EQUINE

Comparison of ultrasonography versus radiography for the diagnosis of dorsal fragmentation of the metacarpophalangeal or metatarsophalangeal joint in horses

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Objective—To compare clinical usefulness of ultrasonography versus radiography for detection of fragmentation of the dorsal aspect of the metacarpophalangeal (MCP) and metatarsophalangeal (MTP) joints in horses.

Design—Cross-sectional study.

Animals—36 horses with fragmentation of the MCP (n = 19) and MTP (29) joints.

Procedures—In all joints, radiography (4 standard projections) and ultrasonography were performed prior to arthroscopic examination and fragment removal. Number and location of fragments identified radiographically and ultrasonographically were compared with arthroscopic findings.

Results—Radiographic and arthroscopic findings were in agreement with respect to both number and location of fragments in 21 of the 48 (44%) joints. Ultrasonographic and arthroscopic findings were in agreement with respect to number and location of fragments for 46 of the 48 (96%) joints. In the remaining 2 joints, arthroscopy revealed additional fragments that were not identified ultrasonographically. When ultrasonographic findings were compared with radiographic findings, more fragments were seen ultrasonographically in 3 joints and fewer fragments were seen ultrasonographically in 1 joint. Ultrasonographic findings also confirmed the absence (4 joints) or presence (3 joints) of fragmentation at the dorsoproximal aspect of the joint that had been suspected on the basis of radiographic findings. Ultrasonography was also able to determine the location of the fragments in the joints where this was not possible radiographically.

Conclusions and Clinical Relevance—Results of the present study suggested that ultrasonography was a useful method for determining the number and location of fragments in horses with dorsal fragmentation of the MCP or MTP joint. (*J Am Vet Med Assoc* 2009;235:70–75)

Osteochondral fragmentation of the MCP and MTP joints is common in horses. Most of these fragments are located in the dorsal aspect of the joint, although fragments can also be seen in the palmar or plantar aspect of the MCP or MTP joint.[1,2] Dorsal fragments can be found in the area of the sagittal ridge, condyles of the third metacarpal or metatarsal bone, or dorsoproximal aspect of P1 or within the synovial pad.[1,3–7] These fragments are often removed arthroscopically, either because they are associated with clinical signs or because they can be responsible for clinical problems in the future.[8,9]

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Presented in part at the European Association of Veterinary Diagnostic Imaging Annual Conference, Chalkidiki, Thessaloniki, Greece, August–September 2007; Hippos, the Congress of Equine Veterinarians and Farriers, Liège, Belgium, January 2008; and the 10th International Congress of the World Equine Veterinary Association, Moscow, January–February 2008.

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Abbreviations

MCP	Metacarpophalangeal
MTP	Metatarsophalangeal
P1	Proximal phalanx

Radiography is the most commonly used imaging modality for detection and localization of fragments in the MCP or MTP joint.[10] Occasionally, however, radiographic and arthroscopic findings do not correspond, meaning that fragments not detected radiographically are identified arthroscopically and vice versa.[11] Ultrasonography has traditionally been used to evaluate tendon and ligament injuries, but it has also been suggested that ultrasonography may be valuable in determining the location, size, and anatomic relationship of fragments of the MCP and MTP joints.[12–16] To our knowledge, studies comparing radiographic, ultrasonographic, and arthroscopic findings in horses with dorsal fragmentation of the MCP and MTP joints have not been published. The purpose of the study reported here, therefore, was to compare the clinical usefulness of ultrasonography versus radiography for detection of fragmentation of the dorsal aspect of the MCP and MTP

joints in horses. Arthroscopic findings were used as the gold standard for comparison with ultrasonographic and radiographic findings.

Materials and Methods

Horses—Thirty-six horses examined by the Department of Medical Imaging of Domestic Animals and Small Animal Orthopaedics and by the Department of Surgery and Anaesthesiology of Domestic Animals of the Faculty of Veterinary Medicine at Ghent University because of fragmentation of the dorsal aspect of the MCP or MTP joint were included in the study. Dorsal fragmentation was present either at the dorsal eminence of P1 or in the dorsoproximal aspect of the joint (ie, the area of the sagittal ridge, condyles of the third metacarpal or metatarsal bone, or the synovial pad). In all horses, radiography and ultrasonography of affected joints were performed prior to arthroscopic removal of fragments.

