Lameness and Diagnostic Imaging in the Sports Horse: Recent Advances Related to the Digit

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1. Introduction
Accurate lameness diagnosis is dependent on a good clinical examination, localization of the sources of pain causing lameness, high-quality diagnostic imaging, knowledge of both image interpretation and the limitations of each imaging modality, and recognizing the need to correlate all pieces of information. The purpose of this paper is to provide a review of recent advances in imaging of the digit of sport horses, with particular reference to radiography, nuclear scintigraphy, and magnetic resonance imaging (MRI), with some reference to ultrasonography.

2. Traditional Radiography, Computed Radiography, and Digital Radiography
There has been an explosion of computerized and digital radiography in recent years. This is not a forum for explanation of the relative merits of computerized or digital radiography, but it is important to recognize that computerized or digital radiography does not necessarily equate with better. Excellent quality conventional radiographs can be vastly superior to poor-quality digital images. Attention to detail is crucial to achieve excellent quality images whichever technique is used. However, excellent quality computerized or digital images can potentially yield more information than conventional images and enhance our diagnostic capabilities. For example, the detection of distal border fragments of the navicular bone has increased with the advent of digital images.

3. Palmar Process Fractures of the Distal Phalanx
Palmar process fractures of the distal phalanx have been well documented in racehorses and a predilection for the medial palmar process of the right forelimb and the lateral palmar process of the left forelimb has been associated with racing counterclockwise.1 There is some evidence in racehorses that such fractures may be manifestation of stress-related bone injury.

In the sports horse, a recent, albeit small, study (22 horses) performed at the Animal Health Trust showed that the medial palmar process was at most risk of injury (81%).2 In many horses, acute severe lameness had not been recognized by the owner; at the time of clinical examination, 2–50 wk (mean, 12.5 wk) after lameness recognition, most horses20 showed mild or moderate lameness, which was exacerbated on a circle, especially on a hard surface with the lame limb on the inside. Digital pulse amplitudes were elevated in only six horses, three of which had a positive response to hoof testers. A further three horses reacted to hoof testers. There
was a preponderance of general purpose riding horses (68%), compared with 37% in the normal clinic population. Lameness was improved or abolished by palmar (abaxial sesamoid) nerve blocks in the majority of horses; it was improved by intraarticular analgesia of the distal interphalangeal (DIP) joint in five of six horses.

In 8 of 22 horses (36%), the fracture was only identified in either a dorsoproximal-palmaromedial oblique (DPr-PaMO) or a dorsomedial-palmarolateral oblique (DM-PaLO) radiographic view of the distal phalanx3 (Fig. 1). In a further three horses (14%), the fracture was only identified on the appropriate oblique view or a palmaroproximal-palmarodistal oblique (PaPr-PaDiO) view. Therefore, in 50% of horses, no radiographic abnormality was identified in conventional radiographic views of the foot. This highlights the need for the routine use of oblique projections when evaluating horses with foot pain. The use of flexed oblique views also enables optimal evaluation of the dorsal articular margins of the DIP joint.3

Nuclear scintigraphic examination should not be necessary in most horses to detect a palmar process fracture. However, in this study, scintigraphy was positive in all 12 horses, with focal intense increased radiopharmaceutical uptake (IRU) in the distal phalanx in 10 horses and focal moderate or mild IRU in 2 horses (Fig. 2). Nuclear scintigraphy can be useful to highlight the potential presence of a fracture and prompt acquisition of different radiographic views to identify a fracture, bearing in mind that the X-ray beam must be perpendicular to the plane of the fracture.

Whether palmar process fractures of the distal phalanx are complete or incomplete, articular or non-articular does not seem to influence prognosis in sport horses.2 Many palmar process fractures occur immediately palmar to the insertion of the collateral ligament (CL) of the DIP joint; this may be because of stress concentration causing a focal weak point. Delayed union fracture of the medial palmar process has been seen in association with ipsilateral desmitis of the CL of the DIP joint.4 It is possible that ligamentous injury may create some instability of the DIP joint and thus contribute to delayed union. In some sports horses with acute onset of lameness associated with a palmar process fracture, alteration of trabecular architecture adjacent to the fracture indicates pre-existing osseous pathology, suggesting that the fracture may be the end stage of a repetitive strain injury. This could be the result of repetitive compression or tension mediated through the insertion of the ipsilateral collateral ligament of the DIP joint.

