ULTRASONOGRAPHIC EXAMINATION OF JOINTS, A REVOLUTION IN EQUINE LOCOMOTOR PATHOLOGY

L'ÉCHOGRAPHIE DES ARTICULATIONS, UNE RÉVOLUTION EN PATHOLOGIE LOCOMOTRICE ÉQUINE

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SUMMARY

Equine diagnostic ultrasonography was initially used for the diagnosis and documentation of tendon injuries. Since 1990, this technique became an essential complement to radiography for the diagnosis of equine joint lesions. Ultrasonography provides precise information on the synovial membrane and fluid, articular cartilage, subchondral bone, joint margins, ligaments and menisci, as well as on the anatomical structures involved in any periarticular thickening. With the improvement of ultrasound machines and image resolution, both in superficial and deep fields, all limb joints can now be examined, even the most proximal ones, as well as most axial joints of the equine spine, pelvis and head. Within two decades, a large number of new conditions of the equine locomotor system have been discovered using ultrasonography; this knowledge has deeply changed the diagnostic approach and understanding of lameness in horses. As professional athletes, horses provide an excellent animal model of spontaneous locomotor sport-induced injuries. The quality of imaging documentation is improved by the size of the anatomical structures being viewed. Strict standardization of the technical approach of every joint structure and accurate knowledge of the equine locomotor system anatomy are required to guarantee the sensitivity and specificity of diagnostic ultrasonography of joint injuries.

Key-words: horse, locomotor system, diagnostic imaging, ultrasonography, joint.

RÉSUMÉ

D'abord utilisée pour le diagnostic et la documentation des lésions tendineuses, l'échographie est devenue depuis 1990 un complément indispensable à la radiologie dans le diagnostic des affections articulaires chez le cheval. Cette technique fournit des informations précises sur la membrane et le contenu synovial, le cartilage articulaire et l'os sous-chondral, les marges articulaires, les ligaments et les ménisques, ainsi que sur les formations impliquées lors d'épaississement péri-articulaire. L'amélioration des appareils et de la résolution de l'image, en régions superficielles comme en profondeur, permettent maintenant d'envisager l'examen de toutes les articulations des membres, y compris les plus proximales, et de la plupart des articulations axiales (colonne vertébrale, bassin et tête) du cheval. En 20 ans, un grand nombre d'entités pathologiques nouvelles ont été mises en lumière grâce à l'échographie ; ces connaissances ont profondément changé l'approche diagnostique et la compréhension des boiteries chez le cheval. Athlète professionnel, le cheval constitue un excellent modèle animal de pathologie locomotrice sportive spontanée ; la taille de ses formations anatomiques facilite et améliore la documentation lésionnelle par imagerie. L'échographie articulaire nécessite une codification stricte de l'abord technique de chaque formation et une connaissance précise de l'anatomie de l'appareil locomoteur du cheval, conditions indispensables pour garantir les performances de la technique en matière de sensibilité et de spécificité.

Mots-clés : cheval, appareil locomoteur, imagerie diagnostique, échographie, articulation.

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INTRODUCTION

The first use of ultrasonography in horses was dedicated to the management of reproduction in mares. Then, since 1983, this technique was used for the diagnosis and documentation of tendon injuries (Rantanen *et al.* 1983). At the beginning of the '90's ultrasonographic assessment of joint disorders has been quickly developed (Denoix 1989a; 1989b; 1991; Denoix *et al.* 1993a; 1993b). The diagnostic data obtained with this technique have brought in depth changes in the knowledge of injuries responsible for pain in the anatomic structures of the equine locomotor system and in the understanding of their etiopathogenesis.

Technologic improvement of ultrasound machines and image resolution has continuously increased the diagnostic capabilities of ultrasonography and enlarged the field of its applications. Now this technique is essential within the different modalities that can be used for the diagnosis of the causes of lameness and performance limitations in race, sport and pleasure horses. Between 1988 and 2009, about 20 000 clinical cases has been examined using ultrasonography. Through these exams numerous new clinical entities have been discovered and are now confirmed with the use of modern cross-sectional imaging modalities such as magnetic resonance imaging and CT scan.

GENERAL INDICATIONS OF ULTRASONOGRAPHIC EXAMINATION OF EQUINE JOINTS

The first joint areas investigated with ultrasonography in horses have been the metacarpophalangeal region (fetlock joint) (Denoix 1989a; 1993; Busoni *et al.* 1996; Denoix *et al.* 1996a) and the femorotibiopatellar (stifle) joint (Denoix *et al.* 1994a; Denoix & Lacombe, 1996; Denoix *et al.* 1996b). Soon, other regions such as the carpus (Denoix & Audigié, 1996), shoulder, tarsus and foot (Denoix *et al.* 1994b; Denoix 1996; Denoix & Busoni,1998; Busoni & Denoix, 2001) have been investigated systematically in an attempt to identify new pathologic entities responsible for pain that were not known because of the limitations of radiography. The general objective was to improve the diagnosis and knowledge of painful lesions in horses and to develop a complementary and alternative technique to more invasive approaches such as arthrography or arthroscopy.

Ultrasonography is always indicated when the origin of the pain has been demonstrated or suspected with the clinical examination (and especially the diagnostic analgesic techniques). Nowadays, this technique is systematically associated with radiography for the evaluation of any joint disorder. Even when radiographic findings are identified, an ultrasonographic exam is performed for the assessment of articular or periarticular soft tissues injuries, evaluation of bone and articular surfaces and to get a more complete screening of the area(s) of interest. Combined data may be essential when the prognosis and the management of the condition are concerned. Besides, for routine check up of high level equine athlets, examination of both front feet, both stifles, proximal suspensory ligaments in frontlimbs and hind limbs as well as lombosacral and sacroiliac areas is systematically performed.

Moreover, ultrasonography plays now an major role in the treatment and management of equine athlete injuries (Denoix 1992). Ultrasonographic guided injections have considerably improved the efficacy and safety of intra-articular injections in proximal joints as well as in synovial intervertebral joints of the cervical and thoracolumbar spine (Denoix & Heitzmann, 2005; Denoix 2006). Allowing a non-invasive control of soft tissue healing, this technique is essential in the management of horses following rehabilitation programs.

MATERIALS AND METHODS

The material and general techniques used for examining most of the equine joints are now well established (Denoix 1996; Denoix & Busoni, 1998; Denoix 1998a; Denoix 2003; Denoix & Audigié, 2004). A 7.5 to 13 MHz linear probe is used for a lot of indications including examination of the tendons of the metacarpal/tarsal and digital areas, the fetlock joints, the carpus (including the carpal canal) and tarsus as well as the stifle. A 5 to 7.5 MHz microconvex probe is required for examining the palmar aspect of the equine foot and performing ultrasonographic guided injections in small and superficial joints. A 3.5 to 8 MHz convex probe is useful to complement imaging of the proximal suspensory ligament as well as to image proximal joints (shoulder, hip, caudal aspect of the stifle) and intervertebral joints in the cervical and thoracolumbar spine. Finally, a 5 to 7.5 MHz endorectal probe is required for examining the ventral aspect of the lumbosacral and sacroiliac joints.

Normal images of the joint structures of the frontlimbs and hind limbs have been performed on sound horses and compared to anatomical specimen and cross-sections in order to establish reference data (Denoix *et al.*1996; Denoix 2002). Besides, ultrasound images of the distal limbs (Denoix 2002), stifle (Denoix *et al.* 1994a), and back (Denoix 1999), have been compared to magnetic resonance images made in the same anatomical planes. The objective has been to precise the exact shape, size and topography of every anatomical structure of the equine joints ***(figure 1)***.

Since 1989, 800 to 1200 horses have been examined every year, most of them having several joints scanned. Images were recorded on U-matic videotapes until 2001 and thereafter, they were digitally stored on hard discs. These images represent a very extensive database of the multiplejoint conditions affecting horses of different age and disciplines (racing, sport, endurance, driving, pleasure…).

