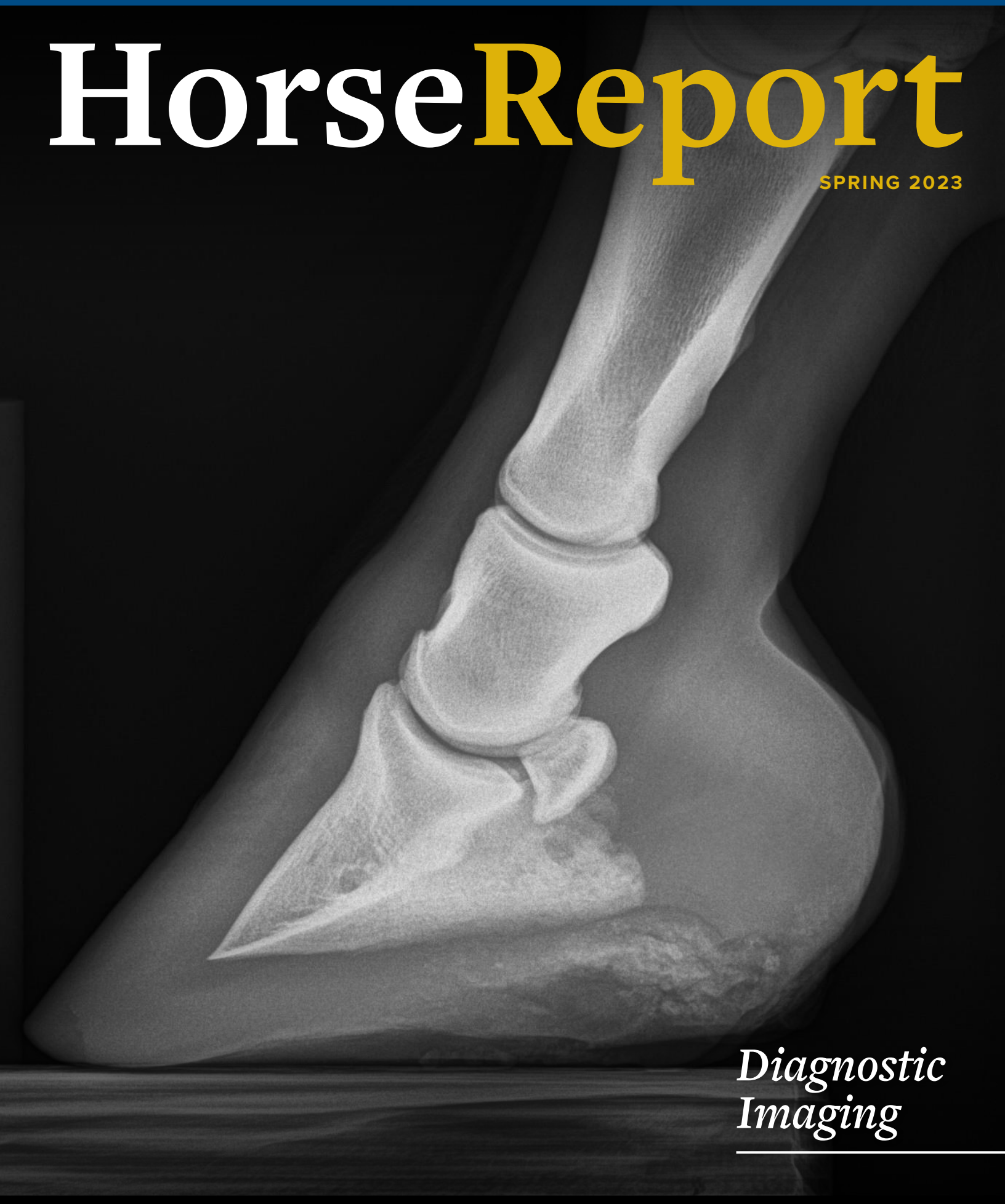
UC DAVIS SCHOOL OF VETERINARY MEDICINE • CENTER FOR EQUINE HEALTH

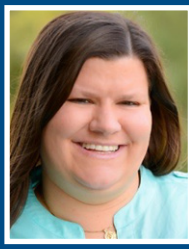
HorseReport

SPRING 2023



Diagnostic Imaging

THANKS TO OUR COLLABORATORS



Kathryn Phillips, DVM, DACVR, DACVR-EDI – Dr. Phillips is a double board-certified radiologist with expertise in diagnostic imaging in a variety of species. Her research focus is on equine and exotic animal imaging.

