Imaging in Practice

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The physical examination and gait analysis are the most important aspects of a musculoskeletal examination. However, knowing how to integrate and interpret diagnostic imaging modalities can significantly enhance both diagnostic potential and prognostic value.

1. Introduction

The current generation of veterinarians relies extensively on evolving technology to provide a high quality of service to their clients. Although this technology enhances many aspects of practice, diagnostic imaging seems to be the element that is changing most rapidly. In many ways, this is an exciting time to be an equine veterinarian. Suddenly, it is possible to visualize, diagnose, and treat conditions that were previously obscure or surmised to exist at best. Digital advances in radiology and ultrasound offer the ability to enhance the images, which provides outstanding detail and better information. The recent availability of magnetic resonance imaging (MRI) in the practice setting has revolutionized the way clinicians can view some anatomical regions, particularly the foot and lower limb. However, with these exciting and innovative advancements in technology comes the added and inherent responsibly associated with interpreting the images accurately. Additionally and possibly more importantly, clinicians must learn to integrate the proper modalities at the correct time in the diagnostic process.

Lameness is one of the most common problems facing equine veterinarians. The sore or lame horse, incapacitated and unable to perform, permeates every aspect of the equine profession from racing and showing to backyard trail riding. Properly and effectively diagnosing and treating these musculoskeletal ailments can be a real challenge, even to the most experienced of clinicians. Part of the difficulty lies in the fact that both effective palpation and gait observation can be difficult to master. More importantly, these skills vary greatly between individuals. Even the interpretation of regional anesthesia can be somewhat subjective, and therefore, prone to differences in opinion [1].

Although deciphering the significance of the imaging modalities in relation to the musculoskeletal abnormality can be fraught with inconsistencies, it can often provide some concrete observations about the nature of the disease or injury. This is particularly true with radiology, nuclear scintigraphy, and ultrasound.

2. Radiology

Radiology is an anatomical imaging modality most adept at determining the nature of the bone being examined. Classically, this has meant identifying fractures or osteoarthritis. In the case of the latter, radiology has been called a historical account of where the joint has been and not necessarily where it is currently. More meticulous and vigorous interpretation, however, can lead to earlier detection of disease processes in certain regions. In these cases, subtle differences in bone density, trabecular detail, and cortical thickness can be identified. Additionally, proper positioning and technique are imperative to such rigorous interpretation.

3. Nuclear Scintigraphy

Nuclear scintigraphy is classified as a metabolic imaging modality, because it relies on the inherent living properties of the tissue to produce an image. A bone seeking agent, usually methylene diphosphonate (MDP), is labeled with a radioactive compound (technetium 99m) to produce a radiopharmaceutical. This is injected intravenously; then, imaging commences. The vascular phase is carried out immediately on injection and images the radiopharmaceutical as it courses through the blood vessels. The soft tissue or pool phase is done within the first 20 - 30 min after injection when the radiopharmaceutical is still present in the soft tissues. The bone phase is done 2 - 3 h after injection when the radiopharmaceutical has been cleared from the soft tissues and is only present in the bone [2]. Nuclear scintigraphy has classically been used to identify abnormalities in bone remodeling, such as stress fractures or osteoarthritis, but it has also become very useful for identifying injuries at the origin or insertion of tendons and ligaments to bone, also known as enthesopathies. Although it is technically easier to produce an image with nuclear scintigraphy than it is with either radiology or ultrasound, image quality is more dependent on the equipment used. Furthermore, the interpretation is such that it must be done in relation to the clinical examination, and it takes some degree of experience to determine the significance of each "hotspot."

4. Ultrasound

Ultrasound is also an anatomical imaging modality, similar to radiology, in that it provides structural information about the site in question. Conventional ultrasonography can identify changes in soft-tissue density and fiber integrity of tendons and ligaments [3]. With proper training and meticulous skill, subtle changes in fiber orientation and consistency can even be identified before palpable detection of these abnormalities, especially in regions that are notoriously difficult to elicit a painful response using palpation. Unlike radiology and nuclear scintigraphy, the ultrasound examination is heavily reliant on the operator's skill level in producing any image, especially one of diagnostic quality. In addition, when the image has been obtained, it must be properly interpreted.