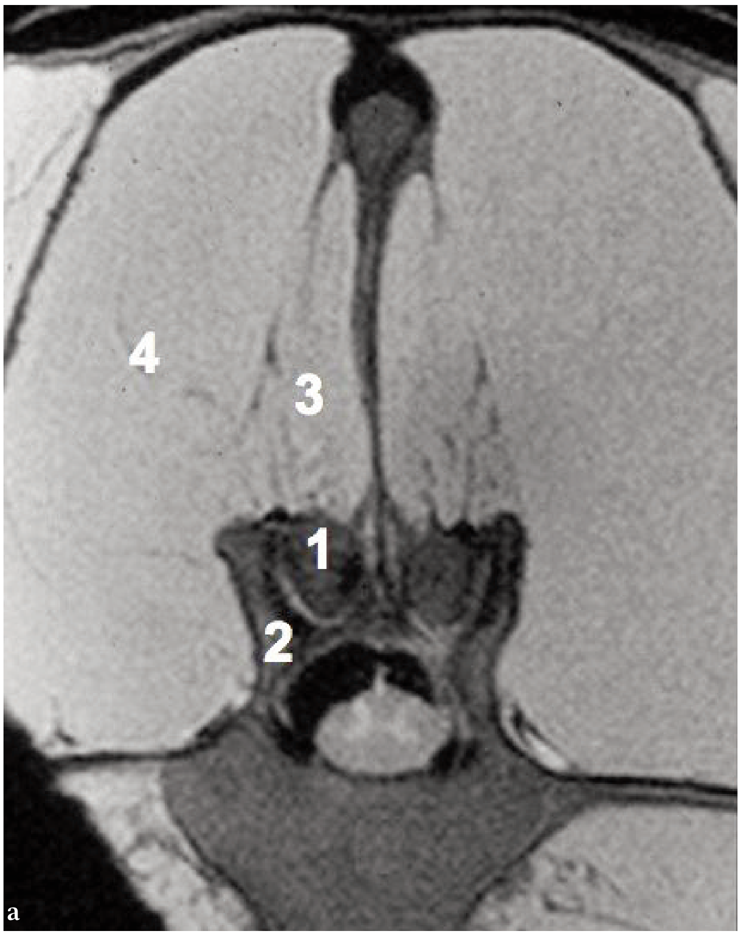
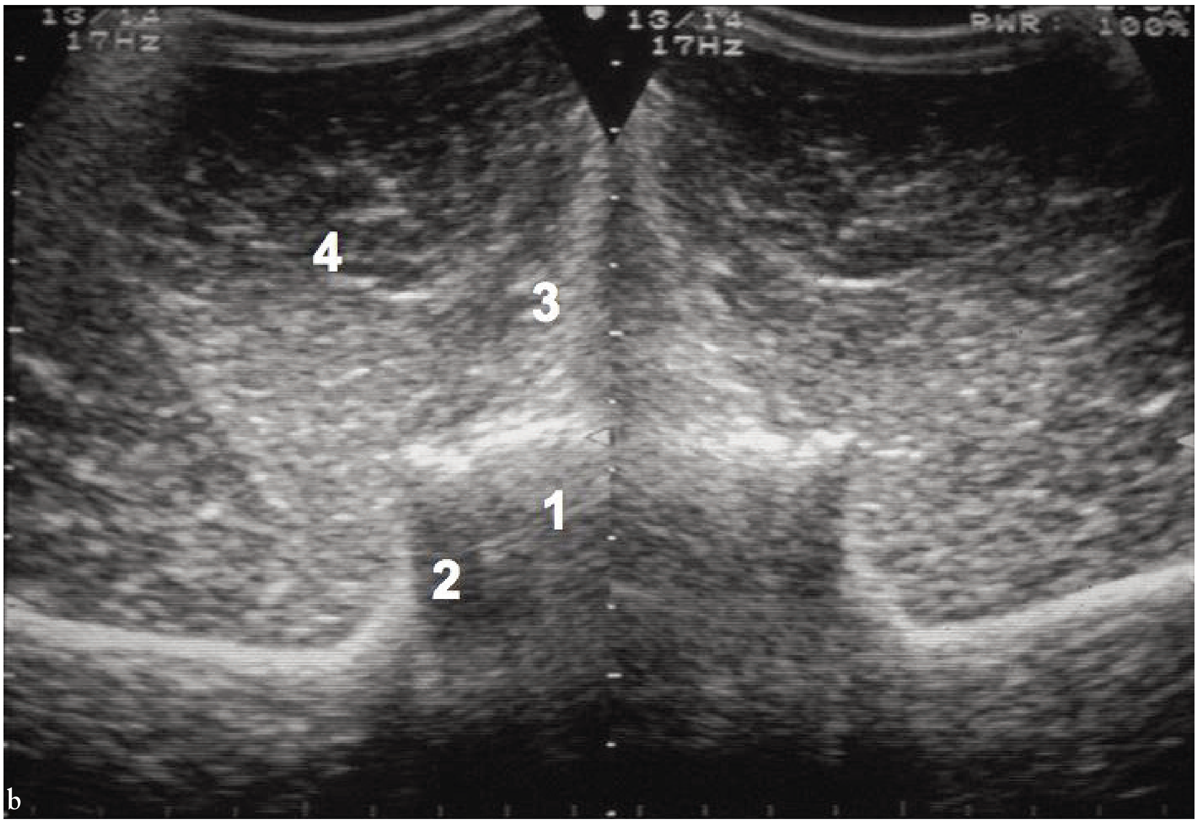


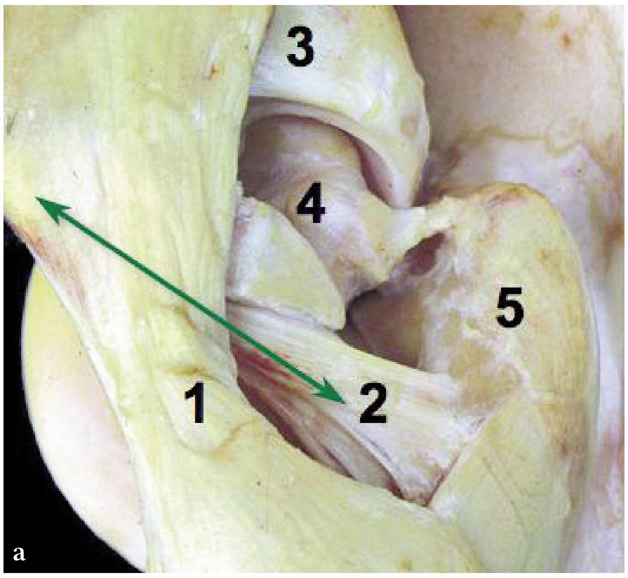
Figure 1: *Normal transverse sections of the articular processes of the equine lumbar spine.*
1a: *magnetic resonance image of an anatomical specimen;* ***1b:*** *corresponding transverse ultrasonographic section made on a clinical case.*
1- Caudal articular process of the first lumbar vertebra;
2- Cranial articular process of the second lumbar vertebra;
3- Multifidus muscle;
4- Longissimus muscle.