There is a recent report of a lateral palmar process fracture that was not visible radiographically, but was
detected using computed tomography.\textsuperscript{5} Frontal plane fractures of a palmar process of the distal phalanx may only be detectable in a PaPr-PaDiO radiographic view and are easily missed if not correctly positioned and exposed\textsuperscript{6} (Fig. 3).

4. Distal Border Fragments of the Navicular Bone
There have been several recent studies that have suggested that distal border fragments of the navicular bone are associated with navicular disease.\textsuperscript{7-10} Such fragments may represent a fracture, enthesophyte formation, or dystrophic mineralization in the distal sesamoidean impar ligament (DSIL). However distal border fragments have also been identified as incidental abnormalities in clinically normal horses. The advent of digital radiography has resulted in an increased recognition of distal border fragments, which may occur uniaxially or biaxially. The presence of a radiolucent zone at the medial or lateral angle of the distal border of the navicular bone is a good indicator of the presence of a distal border fragment (Fig. 4). Correlation with magnetic resonance (MR) images has shown that, in association with a radiolucent zone at the medial or lateral angle of the navicular bone, there is often associated more widespread osseous pathology on the ipsilateral aspect of the bone and in a few horses associated adhesion of the deep digital flexor tendon (DDFT)\textsuperscript{6,11} (Figs. 5 and 6). Such fragments may cause lameness associated with relative movement between the fragment and the navicular bone. Fragments may also be associated with DSIL pathology and/or adhesions between the DSIL and the DDFT.

5. Ossification of the Cartilages of the Foot
Ossification of the cartilages of the foot (sidebone) has been commonly recognized, although its clinical significance has until recently been speculative. Ossification of the lateral cartilage of the foot was more common than the medial cartilage in Finn horses\textsuperscript{12} and Warmbloods.\textsuperscript{13}

In a recent study at the Animal Health Trust, dorsopalmar foot radiographs of 268 horses were evaluated.\textsuperscript{14} Ossification of the cartilages of the foot was graded according to Ruohoniemi et al.\textsuperscript{12}: grade 0 = no ossification; grade 1 = minimal ossification at the base of the cartilage; grade 2 = mild ossification at the base of the cartilage to the palmar level of the distal interphalangeal joint; grade 3 = moderate ossification to the level of the proximal edge of the navicular bone; grade 4 = advanced ossification extending clearly above the navicular bone, but remaining in the distal half of the middle phalanx (Fig. 7); and grade 5 = extensive ossification to the level of the proximal half of the middle phalanx (Fig. 8). The presence of separate centers of ossification (SCOs) was recorded. A maximum
ossification grade was assigned to each horse, being the highest grade assigned to any cartilage of the foot. Possibly significant ossification was defined as a grade 3 ossified cartilage plus a SCO or grade 4 or 5 ossified cartilage.

There was a significant effect of breed on maximum ossification grade ($p = 0.002$), with high grades relatively over-represented in large Native ponies (Dales, Highland, Fell, and Connemara) and

Fig. 5. Dorsal T1-weighted spoiled gradient echo MR image of the same foot as Fig. 4, A and B. Lateral is to the right. Note the distal border fragment and the osseous reaction in the navicular bone characterized by reduced signal intensity.

Fig. 6. (A) Dorsoproximal-palmarodistal oblique radiographic view of a right front navicular bone. Lateral is to the right. There is a radiolucent area at the lateral angle of the distal border of the navicular bone, distal to which is a mineralized fragment (arrows). (B) Transverse T2-weighted gradient echo MR image of the same foot as A. There is an adhesion of the deep digital flexor tendon to the distal border of the navicular bone at the site of the fragment (arrow).

Fig. 7. Dorsopalmar radiographic view of a right front foot of a 6-yr-old Thoroughbred cross with symmetrical grade 4 ossification of the cartilages of the foot.