5. MRI

MRI is a new addition to the private practice environment. The recent availability of MRI units capable of imaging the standing horse has brought this technology to the private-practice environment. Although the images will not be equivalent in all aspects to those produced by larger magnets that require general anesthesia, the standing units will provide information about anatomical regions that were not previously accessible using the aforementioned imaging modalities. MRI acquires images by placing the region of interest in an external magnetic field and applying a radiofrequency pulse. MRI is a multiplanar modality that does not rely on ionizing radiation to produce an image. Furthermore, the application of different sequences can provide both anatomical and physiological information about the tissues being imaged. However, the nature of MRI means that the application and interpretation is even more reliant than the current imaging modalities on experience and knowledge of the disease process or injury being imaged.

6. Pre-Purchase Examination

The pre-purchase examination is an important service provided by most performance-horse veterinarians. The client, whether a top professional or a complete amateur, is seeking advice on the purchase of a horse. In this way, the veterinarian is almost functioning as a financial advisor, passing judgment on whether the horse is a sensible purchase for the use intended. This process revolves mainly around the professional opinion of the examining veterinarian. Imaging, particularly radiology, can provide some objective information about the medical condition of the prospective purchase. Anatomical regions to examine radiographically in a pre-purchase examination are the front feet and the hocks. In these cases, the function of radiographs as a "historical account of where the joint has been" can provide useful prognostic information before the purchase.

Feet

Some important considerations in the front feet are the condition of the navicular bone, particularly the corticomedullary junction as seen on the lateral and the skyline view, the presence of osteophytes around the coffin or pastern joints, the amount of sole present, and the orientation of P3 within the hoof (both positive and negative rotation).

Hock

In the hock, the most common conditions to investigate are presence of osteophytes in the distal tarsal joints, loss of joint space, and presence of sclerotic tarsal bones, particularly the central tarsal bone. Additionally, osteochondral fragments or defects can be detected on the distal intermediate ridge of the tibia, the medial and lateral trochlear ridges, and the medial and lateral malleoli. Finally, there should be at least several inches of proximal MT3 on the radiographs to examine for sclerosis at the origin of the suspensory ligament (OSL).
Although it may not always be as common or convenient to radiograph some of the other joints, the stifles and fetlocks can yield important information as well.

Stifle

Stifle films will sometimes reveal osteochondral fragmentation or defects along the lateral trochlear ridge or the medial condyle. These findings are often considered to be found only in young horses, but they may be even more important if found in mature horses. It is also important to look for osteophytosis anywhere but particularly along the medial aspect of the tibial plateau.

Fetlocks

The fetlocks may be radiographed routinely or specifically, such as in cases where the clinical examination has revealed evidence of articular abnormalities like joint effusion or a positive

response to digit flexion. The typical radiographic lesions are often encountered including osteophytes or osteochondral fragmentation. However, an important finding for the pre-purchase examination can be supracondylar bone loss. This narrowing of the cortical bone just above the condyles is often indicative of severe and recurrent joint inflammation, and this may be a very important negative finding in the pre-purchase examination.
Additional joints and regions may be radiographed as part of a pre-purchase examination, but they will not be covered in this manuscript.

7. The Foot: An Anatomical Region Conducive to Rigorous Imaging Techniques

The foot is one of the most common locations of lameness encountered in the equine practice. Many horses exhibit lameness that is easily abolished by a palmar digital (PD) nerve block or improved by the PD block and an abaxial sesamoid block. Conventional radiographs of the foot often do not yield any diagnostic information, and for years, such a condition was diagnosed as "navicular syndrome."