Mathieu Spriet, DVM, MS, DACVR, DECVDI, DACVR-EDI – Dr. Spriet is a multiple board-certified radiologist. His research focus is in advanced musculoskeletal imaging in horses, particularly the development of PET imaging for lameness assessment in sport horses and prevention of catastrophic breakdown in racehorses.

Betsy Vaughan, DVM, DACVSMR – An expert in large animal ultrasound, Dr. Vaughan's interests include equine musculoskeletal injuries and rehabilitation, as well as equine and livestock abdominal imaging.

Mary Beth Whitcomb, DVM, MBA, ECVDI (LA-Associate) – Professor Emeritus Whitcomb is an expert in large animal ultrasound. Her research focus is ultrasonographic techniques and educational models for the diagnosis of upper limb lameness in horses.

DIRECTOR'S LETTER

I hope that the longer days and sunnier spring weather have been translating into more time with your horses. I am personally enjoying a return to three-day eventing competitions after a very wet winter here in Northern California.

The focus of this issue of the *Horse Report*, diagnostic imaging, is important to me professionally as a veterinarian and researcher and personally as a horse owner. It has been more than a year since my Thoroughbred gelding, Chat, sustained a coffin bone fracture. The diagnosis and treatment plans for his injury relied on X-rays, which were performed at the UC Davis veterinary hospital. I am happy to say that Chat is now in full work after repeated follow-up exams with our imaging team. We are incredibly fortunate to have advanced imaging equipment and highly trained clinicians and veterinary technicians on hand to provide this important service at UC Davis.

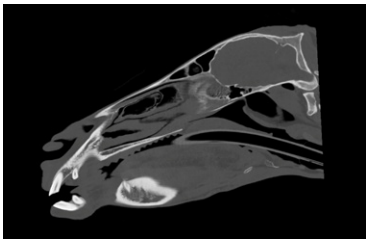
Our faculty contributors for this issue - Drs. Kathryn Phillips, Mathieu Spriet, Betsy Vaughan and Mary Beth Whitcomb - are experts in all forms of equine diagnostic imaging. In addition to providing top-of-the-line care for patients, they also conduct research to advance imaging approaches and applications, which continues to make UC Davis a leader in this area. We are grateful for their time and expertise to provide the most up-to-date information on this topic.

From X-rays to CT, our goal for this issue is to demystify these commonly performed but often poorly understood technologies. Diagnostic imaging is central to diagnosis and treatment in many cases. Understanding the basics of the different modalities can help you more effectively work with your veterinarian to determine the best approaches for your horses when they are ill or injured.

Best wishes,

Carrie J. Finno, DVM, Ph.D., Diplomate ACVIM
CEH Director

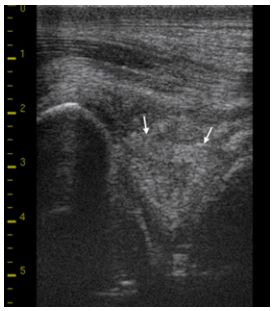
EQUINE DIAGNOSTIC IMAGING



COMPUTED TOMOGRAPHY (CT)

3D | 15 MIN. | $$ | ☢

Best for: bones and soft tissues



ULTRASOUND

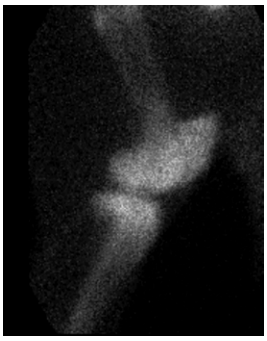
2D | 30 MIN. | $

Best for: soft tissues and bone surfaces

X-RAY (RADIOGRAPHS)