Fig. 8. Dorsopalmar radiographic view of a left front foot of an 8-yr-old hunter with symmetrical grade 5 ossification of the cartilages of the foot.

Fig. 9. Dorsoproximal-palmarodistal oblique radiographic view of the same foot as Fig. 6, A and B. Lateral is to the right. There is a radiolucent area at the lateral angle of the distal border of the navicular bone, distal to which is a mineralized fragment (arrows). There is an adhesion of the deep digital flexor tendon to the distal border of the navicular bone at the site of the fragment (arrow).
cob types, compared with other breeds (Irish draught, Crossbred, Thoroughbred, Thoroughbred cross, Warmblood, Pony). There was no significant correlation of height with maximum ossification grade. However, there was a significant positive correlation between body weight and maximum ossification grade ($p = 0.03$). Maximum ossification score was significantly but negatively correlated with height to body weight ratio ($p = 0.004$), i.e., greater ossification grades were associated with lower height/body weight ratios.

There was a positive correlation in grade between medial and lateral cartilages ($p < 0.001$). Grades were significantly different between medial and lateral cartilages in the right forelimb ($p = 0.02$) but not in the left. Overall, the lateral grade was significantly different to the medial grade ($p = 0.006$), and the lateral cartilage of the foot was usually the largest. There was no significant difference in grades between left and right feet, comparing both lateral and both medial cartilages.

There was no significant effect of age on grade. There was no significant effect of sex on maximum ossification grade. “Possibly significant ossification” was seen in 18.5% of mares, 15.8% of geldings, and 25% of stallions. There was no significant sex predilection between those horses with possibly significant ossification compared with horses with low grades.

There was generally left right symmetry between feet. It was concluded that large medial cartilages, asymmetry between feet, and a marked lack of correlation in size between the cartilages within a foot may be more indicative of an abnormality.

6. Nuclear Scintigraphy and Ossification of the Cartilages of the Foot

A second study was performed to correlate the findings of radiography and nuclear scintigraphy. Two hundred and twenty-three front feet of 186 horses that had dorsopalmar radiographic views and dorsal scintigraphic images were included in the study. The cartilages of the foot were graded radiographically and scintigraphically. Quantitative evaluation of the scintigraphic images was carried out using region of interest (ROI) analysis (Fig. 9).

For statistical analysis, radiopharmaceutical uptake (RU) ratios of regions B, C, and D to A were used (Fig. 9). Correlations between a radiographically detected SCO and focal RU and between IRU and radiographic abnormalities were assessed.

There was good correlation and excellent agreement between radiographic and scintigraphic grades. ROI analysis showed a proximal to distal increase in RU ratios within each cartilage of the foot. Thus, there was highest RU at the base of each ossified cartilage. A radiographically identified SCO could be detected scintigraphically in 12/17 feet (70.6%).

Thirty-eight feet had IRU in the region of a cartilage, 25 of which (65.8%) had corresponding radiographic abnormalities. Fracture of an ossified cartilage was associated with IRU in all horses. Eighty-two percent (16/19) of cartilages with radiographic changes associated with IRU were moderately or severely ossified, indicating that this is a risk factor for injury. In feet where one cartilage was grade 4 and the other was less ossified, RU ratio B/A for the less ossified side was significantly lower than for the grade 4 ossified side, indicating increased modeling at the base of the more severely ossified cartilage. This observation was not noted for feet with a grade 5 and a less ossified cartilage, but this result should be interpreted with care because of the low number of feet in this group. If one cartilage of the foot is extensively ossified and the other one is not, forces mediated by ligamentous attachments to the cartilages may be transmitted differently through a rigid osseous structure compared with an unossified cartilage. This may result in increased stress, modeling, and risk for bone trauma or fracture at the base of the unilaterally extensively ossified cartilage compared with two symmetrically ossified cartilages.

In four feet with IRU in regions A and B, there was no detectable radiographic abnormality. Three of
these feet had an ipsilateral grade 4 ossified cartilage. Three of nine feet, which had IRU in region A but no detectable radiographic abnormality, had grade 4 or 5 ossified cartilages. Experience with MRI has subsequently shown, in similar horses, that such IRU may be associated with increased signal intensity in fat-suppressed images consistent with bone trauma. We speculate that severe ossification results in abnormal biomechanical forces at the base of the cartilage predisposing to bone trauma or fracture.