The most important view for determining subtle changes in the navicular bone is the navicular skyline or flexor tangential view [4]. This view is taken from the palmar aspect of the foot with the horse "standing" on the cassette (a tunnel is used to protect the cassette). Proper positioning is imperative for accurate interpretation of this view, because any overlap or obliquity can alter the perception of bone density. However, with a properly positioned view, subtle changes in the density of the medullary cavity of the navicular bone along with early changes along the flexor cortex can be readily identified. Such changes may indicate the beginning of a degenerative remodeling process in the navicular bone. Some of these navicular changes can also be detected on a properly positioned lateral view of the foot where alterations in the trabecular bone can be seen. It is especially important to examine the trabecular pattern of the navicular bone on the lateral view if the skyline view shows evidence of medullary sclerosis and there are no corresponding clinical signs. Additionally, the trabecular pattern of navicular bone should be examined in a pre-purchase examination. A normal trabecular pattern on the lateral view with questionable loss of medullary cavity on the skyline view usually indicates improper positioning on the latter view. The skyline view should be repeated whenever possible or disregarded if the view cannot be repeated if the horse is no longer accessible (i.e., overseas pre-purchase examination).

Another condition in the foot that can be detected radiographically but is often overlooked or misdiagnosed concerns a lucency on the wing of P3. This ovoid lucency is associated with the attachment of the collateral ligament of the coffin joint and may indicate an injury to this structure. Lameness associated with this condition can be blocked out or improved with either a PD, abaxial joint block, or coffin joint block. Interpretation of foot radiology can be enhanced when it is carried out in conjunction with nuclear scintigraphy.

Nuclear scintigraphy has greatly improved our ability to decipher the cause of the lameness in the foot [5,6]. Three distinct patterns of increased radiopharmaceutical uptake (IRU) tend to become evident in cases that block sound or improved to the palmar digital or abaxial sesamoid block. First, the focal IRU can be associated with the navicular bone itself. Second, IRU can be associated with the insertion of the deep digital flexor (DDF) tendon to P3. Third, the diffuse

IRU can be associated with P3. In many cases, there is a combination of one or more of these patterns. The value of scintigraphy of the foot may lie in the prognostic information it provides. Focal and intense IRU associated with the navicular bone is not usually very good news for the athlete showing foot soreness, whereas IRU associated with the attachment of the DDF often resolves. IRU associated with P3 is a bit more difficult to interpret, but it must be done in light of breed and foot conformation. Two other patterns involve focal IRU along one or both wings of P3. One is caused by an injury to the collateral ligament of the coffin joint, whereas the other is likely associated with the attachment of the collateral cartilages of the foot. The latter is more probable if the IRU is located both medial and lateral on the foot.

Ultrasound of the foot has been discussed more recently as a method to evaluate the navicular bursa and insertion of the DDF to P3 [7]. In our experience, ultrasound examination of the foot is only feasible in horses that do not have a thick frog or sole. Most of the horses that we would like to image are of the Warmblood breeds, and their frogs tend to be too substantial to allow for adequate ultrasound wave penetration. In addition, there is only a very small window on midline that can be imaged, whereas many of the injuries documented with MRI occur abaxially. Ultrasound examination can help diagnose collateral ligament damage in the foot, especially when IRU is seen on scintigraphy or the ovoid lucency on the wing of P3 is observed radiographically as mentioned above. Only the proximal margin of the collateral ligament can be imaged in most cases.

8. MRI of the Foot

MRI of the foot has become more feasible in private practice because of the availability of a unit capable of imaging standing horses [8,9]. It is possible to diagnose injuries to soft-tissue structures that were previously inaccessible, such as the insertion of the DDF, the impar ligament, or the distal insertion of the collateral ligament. Additionally, by using different imaging sequences, anatomical and physiological changes in the navicular bone itself can be documented. Although only in its infancy, equine MRI has the potential to radically change the way cases of foot soreness are diagnosed and treated.

