Diagnosis of Skeletal Injury in the Sport Horse

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KEYWORDS

• Horse • MRI • Standing CT • Cone beam • Subchondral bone injury

KEY POINTS

- Imaging modalities have variable sensitivity and specificity to detect skeletal injury, which often occurs in a discipline-specific pattern.
- Increased knowledge from advanced imaging (computed tomography/magnetic resonance) is improving the ability to detect corresponding changes on radiographs.
- Nontraditional radiographic projections can be used in the field to improve recognition of bone injury.
- MRI remains the gold standard for whole joint organ evaluation, but notable differences are present between high- and low-field magnets for evaluation of cartilage and subchondral and trabecular bone lesions.
- Standing computed tomography is a novel technique that requires refinement, particularly for cone beam imaging, but there is increased availability in both academia and private practice.

INTRODUCTION

With the exception of acute fracture secondary to a monotonic episode of supraphysiologic loading, skeletal injury in the sport horse is typically a manifestation of stress-induced overload injury secondary to cyclical loading.[1–3] The subchondral bone is a commonly affected region with the location of injury dependent on discipline.[4–9] Osteoarthritis is a common sequela, which may become performance limiting.[10,11] Stress fractures of equine long bones (eg, tibia, humerus) occur due to an analogous process of cyclical loading similar to humans.[12–15] Both subchondral and cortical cyclical loading can lead to catastrophic failure of the affected bone, a consequence most commonly seen in the Thoroughbred racehorse.[4,15,16]

Diagnosis of bone injury relies on recognition of pathophysiologic changes to bone that occur in the limb as it responds to stress according to Wolff's law, namely modeling and remodeling. These initially adaptive responses occur at predictable

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locations depending on the discipline performed by the horse and affect diarthrodial joints, various long bones, and tendon and ligament entheses.[17–21] This adaptive response is often referred to as a repetitive stress response. The point at which adaptive changes to bone become pathologic is influenced by numerous factors, intrinsic, such as genetics, age, and size, as well as extrinsic, such as discipline, footing, training schedule, and exercise intensity.[9,22,23] Repetitive stress injuries follow discipline-specific patterns that mirror the location of the repetitive stress response.[17,24–26] With some exceptions, the distinction between adaptive response and pathologic condition can be unclear and should be based on the presence of clinical lameness with corroboration of imaging findings and response to diagnostic analgesia, where appropriate, as opposed to diagnostic imaging findings alone.[14,27,28]

The appearance of bone injury on any particular diagnostic imaging modality is dependent on what the image represents and is predominantly qualitative. For instance, computed tomography (CT) reflects tissue density relative to water,[29] whereas nuclear scintigraphy of bone reflects osteoblastic activity.[10,30–33] For certain modalities, the degree of bone change can be quantified.[34–36] Some modalities represent only morphologic changes, such as radiography and CT, whereas others reflect physiologic changes (nuclear scintigraphy and PET). MRI is unique in that it provides both morphologic and physiologic information. Representing only a snapshot of a dynamic and changing pathophysiologic process, all imaging modalities have benefits and drawbacks, and they tend to complement each rather than make any imaging modality obsolete.[37] Emerging technologies and research are focusing on the early recognition of subchondral bone and cartilage injury, allowing for more specific diagnoses and targeted therapies.[38–43]

The various manifestations of skeletal injury as identified using radiography, scintigraphy/Positron emission tomography (PET), CT, and MRI are described.

Radiography

Radiography remains the mainstay for diagnosis of skeletal injury in the sport horse because of its affordability, portability, and ease of use for the sport horse practitioner. Radiography is a planar (2-dimensional [2D]) imaging modality that reflects 5 radiographic opacities determined by tissue atomic number, thickness, overlap with other tissues, angulation of the x-ray beam, and tissue homogeneity. The main limitations of radiography include superimposition, lack of direct visualization of cartilage, and the relatively large (30%–50%) degree of bone change required before lesion visualization.[31]

Diagnosis of bone injury on radiographs includes direct fracture visualization, but is otherwise inferred from secondary changes that are associated with whole organ dysfunction leading to degenerative joint disease. Such radiographic changes include thickening and increased opacity of the subchondral and surrounding trabecular bone, subchondral osteolysis, periarticular new bone formation, and joint space narrowing. Increased radiopacity is commonly referred to as sclerosis, although strictly speaking sclerosis reflects bone strength, which cannot be evaluated with any imaging modality. Loss of cartilage can be inferred from decreased joint space, but this depends on proper positioning and is typically only recognized in advanced stages of disease. Thus, radiographs are insensitive, but reasonably specific for bone injury in the sport horse.

Repetitive stress injuries routinely diagnosed with radiographs include, but are not limited to, complete and incomplete fractures of the third metacarpal/