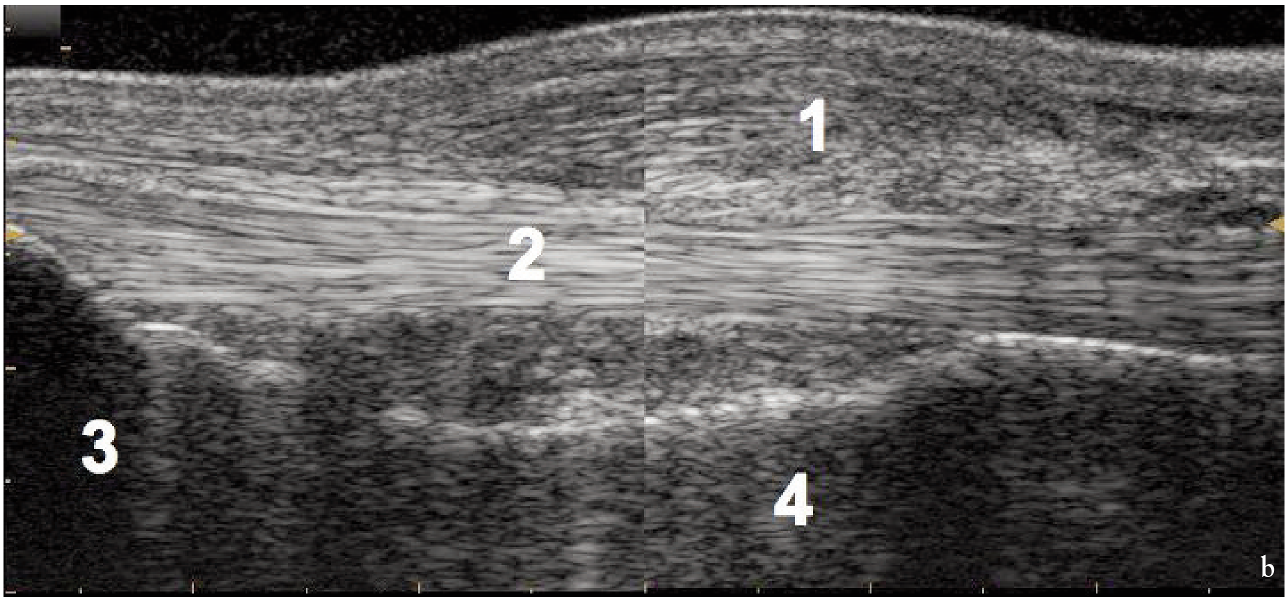


ULTRASONOGRAPHIC FINDINGS AND LESIONS OF EQUINE JOINTS

Most of the soft tissue injuries induce several ultrasonographic changes including ***(figure 2)*** modification of size (usually thickening and rarely thinning), echogenicity (hypoechogenic or hyperechogenic images), architecture (such as alteration of the fiber pattern) and shape. In enthesopathies (insertional desmopathies or tendinopathies), these changes are accompanied with alteration of the bone surface showing remodelling, enthesophytes and/or bone lysis.

On radiographs, most of the soft tissues show the same liquid density. Because of their different fibre arrangement, articular and periarticular soft tissues can easily be differentiated with ultrasonography. Therefore assessment of conditions affecting specific structures can be done.





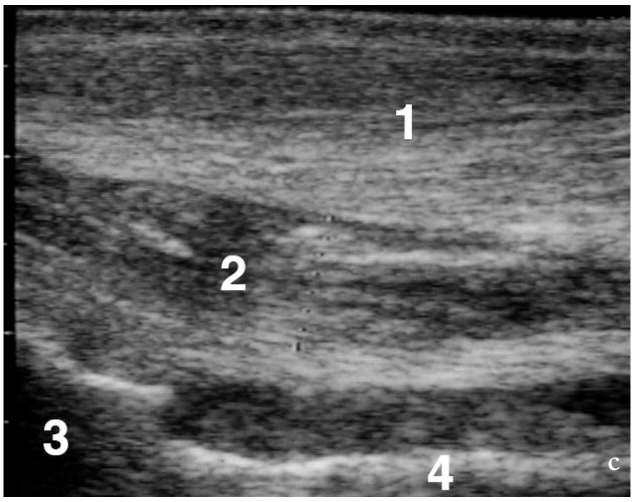


Figure 2: *Ultrasonographic examination of the medial collateral ligament of the equine hock.*
2a: *medial aspect of a dissected hock;* ***2b:*** *normal longitudinal ultrasonographic section of the medial collateral ligament;* ***2c:*** *abnormal ultrasonographic image of the calcanean fasciculus of the short medial collateral ligament (2). This ligament is enlarged and presents a heterogeneously reduced echogenicity with alteration a its fiber pattern.*
1- Long medial collateral ligament;
2- Short medial collateral ligament (calcanean fasciculus);
3- Medial malleolus of the tibia;
4- Talus;
5- Sustentaculum tali of the calcaneus.

Ligaments and capsules

Technique

Examination of the dorsal capsule of the fetlock as well as of the superficial and collateral ligaments in front and hind limbs can be adequately performed with 7.5 to 13MHz linear probes. For special indications such as the collateral sesamoidean and distal impar sesamoidean ligaments within the foot, microconvex and convex probes are required. As the ligament fasciculi are echogenic only if the ultrasound beam is perpendicular to the fibre interfaces, care should be taken to orient the ultrasound beam correctly to avoid misinterpretation of hypoechogenic areas as indicative of lesions. For every clinical indication, lesions must be documented on transverse and longitudinal sections and images must be done on the similar structures of the opposite limb.

Normal appearance

Normal ligaments have an echogenic appearance. In some of them several fascicules have different orientations inducing variation of echogenicity on the same cross section (e.g. lateral collateral ligament of the femorotibial and carpal joints). Others, such as the collateral ligaments of the hock, present different distinct parts that must be examined separately ***(figure 2)***.

Ultrasonographic findings

Complete rupture of collateral ligaments has been observed in the distal interphalangeal, metacarpophalangeal, tarsocrural and femorotibial joints. In these patients, thickening of the injured ligament and hypoechogenicity were limited. In acute desmopathy the ligament looks thickened and presents anechogenic or hypoechogenic areas with alteration of the fiber pattern (Denoix & Busoni, 1998; Denoix 1998a; 1998b; Denoix 2003; Denoix & Audigié, 2004; Jacquet *et al.* 2006) ***(figure 3)***. Swelling around the injured ligament is often observed. Avulsion fracture at the site of insertion can be seen, especially involving the short collateral ligaments of the hock and collateral ligaments of the fetlock or interphalangeal joints. Thickening with a heterogenous echogenicity and fiber pattern alteration are observed in chronic desmopathies. In insertion desmopathies (enthesopathies), these findings are accompanied by bone alterations such as an irregular bone surface, osteolysis with areas of echogenic bone ***(figure 4)*** and osteophyte production at the insertion site (enthesophytes). In equine joints, the most common desmopathy and enthesopathy involve the collateral ligaments of the interphalangeal joints (Denoix 1998b; Denoix 2005) and metacarpophalangeal joint (Denoix *et al.* 1997b), the collateral sesamoidean ligaments and the distal impar sesamoidean ligament (Heitzmann & Denoix, 2007), the collateral ligaments of the hock and the ventral sacroiliac ligament (Denoix *et al.* 2005b).

Clinical significance

Desmopathy is often observed as a primary injury of the joint. In most cases it is associated with secondary synovitis and sometimes, after a period of time, with degenerative joint disease. Ligament rupture is always associated with joint instability, severe synovitis with alteration of the synovial fluid and membrane, periarticular osteophyte proliferation and predispose the joint to cartilage degradation.

Menisci and scuta

Technique

Seven point five to 13 MHz linear and convex probes are adequate for imaging the body (intermediate part) and cranial part (cranial horn and cranial attachment) of the medial and lateral menisci (Denoix & Lacombe, 1996) or the proximal (Denoix *et al.* 1997a) and middle scuta (Denoix 2002). Three point five to 6 MHz convex or sector probes are required to image the caudal horns of the menisci. Complete evaluation of the menisci requires realization of radial (proximodistal) and craniocaudal (transverse, horizontal) sections. As the meniscal fibre fasciculi are echogenic only when the ultrasound beam is perpendicular to the fibre interfaces, the probe plane should be perpendicular to the abaxial surface of the structure to avoid creation of hypoechogenic artifacts on radial cross sections of the menisci. Flexion of the stifle is required for imaging the cranial attachment of the menisci.

Normal appearance

On radial (proximodistal) sections the menisci show up as triangular echogenic structures limited by the anechogenic cartilage of the femoral and tibial condyles ***(figure 5)***. On craniocaudal (horizontal) sections, only the intermediate part of the meniscus is echogenic as fibres are curved cranially and caudally. On radial and transverse sections, the cranial attachment of the menisci presents the same echogenic and architectural appearance as ligaments. On transverse sections, the proximal scutum presents a regular pattern of curved (concave) fibres attached to the flexor surface of the proximal sesamoid bones; several fibre orientations are observed in the middle scutum as many structures inserts on it; this stucture is attached to the palmer tuberculum of the middle phalanx and is in contact with the distal condyle of the proximal phalanx.

