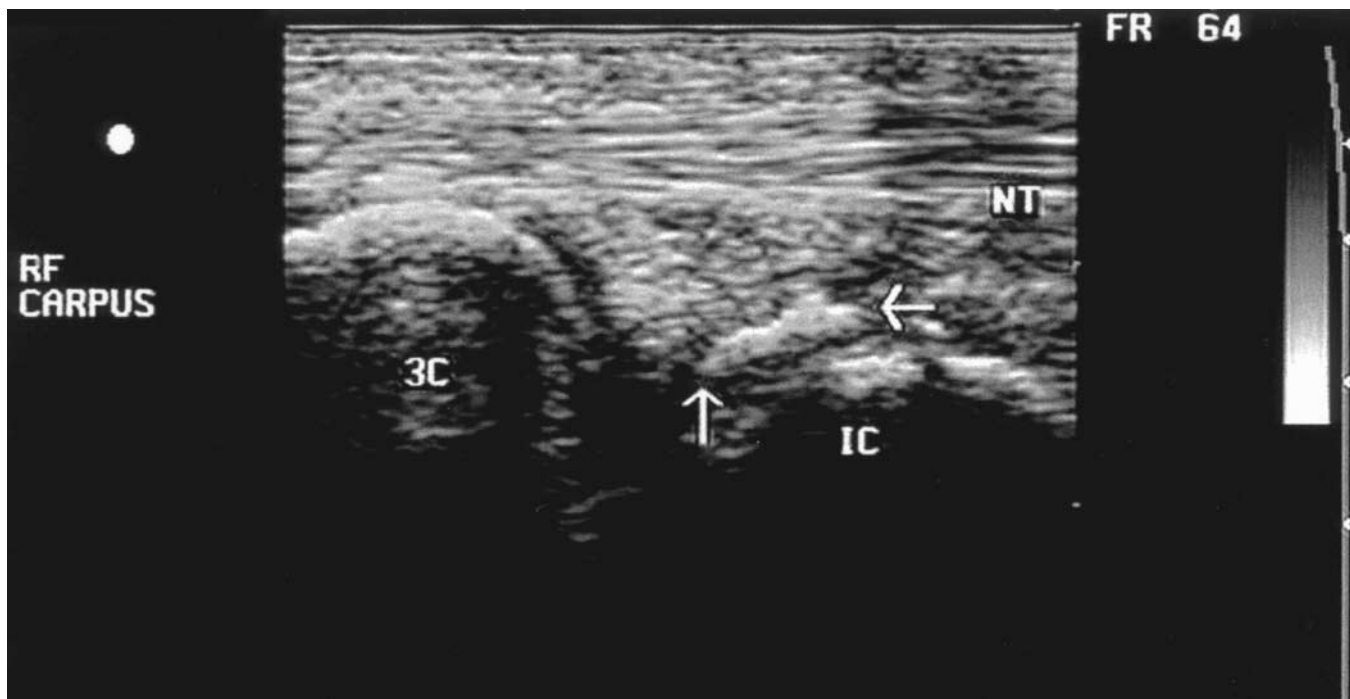


Fig 3: Echogram of the RF midcarpal joint, viewed in longitudinal section. In this view, proximal is to the right of the image, and distal is to the left. There is an osteochondral fragment (chip fracture) off the distal articular margin of the intermediate carpal bone (IC), adjacent to the third carpal bone (3C). The margins of the fragment are indicated by the 2 arrows. Note the joint capsule thickening overlying the fragment.

another example, many of the osteochondral fractures that occur in the joints of performance horses occur on the dorsal surface due to hyperextension of the joint. However, hyperextension may also cause damage to the palmar/plantar soft tissues (flexor tendons, suspensory ligament and distal sesamoidean ligaments), which can significantly alter the prognosis. Therefore, as much of the weightbearing and nonweightbearing areas of the articular surface, the extensor and flexor surfaces (and the soft tissues that cross these areas), as well as the collateral ligaments, should be examined when assessing a problem joint. However, it can be extremely difficult to image any of the major weightbearing areas of a joint without maximally flexing the leg, a manipulation that may be limited due to resentment by the horse if there is significant joint inflammation.

