

Characterization of Nuclear Scintigraphic and Magnetic Resonance Imaging in horses with Proximal Suspensory Desmopathy RESEARCH ABSTRACT

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Comparison of nuclear scintigraphy and magnetic resonance (MR) imaging abnormalities related to the proximal aspect of the metacarpal or metatarsal regions in 26 horses were reviewed to determine if there was any association between Increased Radioactive Uptake (IRU) patterns with a specific diagnosis based on MRI findings. It was hypothesized that there would be no correlation between the degree of IRU in the proximal palmar (plantar) aspect of the third metacarpal (metatarsal) bone and the specific diagnosis based off of MR imaging. Assessment of radiopharmaceutical uptake patterns of the scintigraphic images were done using region of interest analysis. Significance between these regions were calculated and the severity was objectively and subjectively graded. Correlation coefficients were calculated comparing the severity of scintigraphic lesions to MRI abnormalities. This was further subdivided into soft tissue and hard tissue pathology and subsequently correlated. Horses with both soft tissue injuries and bone injuries each diagnosed by MRI had a relatively poor correlation with nuclear scintigraphic findings. Trends were noted with mild scintigraphy horses having a tendency to more likely represent suspensory ligament pathology alone, and more severe scintigraphy findings being more likely to represent a combination of osseous and ligamentous pathology. However, based on the results of this study, the degree of uptake does not specifically indicate the character, specific structures involved, or the severity of the pathology of the region, and additional diagnostics are necessary for an accurate diagnosis.

Take home message:

Magnetic Resonance (MR) imaging is useful for the diagnosis of desmopathy of the proximal aspect of the suspensory ligament. Nuclear scintigraphy is effective at identifying regions of pathology, but is less sensitive at identifying a specific cause of that pathology.

Introduction:

Pain associated with the proximal metacarpal and metatarsal regions are common source of lameness in equine athletes^{1,2}. An accurate diagnosis is imperative to a successful outcome as it may include lengthy lay-up periods or costly treatment options^{3,4}.

Nuclear scintigraphy has been used for decades in equine orthopedic imaging to identify physiologic changes in bone and soft tissue metabolism and has been used to evaluate sources of lameness⁵. MR imaging is the gold standard in imaging human orthopedic conditions and is increasingly being used in the evaluation of lameness in the equine athlete⁶.

In this descriptive retrospective study of 26 horses with lameness localized to the proximal palmar metacarpal or proximal plantar metatarsal region of the limb, the diagnostic and clinical findings are discussed and the scintigraphic images are compared with the MR images. The purpose of this study is to compare the results of clinical cases undergoing nuclear scintigraphy and MR imaging for orthopedic conditions related to the proximal aspect of the metacarpal and metatarsal regions and to determine if there was any correlation between Increased Radioactive Uptake (IRU) patterns with a specific diagnosis based on the MRI findings. It was hypothesized that there would be no correlation between the degree of IRU in the proximal palmar (plantar) aspect of the third metacarpal (metatarsal) bone and the specific diagnosis based off of MR imaging.

Materials and Methods:

Medical records of 26 horses undergoing both nuclear scintigraphy and MRI from July 2006 to February 2012 were reviewed. Criteria for inclusion were based on the IRU patterns observed in the region where the suspensory ligament originates from the palmar or plantar aspect of the metacarpus or metatarsus. Horses with scintigraphic and MRI examinations greater than one week apart were excluded. Data obtained from medical records include signalment, history, clinical signs and response to diagnostic local analgesia.

Fifteen geldings, seven mares and four stallions with a mean age of 9 years (2-17years) were included in the study. There were fifteen Warmbloods, six Quarter horses, two Thoroughbreds, two horses of unknown breeds and a pony. Lameness's were graded on a scale of 0-5 following AAEP guidelines⁷. The average grade of lameness was 2.5 (range of 0/5 to 3.5/5), with a median lameness score of 2.75. Lameness scores were not available for 6 of the 29 horses. There were 15 horses with forelimb lameness and 11 with hindlimb lameness.