In this study, two feet had IRU in the region of a fusion line of SCO with the ossified cartilage: one with irregular new bone on the axial aspect of the fused SCO and the other with a vertical radiolucent line within the SCO proximally. This is suggestive of response to trauma at the fusion site. This has subsequently been verified using MRI in one horse with lameness abolished by a uniaxial, ipsilateral palmar nerve block.

It was concluded that scintigraphy may give information about the potential clinical significance of ossification of the cartilages of the foot and associated lesions, thus prompting further study using a uniaxial ipsilateral palmar nerve block and additional imaging if needed using either MRI and/or computed tomography. This study also verified the observation that marked asymmetry of the cartilages of the foot within a foot may be a risk factor for injury.

7. Fracture of an Ossified Cartilage of the Foot

Clinical records of horses examined at the Animal Health Trust between 1998 and 2004 were reviewed to identify horses with fracture of an ossified cartilage of the foot. Ten horses were identified with a fracture of one or more ossified cartilages of the foot. One horse had bilateral forelimb fractures and one had two fractures (medial and lateral) in the left forelimb. Cob-type horses and Thoroughbred cross horses were over-represented compared with other breeds. There were no localizing clinical signs. The degree of lameness in straight lines ranged from 3 to 6 (0 = sound; 2 = mild; 4 = moderate; 6 = severe; 8 = non–weight-bearing). Lameness tended to be most severe on a 10- to 15-m circle on a hard surface with the lamer limb on the inside of the circle. Lameness was abolished by palmar (abaxial sesamoid) nerve blocks.

All horses had moderate to marked ossification of both medial and lateral cartilages of the foot, often symmetrical in degree. Of the 12 fractures identified in 10 horses, the medial ossified cartilage of the foot was more commonly fractured (58%) than the lateral, and the base of the cartilage was a predilection site (92%; Fig. 10).

Fractures were identified as a radiolucent line within the ossified cartilage and differentiated from separate centers of ossification. Fracture contour tended to be sharp and irregular, in comparison with the more smoothly demarcated separate centers of ossification. Weight-bearing dorsopalmar, dorso-proximal-palmarodistal oblique, and flexed oblique radiographic views of the foot were the most useful for detection of a fracture line within an ossified cartilage, although in some horses it was difficult to make a definitive diagnosis based solely on radiographic findings, and comparison with nuclear scintigraphic images was invaluable. Comparison of solar, lateral, and dorsal scintigraphic images was invaluable to precisely locate the site of IRU (Fig. 11).

8. Osseous Trauma Associated With Ossification of a Cartilage of the Foot

Osseous trauma in the distal phalanx distal to an extensively ossified cartilage of the foot has recently been identified in four horses based on the results of nuclear scintigraphy and MRI (Fig. 12). This has been characterized by increased signal intensity in the distal phalanx in fat-suppressed images.
9. Nuclear Scintigraphy and Navicular Disease

Scintigraphic images of the feet of 264 horses with front foot pain were analyzed subjectively and using ROI analysis. MR images of all feet were analyzed prospectively; the navicular bones were reassessed retrospectively and assigned a grade (0 = normal; 1 = mild abnormality; 2 = moderate abnormality; 3 = severe abnormality). A Spearman rank correlation test was used to test for a relationship between the scintigraphic grade of the navicular bone and MRI grade, with significance set at \( p < 0.05 \). A \( \chi^2 \) test was used to test for a difference between the proportions of diffuse and focal RU between MRI grades. Sensitivity and specificity and positive and negative predictive values of scintigraphy for detection of lesions in the navicular bone were determined.

IRU in the navicular bone was detected in 36.6% of limbs. There was a significant positive correlation between the scintigraphy grade and total MRI grade for the navicular bone (\( p = 0.0005 \)). There was no difference between the significance of either focal or diffuse IRU and total MRI grade for the navicular bone.

There was high specificity but low sensitivity of scintigraphy for detection of MR lesions of the navicular bone (Table 1). The positive predictive value was very high, and the negative predictive value was low for scintigraphy and overall MRI grade.