Radiography—For MCP joints, lateromedial, dorsopalmar, dorsal 45° lateral-palmaromedial oblique, and dorsal 45° medial-palmarolateral oblique radiographic projections of the affected joint were obtained.[a] For MTP joints, lateromedial, dorsoplantar, dorsal 45° lateral-plantaromedial oblique, and dorsal 45° medial-plantarolateral oblique radiographic projections of the affected joint were obtained.[a] Number of fragments visible on radiographic projections was recorded, and for each fragment, an assessment was made as to whether the fragment was lateral or medial and whether the fragment was most likely intra- or extra-articular.

Ultrasonography—Ultrasonography of the dorsal aspect of affected MCP and MTP joints was performed by a single individual (KV) with a grayscale ultrasonography machine[b,c] and a 6- to 9-MHz or 10- to 15-MHz linear transducer. Ultrasonography was performed while horses were standing (n = 5) or after horses had been anesthetized for arthroscopic surgery (31). The dorsal aspect of the joint was scanned in longitudinal and transverse planes. Ultrasonographic examination took approximately 10 minutes for each joint.

Number and location of fragments identified during ultrasonography were recorded. In 4 horses in which the exact location of fragments was doubtful, the ultrasonographic examination was repeated after distension of the joint with 30 mL of saline (0.9% NaCl) solution.

Arthroscopy—After radiographic and ultrasonographic examinations were completed, arthroscopic removal of the fragments was performed. Horses were premedicated with romifidine (80 µg/kg [36 µg/lb], IV) and methadone (0.1 mg/kg [0.045 mg/lb], IV), and anesthesia was induced with midazolam (0.06 mg/kg [0.027 mg/lb], IV) and ketamine (2.2 mg/kg [1 mg/lb], IV) and maintained with isoflurane in 55% oxygen. Flunixin meglumine (1.1 mg/kg [0.5 mg/lb], IV) and procaine benzylpenicillin (2,000 U/kg [909 U/lb], IM) were administered to all horses. Arthroscopic fragment removal was performed by 1 of 2 individuals (AMM and JD) through a standard dorsal approach, as described.[17] Most horses were positioned in dorsal recumbency, although some were positioned in lateral recumbency. Number of fragments removed during arthroscopy and their location were recorded.

Statistical analysis—For each affected joint, ultrasonographic and radiographic findings with regard to number and location of fragments were considered correct if they coincided with arthroscopic findings. The McNemar test was used to compare proportions of correct assessments between ultrasonography and radiography. Analyses were performed for number of fragments, location of fragments, and both number and location of fragments. Analyses were repeated for all affected joints, for joints with fragments in the area of the dorsoproximal aspect of P1, and for joints with fragments in the dorsoproximal aspect of the joint. The Fisher exact test was used to compare proportions of correct assessments for joints in which ultrasonography was performed with the horse sedated versus joints in which ultrasonography was performed after the horse was anesthetized. All analyses were performed with standard software.[d] Values of $P \leq 0.05$ were considered significant.

Results

Horses—A total of 48 affected joints were identified in the 36 horses, including 19 MCP (11 left and 8 right) and 29 MTP joints (17 left and 12 right). Mean age of the horses was 2.8 years (range, 1 to 8 years), and there were 26 Warmblood horses (23 Belgian Warmblood horses, 2 Oldenburgers, and 1 Rijnlander), 5 Trotters, 2 Thoroughbreds, and 3 Quarter Horses. There were 17 stallions, 6 geldings, and 13 mares.

Radiographic findings—Fragments were identified or suspected on radiographs of all 48 joints. In 23 joints, fragments were identified in the area of the dorsoproximal aspect of P1 (19 joints with 1 fragment and 4 joints with 2 fragments; **Figure 1**), and in 2 of these 23 joints, there was evidence of fragmentation at the dorsoproximal aspect of the joint. In 20 of these 23 joints, fragments could be localized to the lateral or medial aspect of the joint on the basis of oblique radiographic projections. In 19 joints, fragments were located between the sagittal ridge and the medial epicondyle (17 joints) or at the level of the medial epicondyle (2 joints), and in the remaining joint, 1 fragment was located medially and a second fragment was superimposed over the dorsolateral aspect of the proximal

