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Verification of scintigraphic imaging for injury diagnosis in 264 horses with foot pain

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For further information and explanation of terminology see www.evj.co.uk/glossary

Summary

Reasons for performing study: **Nuclear scintigraphy is commonly used as a diagnostic aid for foot pain, but there is limited information about different patterns of radiopharmaceutical uptake (RU) and their correlation with the results of other imaging modalities.**

Objectives: **To describe patterns of RU in horses with foot pain.**

Materials and methods: **Scintigraphic images of the feet of 264 horses with front foot pain were analysed subjectively and using region of interest analysis. Magnetic resonance images of all feet were analysed prospectively; the navicular bones were reassessed retrospectively and assigned a grade. A Spearman rank correlation test was used to test for a relationship between the scintigraphic grade of the navicular bone and magnetic resonance imaging (MRI) grade. Sensitivity and specificity of scintigraphy for detection of lesions in the deep digital flexor tendon (DDFT), the collateral ligaments (CL) of the distal interphalangeal (DIP) joint and the navicular bone were determined.**

Results: **Increased radiopharmaceutical uptake (IRU) was detected in: a) the navicular bone (36.6%); b) pool phase images in the DDFT (13.0%); and c) at the insertion of the DDFT on the distal phalanx (14.3%). 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. There was IRU in the medial and lateral palmar processes in 7.6% and 3.4% of limbs, respectively. There was a significant positive correlation between the scintigraphy grade and total MRI grade for the navicular bone and no difference between either focal or diffuse IRU and total MRI grade. There was high specificity, but low sensitivity of scintigraphy for detection of MR lesions of the navicular bone, the DDFT and the CLs of the DIP joint.**

Conclusions: **Positive nuclear scintigraphic results are good predictors of injury or disease of the navicular bone, DDFT and CLs of the DIP joint. However, a negative scintigraphic result does not preclude significant injuries.**

Clinical relevance: **Nuclear scintigraphy is a useful tool in the investigation of foot lameness and may help to determine the significance of MR lesions, especially if >1 lesion is identified that may be contributing to lameness.**

Introduction

Nuclear scintigraphy is a potentially sensitive indicator of bone turnover and is useful both for the identification of primary osseous pathology and change in bone modelling secondary to ligamentous or tendonous injury. Its value in the diagnosis of navicular bone pathology is well recognised (Trout *et al*. 1991; Keegan *et al*. 1996; Lauk and Wanschura 1998; Dyson 2002; Martinelli and Rantanen 2005). However, increased radiopharmaceutical uptake (IRU) has also been seen in the navicular bone in horses without foot-related lameness (Dyson 2002). Ross (1998) described focal IRU in the proximal palmar medial and lateral aspects of the distal phalanx in American racehorses, attributed to stress-related bone injury. Focal IRU in a palmar process of the distal phalanx, seen in a solar image, is a quite common clinical observation, although not necessarily related to the postulated cause of lameness (Dyson 2003). The frequency of this finding and its clinical relevance is unknown.

Although scintigraphic detection of osseous abnormalities in the foot is well accepted, there has been much less reported on the use of scintigraphic imaging for detection of soft tissue injuries within the foot. IRU in lateral pool phase images in the region of the deep digital flexor tendon (DDFT), between the palmar coronary plexus and the distal phalanx or at its insertion on the distal phalanx in solar bone phase images, has been correlated with lesions of the tendon detectable using magnetic resonance imaging (MRI) (Dyson *et al*. 2003a,b; Martinelli and Rantanen 2005). Lesions of the collateral ligaments (CLs) of the distal interphalangeal (DIP) joint detected using MRI have also been associated with IRU at the site of insertion on the distal phalanx in solar bone phase images (Dyson and Murray 2004; Dyson *et al*. 2004; Martinelli and Rantanen 2005). However, there are no descriptions validating the exact site of radiopharmaceutical uptake (RU) that would be expected at the insertion of the DDFT, the CLs of the DIP joint, or the distal sesamoidean impar ligament (DSIL).