It was concluded that positive nuclear scintigraphic results are good predictors of injury or disease of the navicular bone; however, a negative scintigraphic result does not preclude significant disease of the navicular bone. It appears that if bone necrosis is the predominant pathological process (Fig. 14), RU may be normal. End-stage sclerosis is also not associated with IRU.

10. Nuclear Scintigraphy and Soft Tissue Injuries of the Digit

Scintigraphic images of the feet of 264 horses with front foot pain were analyzed subjectively and using ROI analysis. MR images of all feet were analyzed prospectively. Sensitivity and specificity and positive and negative predictive values of scintigraphy for detection of lesions in the DDFT and the CLs of the DIP joint were determined.

IRU was detected in pool phase images in the DDFT in 13.0% of limbs and at the insertion of the DDFT on the distal phalanx in 14.3% of limbs (Fig. 15). There was focal IRU at the insertion of the medial or lateral CL of the DIP joint in 9.4% and 1.5% of limbs, respectively (Fig. 16). There was high specificity, but low sensitivity of scintigraphy for detection of MR lesions of the DDFT and the CLs of the DIP joint (Tables 2 and 3). Nuclear scintigraphy did not detect IRU at the insertion of the distal sesamoidean impar ligament (DSIL).

It was concluded that positive nuclear scintigraphic results are good predictors of injury or disease of the DDFT and CLs of the DIP joint, irrespective of the anatomical location of the lesion in the tendon or ligament. However, a negative scintigraphic result does not preclude significant injuries. Nuclear scintigraphy was not useful for detection of lesions of the DSIL.

11. MRI of the DDFT and the Podotrochlear Apparatus

The MR images of 264 horses with unilateral or bilateral foot pain were analyzed and graded. Descriptive statistics were performed to establish the frequency of occurrence of DDFT lesion types at different anatomical levels, and lesions of the collateral sesamoidean ligament (CSL), DSIL, navicular bursa, DIP joint, and CLs of the DIP joint. A \( \chi^2 \) test was used to test for a difference in the proportion of
Fig. 12. Solar (lateral to the left) (A), dorsal (right to the left of the figure) (B), and lateral (C) scintigraphic images of the front feet of a 7-yr-old event horse with right forelimb lameness improved by a lateral palmar (abaxial sesamoid) nerve block. Radiographically the lateral ossified cartilage was grade 4, and the medial ossified cartilage was grade 1. There is focal increased radiopharmaceutical uptake in the lateral palmar process of the distal phalanx distal to the ossified cartilage (compare with Fig. 17). Transverse short tau inversion recovery (STIR) (D) and T1-weighted spoiled gradient echo (E) MR images of the right front foot. Lateral is to the left. There is increased signal intensity in the lateral palmar process in the STIR image and diffuse decreased signal intensity in the T1-weighted image in the lateral palmar process distal to the extensively ossified cartilage of the foot.
navicular bone grades between limbs with and without DDFT lesions at each level and to compare navicular bone grades for limbs with and without each of DSIL, CSL, navicular bursa, or DIP joint lesions.

Lesions of the DDFT occurred in 82.6% of limbs, occurring most commonly at the level of the CSL (59.4%) and the navicular bone (59.0%). Core lesions predominated at the level of the proximal phalanx (90.3%), whereas at the level of the CSL and navicular bone core lesions, sagittal splits and dorsal abrasions were most common. There was a positive association between DDFT lesions and navicular bone pathology involving all aspects of the bone. Lesions of the DSIL (38.2% limbs) were more common than those of the CSL (10.5%), but the presence of either was associated with abnormalities of the navicular bone, especially involving the proximal or distal borders and the medulla.