2D | 15 MIN. | $ | ☢

Best for: bones



NUCLEAR SCINTIGRAPHY ("BONE SCAN")

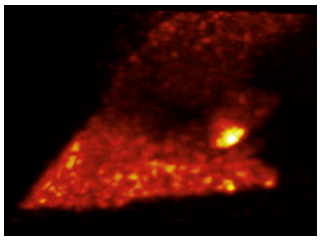
2D | 45 MIN. | $$ | ☢

Best for: bones

MAGNETIC RESONANCE IMAGING (MRI)

3D | 45 MIN. | $$$ | ☢

Best for: bones and soft tissues



POSITRON EMISSION TOMOGRAPHY (PET)

3D | 15 MIN. | $$ | ☢

Best for: bones and soft tissues

More information is available at: https://ceh.vetmed.ucdavis.edu/imaging

Note: 2D = two-dimensional images; 3D = three-dimensional images. Time reflects approximate time to complete a full scan. Dollar signs indicate comparative cost. Radiation symbols indicate that radiation is used in the procedure.

Knowing Is Half The Battle: A Local Dressage Rider's Views on EQUINE DIAGNOSTIC IMAGING

For Woodland-based upper level dressage rider Pam Englund, diagnostic imaging has made a significant impact in the lives of her horses. As a long-time client of the UC Davis veterinary hospital, she has utilized diagnostic imaging services at UC Davis for her horses for everything from suspensory ligament injuries to heart conditions.

"I put my animals in the center of the equation," said Englund. "I want to do whatever will impact their prognosis in the most positive way, which is why I have done the diagnostics that I have done."

Her beloved horse Laser, who was part of her family from ages two through 24, immediately comes to mind. Talking about him still makes her a little teary. One winter, Laser slipped and "did the splits" in his pasture. X-rays and ultrasound imaging helped the veterinary team determine that he had injured his back, but they had to employ a new ultrasound approach to pinpoint the location of the injury. The treatment plan was built around that finding.

"Had we not done all of those things, I wouldn't have known what the issue was and how to treat him," said Englund. "The good news around some of these diagnostics is that they really help you determine the rehabilitation. Do I turn the horse out for a year, or is this a career limiting injury that they are not going to come back from?"

Fortunately, thanks to her diligent approach to Laser's rehabilitation, he recovered and successfully returned to upper level competition. In the following years, Englund and the UC Davis imaging, lameness, internal medicine and farrier services further

Pam Englund and her horse Laser enjoying a victory gallop at the California Dressage Society Annual Championships. Photo credit Sherri Scott.

Pam and Laser at the California Dressage Society Annual Championships. Photo credit Sherri Scott.

managed Laser through laminitis, a torn suspensory ligament, an unexpected heart murmur and a piece of wood that lodged in his neck and almost pierced his jugular vein.

"The X-rays and veterinary and farrier support kept him going for a long time," she reflected. "If I hadn't had the ability to do the diagnostics and the support to navigate the treatments, any of these things could have taken him out of competition."

As part of ongoing management for her horses, Englund has also begun regularly taking advantage of radiographs to do farrier films for her horses every few years to monitor for any changes in the hooves. "Farrier films were very helpful for my farrier to know angles and sole depth," she said.

Looking back, Englund credits the relationships that she has built with UC Davis clinicians and staff for the positive outcomes for her horses.

"It's really important to develop a good rapport with who is treating your animal," she emphasized. "Everyone that I have dealt with at UC Davis has been very knowledgeable, empathetic, and pragmatic. Every horse has been very well cared for. The technicians and night staff that I have dealt with over the years have been impeccable. The whole experience has been really good because I have good relationships with them and they know I'm going to take good care of my horses."

View from the Top:
ADVANCED IMAGING OF THE EQUINE HEAD

A horse's head can account for up to 10% of its total body weight. It is a complex structure composed of 34 different bones and houses the brain, eyes, nose, and mouth. Unfortunately, the large size and complicated anatomy can make diagnosing conditions of the equine head challenging.

