An Approach to Imaging Algorithms for Equine Lameness Diagnosis

Elizabeth M. Charles, DVM, MAa,*, Norman W. Rantanen, DVM, MS, DACVRb

INTRODUCTION

The last 15 years have seen tremendous growth and advancement in equine diagnostic imaging. Increased availability of MRI, CT, and nuclear scintigraphy, as well as technical improvements associated with digital radiography and ultrasound, give the equine practitioner a vast array of diagnostic tools to help determine the cause of lameness. With this surge in diagnostic information comes the need to better understand each of the available imaging modalities. Specifically, the equine practitioner must be able to clearly identify which imaging modality will provide the best information for lameness diagnosis given the history, physical and/or clinical examination, and parameters set forth by the client. Developing a systematic approach to the application of imaging modalities within the process of lameness diagnosis gives the equine practitioner a consistent method and evidence-based approach to lameness diagnosis. This process will improve patient outcomes and provide a framework to gather clinical data that can be shared with colleagues.1

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a Western University of Health Sciences, College of Veterinary Medicine PO Box 38, Temecula, CA 92593, USA; b PO Box 2950, Fallbrook, CA 92088, USA
* Corresponding author.
E-mail address: echarles@westernu.edu
Historically, lameness evaluation has relied heavily on practitioner experience and subjective clinical impressions. Improvement in imaging modalities available for use in equine patients has not changed this dramatically because localization of lameness during the clinical examination is still paramount in determining which imaging modality is most appropriate. However, advances in imaging allow for a more definitive diagnosis of lameness. The best current example of this progress is illustrated by considering lameness that originates in the foot.

Before the use of advanced imaging, a right forelimb lameness that blocked to a palmar digital nerve block (PDNB) and then switched to a left forelimb lameness that was also alleviated with a PDNB was a clinical pattern attributed to “navicular disease” and was often treated with conservative therapy or neurectomy. Now, veterinarians understand that this clinical presentation could be the result of numerous types of injuries within the hoof capsule, not just injury to the navicular bone. Many of these injuries will not respond to the traditional conservative therapy. Advances in the profession have helped lead toward a more scientific, evidence-based approach to lameness, one in which synthesis of the history, clinical examination, and owner expectations and goals for the use of the horse, with diagnostic imaging findings lead to a more accurate diagnosis and appropriate treatment plan. An approach for this process using an algorithmic foundation is presented in this article.

The goal of this article is not to provide an algorithm for every possible lameness scenario. Instead, the goal is to provide a basic framework with an underlying algorithmic foundation that can be applied to choosing imaging modalities during lameness evaluation. The approach presented here is not meant to be a recipe that should be followed in every situation. Instead, it is a guideline for developing a systematic thought process and approach to selecting the appropriate imaging modality, one that takes into consideration the many nuances associated with working with horse owners and equine patients.

In a perfect world, the veterinarian could make all lameness evaluation decisions based on case-controlled studies that not only support how the clinical data should be interpreted but also which diagnostic modality is most appropriate for arriving at the correct diagnosis. The client’s opinions and ideas would not come into play nor would the client’s financial circumstances. Thousands of cases compiled into rigorously reviewed clinical research would support or refute the use of the available treatment options. The profession is moving toward an evidence-based approach to lameness evaluation, diagnosis, and treatment. However, every diagnostic decision the veterinarian makes is influenced by factors unrelated to the actual lameness problem, such as financial constraints. The approach presented attempts to factor in many of the influences affecting the decision-making process so the most appropriate imaging modality for the situation can be selected.

Khalil and colleagues define an algorithm as “a widespread instrument for increasing efficacy and managing quality in medicine by the implementation of specified standards into a systematic, logical, evidence-based, and rational concept.” In human medicine, thousands of algorithms using data collected in thousands of clinical studies have been published to aid clinicians in the delivery of appropriate care to their patients. The same is not true of veterinary medicine. Although more prevalent in small animal medicine and surgery than in equine medicine and surgery, very few algorithms for equine lameness and imaging have been published. This article uses the term algorithm loosely because there are no published data or case numbers to warrant the development of algorithms such as those published in human medicine.