Ultrasonographic findings

In our patients, lesions of the medial meniscus have been found 9 times more frequently than lesions of the lateral meniscus. Several types of meniscal injuries can be observed. Traumatic injuries with hypoechogenic tears in the meniscal body are always accompanied by secondary femorotibial synovitis and arthropathy. Progressive degenerative injuries of the menisci are often found associated with condylar dysplasia or subchondral bone cysts; chronic synovitis with synovial membrane and villi proliferation as well as fluid distension containing echogenic

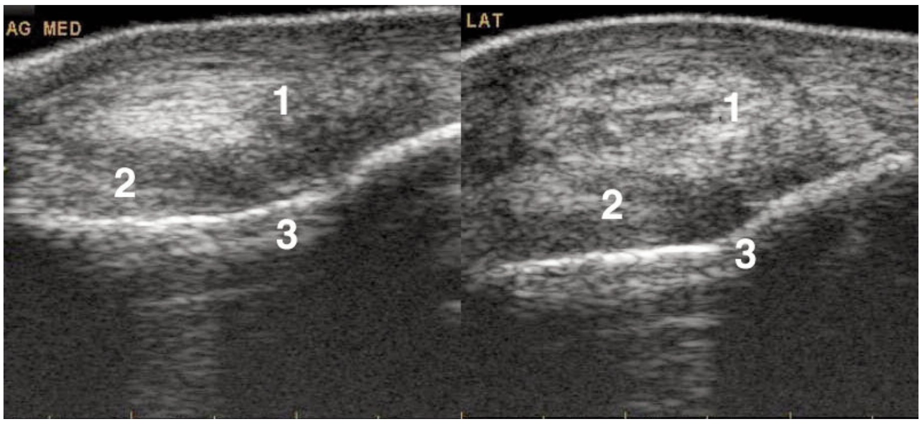
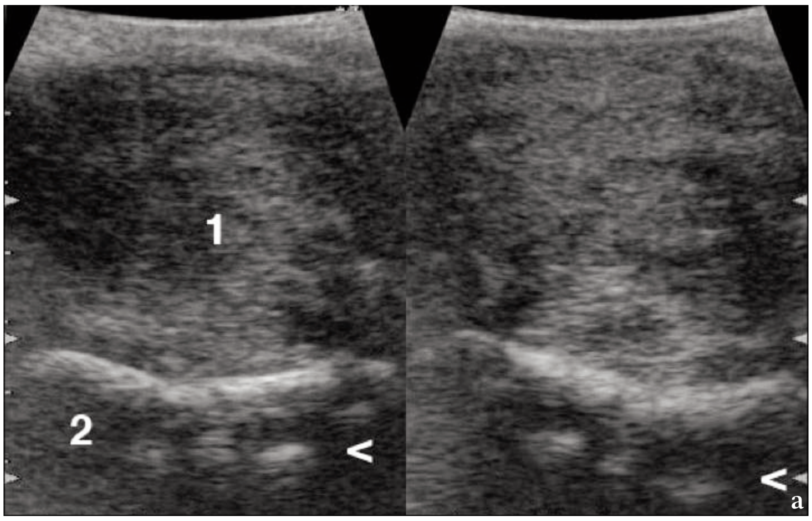


Figure 3: *Transverse sections of the medial and lateral aspects of a front fetlock. Desmopathy of the superficial layer of the lateral collateral ligament (1) which is enlarged and shows areas with reduced echogenicity.*
1- Superficial layer of the medial/lateral collateral ligament;
2- Deep layer of the medial/lateral collateral ligament;);
3- Third metacarpal condyle bone surface; MED- medial aspect; LAT- lateral aspect.



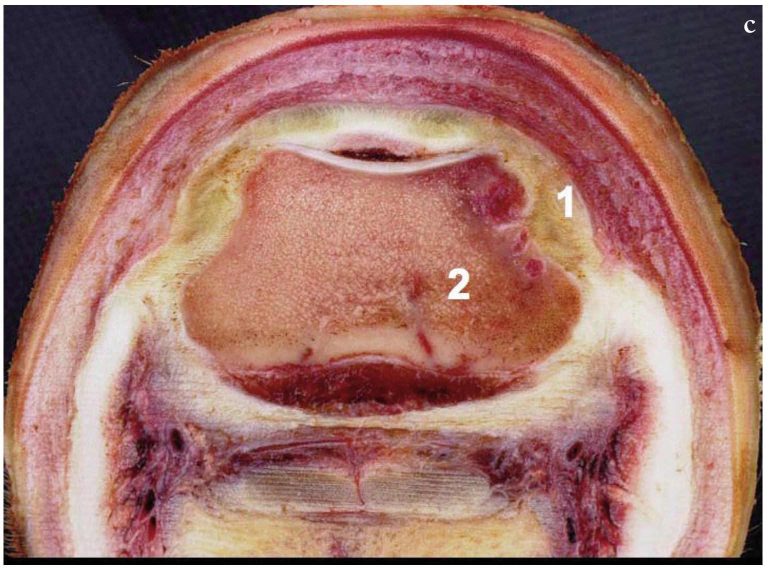


Figure 4: *Severe proximal enthesopathy of the lateral collateral ligament (LCL) of the distal interphalangeal joint.* ***4a:*** *transverse ultrasonographic sections of the coronet using a dorsolateral approach. The LCL (1) is thickened and presents a diffuse reduction of echogenicity. Three echogenic spots (arrow-head) can be seen within the distal phalanx (2) under the bone surface of the enthesis;* ***4b:*** *transverse T1GE magnetic resonance imaging scan of the same foot. Three spots with central hypersignal surrounded with bone sclerosis can be seen in the osseous part of the enthesis;* ***4c:*** *post-mortem transverse section of the same foot; Three sites of osteonecrosis can be seen within the bone component of the enthesis, close to the thickened LCL.*
1- Lateral collateral ligament;
2- Distal phalanx.

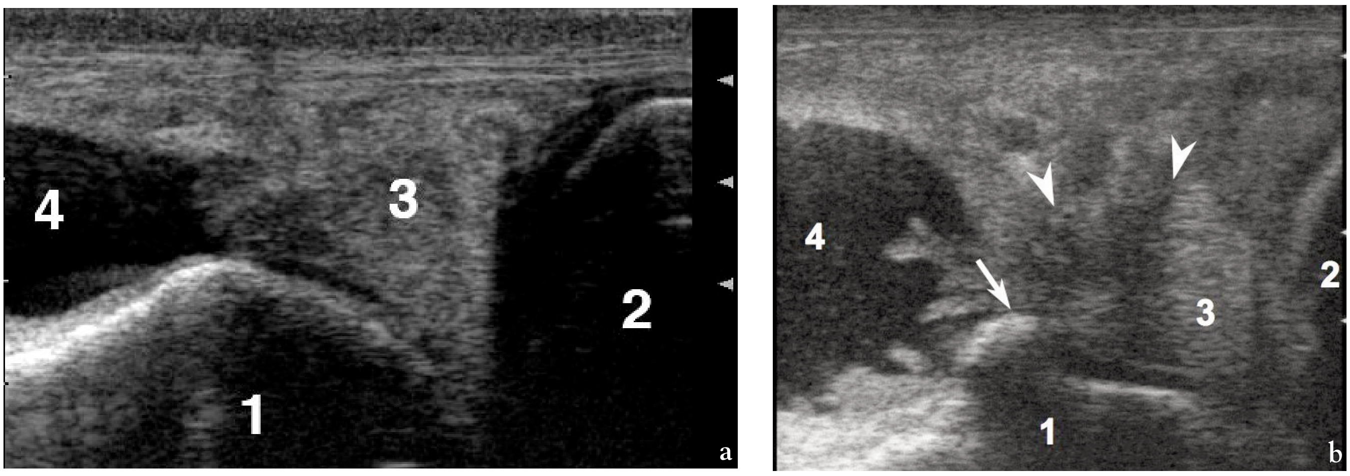


Figure 5: *Proximodistal section of the dorsomedial aspect of the medial femorotibial joint.*
5a: *normal appearance of the medial meniscus;* ***5b:*** *abnormal findings including degeneration of the medial meniscus (arrow-heads), fluid distension with echogenic debris (4), proliferative synovitis and severe periarticular remodelling of the medial femoral condyle (arrow).*
1-Medial femoral condyle;
2- Medial tibial condyle;
3- Medial meniscus (cranial horn);
4- Synovial fluid in the medial femorotibial recess.