Injury and illness related to the equine head are often identified through diagnostic imaging. Due to the complex nature of the equine head, advanced technologies such as advanced ultrasound, computed tomography (CT), and magnetic resonance imaging (MRI) can provide information that is more detailed than conventional X-rays.

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Computed tomography and MRI are cross-sectional imaging techniques, which means that they create images in different planes (or "slices") through the body part of interest. With X-rays, anatomical structures can appear superimposed on one another, which makes it difficult to view specific features. Cross-sectional images avoid complications related to superimposition of structures in complex regions. The slices can also be combined to produce three-dimensional images, which provide additional anatomic information.

In recent years, these technologies have become more available and affordable, enabling veterinarians to document and learn from more cases. The best approach depends on factors such as what is being imaged, whether the injury or illness is recent or ongoing, as well as time, logistic and financial considerations.

Advanced Ultrasound

Ultrasound is routinely utilized at UC Davis to evaluate the equine head and provides valuable information regarding both soft tissue and bone. Structures most commonly evaluated include the salivary glands and ducts, lymph nodes, temporomandibular joint (TMJ), tongue, and eyes. Ultrasound-guidance can be safely used to remove items such as salivary stones, wires or foxtails or to biopsy lymph nodes or masses with a minimally invasive approach.

Ultrasound can be performed in the standing horse and is more affordable than CT or MRI. In some cases, ultrasound findings are sufficient for diagnosis and treatment planning.

In others, it may indicate the need for further imaging such as CT or MRI.

Computed Tomography (CT)

Computed tomography is useful for evaluating areas with complex anatomy that are challenging to assess with radiographs and ultrasound. Although commonly the method of choice for bone, CT can also evaluate soft tissue structures. It is very useful to evaluate the equine head, particularly structures such as the teeth, sinuses, hyoid apparatus, and tongue. It can be used to identify invasive masses, displaced teeth, and conditions of the eyes and ears. Thanks to the development of larger bore scanners, CT can also be used to image the equine neck for bone abnormalities that can interfere with the spinal cord.

In comparison to other imaging modalities, CT is fairly rapid; a full head scan only takes a couple of minutes. It is also often more readily available and affordable than MRI.

The use of CT in the equine clinic has advanced quickly, especially with the advent of instruments that permit CT imaging of horses standing under sedation as opposed to under general anesthesia.

Magnetic Resonance Imaging (MRI)

Whereas CT is particularly useful for imaging bone, MRI is the gold standard for imaging soft tissues. By measuring differing magnetic properties, MRI is able to provide not only anatomic information (size and shape of structures), but also physiologic information (early changes before alteration of size and shape).

In comparison to CT, MRI scans take longer at 40-50 minutes. The increased time and higher cost of the instrument itself make MRI a more costly approach.

Although MRI can be employed in a horse under standing sedation for evaluation of limb lameness, currently equine head MRI requires horses to be under general anesthesia.

While there are pros and cons to each modality, these approaches should be considered complimentary to one another. They are all capable of performing detailed examinations of the equine head. In fact, more than one approach may be utilized depending on the nature of the case. It is important to note that insurers can have varying policies when it comes to imaging, so it is wise to review the existing coverage prior to signing off on a diagnostic procedure.

Standing Sedation vs General Anesthesia

One of the most significant advances in equine imaging is the ability to perform diagnostics on standing sedated horses. Previously, imaging required horses to undergo general anesthesia, which adds to the cost, requires additional staff and equipment, and in rare cases, results in adverse reactions to anesthesia drugs. The ability to utilize these technologies on standing horses under sedation allows for more routine use and provides more options for patients that are not able to undergo anesthesia.

A horse receiving a standing MRI scan of a front hoof.

Positron Emission Tomography (PET): NOT JUST FOR RACEHORSES

Equine standing positron emission tomography (PET) has been a game changer for monitoring racehorse health and guiding training and medical care, which has contributed to reduced injuries and fatalities. However, PET is not just for racehorses.