It was concluded that there are close interactions between injuries of the components of the podotrochlear apparatus, the DDFT, the navicular bursa, and the DIP joint. Core lesions of the DDFT at the level of the proximal phalanx may have a different etiology than lesions occurring further distally. Further knowledge about the biomechanical risk factors

| Table 1. Sensitivity and Specificity of Bone Phase Scintigraphy for Detection of MR Lesions in the Navicular Bone (NB) Overall or for Specific Regions |
|-----------------------------------------------|------------------|------------------|------------------|------------------|------------------|
|  | Sensitivity (%) | 95% CI | Specificity (%) | 95% CI | PPV (%) | NPV (%) |
| Diffuse IRU versus NB overall | 11.8 | 9.0–15.2 | 93.8 | 79.2–99.2 | 96.4 | 7.1 |
| Focal IRU versus NB overall | 23.7 | 19.8–27.9 | 96.9 | 83.8–99.9 | 99.1 | 8.3 |
| Diffuse or focal IRU versus NB overall | 35.9 | 31.4–40.5 | 90.3 | 74.2–98.0 | 98.2 | 8.9 |
| Diffuse or focal IRU versus NB flexor border | 38.1 | 32.4–44.0 | 71.3 | 64.4–77.5 | 65.6 | 44.4 |
| Diffuse or focal IRU versus NB distal border | 36.5 | 31.8–41.4 | 79.7 | 68.3–88.4 | 91.4 | 17.5 |
| Diffuse or focal IRU versus NB dorsal border | 33.6 | 26.1–41.7 | 65.3 | 59.9–70.5 | 31.3 | 67.6 |
| Diffuse or focal IRU versus NB proximal border | 37.4 | 31.2–43.9 | 69.2 | 62.9–75.0 | 54.9 | 52.4 |
| Diffuse or focal IRU versus NB medulla | 40.9 | 35.2–46.8 | 76.2 | 69.4–82.2 | 73.0 | 45.0 |

CI, confidence interval; PPV, positive predictive value; NPV, negative predictive value; Reprinted from Equine Vet J 2007;39:350–355 with permission.
for injury may have importance for both disease prevention and management.

12. Radiography, Nuclear Scintigraphy, and MRI of the Palmar Processes of the Distal Phalanx

Focal IRU in the medial or, less commonly, the lateral palmar process of the distal phalanx has been seen in horses with other primary causes of foot pain resulting in lameness.\textsuperscript{17} Solar, lateral, and dorsal bone phase scintigraphic images of the feet of 258 horses with front foot pain were analyzed subjectively and using profile analysis and compared with radiographs and MR images of the palmar processes of the distal phalanges.\textsuperscript{20} There was focal moderate or intense IRU in the medial or lateral palmar processes in 2.8\% and 1.2\% of limbs, respectively, in solar images of the distal phalanx (Fig. 17). Profile analysis revealed that there was generally slightly higher RU medially compared with laterally in most feet. Major radiographic abnormalities of the palmar processes included marked cortical irregularity and multiple radiolucent zones within the palmar processes (21.1\% of feet), new bone on the ventral aspect of the palmar process (11.8\%), and palmar elongation of the palmar processes (4.6\%), but only cortical irregularity was significantly associated with focal IRU in a palmar process of the distal phalanx.

There was no relationship between the thickness of the sole measured in lateromedial radiographs and focal IRU in a palmar process. Medial and lateral sole depth were compared in dorsopalmar images. In general, lateral sole depth was higher than medial. The solar angle of the distal phalanx to the horizontal was measured in lateromedial images. There was no relationship between focal IRU and the solar angle of the distal phalanx.

In MR images, abnormalities of the palmar processes were seen most commonly medially and included diffuse mild decreased signal intensity in T1- and T2-weighted images (Fig. 18); marked decreased signal intensity in T1- and T2-weighted images with or without a focal cortical defect (Fig. 19); diffuse increased signal intensity in fat-suppressed images (Fig. 20); cortical irregularity; and enthesophyte formation axially at the insertions of the DSIL and DDFT. Abnormalities were most commonly seen in the medial palmar process. There was a significant correlation between scintigraphic grade and MRI grade ($r$ statistic = 0.20, $p < 0.0001$). IRU was significantly over-represented in palmar processes assigned MRI grades 2 (4.5\%) and 3 (25.3\%) compared with palmar processes assigned MRI grades 0 (1.9\%) and 1 (1.7\%) ($p < 0.0001$).