spots are always present ***(figure 5b)***. Collapsus and prolapsus of the medial meniscus always accompany severe degenerative changes of the femorotibial joint. Mineralization of the medial meniscus has been bound in the cranial horn, body and caudal horn of young, adult and old horses. Thin and horizontal hypoechogenic images crossing the meniscal body are common in sound horses without lameness; their clinical relevance should not be overestimated. Abnormal findings and lesions of the proximal scutum including desmopathy, enthesopathy or rupture of the palmar ligament, have been described previously (Denoix *et al.* 1997b).

Clinical significance

The most common meniscal injury in sport and race horses is the cranial enthesopathy of the medial meniscus, found between the cranial horn and the tibial plateau. Traumatic injuries are quite rare primary lesions inducing secondary femorotibial arthropathy. Progressive meniscal degeneration with collapsus and prolapsus is often found at an advanced stage showing the relative tolerance of earlier stages. Severe femorotibial arthropathy with extensive periarticular bony proliferation induces secondary trauma over the proximal surface of the medial meniscus.

Synovial fluid and membrane

Technique

When examining the synovial fluid and membrane pressure on the probe should be limited to prevent collapsus of the recesses. Pressure on the other recesses of the joint is useful in evaluating the intra-articular pressure and the synovial fluid itself. Mobilising the joint just before examination help in assessing the presence of echogenic material in the fluid.

Normal appearance and ultrasonographic findings

The normal synovial fluid is totally anechogenic ***(figure 6)***. In normal joints the amount of synovial fluid is limited and pressure on the probe easily collapses the recesses. The presence of synovial fluid is abnormal in the dorsal recess of the proximal interphalangeal and fetlock joints, the subextensorius recess of the lateral femorotibial joint, the lateral aspect of the scapulohumeral joint and the dorsal aspect of the elbow joint.

The amount and echogenicity of the synovial content can change (Denoix *et al.* 1994; Denoix 1996; Denoix & Busoni, 1998; Denoix 2003). A homogeneous echogenic appearance of the synovial fluid is suggestive of septic arthritis. A heterogeneous echogenic appearance is found with hemarthrosis. Echogenic spots floating in an anechogenic synovial fluid are compatible with meniscal debris, cartilaginous debris or fibrine clots (Denoix *et al.* 1994; Denoix 1996; Denoix & Busoni, 1998) ***(figure 5b)***. 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 plicae are indicative of subacute or chronic synovitis (Denoix 1996; Denoix & Busoni, 1998). Hypertrophy of the proximodorsal plica at the dorsal aspect of the fetlock is found in proliferative synovitis. Recent or inflammatory lesions have a hypoechogenic appearance whereas echogenic lesions with or without bone metaplasia are indicative of a chronic process.

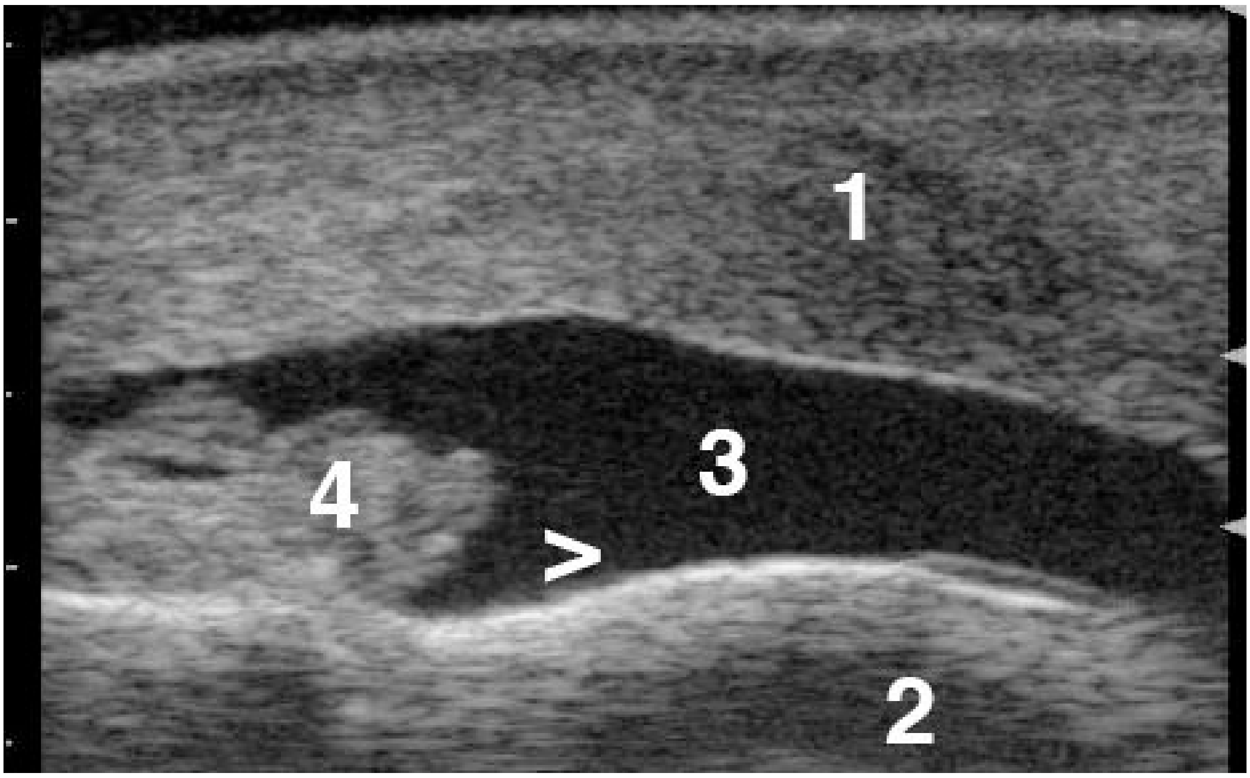


Figure 6: *Longitudinal section of the dorsal aspect of the fetlock showing a severe cartilage degeneration (arrow-head) with anechogenic synovial fluid distension (3) and a chronic synovitis of the proximodorsal plica (4). The bone surface of the metacarpal condyle is in contact with the synovial fluid and no longer covered with articular cartilage.*
1- Articular capsule;
2- Metacarpal condyle;
3- Synovial fluid within the dorsal recess of the joint;
4- Proximodorsal synovial plica.

Clinical significance

Synovial fluid distension and synovial membrane thickening or proliferation are common findings in recent or chronic arthritis. They can be found alone without any other radiographic or ultrasonographic findings, but when identified, careful examination of the complete joint should be done to look for the cause of the synovitis ***(figure 6)***.

Articular surfaces

Technique

Articular surfaces of superficial joints can be examined adequately with 7.5 to 13 MHz linear probes. Examination of deep joint surfaces such as in the scapulohumeral joint or the femoral condyles using a caudal approach, 3.5 to 6 MHz convex probes are required.

Several joint surfaces can be examined on the weight bearing limb; they include the dorsal articular surface of the fetlock joints, the talus and femoral trochlea as well as the caudal aspect of the femoral condyles. Other artiicular surfaces require mobilisation of the examined joint; they include the dorsal part of the interphalangeal joints, the distal part of the metacarpal condyle, the carpal joint surfaces and the distal aspect of the fe moral condyles.

