Magnetic Resonance Findings in the Carpus and Proximal Metacarpal Region of Non-Lame Horses

Annamaria Nagy, DVM and Sue J. Dyson, MA, Vet MB, PhD

There are a variety of magnetic resonance (MR) appearances of structures in the carpus and proximal metacarpal region in non-lame horses. An in-depth knowledge of MR anatomy and normal variants is essential for accurate interpretation of clinical MR examinations, and it also helps in the understanding of radiographic and ultrasonographic findings. Authors’ addresses: Equine Diagnostic Centre, University of Bristol, Langford House, Langford, Bristol BS40 5DU, United Kingdom (Nagy); and Centre for Equine Studies, Animal Health Trust, Lanwades Park, Kentford, Newmarket, Suffolk CB8 7UU, United Kingdom (Dyson); e-mail: annamaria.nagy@bristol.ac.uk. © 2009 AAEP.

1. Introduction

Magnetic resonance imaging (MRI) is becoming more frequently used in the investigation of proximal metacarpal and carpal region pain. Magnetic resonance (MR) examination of the carpus and proximal metacarpal region is possible in some low-field and high-field magnets. One low-field system has the advantage of performing MR examination in a standing sedated horse and can provide useful diagnostic information; however, the images are of inferior quality compared with high-field images or images obtained with the horse under general anesthesia because of both lower resolution and problems of motion artefacts. An in-depth knowledge of anatomy, the normal appearance of tissues, and their variations in high-field images is essential for accurate interpretation of low-field images. The few published studies on MR anatomy of the carpus and proximal metacarpal region were based on high-field images and did not describe variants in non-lame horses. In a cadaver study, we recently described and compared high-field and low-field MR appearance of the carpus and proximal metacarpal region of 30 horses with no history of carpal or proximal metacarpal pain. The aim of this paper is to highlight those MR findings and variants in the carpus and proximal metacarpal region of non-lame horses using high-field and low-field MR images. This should aid understanding and interpretation of MR and conventional diagnostic imaging findings in lame horses.

2. Materials and Methods

High-field and low-field MR images of the left carpus and proximal metacarpal regions of 30 mature horses with no known history of carpal or proximal metacarpal region pain that were humanely destroyed for reasons other than this study were reviewed. Ages ranged from 3 to 21 yr (mean = 10.3 yr; median = 8 yr); breeds included Thoroughbreds and Thoroughbred crosses (n = 15), Warmbloods (n = 5), Irish Draught and other hunter-type horses (n = 5), cob types (n = 3), and other breeds (one Arab cross and one Welsh Section D). Limbs were cut at the level of the mid or proximal aspect of the radius.
High-field MR images were acquired in a 1.5-T cylindrical short-bore GE Signa Echospeed magnet using a human extremity radiofrequency coil. The images acquired included three-dimensional (3D) T1-weighted spoiled gradient echo (SPGR), 3D T2*-weighted gradient echo (GRE), and short tau inversion recovery (STIR) sequences in sagittal, dorsal, and transverse planes (Table 1). Low-field images were obtained in a 0.27-T open magnet using a custom-made radiofrequency coil for equine limbs. The images acquired included motion insensitive (MI) 3D T1- and T2*-weighted GRE, two-dimensional (2D) proton density (PD) spin echo (SE), 2D T2-weighted fast spin echo (FSE) and MI STIR FSE sequences in sagittal, dorsal, and transverse planes (Table 2). Limbs were placed in the low-field magnet in a vertical position with the carpus extended and the sole of the foot as close to horizontal as possible. Image sequences were those used routinely in clinical scanning at the Animal Health Trust. All images were assessed subjectively by the same analyst. Repeatability of image analysis was assessed five times in each of five bones and in each of three soft tissue structures at three different levels in five horses. Images were compared with transverse and sagittal slices of anatomical specimens to facilitate interpretation. Automatic MR image cross-referencing between slices in different planes was also used to verify the identity of structures. The same numbering system is employed to indicate each anatomical structure in each figure.