All MRI and nuclear scintigraphy exams were performed within 4 days of each other at a single referral hospital with high field MRI and scintigraphy capabilities. Late pool (bone) phase images from scintigraphy exams were compared with results of MRI examination. MRI images were obtained using a 1.5 Tesla Siemens Magnetom Espree^a with all horses being examined under general anesthesia. MRI examination regions were chosen based on the result of lameness examination, diagnostic analgesia and nuclear scintigraphy findings. ^{99m}technetium methylene diphosphonate (MDP) was the radiopharmaceutical utilized in all cases according to standard acquisition protocols⁵. Nuclear scintigraphy examinations were performed using an IS2 digital gamma camera^b and interpreted using Mirage post-acquisition software^c. MRI images were reviewed using Osirix^d.

Focal regions of IRU from late pool phase scintigraphy examinations were identified by significant uptake of the radionucleotide ^{99m}technetium methylene diphosphonate (MDP) given intravenously. Region of interest (ROI) analysis was accomplished using dorsal and plantar images utilizing Osirix^d. Once the images were obtained, a standard-sized rectangle square was placed onto the images in the dorsal metacarpal or metatarsal regions (Figure 1). The ROI was positioned so its proximal limit was at the carpometacarpal/tarsometatarsal joint. Location and the degree of uptake based of counts per pixel were recorded. Significance between the regions

of interest on each limb was determined using a paired *t*-test with significance at a $p < 0.05$. The percent difference between limbs was determined using the formula:

$$\frac{\text{Affected Limb (ROI)}}{\text{Affected Limb (ROI) + Unaffected Limb (ROI)}} \times 8$$

Severity was objectively assigned to the scintigraphic lesions based on the percent difference between the ROI of the affected and unaffected limbs. A difference of less than or equal to 54% was assigned a mild grade (grade 1), 55-56% was graded moderate (grade 2) and anything above 57% was severe (grade 3). The two primary authors interpreted these observations independently (NRZ and CEJ).

MRI results were identified and classified by structures involved, signal characteristics, size variations, and the presence or absence of osseous or ligamentous pathology. The abnormalities noted on MR images were subjectively graded as mild (grade 1), moderate (grade 2) or severe (grade 3). Bone lesions were categorized based on presence of bone edema, sclerosis or a combination of the two. Severity of the injury was recorded using the same mild, moderate and severe grading scheme. All images were interpreted by a board certified radiologist and a board certified equine surgeon with experience in interpretation of MR images (TCS and CEJ).

Correlation coefficients were calculated comparing the severity of scintigraphic lesions to MRI abnormalities. This was further subdivided into soft tissue and hard tissue pathology and subsequently correlated.

Results:

Twenty-six horses were examined during the prescribed period. Diagnostic analgesia was performed in 20 of the 26 horses. Lameness was abolished or significantly improved from either a high 2-point or high 4(6)-point in 15 horses. One horse blocked to an abaxial and one to the carpal canal region, 5 horses were not blocked and the blocking history was not available for the remaining 4 horses.

The scintigraphic and MRI findings were assessed and compared to the lame limb, which confirmed pathogenicity was in the limb with clinical lameness. The median lameness score was 2.75/5.0. The horses with the highest grade of clinical lameness, 3/5 ($n=9/26$, 34.6%), had an average of $61.7\% \pm 5.8\%$ difference in the ROI between the affected and unaffected limbs, placing them in the severe category of scintigraphic lesions. In addition, when assessing this same population of horses and evaluating the MRI diagnosed ligamentous pathology, these horses had an average severity grade of 1.83, placing them in the mild to moderate category. The horses with a grade 2/5 and grade 1/5 scores of clinical lameness had an average percent difference in the ROI of the affected and unaffected limbs of $54.2\% \pm 2.5\%$ and $56\% \pm 2.3\%$ respectively. When comparing the grades of lameness to the objectively assigned bone scan grades, horses with a grade 2/5 lameness were in the mild category and horses with a grade 1/5 lameness were in the moderate category of scintigraphic lesions.

Horses with pathologic MRI abnormalities were as follows; 22 horses had suspensory ligament pathology, 14 had osseous pathology (MCIII) and 18 had both. The osseous pathology was categorized by cases with bone edema, sclerosis or a combination.

Nuclear scintigraphy examination had a high correlation with lame limb (correlation coefficient = 1.00), however, the findings were not specific in the etiology of the lameness. *t*-test analysis comparing the ROI of the affected limb compared to the unaffected limb, showed a significant difference between limbs ($p < 0.0001$) (Figure 2). The average percent difference between all limbs was $59\% \pm 0.06$. Comparison of the severity of the scintigraphy uptake and the findings on the MRI did not identify any statistically significant correlations between the intensity of the uptake and the specific abnormality on MRI. A trend of horses with a more severe degree of uptake on scintigraphy and having both ligamentous and osseous pathology was noted, but a significant correlation was not obtained (Figure 3). Also horses with a mild, grade 1, scintigraphy findings appeared to have a trend to having soft tissue injuries alone, but again, statistical differences were not noted (Figure 3).