To date there have been no large scale studies verifying scintigraphy results in the equine foot by comparison with any other imaging modality. Previously, it has been difficult to validate scintigraphic interpretation of foot images without necropsy examination and, as scintigraphic imaging is a physiological test, *post mortem* examination is not necessarily ideal for comparison. Recent advances in MRI have provided the opportunity to use this

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as a 'gold standard' with which to validate the results of scintigraphic imaging.

It was hypothesised that focal, but not diffuse, IRU in the navicular bone would be associated with abnormalities of the navicular bone determined using MRI. It was also hypothesised that focal IRU at the insertion of either the DDFT or a CL of the DIP joint on the distal phalanx would reflect injury of the DDFT or CL respectively, using MRI as a 'gold standard'.

The purposes of this study were to determine: 1) the specific sites of RU for the insertions of the DDFT, the CLs of the DIP joint and the DSIL; 2) the frequency of different scintigraphic abnormalities in horses with foot pain; and 3) the sensitivity and specificity of scintigraphic imaging for detection of soft tissue and osseous lesions in the equine foot using MRI as a 'gold standard'.

Materials and methods

Determination of specific sites of radiopharmaceutical uptake for particular soft tissue structures

To verify the sites of RU at the insertion of the DDFT, DSIL, and medial and lateral CLs of the DIP joint, PE tubing containing 35 MBq of 99^m technetium methylene diphosphonate was attached circumferentially around the solar margin of an isolated distal phalanx. Appropriate lengths of sealed PE tubing also containing 99^m technetium methylene diphosphonate were attached to the proximal aspect of the bone at the fossae where the CLs of the DIP joint insert, and to the solar aspect of the bone at the regions of insertion of the DDFT and the DSIL, alone or in combination. A solar scintigraphic image of the isolated bone was obtained. Images were used to determine the specific site of RU at the insertion of the DDFT, the CLs of the DIP joint and the DSIL.

Evaluation of clinical cases

Case selection: All horses were examined at the Centre for Equine Studies of the Animal Health Trust (AHT) between January 2001 and December 2004. Horses selected for inclusion had unilateral or bilateral forelimb lameness that was abolished by perineural analgesia of the palmar (abaxial sesamoid) nerves, but the results of clinical, radiographic, ultrasonographic and nuclear scintigraphic examinations did not conclusively explain the degree of lameness. Only horses that had undergone nuclear scintigraphic and MRI examinations at the AHT were included. Horses were not included in the study if there was poor RU in the distal aspect of the forelimbs (total count in the lateral image of one or both forelimbs <150,000), or if the series of magnetic resonance (MR) images of either forelimb was incomplete.

Acquisition and analysis of scintigraphic images

All horses received 1 GBq/100 kg bwt 99^m technetium methylene diphosphonate, injected via a catheter into the left or right jugular vein. Horses were sedated with detomidine (Domosedan)[1] (10 mcg/kg i.v.) for image acquisition. All images were obtained using a 500 mm circular field of view GE gamma camera and a low energy, general purpose collimator. Dorsal and lateral pool phase images were obtained in all horses. Dorsal, lateral and solar static bone phase acquisitions were obtained 2.5–3 h after injection of the radiopharmaceutical, over at least 2 min, using a 256 x 256 matrix. Images were transferred via an analogue to digital converter to a SunSparc work station and analysed using nuclear medicine software[2].

For acquisition of solar images, the foot being examined was placed on the gamma camera, which lay on the floor. The digit was extended to avoid superimposition of the proximal interphalangeal joint over the region of the navicular bone. In addition, 2 lead thyroid collars were wrapped around the pastern as a shield.

After acquisition, the solar images were enlarged and a region of interest was drawn around the periphery. Counts outside the foot were deleted. The final images were saved for further analysis.