With the rapid expansion in the availability of this technology, PET is becoming more accessible to diverse populations of horses. Standing PET can be used from the foot to the knee in the front limbs and the foot to the hock in the hind limbs. As a functional imaging technique that detects biological changes in processes such as metabolism and blood flow, it has the ability to "see" injuries to bone and soft tissues at the molecular level, before changes would otherwise be apparent.

To date, over 300 horses have received PET scans at the UC Davis veterinary hospital.

Pioneered at UC Davis in 2015, equine PET imaging initially required horses to undergo general anesthesia. Modifications to allow PET imaging on standing horses under sedation greatly increased its applications and expanded its reach. Scanners have been installed at several racetracks and veterinary hospitals in recent years, with ten different sites expected to be equipped with the technology nationwide by the end of 2023.

PET imaging has become simple with the equine standing MILEPET scanner. A small dose of a radioactive dye is injected intravenously about 30 minutes prior to imaging. This dye distributes through the body and accumulates at sites of active injuries. The horse is then sedated similarly to other veterinary procedures. The scanner is wheeled up to the horse and an openable ring of detectors loosely closes around the limb. It only takes three to five minutes to image each site of interest. In twenty minutes, both front feet and fetlocks can be imaged with PET.

To date, over 300 horses have received PET scans at the UC Davis veterinary hospital. Cases that have benefited from this advanced imaging modality include navicular bone injury, laminitis, and joint disease. Equine patients have included American Quarter Horses, warmbloods, Thoroughbreds, and a mule. Since scans under standing sedation are more accessible and economical than those that require general anesthesia, they can easily be repeated to monitor healing, optimize treatment and inform rehabilitation for the best outcomes.

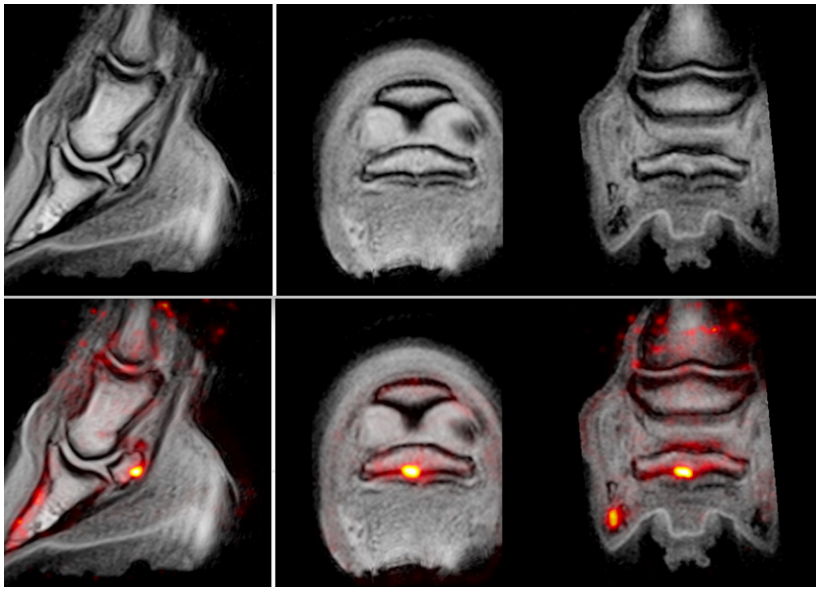
Different imaging modalities can also be combined to provide the most accurate picture. In some cases, PET and X-rays will provide all the information necessary to decide on a treatment plan. In other cases, MRI of a specific area can be performed after PET, and the combination of PET and MRI data provides the most comprehensive assessment of the situation.

The use of PET will keep growing in the sport and pleasure horse populations. Ease of use and affordability make it an excellent first choice for advanced imaging. In addition to identifying injuries, the "functional" imaging properties of PET—assessing the activity of injuries—are particularly helpful for monitoring rehabilitation.

CASE #1: Jool the Mule

A mule named Jool was the first equine imaged with the MILEPET scanner when it was installed at the UC Davis veterinary hospital. A well-known patient at UC Davis, Jool had been suffering from lameness due to chronic tendon lesions that initially improved with the use of stem cell therapy but later recurred. The goal of the PET scan was to assess whether the tendon was still the main issue or if other injuries had developed. The PET scan demonstrated that, in addition to the tendon lesion, the navicular bone was also part of the trouble, which was not apparent on an MRI. This finding led to modifying Jool's shoeing in order to protect her navicular bone.