Dynamic examination of the joint also allows better evaluation of redundant parts of the joint capsule in some of the high-motion joints. For example, the dorsal surface of the fetlock joint has a redundant joint capsule that is relaxed when the horse is bearing weight on the limb. Flexion of the fetlock tenses the dorsal aspect of the joint capsule, allowing better evaluation of this part of the joint; and tearing of the dorsal joint capsule is more accurately imaged if the structure is under tension (Denoix 1996). **Flexion and extension of the joint during echography** can also be helpful in demonstrating mobility of an osteochondral fragment and in evaluating fluid movement within the joint.

Evaluation of the contralateral limb

The same joint on the contralateral limb should serve as a comparison when evaluating articular and periarticular structures. However, there are 2 precautions:

- The examiner must use the same orientation of the transducer and image the contralateral joint at exactly the same location when making comparisons;
- It is important to bear in mind that some joint conditions, in particular osteochondrosis in young horses and osteochondral fragmentation in racehorses, can be present bilaterally.

Ultrasonographic features of the articular and periarticular soft tissues

Diagnostic ultrasound is an excellent means of imaging the articular structures, i.e. joint capsule, articular cartilage, subchondral bone surface and periarticular ligaments and tendons. **The major obstacle to its effective use** is the need to understand the anatomy of the particular joint and appreciate how the various tissue types in and around the joint affect sound-tissue interactions. **It is also important** to understand the information and misinformation (**artefacts**) created during any ultrasound evaluation. There are several texts