All images were viewed blind by a single observer (S.D.), without knowledge of the identity and clinical history of the horse. A subjective assessment of all pool and bone phase images was made. Radiopharmaceutical uptake in the navicular bone in solar bone phase images was described as diffuse or focal and graded on a 0–3 scale: 0 = normal, *Grade 1* (mild) = <20%, *Grade 2* (moderate) = ≥20 <40%, or *Grade 3* (intense) = ≥40% increased uptake relative to uptake in the distal phalanx (Dyson 2002). If IRU was focal, the region of interest for grading was restricted to this site. The location of focal IRU was described as central, acentric medial or acentric lateral. IRU in one of the palmar processes of the distal phalanx was defined as focal, moderate or intense IRU in the palmar process in a solar image.

MR image acquisition

The pastern region and both front feet were examined by MRI using a human extremity radiofrequency coil, with the feet positioned in the isocentre of a short-bore, flared-end 1.5 Tesla GE Signa Echospeed magnet[3] (Dyson *et al*. 2003a). Sagittal, dorsal and transverse MR images were obtained using 3-dimensional (3D) T1 weighted spoiled gradient echo (SPGR), 3D T2* gradient echo (GRE) and short inversion recovery (STIR) or fat saturated 3D T2* GRE sequences, with a slice thickness of 1.5 mm (SPGR and GRE images) or 4 mm (STIR).

Analysis of MR images

The MR images were evaluated subjectively and prospectively by one of 2 trained analysts (R.M. or G.G.). Structures evaluated included the navicular bone, the DIP joint, the DDFT, the DSIL, the collateral sesamoidean ligament (CSL), the navicular bursa, and the CLs of the DIP joint. Signal intensity and homogeneity, anatomical margins and size, and relationships with other structures were described. The DDFT was defined with respect to region and lesion type and an overall grade assigned, defined as the presence or absence of a lesion distal to the metacarpophalangeal joint. The region of the DDFT was defined as the level of the: insertion, DSIL, navicular bone, proximal aspect of the navicular bursa/CSL, proximal interphalangeal (PIP) joint and proximal phalanx. The navicular bones were graded retrospectively by S.D. (Dyson and Murray 2007a). Each border of the navicular bone (palmar or flexor, distal, dorsal, proximal) and the medulla were assessed separately and a total grade for the navicular bone was assigned based on the sum of the grades for each region.

Statistical analysis

Statistical analysis was performed using statistical software (Analyse-it)[4], with significance set at $P<0.05$. A Spearman Rank Correlation test was used to test for a relationship between the

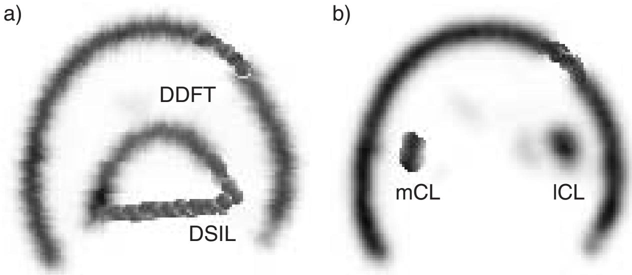

Fig 1: a) and b) Solar scintigraphic images of an isolated distal phalanx with PE tubing containing 99m technetium methylene diphosphonate affixed to the perimeter of the bone and at the sites of insertion of the deep digital flexor tendon (DDFT), the distal sesamoidean impar ligament (DSIL), and the medial (m) and lateral (l) collateral ligaments (CL) of the distal interphalangeal joint. There is a small filling defect in the perimeter tube near the toe.

scintigraphic grade of the navicular bone and MRI grade. A Chi-square test was used to test for a difference between the proportions of diffuse and focal RU between MRI grade, and proportion of scintigraphic navicular bone grades between limbs positive or negative for IRU in the DDFT. Sensitivity and specificity of scintigraphy for detection of MR lesions of the navicular bone, the DDFT and the medial and lateral CLs of the DIP joint was determined.