Normal appearence

The articular cartilage appears as a regular hypoechogenic to anechogenic band (Denoix *et al.* 1996a; 1996b; Denoix 1996; Denoix & Busoni, 1998; Heitzmann & Denoix, 2006) ***(figure 7a)*** 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 edema or fibrillation. Cartilage degeneration induces local or diffuse thinning of the articular cartilage ***(figure 6)***. Linear cartilaginous erosion induces an irregular cartilage surface on transverse sections of the metacarpal condyle.

Ultrasonography is a very adequate procedure for imaging the osteochondral junction. Alteration of the subchondral bone surface can easily be documented in osteochondrosis lesions of the femoral trochlea ridges ***(figures 7a and 7b)***. Subchondral bone cysts are frequently identified in the femoral and metacarpal

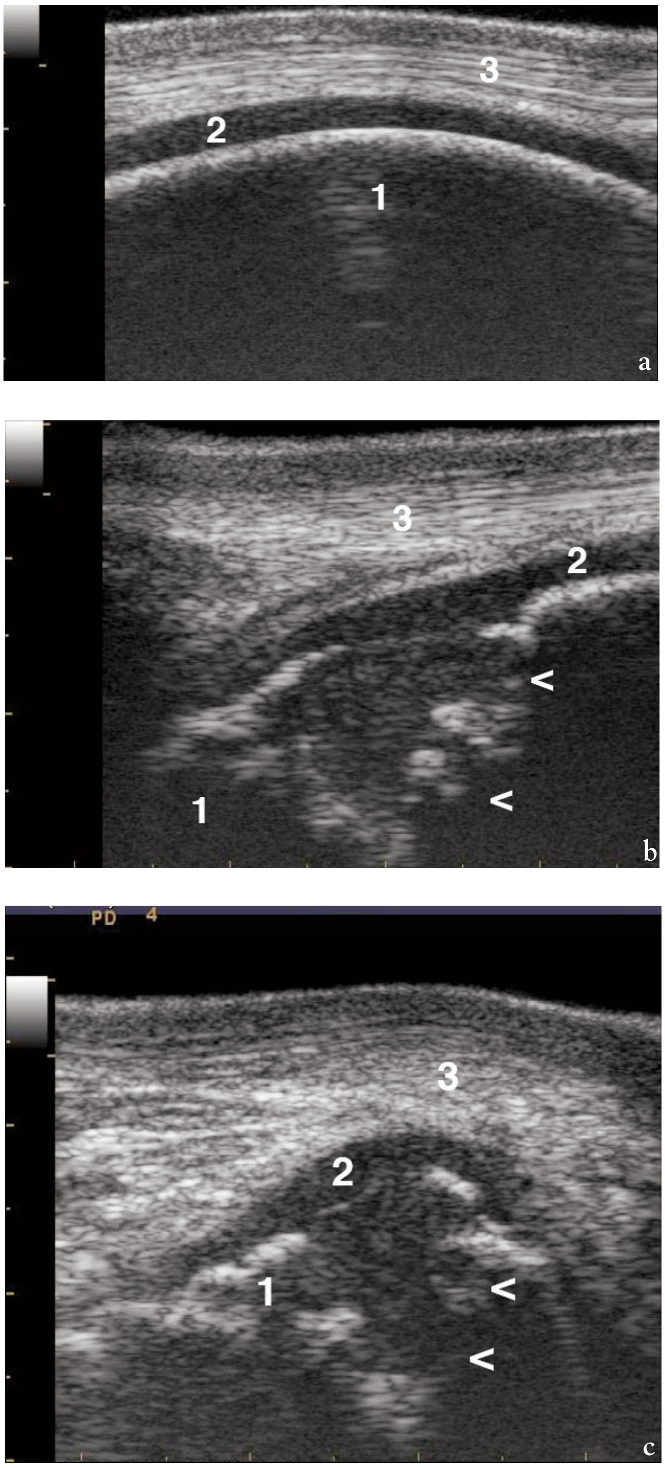


Figure 7: *Ultrasonographic sections of the lateral ridge of the femoral trochlea (LRFT).*
7a: *longitudinal ultrasonographic section of a normal LRFT (1) showing a normal articular cartilage (2);* ***7b:*** *longitudinal ultrasonographic section of the LRFT in a 1 year-old colt, showing a deep osteochondral lesion (arrow-heads) of the proximal third of the ridge;* ***7c:*** *transverse ultrasonographic section of the same lesion.*
1- Lateral ridge of the femoral trochlea;
2- Articular cartilage;
3- Lateral patellar ligament.

condyles (Denoix 1996;Denoix & Busoni, 1998; Jacquet & Denoix, 2007); ultrasonography is more sensitive than radiography for detection of small lesions. Defect of ossification in the deep layers of the articular cartilage can be seen on the lateral ridge of the femoral trochlea and medial ridge of the talus. Cartilaginous defects, subchondral bone lysis with areas of irregular and echogenic suchondral bone as well as synovitis are often associated in osteochondrosis lesions.

Clinical significance

Subchondral bone lysis is always a significant finding. A more complete assessment of extension and severity of osteochondrosis lesions can be made combining radiography and ultrasonography. With the latter, the relation between subchondral bone cysts and the corresponding subchondral bone and articular surfaces can be established precisely. Healing of osteochondrosis lesions can be monitored in foals and yearlings.

Articular margins

Technique

Articular margins of superficial joints are examined adequately with 7.5 to 13 MHz linear probes. Examination of epiaxial synovial intervertebral joint margins requires 3.5 to 6 MHz convex probes. In most of the joints, especially in the fetlock and medial femorotibial joints, probe displacement allows a complete screening of the margins and provides to this technique a high sensitivity in the detection of any periarticular abnormal findings.

Normal appearance

Normal articular margins appear as regular hyperechogenic and smooth bone surfaces, sometimes covered by a thin anechogenic articular cartilage.

Ultrasonographic findings

Ultrasonography is very sensitive to any alteration of the joint margins (Denoix *et al.* 1996a; Denoix 1996; Denoix & Busoni, 1998). Periarticular osteophytes show up as an elevation of the margin profile. An irregular bone surface is indicative of periarticular bone remodelling or fragmentation which can extend over the insertion of the synovial membrane and capsule ***(figure 8)***. Periarticular bony fragments are easily picked up and located with ultrasonography. They appear as isolated hyperechogenic nodules, sometimes covered with a hypoechogenic fibrocartilage. A clear documentation of their size and architecture is useful when surgical removal is considered. Abnormal echogenicity of the underlined bone is indicative of periarticular bone lysis. Osteophyte proliferation with bone remodeling can be found a small distance away from the articular margins. When these findings are not located at an insertion site, they are often indicative of subchondral bone collapse of the joint with callus formation in the injured area.