As the standard of care in equine veterinary medicine continues to improve, attention to a systematic, logical, evidence-based approach to lameness and imaging is
essential. The following basic outline forms the foundation of the algorithmic approach (Fig. 1):

1. Establish a relationship with the client.
2. Obtain a complete history.
3. Discuss expectations, goals, and financial considerations.
4. Examine the horse.
5. Localize the lameness.
6. Choose an appropriate imaging modality.
7. Revisit expectations and goals in light of initial diagnostic imaging results.
8. Further localize the lesion, if necessary.
9. Use an advanced imaging modality, if warranted.
10. Arrive at a final diagnosis.
11. Develop and implement a treatment plan.

The goal of this paper is to focus on the portions of the algorithm that pertain to choosing the appropriate imaging modality. Although it is recognized these decisions are influenced by factors seemingly unrelated to choosing the best imaging modality. For example, availability of imaging modalities within the practice area will influence which imaging modality can be chosen, as will the client’s financial constraints. Thus, the history, clinical examination, expectations and goals, and localization of lameness are all important because the information gained during every step in the process will inform the decisions made with regard to imaging modality.

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Fig. 1. Basic imaging algorithm for equine lameness diagnosis.
ESTABLISH A RELATIONSHIP WITH THE CLIENT

An effective algorithm for use in lameness and imaging does not start with the physical examination of the horse. Effective and appropriate communication with all members of the horse’s team is critical and it begins with establishing a relationship.10 Not only will such effort result in key information regarding the horse’s condition, it will also eliminate confusion and unclear or unmet expectations, as well as reduce the chance of an undesirable outcome for all parties involved.

Because equine practice is so varied (eg, solo practitioner vs referral hospital vs group ambulatory practice), a one-size-fits-all approach to relationship-building and communication does not work. In equine veterinary medicine, establishing a relationship with the client can be difficult because often, it is more than just the client who is involved with the horse. Multiple scenarios are possible. The horse may just have one owner who is also responsible for all the care and training of the horse. A trainer could be involved with the owner. The owner may be an absentee owner and the trainer makes all the decisions. Or, there could be multiple owners, as is common in the racing industry, all with potentially different expectations.

To get an accurate history, understand all the expectations and future goals for the horse, and to communicate effectively about the options available for diagnostics in a lameness case, all parties must be included in the conversation in a way that allows the financially responsible person and/or party to be comfortable. Ultimately, it is the relationship with the client that will direct what the veterinarian can and cannot do from a diagnostic standpoint.

EXPECTATIONS, GOALS, FINANCIAL CONSIDERATIONS

The algorithm for working up a lameness case will depend on the client’s expectations and goals (eg, broodmare expected to be sound enough to stand in the pasture vs preliminary level event horse vs grand prix jumper) as well as the client’s financial resources (eg, obtain the most information for the smallest amount of expense vs no financial restrictions). Veterinarians must assimilate the client’s wishes, stay within the budget, and communicate clearly and often about how the constraints of the budget are affecting the progression of the case, all while trying to arrive at a correct diagnosis.11

OBTAIN A COMPLETE HISTORY

When working up a complicated lameness case, obtaining a complete history is essential and can change the course of decision-making. For example, if the horse has already had diagnostic imaging, this may change the initial choice of modality, depending on whether the previously acquired images are available. A complete history includes signalment (age, sex, breed, use) and a summary of the current problem (ie, precipitating event, duration, treatments tried and response to those treatments, exacerbating activities).12,13 Detailed information about previous medical issues or musculoskeletal injuries as well as how those issues were treated may also be important.

Because the veterinarian depends on the client for historical information, using effective communication skills is critical. Dysert, Coe, and Adams14 have shown that failing to allow the client to voice their concerns at the beginning of the appointment leads to increased client complaints. Thus, allowing the client to tell their story about the horse’s condition is paramount. This is best done by asking an open-ended question and then allowing the client to talk.15 Veterinarians do not often
choose this approach because of concerns that the client will ramble about the problem. Though veterinarians are only beginning to better understand the role of effective communication in the veterinarian-client relationship, research done in human medicine is helpful. Contrary to popular belief, the patient will often provide a succinct summary of his or her concern in less than 3 minutes. Preliminary work in veterinary medicine suggests similar timeframes will hold true in veterinarian-client interactions. After allowing the client the opportunity to share information, the veterinarian can then ask clarifying questions to gain better understanding. Including any other veterinarians involved with the case can shed light on the problem as well.

EXAMINE THE HORSE AND LOCALIZE THE LAMENESS

An in-depth discourse about lameness evaluation and localization is beyond the scope of this article. However, three important points should be considered here because these play a large role in determining which imaging modality to select.