Further information

Scintigraphic images illustrating grades and patterns of RU may be viewed at www.evj.co.uk/suppinfo. Definitions of statistical terms are in the EVJ Glossary: www.evj.co.uk/glossary.

Results

Determination of specific sites of radiopharmaceutical uptake for particular soft tissue structures

The sites of RU at the insertion of the DDFT, the DSIL, and the medial and lateral CLs of the DIP joint are illustrated in Figure 1.

Evaluation of clinical cases: Two hundred and sixty-four horses were included in the study. IRU in the navicular bone was detected in 36.6% limbs (left 35.8%, right 37.3%). Linear IRU in the lateral pool phase image in the region of the DDFT was detected in 13.0% of limbs (left 14.5%, right 11.4%), whereas focal solar bone phase IRU in the distal phalanx at the region of insertion of the DDFT was detected in 14.3% (left 13.0%, right 15.6%) (Table 1). There was focal IRU at the insertion of the medial CL of the DIP joint on the distal phalanx in 9.4% of limbs (left 9.9%, right 8.8%), and at the insertion of the lateral CL of the DIP joint in 1.5% (left and right 1.5%). In no horse was there IRU at the insertion of both the medial and lateral CLs of the DIP joint. There was focal IRU in the medial palmar process of the distal phalanx in 37 (7.6%) of limbs (left 6.9%, right 8.4%), and in the lateral palmar process in 15 (3.4%) (left 2.7%, right 4.2%) and in both medial and lateral palmar processes in 3 limbs. There was no association between IRU at the insertion of a CL of the DIP joint and IRU in one of the palmar processes of the distal phalanx. No limb had focal IRU at the insertion of the DSIL. Overall there was no difference in the presence of IRU between left and right limbs.

The majority of limbs (overall 63.4%, left 64.1%, right 62.7%) had a scintigraphic grade of 0 for the navicular bone, with 28.0% (left 25.6%, right 30.4%) having *Grade 1*, 7.0% (left 8.8%, right 5.3%) *Grade 2* and 1.5 % (left 1.5%, right 1.5%) *Grade 3*. Of the 192 limbs with IRU, in 34.4% the IRU was diffuse and in 65.1% it was focal, usually central. Only one limb had acentric focal IRU, which correlated with an acentric focal flexor cortex defect detected using MRI.

There was a significant positive correlation (P = 0.0005) between scintigraphy and total MRI grades for the navicular bone. There was no difference between the significance of either focal or diffuse IRU and total MRI grades for the navicular bone.

There was a significant difference in the proportion of limbs with each scintigraphic navicular bone grade between limbs with and without IRU in the DDFT pool phase (P = 0.0004). In the limbs with IRU in the DDFT pool phase, navicular bone scintigraphic *Grades 1* (43%), *2* (10%) and *3* (5%) were relatively over-represented and *Grade 0* (42%) was under-represented, compared with limbs without IRU (navicular bone scintigraphic *Grade 0* - 67%, *1* - 26%, *2* - 6%, *3* - 1%). For IRU at the insertion of the DDFT on the distal phalanx, although the proportion of navicular bone scintigraphic grades was significantly different between limbs with and without IRU (P<0.0001), the greatest difference in proportions was for *Grades 0* and *1*. Navicular bone scintigraphic *Grade 1* was relatively over-represented in limbs with IRU in the DDFT (IRU - 53%; no IRU - 24%), while *Grade 0* was relatively under-represented (IRU - 43%; no IRU - 67%). There were few with *Grades 2* (IRU - 2%; no IRU - 7%) or *3* in either group (IRU - 0%; no IRU - 4%), but a slightly greater proportion in the limbs without IRU.

TABLE 1: Relationship between radiopharmaceutical uptake in the deep digital flexor tendon (DDFT) in a lateral pool phase image and at the insertion of the DDFT on the distal phalanx in a solar bone phase image n = 528 (data missing for 6 limbs)

	Pool phase +	Pool phase -	Total
Bone phase +	15	60	75
Bone phase -	53	394	447
Total	68	454	

TABLE 2: Sensitivity and specificity of pool and bone phase scintigraphy for detection of magnetic resonance lesions of the deep digital flexor tendon (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

CI = confidence interval; PPV = positive predictive value; NPV = negative predictive value; DSIL = distal sesamoidean impar ligament.