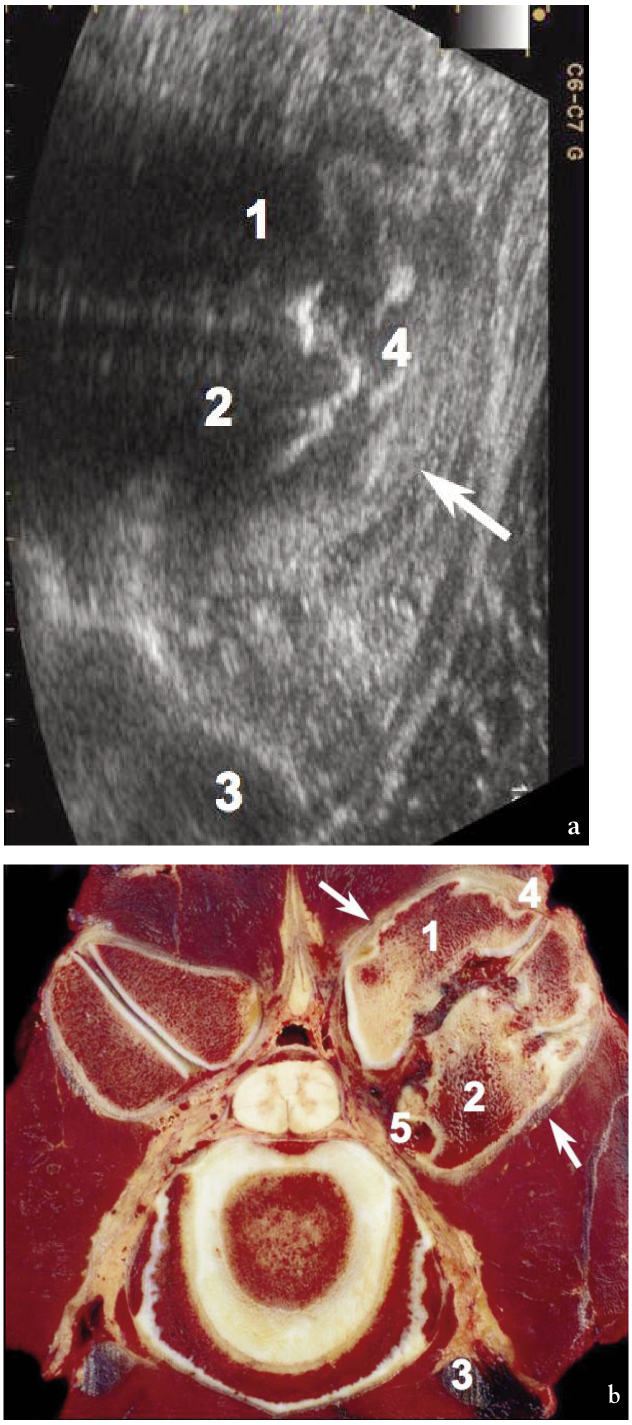


Figure 8: *Transverse sections of the cervical spine presenting a severe hypertrophy and osteochondral fragmentation of the C6-C7 articular processes (AP).* ***8a:*** *transverse ultrasonographic section of the cervical spine showing fragmentation and hypertrophy of the C6-C7 AP and thickening of the articular capsule (arrow);* ***8b:*** *transverse section of a similar post-mortem specimen showing hypertrophy, fragmentation and sclerosis of the AP with severe capsulitis (arrows) and synovitis (5).*
1- Caudal articular process of C6;
2- Cranial articular process of C7;
3- Transverse process of C6;
4- Articular capsule;
5- Synovial membrane and cavity).

Clinical significance

Remodelling of joint margins is indicative of primary or secondary osteoarthrosis. Periarticular osteophytes and modelling are more often located at the side of the joints undergoing higher loads. Periarticular bone modelling with epiphysis deformation can be found as a sequel of over-stress in previous angular limb deformities. Periarticular osteochondral fragments are manifestations of osteochondrosis or acquired chip fractures (Denoix 1992; Denoix 1996). When a surgical removal is considered, ultrasonography can provide useful information for the surgical approach of the fragment (Denoix 1992).

Dynamic examination

Because of its real time capacity, dynamic examination of moving tendons and joints can be performed allowing a better assessment of the anatomical and functional relationships between different structures. The precise location and mobility of periarticular osteochondral fragments can be established (Denoix 1992); this information is useful when surgical removal is considered, periarticular fragments linked to the soft tissues are more easily accessible than free fragments floating in the synovial fluid. Moreover, examination of joints in flexion (fetlock, stifle, tarsocrural joint) increases considerably the extent of the exposed articular surface for a more complete assessment of cartilage and subchondral bone lesions (Denoix 1996; Denoix & Busoni, 1998; Denoix & Audigié, 2004; Heitzmann & Denoix, 2006).

Lumbosacral and sacroiliac joints

These joints are systematically examined in horses presented for poor performance, lack of propulsion, weakness on short turns or irregular gait at high speed (Denoix *et al.* 2005a; Denoix *et al.* 2005b). The ultrasonographic examination is performed on the standing patient using a rectal probe. The last 3 lumbar intervertebral discs and both sacroiliac joints are currently imaged. The most common findings observed on young and adult horses include congenital lumbosacral abnormalities (e.g. sacralisation of the last lumbar vertebra) and lumbosacral disc degeneration (fissuration, mineralization and herniation) (Denoix *et al.* 2005a) ***(figure 9)***. Several conditions can be seen at the ventral aspect of the sacroiliac joints such as periarticular bone remodelling, enthesopathy and desmopathy of the ventral sacroiliac ligament and even fatigue fracture (Denoix & Coudry, 2005). In few cases these findings were confirmed at *post mortem* examination.

ULTRASONOGRAPHY AS AN AID FOR THE TREATMENT OF JOINT PROBLEMS

The diagnostic data obtained during ultrasonographic examination are essential for the management and medical or surgical treatment of the equine patients. The diagnosis of desmopathies

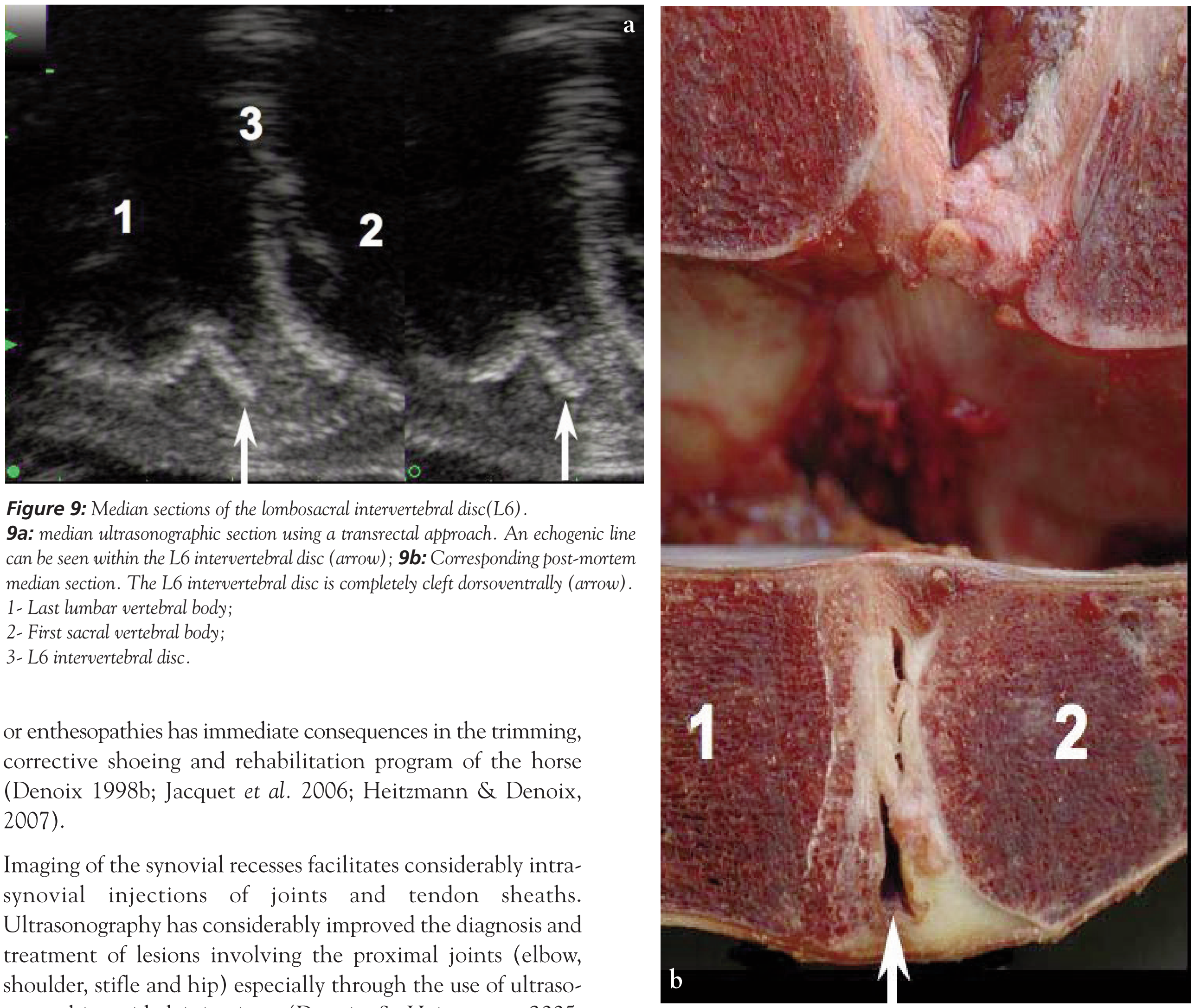


Figure 9: *Median sections of the lombosacral intervertebral disc(L6).*
9a: *median ultrasonographic section using a transrectal approach. An echogenic line can be seen within the L6 intervertebral disc (arrow);* ***9b:*** *Corresponding post-mortem median section. The L6 intervertebral disc is completely cleft dorsoventrally (arrow).*
1- Last lumbar vertebral body;
2- First sacral vertebral body;
3- L6 intervertebral disc.