UC Davis patient Jool undergoing a standing PET scan.

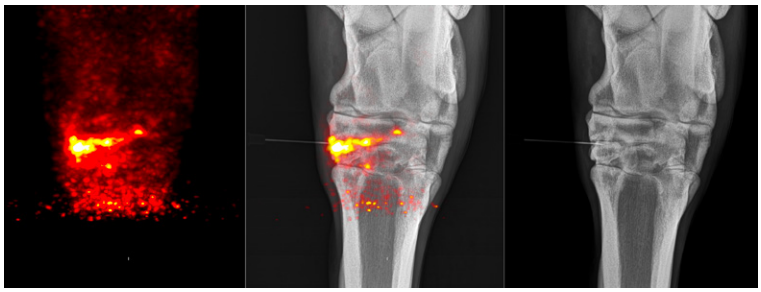


Images from Jool's foot. The top row are MRI images; the bottom row are PET images overlaid on the MRI images. The bright yellow spot highlights a bone injury in the navicular bone that was not recognized on the MRI.

CASE #2: Hock Lameness

Another example of a case scanned with the MILEPET at UC Davis was an American Quarter Horse with lameness localized to the hock but no definitive answers on X-rays and ultrasound. This mare was the first to have standing scans of the hock performed with the MILEPET. The scans were successful and demonstrated early joint disease that was responsible for the pain. The PET results helped target the exact area of the joint to inject.

A UC Davis patient undergoing standing PET scan of the hock.



The image to the left is one of the obtained PET images. The yellow area indicates abnormal bone. When overlaid with the X-ray (middle image), it shows that the injury is centered on one of the small joints of the hock, despite minimal changes on the X-ray (image on the right). With this information, the abnormal joint was injected with corticosteroids to alleviate the pain.

10 THINGS YOU MIGHT NOT KNOW ABOUT EQUINE DIAGNOSTIC IMAGING

Advances in equine diagnostic imaging have expanded rapidly in recent years. We consulted with UC Davis radiologists Dr. Kathryn Phillips and Dr. Mathieu Spriet, and ultrasonographers Dr. Betsy Vaughan and Dr. Mary Beth Whitcomb, to uncover 10 Things You Might Not Know about Equine Diagnostic Imaging.

1 The first veterinary X-rays were performed in the horse. The first scientific paper on diagnostic radiology in veterinary medicine in America, published in 1915, presented radiographs of bony changes associated with lameness in six horses. More than 100 years later, digital radiography has essentially replaced the use of film and darkrooms, making X-rays more portable and accessible.

X-ray of a hoof.

2 Equine diagnostic imaging became a newly recognized specialty in the American College of Veterinary Radiology (ACVR) in 2019. Founded in 1961, the ACVR is one of 22 veterinary specialties of the American Veterinary Medical Association. Diplomates of the ACVR (DACVR) have undergone a three or four-year residency program after obtaining their veterinary degrees, and successfully passed a comprehensive examination. UC Davis faculty members Drs. Mathieu Spriet and Kathryn Phillips are among the first diplomates in the ACVR subspecialty of Equine Diagnostic Imaging.

3 Ultrasound can evaluate bone surfaces. Ultrasound is widely known to assess tendons, ligaments, and other soft tissues. However, it can also provide information about bone fractures or infected bone, especially in areas that are not easily accessible by X-rays such as the pelvis, scapula and ribs.

4 Nuclear scintigraphy (i.e. "bone scan") and positron emission tomography (PET) can answer the question: "Where does it hurt?" These imaging technologies are functional instead of structural. Radioactive tracers specific to bone or tissue are injected in small amounts into the patient's blood stream and collect in areas of high biological activity. The radiotracer gives off energy in the

form of gamma rays, which are detected by a gamma camera. Computer software analyzes the data to produce an image. These approaches enable veterinarians to pinpoint activity at the molecular level (i.e. "hot spots") that may indicate disease or injury.