It was concluded that focal IRU in a palmar process of the distal phalanx is not common, but occurs most frequently in the medial palmar process. There were associations between IRU and marked cortical irregularity detected radiographically and between IRU and abnormalities detected using MRI. However, these findings were rarely seen in isolation, and therefore, their significance as a cause of pain and lameness remains speculative.

Fig. 15. Solar scintigraphic image of a foot with focal intense IRU in the distal phalanx at the axial site of insertion of the deep digital flexor tendon. There was a large axial core defect in the tendon close to its insertion identified using MRI.

Fig. 16. Solar scintigraphic image of a foot with focal moderate IRU in the distal phalanx at the insertion of the medial CL of the DIP joint extending palmarly. MRI revealed evidence of desmitis of the medial CL of the DIP joint.
13. Radiography, Ultrasonography, Nuclear Scintigraphy, and MRI of 233 Horses With Collateral Desmitis of the DIP Joint

Horses were examined between January 2001 and July 2006 and were selected for inclusion in the study if there was unequivocal evidence of collateral desmitis of the DIP joint based on ultrasonography or MRI.21–23 The signalment, case history, results of clinical examination and responses to local analgesic techniques were reviewed in 109 horses (group 1) with primary injuries of a CL. The results of radiographic, ultrasonographic, scintigraphic, and MRI examinations were assessed. One hundred thirteen horses (group 2) in which CL desmitis was seen using MRI in conjunction with other injuries were also reviewed, in addition to 11 horses (group 3) examined ultrasonographically but not using MRI.

Group 1

In group 1 (n = 109), 45 horses had unilateral forelimb lameness, 59 had bilateral forelimb lameness, and 5 had a hindlimb injury (1 bilaterally). The medial collateral ligament was injured most frequently in the lame or lamer limb (80 horses; 73.4%), with medial and lateral injuries in 16 (14.5%) and lateral injuries alone in 13 (11.9%). Mild distension of the DIP joint capsule was a common, non-specific observation. In the majority of horses, no localizing clinical signs were seen. Pain could not be induced by passive manipulation of the distal limb joints in any horse. Occasionally, there was focal heat in the region of the injured ligament, or mild swelling, often only detected after clipping in preparation for ultrasonography. Lameness was often mild in straight lines but was invariably considerably worse in circles, especially on a hard surface. Horses with medial collateral desmitis were sometimes lamer, with the lame limb on the outside of a circle.

Horses ranged in age from 3 to 15 yr. Horses that jumped were over-represented compared with the normal clinic population (show jumping, 28; eventing, 22; racing [National Hunt], 2; dressage, 19; racing (flat), 2; endurance, 1; general purpose, 35).

Lameness was improved >50% by palmar digital analgesia in 45 of 101 horses (44.5%), and 36 (35.6%) were sound. Palmar (abaxial sesamoid) nerve blocks abolished lameness in all horses. Retrospectively a uniaxial ipsilateral palmar block improved lameness in horses in which this was performed. Intra-articular analgesia of the DIP joint produced >50% improvement in lameness at 5 min after injection in only 28 of 94 horses (29.8%), and 1 horse became sound. There was no change or <50% improvement in 65 horses (69%). Intrathecal analgesia of the navicular bursa produced no alteration in lameness in 25 of 25 horses.

Forty-eight horses (44%) had positive ultrasonographic findings (enlargement of the ligament with reduced echogenicity), with or without overlying soft tissue swelling and distension of the DIP joint capsule.

In 103 horses, no radiographic abnormality related to the DIP joint or collateral ligament attachments was identified. Two horses had radiographic abnormalities at the ligament’s origin, three at the insertion, and one had subluxation of the DIP joint. Forty-five of 106 horses (42.5%) had focal, mild, moderate, or intense IRU at the site of insertion of the injured CL on the distal phalanx.