Overall there was poor agreement and correlation between scintigraphic findings with a specific diagnosis. Horses with both soft tissue injuries and bone injuries each diagnosed by MRI had a relatively poor correlation with nuclear scintigraphy findings.

Discussion

Both MRI and nuclear scintigraphy are useful in identifying orthopedic conditions in horses. Each has its relative strengths and weaknesses. Scintigraphy is performed standing under light sedation, but provides a relatively less sensitive technique in identifying the pathology within the limb of the horse when compared to MRI. Scintigraphy provides excellent topographic information about a specific lameness, but does not appear to provide good specificity as to the pathology of an injury. MRI provides excellent tomographic evaluation and anatomical detail of the limb, but requires general anesthesia when performed with a high field system ($>1.0T$). Abnormalities in the suspensory ligament are frequently identified using ultrasonography, which is also performed under light sedation; however, it's of limited accuracy due to the inability to diagnosis bone-related pain.

The findings of this study confirm the proposed hypothesis that the presence and degree of uptake on scintigraphy of the proximal portion of the cannon bone in the region of the origin of the suspensory ligament does not accurately predict the pathological abnormalities found on MRI of the same region. Trends were noted with the mild (grade 1) scintigraphy horses having a tendency to more likely represent suspensory ligament pathology alone (Figure 4), and more severe (grade 3) scintigraphy findings more likely to represent a combination of osseous and ligamentous pathology (Figure 5). This trending implies that more mild uptake on late pool (bone) phase images of the proximal cannon bone region are more likely to represent a soft tissue type of injury. It also implies that more intense uptake will likely represent a combination of both ligamentous and osseous pathology.

This type of trend would be expected since the use of methylene diphosphonate (MDP) as the ligand attached to the radionuclide (technitium) to form the radiopharmaceutical has a high affinity for bone⁵. Methylene diphosphonate has a very high affinity for bone and a much lesser

degree for other structures. It is probable that much of the uptake seen on the scintigraphy exams with ligamentous pathology only are the result of either increased blood flow to the region due to the inflammation associated with the pathology, or bone lesions which are not visible on the MRI images. The increased uptake of the radiopharmaceutical on those cases with bone and bone and ligamentous pathology would be expected to have higher ROI counts due to the remodeling of the bone and the high affinity of the MDP to these regions.

However, based on the results of this study, the degree of uptake does not specifically indicate the character, specific structures involved, or the severity of the pathology of the region. Therefore the presence of increased uptake of radionuclide at this location on scintigraphy exam cannot be used alone to determine which structure is injured. It simply indicates that this is a region of activity that needs to be explored further with additional diagnostic tests.

Specific ligands for orthopedic soft tissues in nuclear scintigraphy are not currently used in the horse. If specific ligands that are specific for soft tissue orthopedic injuries, or radio-labeled antibodies for damaged collagen were available, it might be possible to provide more specificity with the scintigraphy examination alone.

Conclusion

Our analysis confirmed our hypothesis that there was no significant association between increased radiopharmaceutical uptake in the proximopalmar or proximoplantar aspect of the third metacarpal or metatarsal bone and forelimb or hindlimb proximal suspensory desmitis. An osseous lesion could not be distinguished from a ligamentous injury based on scintigraphic images alone. Nuclear scintigraphy is effective at identifying regions of bone pathology, but additional diagnostics are required to make a diagnosis as scintigraphic findings were shown to be nonspecific. In addition, nuclear scintigraphy is also less sensitive at identifying soft tissue injuries in equine orthopedic conditions compared to magnetic resonance imaging and confirms the necessity of additional diagnostics for an accurate diagnosis.