First, lameness detection is a very subjective process. Research indicates that equine practitioners often differ in the interpretation of lameness evaluation performed on the same horse. More specifically, when watching the same horse trot, practitioners often do not agree on which limb is the lame limb. In an effort to move toward more objective assessment of lameness, slow-motion video, force plate evaluation, and, most recently, development of the Lameness Locator Needs a registered trademark. (Equinosis, Columbia, Missouri, USA) have been implemented to increase the ability to accurately assess which limb is lame. As lameness detection becomes more objective and accurate, correct imaging modality selection will also become easier.

Second, many of the diagnostic tests used to determine the source of pain are also subjective. Flexion tests, hoof tester evaluation, and numerous other manual manipulations used to detect and localize pain are all subject to evaluator bias and interpretation, which may or may not be accurate. As mentioned above, as equine practitioners begin to use diagnostic tests that are objective in nature and reliably repeatable, correct imaging modality selection will become easier.

Finally, research evaluating the sensitivity and specificity of diagnostic anesthesia has revealed that absolute anatomic boundaries in the interpretation of results cannot be relied on. For example, significant proximal diffusion of anesthetic along the neurovascular bundle is possible after performing a PDNB or when attempting to desensitize the palmar metacarpal nerves. Type of anesthetic, volume of anesthetic, time following administration of the anesthetic, and the blocking technique used are all factors that need to be considered when interpreting the patient’s response.

SELECTING AN IMAGING MODALITY

The equine practitioner has numerous diagnostic imaging options when working up a lameness case. When selecting a modality, several factors must be considered. As mentioned above, the owner’s goals, objectives, and financial situation all shape the direction of case management. The clinical evaluation may direct toward a modality more suited to soft tissue (ultrasound, MRI) or may put osseous injury higher on the list (radiography, CT, scintigraphy). If the patient is going to be evaluated in the field, options are limited to radiography and ultrasound. The availability of advanced imaging may affect possible options as well.

Radiography is often the first modality of choice for several reasons. It provides excellent visualization of osseous structures, is readily available, can rule out
numerous differential diagnoses, and is cost-effective. Radiography not only helps rule out osseous injury but also gives the practitioner historical and baseline information about the imaged osseous structures. The downside to radiography is its inability to detect lesions unless a significant amount of pathologic change is present. It can also be difficult to identify nondisplaced fractures unless the beam is directed at precisely the angle of the fracture line.

Ultrasound is also readily available and cost-effective. Although ultrasound is generally thought of as providing excellent soft tissue images, it is also more sensitive to small, superficial osseous abnormalities than radiographs are. It is a great adjunct to radiography when an equivocal bone lesion is identified radiographically and is in a region that is accessible with ultrasound. Obtaining diagnostic images is very operator dependent. Therefore, ensuring the sonographer has adequate training and skill is essential.

Certain modalities, such as MRI and scintigraphy, can reveal multiple findings. These findings then need to be evaluated to determine which have clinical significance. In contrast to several findings from one imaging study, a lack of findings also provides important information, even though this is often seen as unrewarding and can be interpreted as a waste of money. Ruling out a diagnosis brings the veterinarian one step closer to finding the answer.

All modalities have advantages and disadvantages that should be considered and presented in the decision-making process. The inherent advantages and disadvantages of each modality do not change. However, the modality that is most appropriate given all the factors in the case is what affects the selection process. What is seen as an advantage to one client (definitive diagnosis with advanced imaging) may be seen as a disadvantage another client (too expensive and does not really need a definitive answer). This complex decision-making process is demonstrated in the following case presentations. The algorithmic approach will be applied to each scenario. Key questions will be considered at each junction to help the reader better understand how to use the algorithmic approach in a real-world situation. Although the emphasis will be on questions related to selecting the best imaging modality for the situation, a brief synopsis of the first four steps in the decision tree is included.

**CASE #1**

*Owner Goals, Expectations, and Financial Considerations*

The first case is a 17-year-old Quarter Horse gelding owned by a 63-year-old widow who uses the horse mostly as a trail-riding horse, but she also does a little arena work with the horse. The horse is not ever used competitively. The owner would like to continue to use the horse as her riding horse, but if he is not able to do so comfortably and safely with minimal management and expense, she will retire him to a large grass pasture if that scenario will allow him a comfortable life. The owner is on a budget but recognizes the importance of understanding the cause of her horse’s lameness. She asks to be informed about all costs as the process unfolds.