| Table 2. Sensitivity and Specificity for Detection of MR Lesions of the DDFT |
|---------------------------------|---|---|---|---|---|---|
|                                | Sensitivity (%) | 95% CI | Specificity (%) | 95% CI | PPV (%) | NPV (%) |
| Pool phase scintigraphy        |               |        |                |        |         |         |
| Overall DDFT score             | 15.1          | 11.1–20.0 | 89.8          | 79.2–96.2 | 87.2 | 18.7 |
| Lesion of DDFT at insertion    | 17.3          | 10.6–26.0 | 88.0          | 82.9–92.0 | 40.9 | 69.0 |
| Lesions of DDFT and DSIL       | 18.5          | 12.7–25.7 | 90.6          | 82.5–94.5 | 63.6 | 55.6 |
| Bone phase scintigraphy        |               |        |                |        |         |         |
| Overall DDFT score             | 16.6          | 12.4–21.6 | 91.5          | 81.3–97.2 | 90.0 | 19.3 |
| Lesion of DDFT at insertion    | 18.3          | 11.4–27.1 | 87.1          | 81.9–91.3 | 40.4 | 69.0 |
| Lesions of DDFT and DSIL       | 19.2          | 13.3–26.4 | 89.4          | 83.8–93.6 | 61.7 | 55.5 |


| Table 3. Sensitivity and Specificity of Bone Phase Scintigraphy for Detection of MR Lesions in the CLs of the DIP Joint |
|---------------------------------------------------------------|---|---|---|---|---|---|
|                                | Sensitivity (%) | 95% CI | Specificity (%) | 95% CI | PPV (%) | NPV (%) |
| Medial CL DIP joint           | 14.8          | 7.9–29.4 | 95.5          | 92.1–97.7 | 52.2 | 77.2 |
| Lateral CL DIP joint          | 7.9           | 1.7–21.4 | 99.3          | 97.5–99.9 | 60.0 | 89.1 |

Alteration in size and signal intensity in the injured CL was identified using MRI in all 109 horses examined in group 1. In addition, 44 horses (40.4%) had a cortical defect or irregularity or abnormal mineralization and/or fluid in the middle or distal phalanx at the ligament’s origin (n = 7) or insertion (n = 37).

Group 2
One hundred thirteen horses had CL desmitis of the DIP joint and concurrent injuries, 85 with multiple injuries involving the DIP joint, deep digital flexor tendon (DDFT), the distal sesamoidean impar ligament, the navicular bursa, or the collateral sesamoidean ligament, usually on the ipsilateral side of the foot; 23 with DDFT tenosynovitis; 3 with ipsilateral fractures of the distal phalanx; and 2 with a fracture of the ipsilateral ossified cartilage of the foot. There was a higher prevalence of medial injuries (105/113, 93%). Ultrasonographic evidence of desmitis was identified in only 13 horses (11.5%). No radiological abnormality was identified at the origin or insertion of the ligament. However, three horses had ipsilateral fractures of the distal phalanx.

Group 3
Eleven horses were not examined using MRI but had unequivocal ultrasonographic evidence of desmitis of the medial (six, 54.5%), lateral (three, 27.3%), or medial and lateral CLs (two, 18.2%). Three horses had associated radiographic abnormalities at the origin or insertion. Eight of nine horses (88.9%) had positive scintigraphic findings.

In horses with primary CL injury (groups 1 and 3), the presence of osseous cyst-like lesions or other osseous pathology at the origin or insertion of a CL of the DIP joint had a negative influence on response to treatment.

14. Conclusions
Correlation between clinical findings and imaging modalities is enabling us to slowly unravel the complexity of the causes of foot pain and to begin to understand some of the risk factors for injury, different pathological mechanisms, and factors influencing prognosis. It is important to emphasize that, although scintigraphy and MRI are hugely valuable tools, in a significant proportion of horses, a conclusive diagnosis can be reached with a thorough clinical ex-

Fig. 17. Solar scintigraphic image of a foot. Medial is to the left. There is focal moderate IRU in the medial palmar process of the distal phalanx. Radiopharmaceutical uptake in the dorsal and lateral images was normal (compare with Figs. 11 and 12).

Fig. 18. Transverse T2-weighted gradient echo (A) and T1-weighted spoiled gradient echo (B) MR images. Medial is to the left. There is mild diffuse decreased signal intensity in the medial palmar process of the distal phalanx.
amination, combined with radiography and ultrasonography. Clinical investigation should follow a logical, step-wise progression.

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References and Footnote