or enthesopathies has immediate consequences in the trimming, corrective shoeing and rehabilitation program of the horse (Denoix 1998b; Jacquet *et al.* 2006; Heitzmann & Denoix, 2007).

Imaging of the synovial recesses facilitates considerably intra-synovial injections of joints and tendon sheaths. Ultrasonography has considerably improved the diagnosis and treatment of lesions involving the proximal joints (elbow, shoulder, stifle and hip) especially through the use of ultrasonographic guided injections (Denoix & Heitzmann, 2005; Denoix 2006). A great step in the management of neck and back pain in equine patients has been made using ultrasonographic guided injections allowing a specific treatment of osteoarthrosis of the synovial intervertebral joints in the cervical ***(figure 10)*** and thoracolumbar spine.

When a surgical treatment using arthroscopy or arthrotomy is considered, a preliminary ultrasonographic examination may provide essential data to determine the surgical approach and positioning of the joint. Precise measures can be made regarding the location, depth and size of the lesion of interest (Denoix 1992).

DISCUSSION

Ultrasonographic evaluation of equine joints is a very informative procedure for diagnosising many articular and periarticular conditions with or without radiographic manifestations. With this procedure a number of new clinical entities has been identified and documented during the last twenty years. Most of them have been confirmed with the use of advanced cross-sectional imaging such as magnetic resonance imaging and CT scan. It can be said that ultrasonography opened a wide new field of knowledge in the understanding of the variety of causes responsible for pain in anatomical structures of the equine locomotor system. The documentation of different types and grades of new clinical entities has been essential for improving the treatment and management of lame horses.

The use and performance of ultrasonography require a strong background knowledge of soft tissue anatomy and of the normal ultrasonographic appearance of every joint structures. In all clinical cases, comparison with the same structures of the controlateral limb improves sensitivity (better identification of lesions) and specificity (reduces false interpretation) of the ultrasonographic diagnosis.

As for every imaging technique, ultrasonography has some limitations in joint imaging. The main ones are related to anatomical particularities of the joints. In the fetlock joint the proximal articular surface of the proximal phalanx and the palmar (plantar) articular surface of the metacarpal (metatarsal) condyle cannot be imaged. In the carpus and tarsus, the

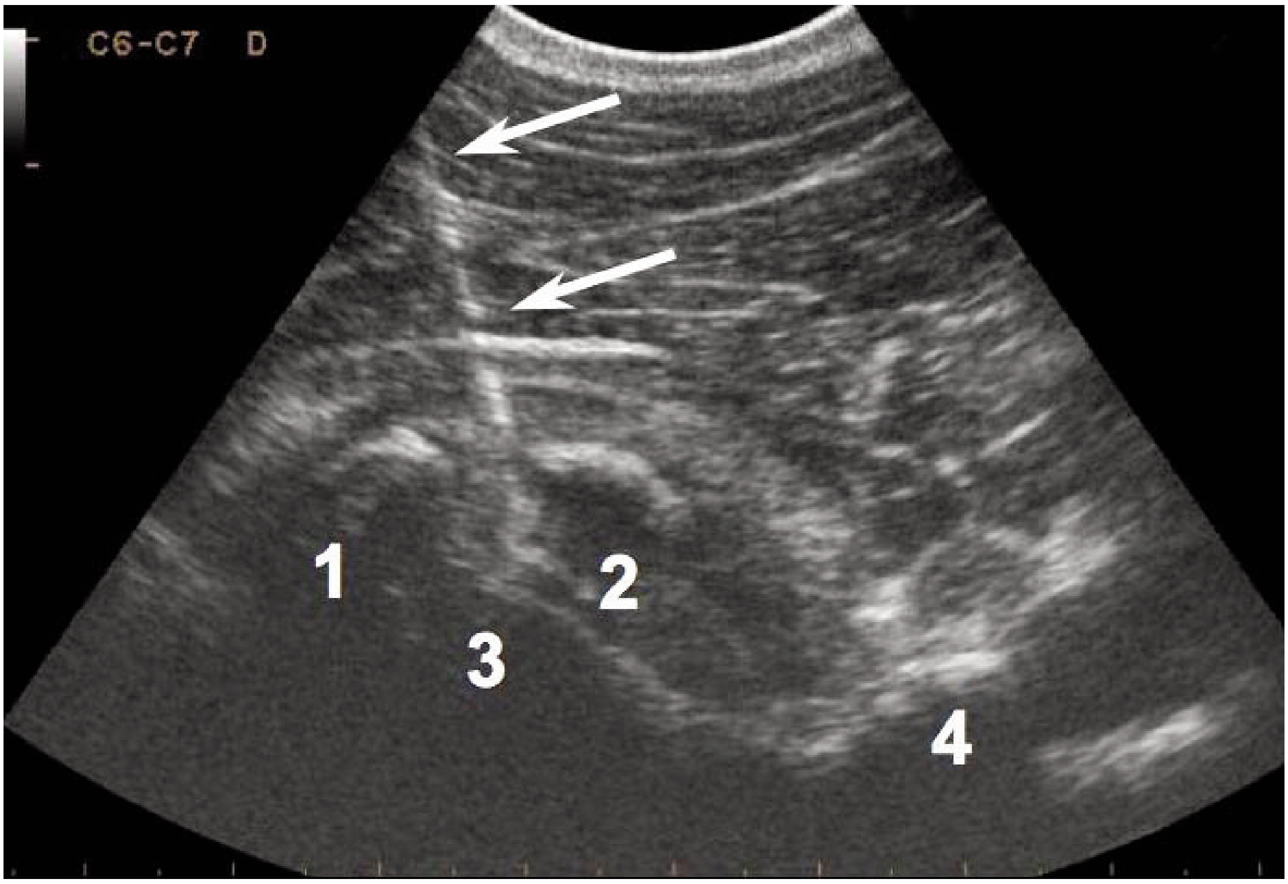


Figure 10: *Transverse section of the cervical spine showing the needle position (arrows) for performing an ultrasonographic guided injection of the synovial joint between the C6-C7 articular processes.*
1- Caudal articular process of C6;
2- Cranial articular process of C7;
3- Joint space;
4- Transverse process of C6.

intra-articular ligaments and most of the articular surfaces cannot be imaged adequately. In the stifle, imaging of the caudal cruciate ligament is difficult and the articular surface of the patella is not accessible.

Despite these limitations, ultrasonography has provided much new diagnostic informations on equine joint pathology through a noninvasive approach of the joints. This procedure still has an essential contribution to the discovery and documentation of a lot of new pathological entities. Nowadays, even in field equine practice, radiography and ultrasonography should be systematically combined for the assessment of every joint condition. This complementary approach provides more information concerning the different anatomical components (bone and soft tissues) of the joint. It helps in interpreting radiographs and fastens the gain of experience. Besides, providing complementary information, the risk of false negative diagnosis is reduced and limitations of each technique are better identified.

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