TABLE 3: Sensitivity and specificity of scintigraphy for detection of magnetic resonance lesions in the collateral ligaments (CLs) of the distal interphalangeal (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

CI = confidence interval; PPV = positive predictive value; NPV = negative predictive value.

When sensitivity and specificity for IRU in the distal phalanx at the insertion of the DDFT were compared with the presence of an injury of the insertion of the DDFT alone, in combination with an injury of the DSIL or with the overall DDFT MRI grade, there was poor sensitivity (16.6–19.2%), but high specificity (87.1–91.5%) (Table 2), with the scintigraphy relating best to the overall DDFT grade. Similar results were obtained for IRU in the DDFT in pool phase images, with low sensitivity, but high specificity (Table 2). Increased RU at the insertion of the medial and lateral CLs of the DIP joint had high specificity (medial CL 95.5%, lateral 99.3%), but low sensitivity (medial 14.8%, lateral 7.9%) for lesions detected using MRI (Table 3).

Overall, scintigraphy had relatively low sensitivity but high specificity for detection of navicular bone lesions graded as *Grade 1* or greater with MRI (Table 4). Focal IRU was more sensitive than diffuse IRU for detection of navicular bone MR lesions, but both diffuse and focal had similar specificity for detection of these lesions. When different regions of the navicular bone were evaluated, scintigraphy was most sensitive for detection of lesions in the medulla, and least sensitive for the dorsal border. Specificity was greatest for detection of MR lesions in the distal border, and least specific for the dorsal border.

Discussion

The isolated bone study clearly showed that the insertion sites of the DDFT, DSIL and CLs of the DIP joint are readily differentiated. This is clearly a nonphysiological 2-dimensional study. In the live horse, there is 3-dimensional RU in bones and soft tissues, which potentially confounds interpretation. Interpretation of live horse images also utilises a combination of solar, lateral and dorsal images for determination of the site(s) of RU.

This study showed a variety of specific RU patterns in the feet of lame horses. There was high specificity of scintigraphy for detection of MR lesions of either the DDFT, or CLs of the DIP joint confirming our hypotheses, however sensitivity was low. There was a positive correlation between scintigraphic grade of the navicular bone and the overall MR grade. However, contrary to our hypotheses there was no difference between the significance of either focal or diffuse IRU in the navicular bone and total MRI grade for the navicular bone, although focal IRU had greater sensitivity. Lesions of the DSIL could not be predicted using scintigraphy.

In a previous study of 62 horses with desmitis of a CL of the DIP joint identified using ultrasonography alone (n = 4), or by high-field MRI (n = 58), scintigraphy was positive in 29 of 57 horses (50.9%) (Dyson and Murray 2004). Three additional horses had focal intense IRU immediately palmar to the site of insertion of the CL of the DIP joint in association with a fracture of the distal phalanx. Martinelli and Rantanen (2005) documented IRU at the insertion of a CL of the DIP joint in 5 of 6 (83.3%) horses with collateral desmitis diagnosed using low-field MRI. It is currently not known whether there is any correlation between IRU at the insertion of a CL of the DIP joint and the duration or severity of CL injury, the proximodistal location of the lesion, or the presence of osseous pathology detectable using MRI.