References:

a – Siemens Medical, 51 Valley Stream Parkway, Malvern, PA 19355-1406

b - IS2 Medical Systems, 20 Gurdwara Rd., #3-10, Ottawa, ON Canada, K2E 8B3

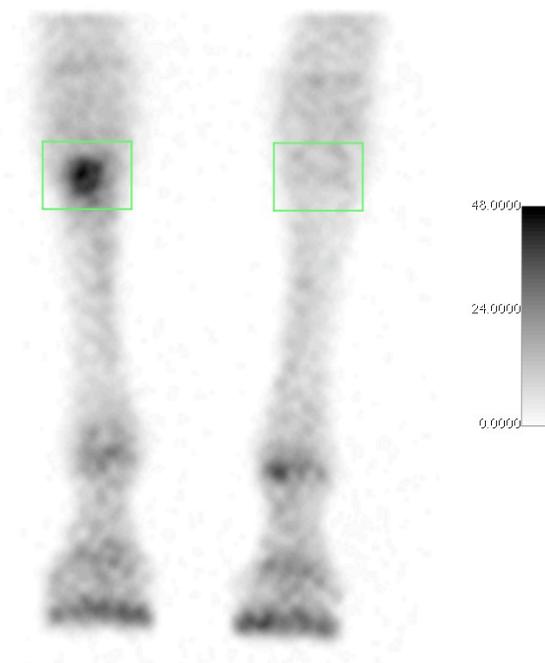
c – Segami, 8325 Guilford Rd, Columbia, MD 21046

d – OsiriX, Antoine Rosset, Geneva, Switzerland

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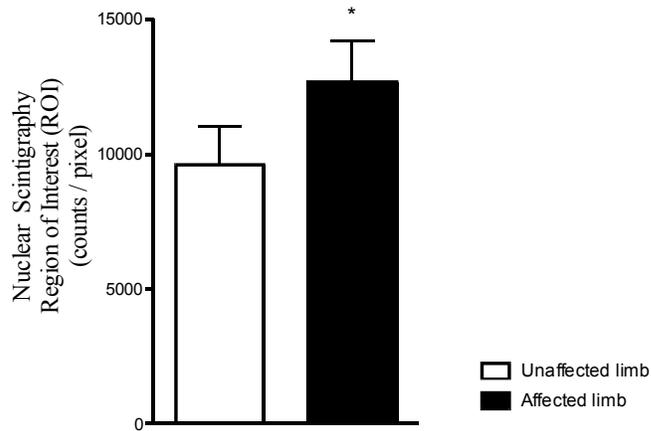
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Figure 1:



Dorsal plane late pool (bone) phase scintigraphy acquisition of the lower front limbs of a horse. Region of Interest (ROI) were obtained using a standard-sized rectangle square was placed onto the images by a computer in the dorsal metacarpal or metatarsal regions. The ROI was positioned so its proximal limit was at the carpometacarpal/tarsometatarsal joint. A standardized sized ROI was utilized for all horses.

Figure 2:



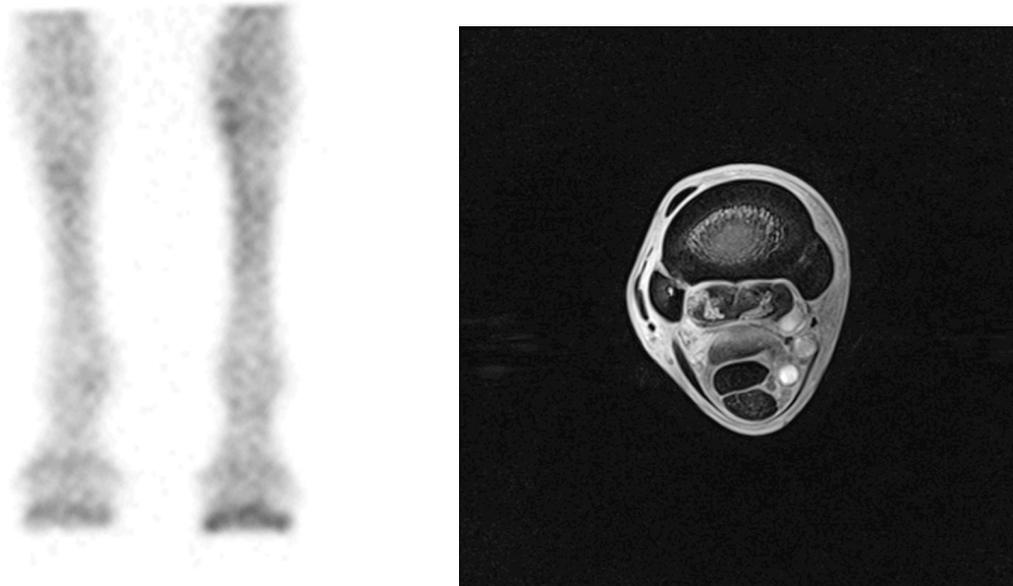
Comparison of the nuclear scintigraphy examination of unaffected (white) and the affected (black) using a paired *t*-test analysis ($p < 0.0001$).