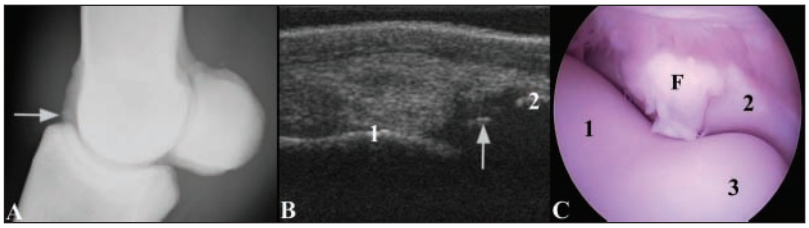

Figure 1—Radiographic (A), ultrasonographic (B), and arthroscopic (C) images of a horse with dorsal fragmentation of the MCP joint. A single fragment was seen in the area of the dorsoproximal aspect of P1 on the lateromedial radiographic projection (A; arrow) and on a longitudinal ultrasonographic image (B; arrow). Arthroscopically, a single P1 fragment was removed (C). 1 = Medial condyle of the third metacarpal bone. 2 = P1. 3 = Sagittal ridge. F = Fragment.

part of P1. In the remaining 3 joints with fragments associated with P1, location within the joint could not be determined from oblique radiographic projections.

In 27 joints (including the 2 joints with fragments associated with P1), fragments were identified or suspected in the dorsoproximal aspect of the joint. In 21 joints, fragments were identified in the dorsoproximal aspect of the joint: there were 18 joints with 1 fragment, 2 joints with 2 fragments, and 1 joint with 4 fragments (**Figures 2 and 3**). In the remaining 6 joints and in 1 joint with an obvious fragment at the dorsoproximal aspect of the joint, fragments or an additional fragment were suspected in the area of the dorsoproximal aspect of the joint but not definitively identified.

In 7 of the 27 joints with fragments identified in the dorsoproximal aspect of the joint, the fragment could be localized to the lateral or medial aspect of the joint on the basis of oblique radiographic projections. In 5 joints with a single fragment, the fragment was localized to the lateral aspect of the joint (2 joints), medial aspect of the joint (1 joint), or central aspect of the joint (2 joints). In 1 joint, 2 fragments were located medially, and in the remaining joint, 3 were located laterally and 1 was located centrally. In 6 joints, fragments were seen in close contact with the joint, whereas in 1 joint, the fragment was located proximal to the MTP joint, making it unclear whether the fragment was intra- or extra-articular (Figure 3).

Ultrasonographic findings—Fragments were identified during ultrasonographic examination of all 23 joints with fragments at the dorsoproximal aspect of P1 and in 23 of the 27 joints (including 2 joints with fragments associated with P1) with fragments at the dorsoproximal aspect of the joint. In 23 joints, fragments were identified in the area of the dorsoproximal aspect of P1 (19 joints with 1 fragment, 3 joints with 2 fragments, and 1 joint with 3 fragments; Figure 1). In all 23 joints, fragments could be localized to the lateral or medial aspect of the joint. In 22 joints, fragments were located between the sagittal ridge and the medial epicondyle (20 joints) or at the level of the medial epicondyle (2 joints). In the remaining joint, which had 2 fragments, 1 fragment was located medially and 1 was located centrally.

Fragments were ultrasonographically identified in the dorsoproximal aspect of the joint in 23 of the 27 joints (including 2 joints with fragments associated with P1). There were 17 joints with 1 fragment (Figure 3), 4 joints with 2 fragments (Figure 2), and 2 joints with 3 fragments. In the remaining 4 joints, a separate fragment could not be identified but the sagittal ridge was irregular. In 2 of the 27 joints, an additional small hyperechoic spot without distal acoustic shadowing was present at the dorsomedial aspect of P1 but was not considered indicative of fragmentation.

In all 23 joints, fragments could be localized to the lateral, medial, or central aspect of the joint and could be identified as intra- versus extra-articular. In 4 joints, joint distension was required for fragment localization, but fragments could be localized in the remaining 19 joints without joint distension. In the 17 joints with 1 fragment, the fragment was located laterally (2 fragments in the synovial pad and 1 fragment at the dorsoproximal aspect of the joint capsule), medially (9 fragments in the synovial pad), or centrally (2 fragments in the synovial pad and 3 fragments at the sagittal