### Results

#### Osseous Structures

The distal physeal line of the radius was identified on transverse and sagittal images as a fine line of low signal intensity (Fig. 1). The subchondral bone in the distal radius, in the carpal bones, and in the proximal articular surface of the third metacarpal bone was usually slightly thicker medially than laterally. In the carpal bones and in the proximal aspect of the third metacarpal bone, the subchondral bone was also often slightly thicker in the dorsal one-third to one-half than on the palmar aspect; this feature was most consistent in the proximal aspect of the third carpal bone (Fig. 1). The endosteal surfaces of the subchondral bone were generally smooth. There was mild irregularity in the center of the palmar aspect of the third carpal bone at the origin of the accessory ligament of the deep digital flexor tendon (AL-DDFT) in 13 of 30 (43%) horses. A small indentation in the palmar aspect of the third carpal bone was seen in 8 of 30 (27%) horses (Fig. 2).

### Table 1. Pulse Sequence Parameters Used in the High-Field (1.5 T) Magnet

<table>
<thead>
<tr>
<th>Pulse Sequence</th>
<th>TE (ms)</th>
<th>TR (ms)</th>
<th>Flip Angle (°)</th>
<th>Slice Thickness (mm)</th>
<th>Interslice Spacing (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Three-plane localizer</td>
<td>2.1</td>
<td>166.5</td>
<td>30</td>
<td>5</td>
<td>-1.5</td>
</tr>
<tr>
<td>Sagittal 3D SPGR</td>
<td>3.3</td>
<td>8.1</td>
<td>30</td>
<td>3</td>
<td>-1.5</td>
</tr>
<tr>
<td>Sagittal 3D T2* GRE</td>
<td>3.1</td>
<td>7.3</td>
<td>30</td>
<td>3</td>
<td>-1.5</td>
</tr>
<tr>
<td>Transverse 3D SPGR</td>
<td>3.3</td>
<td>8.2</td>
<td>30</td>
<td>3</td>
<td>-1.5</td>
</tr>
<tr>
<td>Transverse 3D T2* GRE</td>
<td>3.2</td>
<td>7.3</td>
<td>30</td>
<td>3</td>
<td>-1.5</td>
</tr>
<tr>
<td>Dorsal 3D SPGR</td>
<td>3.2</td>
<td>8.1</td>
<td>30</td>
<td>3</td>
<td>-1.5</td>
</tr>
<tr>
<td>Dorsal 3D T2* GRE</td>
<td>3.1</td>
<td>7.3</td>
<td>30</td>
<td>3</td>
<td>-1.5</td>
</tr>
<tr>
<td>Sagittal fast STIR</td>
<td>25.2</td>
<td>10,500</td>
<td>30</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Transverse fast STIR</td>
<td>25.1</td>
<td>10,500</td>
<td>30</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Dorsal fast STIR</td>
<td>25</td>
<td>6000</td>
<td>30</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>

SPGR, spoiled gradient echo; GRE, gradient echo; STIR, short tau inversion recovery; TE, echo time; TR, repetition time.

### Table 2. Pulse Sequence Parameters Used in the Low-Field (0.27 T) Magnet

<table>
<thead>
<tr>
<th>Pulse Sequence</th>
<th>TE (ms)</th>
<th>TR (ms)</th>
<th>Flip Angle (°)</th>
<th>Slice Thickness (mm)</th>
<th>Slice Gap (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pilot</td>
<td>7</td>
<td>62</td>
<td>45</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>Live pilot</td>
<td>7</td>
<td>62</td>
<td>45</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>T1W GRE</td>
<td>8</td>
<td>130</td>
<td>75</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>T2*W GRE</td>
<td>13</td>
<td>130</td>
<td>32</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>T2W FSE</td>
<td>84</td>
<td>1900</td>
<td>90</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>STIR FSE</td>
<td>27</td>
<td>2840</td>
<td>90</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>PDW SE</td>
<td>24</td>
<td>1300</td>
<td>90</td>
<td>5</td>
<td>1</td>
</tr>
</tbody>
</table>

The same parameters were used for sagittal, transverse, and dorsal sequences. T1W GRE, T1-weighted gradient echo; T2*W GRE, T2*-weighted gradient echo; T2W FSE, T2-weighted fast spin echo; STIR FSE, short tau inversion recovery fast spin echo; PDW SE, proton density weighted spin echo; TE, echo time; TR, repetition time.
The distal palmar medial aspect of the ulnar carpal bone had a variable shape with small fragments immediately adjacent to or separated from it in 5 of 30 (17%) horses. There was one discrete osseous fragment distal and medial to the ulnar carpal bone within the lateral palmar intercarpal ligament in two of these five horses, and there were multiple small fragments in three horses (Figs. 2 and 3). These osseous fragments appeared as focal areas of low signal intensity of variable shape or as a bone piece with definition between cortical (low signal intensity) and trabecular (high signal intensity) bone. Signal intensity in the ulnar carpal bone in fat-suppressed images of limbs with fragments was normal and identical to those without fragments.