Figure 3:

Scintigraphic Grade	MRI		
	Ligamentous only (n)	Osseous only (n)	Both ligamentous and osseous (n)
Mild (n=8)	7	0	1
Moderate (n=2)	0	1	1
Severe (n=16)	3	2	11

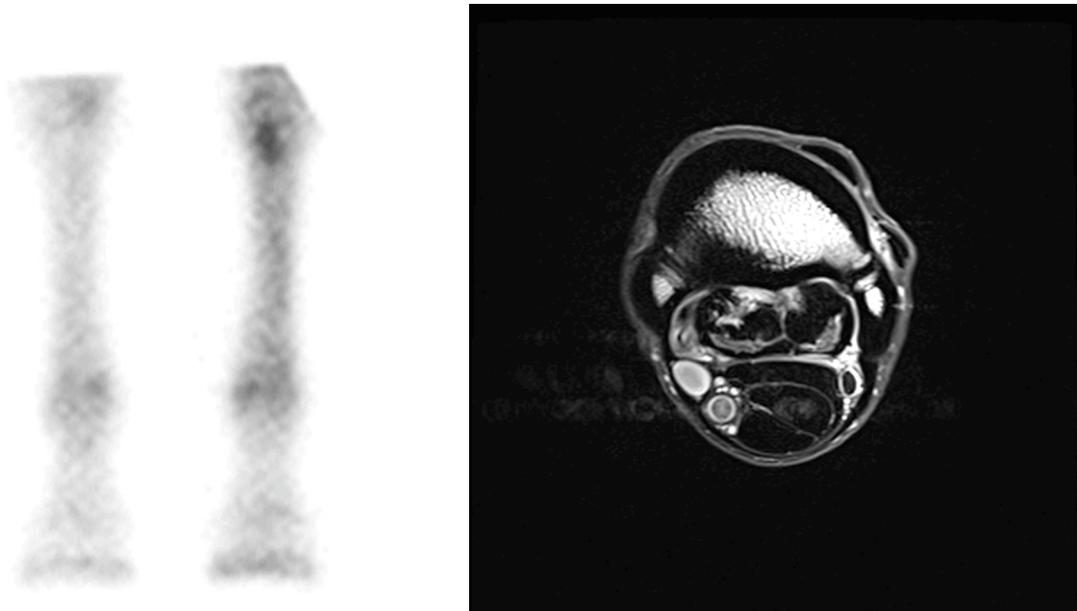
Table comparing objective scintigraphic findings with that of MRI findings. Bone scan grades were assigned based of the percent difference between the ROI of the affected an unaffected limbs (Mild (<54%), Moderate (55-56%) and severe (>57%)). A trend of horses with a more severe degree of uptake on scintigraphy was observed with having both ligamentous and osseous pathology but a significant correlation was not obtained. The mild, grade 1, scintigraphy findings also appeared to have a trend of having soft tissue injuries alone, but again, statistical differences were not noted.

Figure 4:



Palmar late pool (bone) phase projection (left) of the proximal metacarpal region of a horse with a 3/5 right forelimb lameness. This horse had a 51% difference in the ROI of the affected (RF) and unaffected (LF) limb with a mild scintigraphic grade assigned. The MRI image (right) is a T1 VIBE fat saturated axial projection of the proximal metacarpal region of the right forelimb of the same horse with a moderate ligament injury. Note the enlargement and region of high signal in the suspensory ligament.

Figure 5:



Palmar late pool (bone) phase projection (left) of the proximal metacarpal region of a horse with left forelimb lameness. This horse had a 69% difference in the ROI of the affected (LF) and unaffected (RF) limb with a severe scintigraphic grade. The MRI image (right) is a proton density axial projection of the proximal metacarpal region of left forelimb of the same horse showing significant sclerosis and ligament pathology. Note the decrease in signal of the palmar aspect of the metacarpus and the increase in signal within the suspensory ligament. This horse also had significant high signal on T2 STIR sequences consistent with bone “edema.”