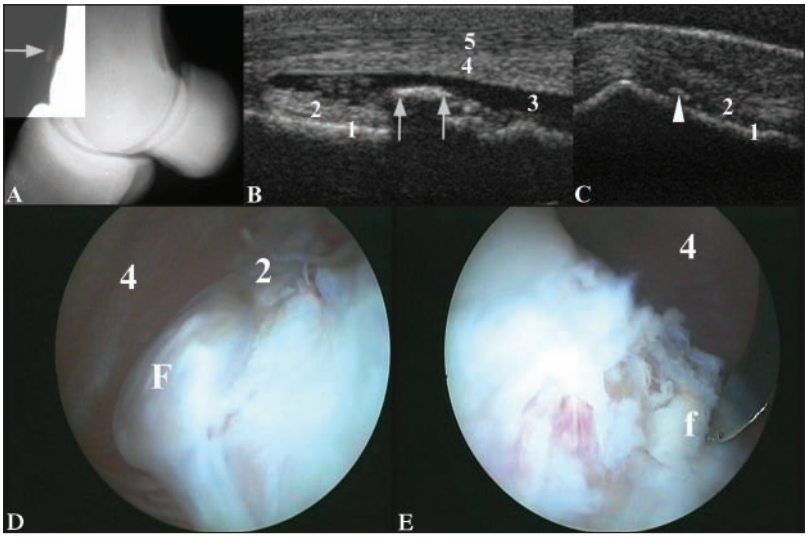

Figure 2—Radiographic (A), ultrasonographic (B and C), and arthroscopic (D and E) images of a horse with dorsal fragmentation of the MCP joint. On the lateromedial radiographic projection, a single fragment (A; arrow) was identified dorsal to the dorsoproximal aspect of the sagittal ridge. On a longitudinal ultrasonographic image obtained after distension of the joint with saline (0.9% NaCl) solution, the fragment appeared to be located in the medial aspect of the synovial pad (B; arrows), and on a transverse ultrasonographic image, another small fragment that was not visible on radiographs was seen in the medial aspect of the joint (C; arrowhead). Arthroscopically, a large fragment was identified in the synovial pad (D) and a small fragment was identified more proximally (E). 1 = Medial condyle of the third metacarpal bone. 2 = Synovial pad. 3 = Fluid in the joint. 4 = Joint capsule. 5 = Digital extensor tendon. F = Large fragment. f = Small fragment.

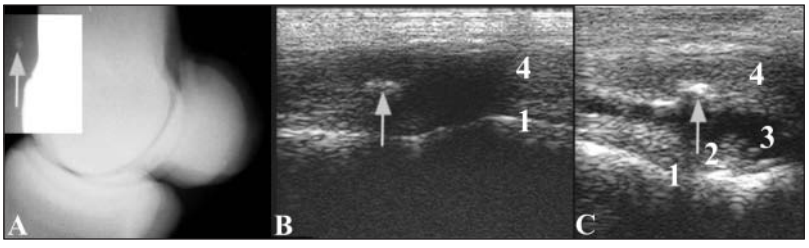

Figure 3—Radiographic (A) and ultrasonographic (B and C) images of a horse with dorsal fragmentation of the MTP joint. On the lateromedial radiographic projection, a fragment was identified dorsal to the third metatarsal bone, proximal to the sagittal ridge (A; arrow). On a longitudinal ultrasonographic image, the fragment appeared to be located proximal to the joint (B; arrow), whereas on a transverse ultrasonographic image obtained after distension of the joint with saline solution, it was determined that the fragment was located in the joint capsule and was not free in the joint (C; arrow). No fragment was found during arthroscopic examination of the joint. 1 = Third metatarsal bone. 2 = Synovial pad. 3 = Fluid in the joint. 4 = Joint capsule.

ridge). In the 4 joints with 2 fragments, all fragments were located medially (7 fragments in the synovial pad and 1 free fragment). In the 2 joints with 3 fragments, 3 fragments were located laterally (2 fragments in the synovial pad and 1 free fragment), 2 were located medially (both in the synovial pad), and 1 was located centrally (near the sagittal ridge).

Arthroscopic findings—Fragments were identified arthroscopically in all 23 joints with fragments at the dorsoproximal aspect of P1 and in 22 of the 27 joints (including 2 joints with fragments associated with P1) with fragments at the dorsoproximal aspect of the joint. A fragment was not identified arthroscopically in the joint with ultrasonographic evidence of a fragment at the dorsoproximal aspect of the joint capsule, and in the remaining 4 joints, only an irregular sagittal ridge was found during the arthroscopic examination.

In 23 joints, fragments were removed from the area of the dorsoproximal aspect of P1 (19 joints with 1 fragment removed, 2 joints with 2 fragments removed, and 2 joints with 3 fragments removed; Figure 1). In 22 joints, fragments were located between the sagittal ridge and the medial epicondyle (20 joints) or at the level of the medial epicondyle (2 joints). In the remaining joint, which had 2 fragments, 1 fragment was located at the dorsomedial aspect of P1 and 1 fragment was loose in the central part of the joint.