*History*

The horse has had a chronic right forelimb lameness that was treated with nonsteroidal antiinflammatory drugs, rest, and corrective shoeing, which allowed the horse to continue as a trail horse for approximately 6 months with minimal evidence of lameness. He presented because his lameness is no longer responsive to the conservative treatment strategy.
**Lameness Examination**

On examination, the horse showed a grade 3/5 right forelimb lameness when trotting in a straight line. Circling, both to the right and to the left, exacerbated the lameness. No evidence of soft tissue swelling was noted nor was the patient sensitive to application of the hoof testers to either front foot. Flexion of the right front distal limb was positive. Following PDNB, the horse was markedly improved, indicating the source of the lameness is likely in the foot, although lameness originating more proximally in the limb cannot be completely ruled out. With the right foot blocked, the horse did not show any evidence of lameness in the left forelimb.

**Imaging Selection**

Based on the patient’s signalment and the blocking pattern, injury to one or more structures in the foot, either osseous or soft tissue in origin, is possible. Radiography is readily available and is often the preferred first-line diagnostic imaging modality. In this case, radiographs of the right front foot were within normal limits. Two options exist for this scenario. Either the lesion is not radiographically evident (early osseous change or soft tissue injury) or the lameness has not been localized correctly.

Taking into account the patient’s breed (Quarter Horse), history (chronic lameness), and response to conservative therapy, a soft tissue injury within the hoof capsule or an osseous abnormality not identified on radiographs are ranked higher than improper localization of the lameness (Fig. 2). MRI provides superior visualization of the soft tissue structures within the hoof capsule. MRI is chosen over further localization, ultrasound, CT, or scintigraphy. The client is informed of the costs associated with MRI as well as the costs associated with continuing to treat the lameness conservatively without a specific diagnosis. She approves the MRI evaluation.

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**Fig. 2.** Case #1 - Initial evaluation and diagnostic imaging.
MRI was performed and revealed a lesion in the flexor cortex of the navicular bone in the left front foot. Review of the original radiographs following lesion identification on MRI confirmed that the lesion was not identifiable on the radiographs (Fig. 3).

CASE #2
Owner Goals, Expectations, and Financial Considerations

The second case is a 10-year-old Warmblood (WB) gelding that is used as a 1.40 m jumper. His owner is involved with his care, but the trainer manages the horse and does most of the riding. The owner hopes the horse will continue competing at his current level successfully. There are no financial constraints in this case (Fig. 4).

History

The horse has had a mild, intermittent lameness over the past 2 months that has responded to short rest and 1- to 2-day treatment with antiinflammatory medication. The horse presented for an acute onset left forelimb lameness following a recent competition. The lameness was more significant than previous bouts of lameness.

Lameness Examination

On examination, the horse showed a grade 3/5 left forelimb lameness that was worse in a circle to the left. The horse was moderately positive to flexion of the left front distal limb. Following a PDNB of the left front foot, the horse was markedly improved, indicating the source of the lameness is likely in the foot. However, similar to first case, lameness originating more proximally in the limb cannot be ruled out. The horse did not show any evidence of lameness in the right forelimb with the left front foot blocked.

Imaging Selection

Radiographs are again the modality of choice because they provide excellent visualization of the osseous structures, are readily available, can rule out numerous differential
diagnoses, and are cost-effective. Radiographs of the left front foot revealed no obvious abnormalities. As in the first case, two options exist for this scenario. The lameness either has been localized appropriately and radiography does not allow the lesion to be identified in the foot (early osseous change not radiographically apparent or lesion is within the soft tissues of the foot) or the lameness is somewhere other than the foot.

The previous case had a significant amount of supporting data, in addition to the blocking pattern, to warrant MRI. The horse’s breed, history, and response to treatment of the foot all pointed to the lameness being caused by injury in the foot. The data in case number two are not as cut and dry. An argument could be made that the blocking pattern, in combination with an acute or chronic presentation of a lameness that blocks to the foot, could suggest of injury to the deep digital flexor tendon at or near its insertion. It must be decided whether to trust the initial block and continue to MRI or reblock to make sure the initial localization is correct. In this case, MRI of the foot was performed. No lesions were identified. Negative radiographs coupled with a negative foot MRI make the likelihood that the lesion is in the foot unlikely. Improper localization of the lameness must now be considered.