In a previous study of 46 horses with lesions of the DDFT diagnosed using high-field MRI alone or in combination with navicular pathology, positive scintigraphy findings for the DDFT were related to the duration of lameness (Dyson *et al*. 2003b). In that study, horses with positive scintigraphy results had significantly shorter duration of lameness compared with horses with negative scintigraphic results. In the current study we did not relate presence or absence of IRU to duration of lameness. There are some difficulties of determining the precise time of onset of lameness because owners often retrospectively recognise that performance was altered prior to the onset of overt lameness. We also believe that some lesions may be present prior to recognisable lameness (Dyson *et al*. 2005). In the current study, IRU at the insertion of the DDFT on the distal phalanx correlated best with the overall grade of DDFT lesion, rather than the presence of a lesion at the insertion. This probably indicates that strain on the insertion site is occurring in tendon injury even if the site of failure is further proximal. In contrast, in a study using low-field MRI, 9 of 30 horses had lesions of the DDFT, 2 of which had IRU at the insertion of the DDFT on the distal phalanx (Martinelli and Rantanen 2005). Both of these horses had lesions at the insertion characterised by increased signal intensity in STIR sequences. However, more proximal lesions may have been missed.

In the current study, IRU in the navicular bone was identified in 36.5% of limbs, whereas, in a recent study of 30 horses (Martinelli and Rantanen 2005), it was detected in 23 (76.7%). It is not clear whether this was unilateral or bilateral, but is suggestive of a higher frequency of IRU. This may be a reflection of different study populations worked in different environmental conditions and that also included horses with radiological abnormalities of the

TABLE 4: Sensitivity and specificity of scintigraphy for detection of magnetic resonance lesions in the navicular bone (NB) overall, or for specific regions

	Sensitivity %	95% CI	Specificity %	95% CI	PPV%	NPV%
Diffuse IRU vs. NB overall	11.8	9.0–15.2	93.8	79.2–99.2	96.4	7.1
Focal IRU vs. NB overall	23.7	19.8–27.9	96.9	83.8–99.9	99.1	8.3
Diffuse or focal IRU vs. NB overall	35.9	31.4–40.5	90.3	74.2–98.0	98.2	8.9
Diffuse or focal IRU vs. NB flexor border	38.1	32.4–44.0	71.3	64.4–77.5	65.6	44.4
Diffuse or focal IRU vs. NB distal border	36.5	31.8–41.4	79.7	68.3–88.4	91.4	17.5
Diffuse or focal IRU vs. NB dorsal border	33.6	26.1–41.7	65.3	59.9–70.5	31.3	67.6
Diffuse or focal IRU vs. NB proximal border	37.4	31.2–43.9	69.2	62.9–75.0	54.9	52.4
Diffuse or focal IRU vs. 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; IRU = increased radiopharmaceutical uptake.

navicular bone. Horses at the AHT with IRU in the navicular bone and radiographic abnormalities consistent with navicular bone pathology did not undergo MRI and, therefore, were not included in the current study. Further analysis of scintigraphy of the navicular bone and MR findings of the podotrochlear apparatus and DDFT are described elsewhere (Dyson and Murray 2007a,b).

Dorsal and lateral pool phase images were obtained routinely, but generally the lateral image was most useful, especially for detection of linear IRU in the region of the DDFT. Early RU into bone was sometimes seen in either the dorsal or lateral image in association with regions of intense IRU in the bone phase images. In the osseous phase, dorsal, lateral and solar images were acquired. The solar image was most useful for detection of IRU in the navicular bone, the palmar processes of the distal phalanx, and the regions of insertion of the DDFT or the CLs of the DIP joint on the distal phalanx. However, comparison with both the lateral and solar images was useful to determine the precise anatomical locations of IRU. The dorsal view was useful for differentiation between RU in a palmar process or in the ipsilateral ossified cartilage of the foot (Dakin *et al*. 2006; Nagy *et al*. 2007).

Although nuclear scintigraphic images are of considerably lower resolution than high-field MR images, differences of pattern of RU at specific sites could be identified. There was some variation in the pattern of RU at the insertion of the DDFT on the distal phalanx between horses. In some, the IRU extended in a curved band across the entire region of insertion, whereas in others IRU was much more focal, either axially or 2 abaxial foci. Likewise, there was some variation in the pattern of IRU associated with the insertion of a CL of the DIP joint on the distal phalanx. Although IRU was focal in most horses, in some it also extended abaxial and palmar to the insertional site, as previously documented (Dyson and Murray 2004; Dyson *et al*. 2004). These differences may reflect the direction and magnitude of strain on the bone at the insertions influenced by conformation of the distal aspect of the limb, position of the foot at the time of injury, severity of the injury, and presence of injury of other closely related anatomical structures.