In 22 of the 27 joints (including 2 joints with fragments associated with P1), fragments were removed from the dorsoproximal aspect of the joint. In 16 joints, a single fragment was removed; fragments were located laterally (2 fragments in the synovial pad), medially (9 fragments in the synovial pad), or centrally (2 fragments in the synovial pad and 3 fragments near the sagittal ridge). In 4 joints, 2 fragments were removed; these fragments were all located medially (7 fragments in the synovial pad and 1 free fragment in the joint). In 1 joint, 3 fragments were removed (2 fragments in the medial aspect of the synovial pad and 1 free fragment in the lateral aspect of the joint). In the remaining joint, 5 fragments were removed (3 fragments in the lateral aspect of the synovial pad and 2 fragments near the sagittal ridge).

Postoperative radiographic findings—No fragments were identified on postoperative radiographs, except for the fragment in the proximal aspect of the joint capsule (Figure 3).

Comparison of radiographic, ultrasonographic, and arthroscopic findings—In 21 of the 48 (44%) joints, radiographic and arthroscopic findings were in agreement with respect to both number and location of fragments. By contrast, ultrasonographic and arthroscopic findings were in agreement with respect to number and location of fragments for 46 of the 48 (96%) joints. In the remaining 2 joints (4%), arthroscopy revealed additional fragments that were not identified ultrasonographically (1 joint with fragmentation at the dorsomedial aspect of P1 and 1 joint with fragmentation in the dorsoproximal aspect of the joint). Overall, ultrasonography had a significantly ($P < 0.001$) higher correct assessment rate than radiography with respect to both number and location of fragments.

When ultrasonographic findings were compared with radiographic findings, more fragments were seen ultrasonographically in 3 joints (1 joint with fragmentation at the dorsoproximal aspect of P1 and 2 joints with an additional fragment in the synovial pad; Figure 2) and fewer fragments were seen ultrasonographically in 1 joint. Ultrasonographic findings also confirmed the absence (4 joints) or presence (3 joints) of fragmentation at the dorsoproximal aspect of the joint that had been suspected on the basis of radiographic findings.

Ultrasonography had a significantly ($P = 0.031$) higher correct assessment rate than radiography for number of fragments at the dorsoproximal aspect of the joint, but no significant ($P = 0.750$) difference was found between methods for fragments at the dorsoproximal aspect of P1. For all joints together, ultrasonography had a significantly ($P = 0.016$) higher correct assessment rate than radiography for the number of fragments.

Ultrasonography had a significantly ($P < 0.001$) higher correct assessment rate than radiography for location of fragments at the dorsoproximal aspect of the joint, but no significant ($P = 0.062$) difference between methods was found for fragments in the area of the dorsoproximal aspect of P1. For all joints together, ultrasonography had a significantly ($P < 0.001$) higher correct assessment rate than radiography for location of fragments.

In 5 joints (5 horses), ultrasonography was performed while the horse was standing, and in 43 joints (31 horses), ultrasonography was performed after horses were anesthetized. In 4 of the 5 joints examined while the horse was standing and 42 of the 43 joints examined after horses were anesthetized, ultrasonographic findings were in agreement with arthroscopic findings in regard to number and location of fragments. There was no significant ($P = 0.20$) difference in correct assessment rate between ultrasonography performed with the horse sedated and ultrasonography performed with the horse anesthetized.

Discussion

Results of the present study suggested that ultrasonography was a useful method for determining the number and location of fragments in horses with dorsal fragmentation of the MCP or MTP joint, consistent with the suggestion of a previous author.[15] Ultrasonographic and arthroscopic findings were in agreement with respect to number and location of fragments for 46 of the 48 (96%) joints in the present study, whereas radiographic and arthroscopic findings were in agreement with respect to number and location of fragments for only 21 of the 48 (44%) joints. Ultrasonographic findings also confirmed the absence (4 joints) or presence (3 joints) of fragmentation at the dorsoproximal aspect of the joint that had been suspected on the basis of radiographic findings.

In horses with dorsal fragmentation of the MCP and MTP joints, detection of all fragments is important when surgical removal is planned. In 3 joints in the present study, more fragments were seen ultrasonographically than radiographically, possibly because superimposition of bony structures on radiographs made it difficult to

identify small fragments. In 2 joints, arthroscopy revealed additional fragments that were not identified ultrasonographically. Presumably, these undetected fragments were in the acoustic shadow of larger, more dorsally located fragments.