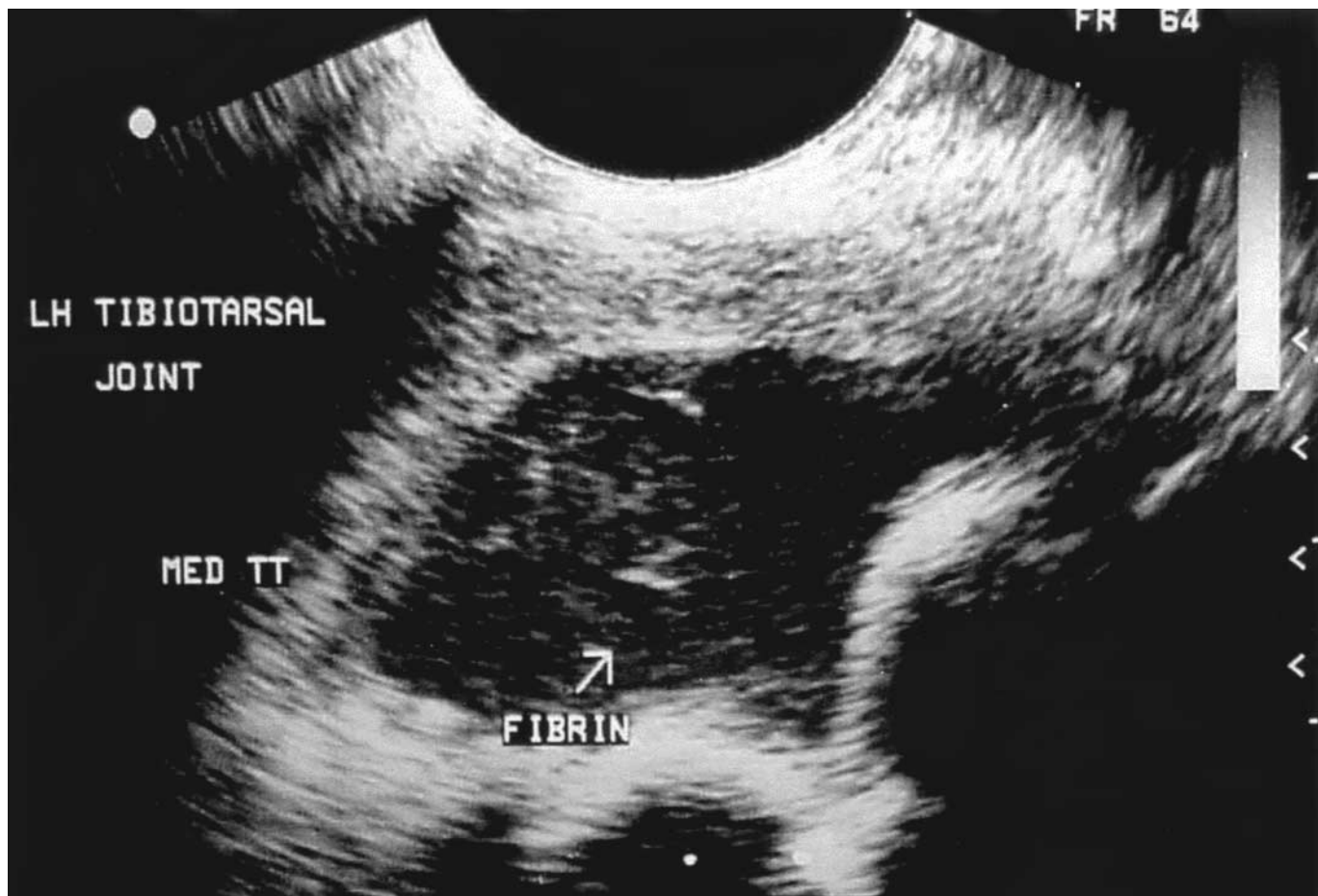


Fig 4: Echogram of the dorsomedial pouch of the tarsocrural joint, showing marked fluid accumulation within the joint space. Echogenic material is evident within the synovial fluid, and was found dispersed throughout the joint. Fluid analysis revealed a white blood cell count of $60 \times 10^9/l$ (predominantly neutrophils), indicating a septic process.

that describe the anatomy of specific joints in the horse (Sisson 1975; Sack and Habel 1977; Dyce *et al.* 1987; Kainer 1987). **The examiner should have at least a working knowledge of the joint before attempting ultrasonographic evaluation.**

Following are some general features of articular structures that are pertinent to echography of any joint.

Periarticular structures

In the distal limb, **stability** of a joint is provided by the integrity of the joint capsule and the surrounding tendons and ligaments, as well as the contours of the joint surfaces. In the proximal limb, **additional stability** is provided by various muscle groups; these overlying tissues increase the distance between the skin and the articular structures. Many joints also have **bursae** and **sheaths** associated with the tendons and ligaments that cross them. **It is important to have an understanding of the locations of these structures and their relationship to the articular tissues.**

Normal echographical appearance

Tendons and ligaments appear as moderately echogenic structures with relatively well-defined margins. The tendons and ligaments that surround a joint are similar in appearance, owing to their parallel fascicular arrangement. It is this arrangement of fibres, aligned to resist tensile forces, that creates the intense specular reflections (echoes) seen when the sound beam is perpendicular to the direction of the fascicles. **The examiner must pay particular attention to the course of the tendon or ligament being imaged and maintain the transducer at 90° to the structure, because these tissues change orientation as they incline distally toward their insertion.**

Most of these structures have a uniform fascicular orientation and, therefore, a **homogeneous ultrasonographic appearance**. Some have a **mixed fascicular arrangement** which gives them a heterogeneous appearance. The lateral collateral ligaments of the stifle, hock and elbow, and the collateral ligaments of the fetlock and carpus, have spiral or

crossed fibres (Denoix 1996). This mixed arrangement of fascicles is necessary to allow the collateral ligaments to function in both extension and flexion. In the tarsocrural joint, the superficial collateral ligaments are under tension while the limb is extended and relaxed while the limb is flexed, whereas the short collateral ligaments are tensed only when the tarsus is flexed (Updike 1984). **Therefore, the short collateral ligaments should be examined while the leg is flexed (see *Relaxation artefacts*, below).**

Periarticular tendons and ligaments should be evaluated with the same criteria used for the digital flexor tendons and suspensory apparatus: **assess the cross-sectional area and architectural changes; grade the echogenicity and fibre pattern** of each structure; and **subjectively evaluate the margins** in terms of definition and the distance between the tendon/ligament and adjacent structures.

Relaxation artefacts

Relaxation artefacts occur when a structure that is normally under tension (in this case, a tendon or ligament) is examined while it is relaxed. The normally bright specular reflections may be decreased and hypoechoic areas may be apparent. To avoid relaxation artefacts, tendons and ligaments should be under tension (i.e. weightbearing or the joint flexed or extended) during examination. **Relaxation artefacts can also occur in some abnormal conditions.** For example, complete disruption of the suspensory apparatus relieves the tension in the straight sesamoidean ligament, resulting in a relaxation artefact; and rupture of a collateral ligament relaxes the tensile forces in the ligament and can create relaxation artefacts proximal and distal to the rupture site.

Appearance of periarticular lesions

Injuries to periarticular soft tissues can manifest in several ways, depending on the time elapsed since injury and the nature of the injury. **Thickening and hypoechogenicity** of the fibrous structures around the joint can be caused by structural damage that leads to haemorrhage and oedema formation (**Fig 1**). In chronic injuries, thickening and **hyperechogenicity** can be caused by fibroplasia and, in some instances, cartilage or bone metaplasia. Insertional changes, such as enthesophyte formation, can also occur with injury to the collateral ligaments.