Origin of the Suspensory Ligament

The OSL in both the fore and hindlimbs can be a challenging area in which to diagnose lameness problems and to image accurately [10]. Clinically, our practice is presented with a relatively high number of these cases. Some tend to be the primary source of the lameness, whereas others seem to be secondary to another problem. For instance, strains to the OSL in the forelimb are often associated with foot lameness, but strains to the OSL in the hindlimbs can be secondary to an underlying neurologic or top line conditions. In our clinic, palpation of an abnormal OSL in the forelimb will often elicit a painful response, whereas the anatomical location of the OSL in the hindlimb seems to make a painful response in that region much less frequently or not at all. Both problems tend to present with a shortened cranial phase of the stride in that limb, especially when it is on the outside of the circle; however, this finding is more variable in the hindlimb. Regional anesthesia can be carried out by local infiltration of the region or by attempting to block out the nerve supplying that region. In the forelimb, this is the lateral palmar nerve at the base of the accessory carpal bone, and in the hindlimb, it is the lateral plantar nerve as it courses deep into the OSL at the level of the chestnut.

Radiographs of this area can be useful in evaluating the bone in the region of the OSL. In cases of chronic strain, there can be sclerosis of the bone in the proximal metacarpus or metatarsus. This can be seen most readily on an anterio-posterior view, although evaluation of the lateral view of the metatarsus can provide some information about trabecular thickening as well.

Nuclear scintigraphy has proven to be very useful in identifying problems in the OSL of both the fore and hindlimbs. IRU is usually seen as a triangular pattern with the apex extending distally on the palmar or plantar aspect of the metacarpus or metatarsus. The pattern of IRU seems to mimic the region of intimate contact between the bone and the OSL. On the dorsal view, the region of IRU tends to be located in the center of the bone, whereas IRU on one side or the other may indicate a splint bone problem instead. IRU on the bone scan is usually indicative of a more clinically established problem, although it does not always signify that there will be radiographic changes.

Ultrasound remains the most sensitive method of imaging the OSL. It takes some skill to master the technique, especially in the hindlimb. Changes that can be noted with ultrasound range like roughening of the bone at the OSL, fiber abnormalities and disruptions, and complete tears. Some of these changes can be consistent with the normal aging or wear and tear processes, and the ultrasound examination should be correlated with the clinical examination, particularly the regional anesthesia.

Stifle

The stifle is another region that benefits from integrating the imaging modalities with the clinical examination. The physical examination may reveal stifle effusion. However, in many cases, there are no palpable abnormalities. The lameness examination will usually reveal a gait deficit when trotting in hand, but it often becomes more evident when lunging or when under saddle. With a rider, the lameness is usually worse in the correct diagonal with the lame limb on the inside and in the incorrect diagonal with the lame limb on the outside. Regional anesthesia of the stifle joint is the best way to document that the lameness originates there. At our clinic, when the lameness is subtle to moderate, we prefer to block the horse under saddle.

When the horse blocks out to the stifle joint, radiographs are usually obtained. The classic changes associated with developmental orthopedic disease involve lytic lesions along the lateral trochlear ridge of the femur and cystic lesions in the medial condyle. The latter lesion is also becoming more frequently detected in adult performance horses and can range from flattening of the condyle to different sizes and depths of lytic lesions. However, in the adult horse, the etiology is thought to be traumatic instead of developmental. Other radiographic changes noted in documented cases of stifle lameness include osteophyte production on the medial aspect of the tibial plateau and osteophyte production on the proximal aspect of the medial condyle of the femur. Finally, in some cases, there is an ovoid lucency on the proximal aspect of the mid-dorsal tibia, just medial to the intercondylar eminence of the tibia and just below the articular surface.

This lucency is often indicative of an injury or tearing of the medial ligament of the medial meniscus.

Nuclear scintigraphy of the stifle has historically been less fruitful than imaging other anatomical regions. However, the recent diagnostic yield of nuclear scintigraphy of the stifle in our clinic has improved. In cases of stifle cysts, whether developmental or traumatic, there is often a focal area of IRU in the medial condyle. In cases involving injury to the medial ligament of the medial meniscus, there can be a small, focal area of IRU on the proximal dorsal aspect of the tibia. Although these patterns of IRU do occur, it is more common to find a diffuse IRU involving the entire stifle joint.