The endosteal surface of the palmar cortex of the proximal aspect of the third metacarpal bone was slightly irregular in 22 of 30 (73%) horses. Mild periosteal irregularity was difficult to appreciate because of the low signal intensity of the suspensory ligament fibers at their origin, and it was seen in 7 of 30 (23%) horses. In 25 of 30 (83%) horses, there were small indentations (one in 11 horses, two in 12 horses, and three in 2 horses) in the proximal axial aspect of the palmar cortex of the third metacarpal bone (Figs. 4 and 5). Marked endosteal or periosteal irregularity was not seen in any horse. In 27 of 30 (90%) horses, there was a variable-sized smooth

---

**Key to Figure Legends**

1, radius; 2, radial carpal bone; 3, intermediate carpal bone; 4, ulnar carpal bone; 5, accessory carpal bone; 6, second carpal bone; 7, third carpal bone; 8, fourth carpal bone; 9, second metacarpal bone; 10, third metacarpal bone; 11, fourth metacarpal bone; 12, extensor carpi radialis tendon; 13, common digital extensor tendon; 14, lateral digital extensor tendon; 15, tendon from common to lateral digital extensor tendon; 16, extensor carpi obliquus tendon; 17, ulnaris lateralis tendon; 18, flexor carpi radialis tendon; 19, flexor carpi ulnaris; 19A, muscle; 19B, tendonous part; 20, superficial layer of the flexor retinaculum; 21, superficial digital flexor tendon; 22, deep digital flexor tendon; 23, suspensory ligament; 23A, medial lobe; 23B, lateral lobe; 23C, fibers originating from the base of the fourth metacarpal bone; 24, accessory ligament of the deep digital flexor tendon; 25, medial collateral ligament of the carpus; 26, lateral collateral ligament of the carpus; 27, radiocarpal ligament; 28, medial palmar intercarpal ligament; 29, lateral palmar intercarpal ligament; 30, palmar carpal ligament; 31, transverse intercarpal ligaments in the proximal and distal rows of carpal bones; 32, carpometacarpal ligament; 33, intersosseous ligaments between the metacarpal bones; 34A and 34B, deep layers of the flexor retinaculum; 35A, medial palmar metacarpal artery; 35B, medial palmar metacarpal vein; 35C, medial palmar metacarpal nerve; A, synovial fluid; B, fat pad.

---

in the dorsal aspect of the intermediate bone is caused by the cutting plane; on true sagittal images, the cutting plane goes through the medial cortex dorsally and through the medulla of the bone in its more palmar aspect.
bony prominence on the axial aspect of the base of the second metacarpal bone at the insertion site of the flexor carpi radialis tendon (white arrow). There is a small osseous fragment within the lateral palmar intercarpal ligament (white arrowhead) that appears as a small rounded area of low signal intensity. Note that there are fibers of the SL originating from the fourth metacarpal bone. The vertical intermediate signal intensity in the center of the medial lobe of the SL and within the lateral lobe (between the fibers originating from the fourth metacarpal bone and the more axial part of the lateral lobe) represents muscle tissue. The septum between the medial and lateral lobes can be seen axially as a fine vertical line of intermediate signal intensity.

Fig. 2. Dorsal high-field T2*-weighted GRE MR image of the carpus and proximal metacarpal region of an 11-yr-old Warmblood gelding. Medial is to the left. Note the small indentation in the palmar distal aspect of the third carpal bone (black arrowhead). There is a bony prominence on the axial aspect of the base of the second metacarpal bone at the insertion site of the flexor carpi radialis tendon (white arrow). There is a small osseous fragment within the lateral palmar intercarpal ligament (white arrowhead) that appears as a small rounded area of low signal intensity. Note that there are fibers of the SL originating from the fourth metacarpal bone. The vertical intermediate signal intensity in the center of the medial lobe of the SL and within the lateral lobe (between the fibers originating from the fourth metacarpal bone and the more axial part of the lateral lobe) represents muscle tissue. The septum between the medial and lateral lobes can be seen axially as a fine vertical line of intermediate signal intensity.