At this juncture, two options exist. Reblocking the horse to try and further localize the lameness using a different approach than the initial examination could be considered. Alternatively, another imaging modality could also be considered. In this case, because the horse has a significant lameness and no evidence of soft tissue involvement (no swelling, no pain on palpation of the tendons and ligaments), nuclear scintigraphy (a limited scan of the front limbs instead of a complete exam of the front limbs, if money were an issue) is the most helpful modality because it will further localize the lameness, especially if osseous in nature. A limited scan of the front limbs revealed an area of increased uptake in the medial aspect of the fetlock, localizing the cause of the lameness to this region (Fig. 5).

Radiographs of the fetlock were within normal limits. MRI of the fetlock revealed an articular cartilage and subchondral bone defect in the medial condyle of the third metacarpal bone. Adjacent to the third metacarpal bone injury, there was diffuse fluid in the trabecular bone of the proximal phalanx.

Fig. 4. Case #2- Initial evaluation and diagnostic imaging.
This case illustrates several important points. First, diagnostic anesthesia can be very misleading. Though it is often reliable, when the blocking pattern points to a certain location but the next steps in the diagnostic plan are not supportive of a lesion in this region, another cause for the lameness must be considered. In this case, nuclear scintigraphy (instead of reblocking) led to appropriate localization of the lesion that could then be further characterized using MRI. Following MRI of the fetlock, an intraarticular fetlock joint block was performed that completely resolved the lameness, confirming that the lesion identified in the fetlock was the cause of the patient’s lameness (Fig. 6).

Second, financial constraints were not an issue in this case. Multiple modalities were used without worrying about the overall cost to the owner. However, a limited budget would have required a different decision-making process for this case, one that may not have led to a definitive diagnosis. Instead of using scintigraphy for localization, further diagnostic blocks could have been used leading to correct localization to the fetlock, at which point MRI could have been considered because radiographs of the fetlock were inconclusive. In this case repeating the PDNB would have likely produced the same result. Therefore, a comparison of the response achieved by the PDNB to intraarticular analgesia of synovial structures that could have been affected by PDNB would have been necessary to further localize the lameness.

CASE #3
Owner Goals, Expectations, and Financial Considerations

The final case is a 10-year-old Hanoverian mare that is used predominantly as a lower-level dressage horse, but the owner also enjoys jumping. The owner would like the mare to continue competing with the hope that she will improve and move up. She is concerned about how much everything is going to cost, but is willing to do whatever is necessary as long as she is informed about the total bill at each step in the plan. She
informs the veterinarian that she may have to wait to do certain tests so she can save enough money to pay at the time of service (Fig. 7).

**History**

The mare has started to resist moving in a collected frame. The owner also notes that the mare’s behavior has changed. The mare used to be very willing to work and is now no longer interested. The mare has also started refusing jumps.
**Lameness Examination**

On examination, the horse showed a short, choppy gait in the front, though no overt lameness was appreciated. The mare was resistant to circle to the right when on the lunge line. She was also sensitive to hoof testers in both front feet as well as sensitive to palpation of the caudal neck. Her lateral cervical range of motion, subjectively assessed using the treat at the flank test, was decreased to the right when compared with the left.

**Imaging Selection**

Based on the clinical picture, short choppy gait in front with a resistance to bend and subjective decrease in cervical range of motion, the likelihood of two separate issues, one in the feet and one in the neck, was considered. If there was no evidence of foot pain, cervical radiographs could have been considered. If there was no evidence of cervical involvement, diagnostic analgesia of the feet could have been considered. Multiple issues coupled with the owner’s report of poor performance made nuclear scintigraphy the modality of choice, specifically a front-end bone scan, including the neck.

Scintigraphic examination revealed increased radiopharmaceutical uptake in the caudal cervical facets, specifically C6-C7. Mild, diffuse increased radiopharmaceutical uptake was also seen in both front coffin bones.

Discussion with the owner led her to opt for treatment of the facet joints. Because treatment of the facet requires ultrasound guidance, facet arthrosis was confirmed when the joints were treated. Following treatment, the mare was significantly...
improved for approximately 8 months, at which point she began showing similar clinical signs. Treatment of the facet joints was done again with similar response (Fig. 8).

**SUMMARY**

Continued growth and advancement in equine diagnostic imaging, coupled with increased availability of advanced imaging modalities, will require equine practitioners to better understand each of the available modalities. The algorithmic approach described above gives practitioners a system for assimilating information gathered during the history, physical and/or clinical examination, and other parameters set forth by the client into an appropriate diagnostic imaging plan. This systematic approach will lead to more accurate diagnoses and improved patient outcomes.

**REFERENCES**