Ultrasound has become more useful and more frequently employed in our practice when a stifle lameness is diagnosed. The most common examination involves the medial aspect of the joint, particularly the medial joint pouch and medial meniscus. Ultrasound is very good at showing stifle arthropathies that are not visible on radiographs. Ultrasonic examination of the medial joint pouch can document the amount and character of the synovial fluid as well as the thickness and character of the synovial membrane. Small, immature osteophytes can be detected ultrasonically on the distomedial aspect of the femur before they are radiographically evident. Examination of the medial meniscus can determine whether there are any tears or fiber disruptions, including whether the meniscus appears protruded from its "normal" position.

When discussing the stifle, it is important to mention the value of incorporating arthroscopy into the diagnostic continuum. In cases where the lameness can be blocked out to the stifle joint and the conventional imaging techniques mentioned above yield equivocal results, arthroscopy can provide useful information. Additionally, it can sometimes treat the problem as well [11]. Conditions that can be identified include generalized synovitis, occult cartilage damage, cruciate ligament injuries, and some meniscal injuries. In addition, arthroscopy can provide prognostic information as well.

9. Conclusion

Although lameness is one of the most common reasons for a consultation in clinical practice, it remains a challenging aspect of equine veterinary medicine. The most effective way to diagnose the cause of musculoskeletal abnormalities is to integrate a thorough physical examination and an observant gait analysis with the proper combination of imaging modalities. Rigorous acquisition and interpretation of the images can enhance both diagnostic potential and prognostic information [12] (Figs. 1-10).

Figure 1. The navicular skyline view is taken by focusing the radiographic beam on the palmar aspect of the foot (region in red). To view click on figure

Figure 2. Properly positioned skyline view of the navicular bone with good corticomedullary definition. To view click on figure

Figure 3. Sclerotic navicular bone with loss of the corticomedullary junction. To view click on figure

Figure 4. Lucency in the cortex of the navicular bone. A lucency in this region is considered clinically significant when it crosses the corticomedullary junction. This is shown by the black arrows. To view click on figure

Figure 5. Standing MRI of the equine foot. On this sagittal view, the structures of the foot can be visualized in ways not previously possible. The white arrow indicates a defect in the navicular bone at the insertion of the impar ligament. To view click on figure

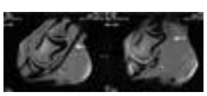

Figure 6. Sagittal views of the front feet of a horse showing a severe tendon lesion. In the normal foot on the left, the white arrows show the DDF tendon (black). In the other foot (seen on the right), the white arrows show no normal tendon signal in the same regions. To view click on figure

Figure 7. Flexed lateral radiograph of the fetlock showing narrowing just proximal to the condyles (black arrow) consistent with articular inflammation (supracondylar bone loss). To view click on figure

Figure 8. Nuclear scintigraphy of the proximal metacarpus shows IRU associated with the OSL. The dorsal view (as seen on the left) shows IRU in the middle of the proximal metacarpus. The lateral view shows IRU in the classic triangular pattern. To view click on figure

Figure 9. Lateral view of the stifle in a 10-yr-old Warmblood showing an osteochondral defect on the lateral trochlear ridge. This middle-aged athlete had not experienced any lameness associated with the stifle until just before this radiograph was taken. Because no prior radiographs of this stifle had been taken, it could not be determined whether this lesion was a new one or an old OCD lesion that had just become clinical. To view click on figure

Figure 10. This is a posterior-anterior view of the stifle in a 22-yr-old horse still competing in athletic events. The large white arrows show osteophytosis along the joint margins and in the region of the collateral ligament origin and insertion. The small white arrow shows mineralization in the medial meniscus. This was confirmed with ultrasound. The black arrow shows an articular defect in the medial condyle. To view click on figure

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