Tendons, Ligaments, and Fasciae

The low signal intensity of the extensor carpi radialis (ECR) tendon was often interrupted by variable numbers of oblique bands of intermediate signal intensity (Fig. 1). Therefore, the tendon had a “striped” appearance on sagittal and dorsal T1-weighted SPGR and T2*-weighted GRE high-field images and had low or intermediate signal intensity on the transverse images corresponding to the location of the bundles (Fig. 6). These bands could only occasionally be clearly identified on high-field STIR images, which is probably caused by the relatively large slice thickness compared with the thickness of the ECR tendon and the bundles. On low-field images, the bands in the ECR tendon were only identified if they were well separated from each other on high-field images. If they were close to each other, they appeared as a larger area of intermediate signal intensity in the ECR tendon in all available sequences.

Fig. 3. (A and B) Dorsal and transverse T1-weighted high-field SPGR MR images showing variations in the shape of the medial palmar aspect of the ulnar carpal bone and osseous fragment(s) (B, arrows) within the lateral palmar intercarpal ligament. The views in B illustrate magnified images from two horses with no history of carpal pain. In the top row, there are dorsal images (medial is to the left), and in the bottom row, there are corresponding transverse images (medial is to the left and dorsal is to the top).
The superficial and deep digital flexor muscles had heterogeneous intermediate signal intensity in the antebrachium. At the level of the distal aspect of the radius, the muscles started to become tendinous, which resulted in regions of tendinous tissue of low signal intensity interrupting the intermediate signal intensity of the muscle tissue. The proportion of tendinous tissue increased distally. In the proximal aspect of the carpus, both the superficial digital flexor tendons (SDFT) and deep digital flexor tendons (DDFT) contained variable amounts of muscle tissue (Fig. 7). By the level of the distal row of carpal bones, both tendons had uniform low signal intensity.

The collateral ligaments of the carpus, which have deep and superficial components, had heterogeneous low signal intensity and slightly irregular margins (Figs. 2 and 6). The medial collateral ligament was rounded proximally and became narrower and more oval-shaped distally, whereas the lateral collateral ligament was narrow close to its origin and got wider distally. The superficial and deep parts of the collateral ligaments could not be distinguished clearly, and therefore fibers were seen running in different directions on dorsal images (Fig. 2). The small lateral digital extensor tendon ran under the lateral collateral ligament of the carpus, and the two structures could not always be distinguished clearly (Fig. 6A).

There is a strong carpal fascia that is attached to the medial and lateral aspects of the distal aspect of the radius, the accessory carpal bone, and the collateral ligaments of the carpus. The dorsal part forms the extensor retinaculum and could not always be identified in MR images. The flexor reti-
The palmar retinaculum is the palmar part of the fascia; it surrounds the palmar aspect of the carpus and continues distally to the proximal row of carpal bones (Fig. 6). It extends from the accessory carpal bone to the medial collateral ligament of the carpus and to the proximal palmar aspects of the second and fourth metacarpal bones. It has strong fibers joining the medial collateral ligament, and it can be difficult to differentiate between the two structures. In the medial aspect of the carpal region, the flexor retinaculum is composed of three layers. The superficial layer was superficial to the medial palmar vein. It was thicker medially and easier to identify than the deep layers. The two deeper layers were separated by the flexor carpi radialis tendon and could not always be clearly identified. The flexor retinaculum had homogeneous intermediate to low signal intensity in all pulse sequences. In the proximal metacarpal region, the fibers of the flexor retinaculum were thicker laterally than medially. In the proximal metacarpal region, the fibers of the flexor retinaculum diverged close to the insertion on the metacarpal bones, which resulted in increased thickness.