5 A computed tomography (CT) scan can acquire hundreds of images in less than a minute. Tomography means imaging by sections or slices. The sections can then be stacked to produce a three-dimensional image. CT scanners produce cross-sectional images using a rotating X-ray tube. Typically, the X-ray tube performs a 360-degree rotation around the patient in one second. The number of images per rotation depends on the number of detectors. Scanners with more detectors can produce more images per rotation. A single slice CT scanner acquires one image per rotation. A two-slice CT scanner acquires two images per rotation, etc. The most common types in veterinary medicine are 8, 16, 32, or 64, although some human medical centers have instruments with up to 640 CT slice counts.

6 Magnetic resonance imaging (MRI) is effective at diagnosing lameness when used as a targeted approach. The gold standard for musculoskeletal imaging in humans, MRI is a valuable tool for early detection and treatment of injuries in horses. However, it is not a scanning tool to be used indiscriminately. Combinations of physical examinations, lameness examinations, nerve blocks, and joint blocks are necessary to localize the lameness to a specific region before initiating an MRI scan.

An equine patient undergoing a standing MRI.

The first equine PET scan was performed at UC Davis on a horse under general anesthesia.

7 UC Davis pioneered the use of positron emission tomography (PET) scans in horses. This presented a major breakthrough, as PET imaging of horses had not been possible due to positioning restrictions inside the standard PET instruments. Although PET is used in human medicine for the detection of cancer metastasis and for functional assessment of the brain, UC Davis studies demonstrated promising applications for assessing the musculoskeletal systems of horses.

8 Diagnostic imaging approaches can assess and monitor healing. Since diagnostic imaging is non-invasive, scans are easily repeated to evaluate how well an injury is healing and inform treatment and rehabilitation. Modalities such as ultrasound are often used to monitor healing after tendon and ligament injuries and even after surgical procedures to quickly identify post-operative complications.

9 The primary patient-related image artifact is motion. Artifacts are distortions in the acquired images and can interfere with interpretation and diagnosis. For some imaging modalities, voluntary (breathing) and involuntary (heartbeat and gastrointestinal movement) motion can result in image artifacts. Imaging protocols are optimized to keep scan times short enough to reduce the risk of motion artifacts, but long enough to allow sufficient data acquisition.

10 Acquiring the image is only part of the equation. Hospitalization, standing or general anesthesia, and image interpretation by a trained specialist all factor into the overall time and cost of a diagnostic imaging procedure. In some cases, more than one diagnostic imaging modality is required to identify the issue. Although diagnostics may involve upfront costs, they can also save money by ensuring an accurate diagnosis and appropriate treatment.

UC DAVIS VETERINARY MEDICINE
Center for Equine Health

#1 U.S. News and World Report

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UC DAVIS IMAGING SERVICES

Diagnostic imaging services for horses at the UC Davis veterinary hospital include radiography (X-ray), ultrasound, computed tomography (CT), magnetic resonance imaging (MRI), nuclear scintigraphy ("bone scan"), and positron emission tomography (PET). Imaging is fundamental to patient care across multiple specialties, including surgery, neurology, and ophthalmology.

Dr. Charlene Pige analyzing a CT scan of a horse's head.

UC Davis is at the forefront of advances in diagnostic imaging technology. It is one of only a few veterinary hospitals in the country with a service dedicated exclusively to large animal ultrasound and staffed by faculty specifically trained in its use. Advanced imaging capabilities for horses include both standing PET and MRI. The planned acquisition of a new CT unit with the ability to image the equine head and neck will provide additional diagnostic options for patients.

In the future, the All Species Imaging Center, currently under construction as part of the new Veterinary Medical Center, will act as a central hub of imaging services for all hospital specialties. Diagnostic imaging specialists, accompanied by the largest team of residents at any veterinary hospital, will utilize the most cutting-edge elements of imaging techniques such as CT, MRI, nuclear scintigraphy, and PET scanning. Advanced technologies and clinical research will provide innovative detection, diagnosis, and treatment of disease and trauma.