Increased RU in a palmar processes of the distal phalanx was seen more commonly in the medial palmar (7.7%) than the lateral palmar (3.4%) of the distal phalanx. Focal IRU at the insertion of a CL of the DIP joint was also seen more commonly medially (9.4%), than laterally (3.4%) which concurs with other reports of CL injury of the DIP joint (Dyson and Murray 2004; Dyson *et al*. 2004; Martinelli and Rantanen 2005). However, there was no association between IRU in a palmar process and IRU at the site of insertion of a CL of the DIP joint. In a small proportion of horses (22%) with IRU apparently in a palmar process in the solar image, comparison with dorsal and lateral images revealed that IRU was actually located in the ipsilateral cartilage of the foot or at its base, presumably reflecting bone trauma or fracture (Nagy *et al*. 2007). However, in the majority of the horses in this study, IRU was restricted to the palmar process.

The MR appearance of the palmar processes was not compared with scintigraphy findings in this study. However, in some horses IRU has been associated with evidence of abnormal mineralisation in the palmar process (S. Dyson and R. Murray, unpublished data), possibly because of chronic repetitive trauma; and, detailed analysis is required.

There are some limitations of the current study; for example, it was limited to horses with foot pain. In a previous study (Dyson 2002), a low frequency of occurrence of false positive scintigraphic results was documented in horses without lameness and those with lameness unrelated to the foot. In the current study not all anatomical structures seen using MRI were analysed. Not all patterns of RU were analysed and related to MRI findings. For example, during the study period there were 3 horses with diffuse IRU in the palmar aspect of the distal phalanx that had evidence of primary bone trauma verified using MRI; 2 further horses had more focal regions of IRU associated with osseous cyst-like lesions (OCLLs) in the proximal palmar aspect of the distal phalanx detected only using MRI. Five horses had IRU in the distal phalanx or navicular bone with MR evidence of a previous penetrating injury (Kristoffersen *et al*. 2004). Four horses had IRU at the base of an ossified cartilage of the foot and MR evidence of osseous trauma at the junction between the ossified cartilage and the distal phalanx. Therefore, in the current study, the potential value of scintigraphy is underestimated.

The clinical value of scintigraphy is also underestimated, because some horses with scintigraphic abnormalities identified during the study period did not undergo MRI, as scintigraphy in combination with radiography and/or ultrasonography yielded a definitive diagnosis. These included horses with: lesions of a CL of the DIP joint detected ultrasonographically and verified using scintigraphy; IRU in a navicular bone and positive radiographic findings; a fracture of either the distal phalanx or an ossified cartilage of the foot suspected radiographically and confirmed with scintigraphy; a radiographically detected OCLL in the distal phalanx and focal IRU; and IRU around the solar margin of the distal phalanx associated with atypical laminitis.

In conclusion, positive nuclear scintigraphic results are good predictors of injury or disease of the navicular bone, DDFT and CLs of the DIP joint. However, a negative scintigraphic result does not preclude significant injuries. Further information is required about the significance of focal IRU in a palmar process of the distal phalanx. Nuclear scintigraphy is a useful tool in the investigation of foot lameness and may help to determine the significance of MR lesions, especially if several lesions are identified that may or may not be contributing to lameness.

Manufacturers' addresses

[1]Pfizer Ltd., Sandwich, Kent, UK.
[2]Hermes Nuclear Diagnostics, Gravesend, Kent, UK.
[3]General Electric, Milwaukee, Wisconsin, USA.
[4]Analyse-it Software Ltd., Leeds, UK.

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