The palmar carpal ligament originates from the caudal aspect of the distal radius and forms the dorsal wall of the carpal canal. The transverse intercarpal ligaments (31) can be clearly identified, and their fiber structure can be easily assessed on the high-field image. On low-field GRE images, these ligaments are ill-defined and have only slightly lower signal intensity than the synovial fluid. Among all low-field sequences, the transverse intercarpal ligaments were best visualized on FSE images, where the fibers were more clearly separated from the synovial fluid. On the high-field T2*-weighted GRE image, there is a fine line of intermediate signal intensity in the extensor carpi radialis tendon (arrow). This corresponded to the area of an oblique band of intermediate signal intensity identified on sagittal images and is an artefact caused by lack of tension in the tendon of cadaver limbs. Note that this line was much more obvious on the low-field T2*-weighted GRE image (arrow) and was absent on the FSE image. This potential artefact should be taken into account when interpreting altered signal intensity in tendons of a standing sedated horse, because posture can cause decreased tension in the extensor carpi radialis tendon. The very different appearance in different pulse sequences should also be considered.
more square-shaped distally. The dorsal margins of the lobes were slightly irregular proximally. The amount and distribution of the muscle and adipose tissue within each lobe was variable (Fig. 9). Close to the origin, an area of intermediate to high signal intensity in T1 and T2 weighted images, correlating with muscle and adipose tissue, was located in the palmar aspect of both lobes of the SL. More distally, the muscle and adipose tissue became more centrally located and then became more diffusely distributed within the collagenous tissue. The signal intensity of the muscle and adipose tissue often decreased slightly from proximal to distal. On low-field images, the SL had intermediate signal intensity that was slightly lower than that of the AL-DDFT (Fig. 5). The SL was surrounded by loose connective tissue, which had intermediate to high signal intensity in all pulse sequences. The palmar metacarpal veins, arteries, and nerves ran abaxial to the SL. They appeared as focal or diffuse areas of heterogeneous low signal intensity within the high signal intensity connective tissue on T1 weighted GRE images and depending on the amount of blood in the vessels, low to high signal intensity on T2*-weighted GRE images (Fig. 4). The presence of these vascular structures resulted in loss of definition of the abaxial margins of the SL on low-field GRE images. Low signal intensity bundles were seen between the proximal aspect of the SL and the palmar aspect of the third metacarpal bone at a variable proximodistal location in all horses (Figs. 1, 5, and 8). Similar bundles were seen between the SL and the AL-DDFT in all horses.

The transverse intercarpal ligaments of the carpal bones had intermediate signal intensity. On high-field images, the fiber pattern could be assessed, and in some ligaments, synovial fluid of high signal intensity interdigitated between fibers (Fig. 6A). However, in low-field images, these ligaments were difficult to differentiate from the synovial fluid and were best assessed on FSE (Fig. 6C) and STIR images. The medial and lateral palmar intercarpal ligaments had intermediate to high signal intensity and could be identified on transverse and dorsal images (Fig. 2). There are two small ligaments toward the palmar aspect of the carpometacarpal joint. The medial ligament originates from between the second and third carpal bones, and it inserts in between the third metacarpal bone and the base of the second metacarpal bone (Fig. 2). The lateral ligament originates from between the third and fourth carpal bones and inserts in between the third metacarpal bone and the base of the fourth metacarpal bone. These ligaments had intermediate signal intensity in all pulse sequences in both low-field and high-field images. The fiber structure could only be well evaluated in T1- and T2*-weighted high-field images. The majority of the fibers were oriented proximodistally, and therefore, the carpometacarpal ligaments were best evaluated on dorsal and sagittal images. The interosseous ligaments between the second and third metacarpal bones and the fourth and third metacarpal bones had heterogeneous intermediate signal intensity, and their fiber alignment was best evaluated on transverse images. In their proximal aspects, fibers were sometimes interspersed by high signal intensity of synovial fluid of the carpometacarpal joint on T2*-weighted GRE images.

Joints and Tendon Sheaths

The antebrachio-carpal joint has a small dorsal and a large palmar pouch. The palmar pouch always contained a significant amount of synovial fluid. The
The middle carpal joint also has a small dorsal pouch, which had a minimal amount of synovial fluid, and a larger palmar pouch. The lateral palmar pouch extended markedly in a palmar direction and was identified distal to the accessory carpal bone between the lateral collateral ligament and the ulnaris lateralis tendon in 19 of 30 (63%) horses. In the palmar pouch of the carpometacarpal joint, synovial fluid was seen lateral (4 of 30 horses [13%]) and both medial and lateral (26 of 30 horses [87%]) to the proximal aspect of the SL and/or the AL-DDFT just distal to the level of the carpometacarpal joint.