Knowing the location of the fragments in horses with dorsal fragmentation of the MCP and MTP joints is helpful when determining where to locate arthroscopic portals,[17] and oblique radiographic projections are often used to determine whether fragments are located medially or laterally within the joint.[17] In the present study, fragments could not be localized to the medial or lateral aspect of the joint in 3 joints with fragments in the area of the dorsoproximal aspect of P1 or in 14 joints with fragments in the dorsoproximal aspect of the joint. Fragments for which location could not be determined radiographically were often found ultrasonographically to be small (< 3 mm) and located near the sagittal ridge, hampering radiographic visualization. It is possible that these fragments could have been localized if multiple additional oblique radiographic projections had been obtained, but this is often difficult to do in practice. In addition, obtaining additional radiographic projections cannot be considered a viable option if another method, such as ultrasonography, that does not involve radiation exposure is available.

Previous authors[15,18] have suggested that dynamic ultrasonography (ie, ultrasonography during flexion and extension of the joint) may be helpful in identifying the location of osteochondral fragments and in determining whether fragments are intra- or extra-articular, particularly when results of survey ultrasonography are inconclusive. However, the necessary manipulations may be difficult in standing horses with joint inflammation and in uncooperative young horses. In 4 joints in the present study, ultrasonography was repeated after distension of the joint with saline solution to assist in fragment localization, which allowed location of the fragments to be determined. A disadvantage of joint distension is the possible introduction of small air bubbles into the joint. However, these did not prevent visualization of fragments in the present study.

In all 23 joints in the present study with fragments in the area of the dorsoproximal aspect of P1, fragments were located medially in the joint, which was in agreement with findings of other studies.[19–21] For 1 of these joints, 1 fragment was superimposed on the dorsolateral aspect of the proximal part of P1 on radiographic projections. However, arthroscopically, this fragment was found to be free-floating and may have moved between the time radiographs were obtained and surgery was performed. In 2 joints, small fragments were identified ultrasonographically in the extreme medial aspect of the joint. These fragments were difficult to identify arthroscopically, likely because small fragments are rapidly covered by synovial tissues.[17] In these cases, arthroscopic removal would have been difficult without prior ultrasonographic localization.

Most often, osteochondral fragments are identified ultrasonographically as hyperechoic lines with distal acoustic shadowing that are located superficial to the surface of the adjacent bone.[15] In 2 joints in the present study, small (< 2 mm) hyperechoic spots without distal acoustic shadowing were seen in the area of the dorsoproximal part of P1 ultrasonographically but were not identified radiographically or arthroscopically. These structures were not considered to be clinically important and most likely represented low-density calcifications, cartilaginous debris, fibrin clots, or areas of fibrosis in the synovial capsule.[15,22]

In most horses in the present study, ultrasonography was performed for safety reasons after horses had been anesthetized. Most of these horses were quite young, uncooperative stallions with fragments of the MTP joint. In addition, because ultrasonography was used to help determine fragment location prior to surgery and at least some of the fragments were floating free in the joint, it made sense to perform ultrasonography as closely before surgery as possible. In general, however, ultrasonography is better performed in standing horses, because surgery would typically only be performed if an intra-articular fragment were detected. No differences were found between results of ultrasonography performed in standing horses versus horses that had been anesthetized in the present study. Ultrasonography increased anesthetic time by approximately 10 minutes, but the improved localization associated with ultrasonography may have decreased arthroscopic time.

In the present study, removal of all fragments was confirmed by means of postoperative radiography because radiographic evidence of fragmentation was the method of determining which horses would be included in the study. Because ultrasonography was superior to radiography for fragment detection and location, postoperative ultrasonography could also be a useful method for confirming fragment removal.

An important limitation of the present study was that only horses in which fragmentation was identified or suspected on the basis of radiographic findings were included. It is possible that some horses not included in the study in which fragments were not seen on radiographs would have been found to have fragments ultrasonographically.

In the present study, arthroscopy was considered the gold standard, and all fragments that were identified, other than 1 located within the joint capsule, were removed. However, in some horses undergoing arthroscopy of the MCP or MTP joint, synovial proliferation may at times prevent visualization and removal of some fragments.

a. Mobilux, X-ray Equipment Verachtert, Antwerp, Belgium.
b. GE Logiq 200 Pro, GE Medical Systems, Milwaukee, Wis.
c. Mylab 30, Esaote, Firenze, Italy.
d. SAS, version 9.1.3, SAS Institute Inc, Cary, NC.

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