Joint capsule and intra-articular soft tissues

The joint capsule, intra-articular ligaments and menisci are primarily connective tissue with low cell density. **Figure 2** is an echogram of a normal tarsocrural joint, illustrating the joint capsule overlying the articular cartilage and subchondral bone surface. While not apparent in this figure,

the joint capsule is continuous with the periosteum or perichondrium, but it does not necessarily insert directly at the perimeter of the articular cartilage. There tends to be redundancy of the joint capsule in the more high-motion joints, such as the fetlock, carpus, tarsus and stifle. In fact, this redundancy can cause relaxation artefacts if the redundant aspect of the joint is examined in the weightbearing position rather than during flexion.

Inflammatory conditions can cause capsular changes that include thickening (due initially to haemorrhage and oedema and, later, fibrosis), calcification, and insertional capsulopathies (enthesophytes). Osteoarthritis in high-motion joints typically involves periarticular changes which begin with congestion and thickening of the joint capsule. The synovial membrane becomes hyperplastic and, in more chronic cases, synoviocyte metaplasia may lead to the formation of synovial chondromas, which are seen as nodules of cartilage. These nodules may undergo endochondral ossification, resulting in ovoid radiodense bodies within the joint capsule. **Figure 3** illustrates the often marked joint capsule thickening that can accompany traumatic injuries to a joint.

Synovium

Synovitis usually accompanies capsulitis and joint injury; however, **thickening of the thin synovial membrane is difficult to appreciate echographically.** Synovial effusion is helpful in assessing synovial membrane proliferation and thickening. In cases of severe synovitis, synovial fluid that is fibrinous, cellular or haemorrhagic can cloud evaluation of the joint capsule and synovium (**Fig 4**).

Menisci

The equine stifle has 2 menisci that are composed of specialised fibrocartilage. A frontal scan (lateral-to-medial or medial-to-lateral longitudinal orientation) of the femorotibial joints usually produces the most pertinent information about the menisci and collateral ligaments of the stifle. The menisci have a triangular shape and a homogeneous appearance when the transducer is perpendicular to their abaxial border. A complete description is presented in various texts and should be studied before the examiner attempts to evaluate the stifle (Denoix 1996, 1998).

Meniscal evaluation in man is enhanced by fluid accumulation in the joint and by distraction of the limb (placing traction on the limb by pulling it away from the body). This manoeuvre allows the posterior horn of the meniscus to be more easily imaged. Damage to the caudal horn of the meniscus in horses is often not appreciated via the normal cranial arthroscopic approach to the femorotibial joint; it requires a second, more caudal approach. **However, damage to the caudal horn of the meniscus can be identified during echographic evaluation of the stifle.** Distraction of the limb is, however, difficult in the standing horse; and flexion and

distraction of the limb in a horse with a clinically significant (i.e. painful) stifle injury can be even more difficult. General anaesthesia would be required to achieve adequate distraction of the equine limb and therefore more complete echographic examination of the stifle thought to have meniscal or another type of injury. We are currently investigating the usefulness of distraction for ultrasonographic evaluation of the equine stifle. At present, any stifle joint that is to be explored arthroscopically is first evaluated echographically. This protocol also enables comparison between what is viewed and what is found arthroscopically.

Synovial fluid

There is minimal synovial fluid in a normal joint, so the joint capsule and adherent synovium are normally in close apposition with the articular cartilage. Synovial fluid accumulation occurs with many abnormal joint conditions, and a thorough evaluation of the various articular structures is therefore indicated when synovial effusion is present. The echographical properties of the fluid can help in assessing the nature of the fluid. **Effusion associated with acute synovitis is typically anechoic**, with occasional fibrinous accumulations. Haemorrhage or sepsis increases the cellularity and fibrin deposition with the joint and appears as echogenic fluid (Fig 4).

Ultrasonography can also be used to aid aspiration of synovial fluid by identifying areas of fluid accumulation. Utilisation of this technique, particularly in the deeper joints such as the hip and shoulder, can minimise trauma to the joint and reduce the potential for blood contamination of the fluid sample.

Echography of the articular surface (cartilage and subchondral bone) is discussed in Part 2 in the next issue.

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