4. Discussion
High-field MR images were of superior quality and provided more detail and better definition of structures than low-field images. However, most structures could also be satisfactorily evaluated on low-field images. There was a variety of MR appearance of tissues in the carpus and proximal metacarpal region in horses with no history of carpal or proximal metacarpal region pain. It was possible to evaluate several structures that cannot be imaged using radiography and ultrasonography, including the small palmar ligaments of the carpus, the abaxial margins of the SL, the interosseous ligaments between the metacarpal bones, and the carpometacarpal ligaments.
The thickness of the subchondral bone in the distal aspect of the radius, in the carpal bones, and in the proximal aspect of the third metacarpal bone was variable, and it likely reflects the exercise history of the horse. The dorsal and medial aspects of the subchondral bone were thicker than the palmar and lateral aspects, which is consistent with the results of a previous study investigating response to exercise in the subchondral bone. Care should be taken in interpretation of signal intensity of the medulla of the carpal or metacarpal bones in transverse images close to the proximal or distal subchondral bone plate or in sagittal images close to the medial or lateral cortices, because part of the slice may pass through the subchondral bone and thus, have low signal intensity (Fig. 1).

Variability in shape of the distal medial aspect of the ulnar carpal bone and discrete osseous fragments were seen in 5 of 30 (17%) horses. Small osseous fragments in an identical location have been described as incidental findings and as a result of avulsion of the lateral palmar intercarpal ligament. The high incidence in non-lame horses observed in this study suggests that these fragments are likely to be congenital (i.e., separate centers of ossification) or a result of dystrophic mineralization in the lateral palmar intercarpal ligament of no clinical significance. Dissection of one carpus with a fragment identified on MR images revealed firm nodules within the lateral palmar intercarpal ligament; there was no disruption of the ligament fibers, and the insertion sites of the ligament were intact. Histopathological examination revealed that the firm nodules corresponded to areas of fibrocartilaginous metaplasia that could not be differentiated histologically from a separate center of ossification. Similar fragments have been identified with radiographs and MRI in lame horses but have been considered incidental findings. In all horses alternative causes of lameness were identified. Moreover, signal intensity in the ulnar carpal bone was normal in fat-suppressed MR images, suggesting no evidence of active bony reaction.

We had speculated that the intermediate signal intensity bands in the ECR tendon were a result of an artefact related to lack of tension in the tendon. This was confirmed by performing high-field MR imaging on a cadaver limb that had been disconnected as proximal as possible to include the humerus (i.e., the origin of ECR was intact). The ECR tendon had uniform low signal intensity in both T1-weighted SPGR and T2*-weighted GRE sequences. When the tendon was transected at the level of the mid-radius, intermediate signal intensity bands appeared at the level of the carpus in images from both pulse sequences. This may be caused by a magic angle artefact affecting differently orientated collagen fibers in the collapsed tendon. Although we observed this feature in cadaver limbs disconnected at the level of proximal or mid-radius, it should be taken into account when interpreting altered signal intensity in tendons of a standing sedated horse. There is a possibility that reduced tension in the ECR tendon is caused by posture.

It is important to recognize the variable appearance of the proximal aspect of the SL in normal horses, including the amount, pattern, and location of muscle and adipose tissue within the SL. The difference in shape and size between the medial and lateral lobes of the SL has been previously recognized and was also observed in this study. For accurate interpretation of alteration in size and shape of the medial and lateral lobes, comparison must be made with the contralateral limb (if normal) or with normal data. Decrease in signal intensity in the muscle tissue has been associated with chronic injury. However, the current study showed that the muscle tissue may have intermediate to high signal intensity in non-lame horses, depending on the pulse sequence used. Moreover, the signal intensity often decreased slightly moving proximally to distally. However, it is possible that altered signal intensity in the muscle tissue may reflect previous unknown injury. There are fibers originating from the base of the fourth metacarpal bone that are not always clearly identifiable in low-field images. These should not be confused with adhesions. These fibers were only seen extending up to ~6–7 cm distal to the carpometacarpal joint. The palmar metacarpal vascular structures can cause loss of definition of the abaxial margins of the SL on low-field images, probably because of volume-averaging artefact. This loss of definition may be difficult to differentiate from true lesions.

There was a large individual variability in the appearance of the AL-DDFT. In 21 of 30 (70%) horses, there were areas of heterogeneous signal intensity in transverse images that were associated with intermediate signal intensity bands crossing in oblique directions on sagittal images. This must be kept in mind when interpreting the significance of increased and heterogeneous signal intensity on transverse images. The intermediate signal intensity bands were also present on FSE images. The FSE sequence has a longer echo time than other sequences used in this study, and it is, therefore, less susceptible to magic angle artefact. This suggests that the MR appearance of the AL-DDFT is related to some difference in internal architecture compared with other tendons and ligaments. It is also possible that the presence of these bands is related to partial relaxation of the AL-DDFT. The origin of the AL-DDFT and the insertion of the DDFT were intact in all limbs, but the limbs were not loaded. However, similar bands were not identified in the flexor tendons, although they had been cut distal to their origin. Age-related changes in mechanical properties of the AL-DDFT have been described. However, in this study, the AL-DDFT had greater signal intensity than the flexor tendons or the SL (with or without intermediate signal intensity bands) in all horses including 3-yr-old unbroken
horses. Differentiation of the intermediate signal intensity bands from true lesions can be difficult. The bands had intermediate signal intensity in all available pulse sequences, including STIR images. Cross-referencing sagittal and transverse images can be useful to verify the position of regions of increased signal intensity in both planes. However, this is of limited accuracy in low-field systems compared with high-field systems because of the greater thickness of the slice. A genuine lesion is likely to be associated with a region of increased signal intensity that extends further proximodistally than these bands. Comparison of size and shape of the AL-DDFT with the contralateral limb, if normal, may be helpful. The low signal intensity bundles between the palmar cortex of the third metacarpal bone and the SL and between the SL and the AL-DDPT may represent adhesions. However, because they were seen in all horses, they are more likely to represent denser connective tissue than the surrounding loose connective tissue, which has high signal intensity, or to be a result of volume-averaging artefact.

There were some limitations to this study. MRI was performed in cadaver limbs, and therefore, flow and motion artefacts did not occur. This often compromises image quality in live horses, especially when using a low-field magnet in a standing patient. Only left forelimbs were examined in this study; therefore, comparison with the contralateral limb was not possible. However, a previous study of the carpus showed good left-right symmetry. None of the horses had a history of carpal or proximal metacarpal region pain; however, the possibility of an unknown injury or subclinical lesion must be considered when interpreting the results.

In this study, we used pulse sequences that are routinely used in clinical scanning at the Animal Health Trust. In the high-field system, FSE sequences were not acquired based on the results of previous studies. We fully appreciate that signal intensity of structures at or near the magic angle will be affected by the magic angle effect (MAE), and that the longer echo time of the FSE sequences makes this a useful sequence. However, we did not identify high signal intensity, which might be caused by MAE in any of the structures of the carpus or proximal metacarpal region; therefore, we did not feel it was necessary to run any additional sequences. Moreover, there were few anatomical structures in the carpus and proximal metacarpal region that we considered at risk of being affected by the MAE. The structures that had greater signal intensity than might have been expected (e.g., AL-DDPT) had similarly higher signal intensity in both low-field and high-field images. This makes it unlikely that the signal intensity was affected by MAE, because the position of the limb relative to the static magnetic field was different.

This study revealed variability in the MR appearance of structures in the carpus and proximal metacarpal region of limbs obtained from horses with no history of lameness. High-field MR images helped to interpret low-field MR findings. An in-depth knowledge of high-field and low-field MR anatomy is essential for accurate interpretation of clinical MR examinations and may also help to understand radiographic and ultrasonographic findings.

We are grateful to the Bransby Trust for generous financial support.

References and Footnotes

5. Nasvall KE, Dyson SJ, Murray RC. The appearance of the proximal part of the metacarpal/metatarsal interosseous ligaments in magnetic resonance images of horses with no history of lameness, in Proceedings. 47th Congress of the British Equine Veterinary Association 2008;142.

IMAGING I

AAEP PROCEEDINGS / Vol. 55 / 2009 417