MANUAL OF
EQUINE
LAMENESS
MANUAL OF EQUINE LAMENESS

Edited by
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DVD included featuring additional anatomical images and video clips demonstrating key procedures and examples of conditions in motion.
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COMMON TERMINOLOGIES AND ABBREVIATIONS

Terminology
Distal or third phalanx
Middle or second phalanx
Proximal or first phalanx
Distal interphalangeal joint
Proximal interphalangeal joint
Metacarpo/metatarsophalangeal joint
Distal sesamoidean ligaments
Distal sesamoidean impar ligament
Collateral suspensory ligaments of navicular bone
Collateral ligaments of coffin joint
Deep digital flexor tendon
Superficial digital flexor tendon
Metacarpus/metatarsus

Second and fourth metacarpal/metatarsal bones
Digital flexor tendon sheath
Common digital extensor tendon
Long digital extensor tendon
Tarsometatarsal joint
Distal intertarsal joint
Proximal intertarsal joint
Tarsocrural joint
Medial femorotibial joint
Lateral femorotibial joint
Femoropatellar joint
Scapulohumeral joint
Sacroiliac joint
Computed tomography
Magnetic resonance imaging
Ultrasonography
Osteochondrosis
Osteochondritis dissecans

Abbreviations
P3, coffin bone
P2
P1
DIP joint or coffin joint
PIP joint or pastern joint
MCP/MTP joint or fetlock joint
DSL
DSIL
CSL

CLs of DIP joint
DDFT or DDF tendon
SDFT or SDF tendon
MC/MT or MC3/MT3 or MCIII/MTIII, cannon bone
MC2 or MCII, MC4 or MCIV, MT2 or MTII, MT4 or MTIV; splint bones
DFTS or digital sheath
CDET
LDET
TMT joint
DIT joint
PIT joint
TC joint
MFT joint
LFT joint
FP joint
SHJ or shoulder joint
SI joint
CT
MRI or MR
US
OC/OCD
OCD
<table>
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<th>Common Terminologies and Abbreviations</th>
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<tr>
<td>Subchondral cystic lesion</td>
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<td>Angular limb deformity</td>
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<td>Osteoarthritis</td>
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<tr>
<td>Accessory ligament of deep digital flexor tendon</td>
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<tr>
<td>Accessory ligament of superficial digital flexor tendon</td>
</tr>
<tr>
<td>Developmental orthopedic disease</td>
</tr>
<tr>
<td>Proximal suspensory desmitis</td>
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<tr>
<td>Suspensory ligament</td>
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<tr>
<td>Nonsteroidal anti-inflammatory drug</td>
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<tr>
<td>Hyaluronan or hyaluronic acid</td>
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<td>Polysulfated glycosaminoglycans</td>
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<tr>
<td>Platelet-rich plasma</td>
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<td>Interleukin receptor antagonist protein or conditioned serum</td>
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<td>Extracorporeal shockwave treatment</td>
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<tr>
<td>Intra-articular</td>
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<td>Dorsopalmar/plantar</td>
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<tr>
<td>Mediolateral</td>
</tr>
<tr>
<td>Triamcinolone</td>
</tr>
<tr>
<td>Methyl prednisolone acetate</td>
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<tr>
<td>Dimethyl sulfoxide</td>
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<tr>
<td>Diclofenac cream</td>
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<tr>
<td>Mesenchymal stem cell</td>
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<td>Proximal sesamoid bone</td>
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Functional Anatomy of the Equine Musculoskeletal System

ANATOMIC NOMENCLATURE AND USAGE

Informative and logical names for parts of the horse's body, as well as positional and directional terms, have evolved through the efforts of nomenclature committees. Nomina Anatomica Veterinaria is the standard reference in veterinary science. Some older terminology is still widely used. For example, the following are acceptable synonyms: navicular bone for distal sesamoid bone, coffin joint for distal interphalangeal joint, pastern joint for proximal interphalangeal joint, and fetlock joint for metacarpophalangeal joint. It is useful to be familiar with the older terms because many times they are used interchangeably.

Figure 1.1 provides the appropriate directional terms for veterinary anatomy. With the exception of the eye, the terms anterior and posterior are not applicable to quadrupeds. Cranial and caudal apply to the limbs proximal to the antebrachiocarpal (radiocarpal) joint and the tarsocrural (tibiotarsal) joint. Distal to these joints, dorsal and palmar (on the forelimb) or plantar (on the hindlimb) are the correct terms. The term “solar” is used to designate structures on the palmar (plantar) surface of the distal phalanx and the ground surface of the hoof.

THORACIC LIMB

Digit and Fetlock

The foot and pastern comprise the equine digit, a region including the distal (third), middle (second), and proximal (first) phalanges and associated structures (Figure 1.2). The fetlock consists of the metacarpophalangeal (fetlock) joint and the structures surrounding it. The digits and fetlocks of the thoracic limb and the pelvic limbs are similar in most respects. The term “palmar” is used when referring to structures of the forelimb, whereas “plantar” is used when referring to the hindlimb.

Foot

The foot consists of the epidermal hoof and all it encloses: the connective tissue corium (dermis), digital cushion, distal phalanx (coffin bone), most of the cartilages of the distal phalanx, distal interphalangeal (coffin) joint, distal extremity of the middle phalanx (short pastern bone), distal sesamoid (navicular) bone, podo-trochlear bursa (navicular bursa), several ligaments, tendons of insertion of the common digital extensor and deep digital flexor muscles, blood vessels, and nerves. Skin between the heels is also part of the foot.
Chapter 1

The hoof is continuous with the epidermis at the coronary. Here the dermis of the skin is continuous with the dermis (corium) deep to the hoof. Regions of the corium correspond to the parts of the hoof under which they are located: perioplic corium, coronary corium, laminar (lamellar) corium, corium of the frog, and corium of the sole. Examination of the ground surface of the hoof reveals the sole, frog, heels, bars, and ground surface of the wall (Figure 1.3). The ground surface of the forefoot is normally larger than that of the hind foot, reflecting the shape of the distal surface of the enclosed distal phalanx.

The hoof wall extends from the ground proximad to the coronary border where the soft white horn of the periople joins the epidermis of the skin at the coronet. The regions of the wall are the toe, medial and lateral quarters, and heels (Figures 1.3, 1.4). From the thick toe, the wall becomes progressively thinner and more elastic toward the heels, where it thickens again where it reflects dorsad as the bars. Ranges for the angle of the toe between the dorsal surface of the hoof wall and the ground surface of the hoof vary widely. In the ideal digit, the dorsal surface of the hoof wall and the ground surface of the hoof should be parallel, reflecting the axial alignment of the phalanges.

The highly vascular and densely innervated collagenous connective tissue of the coronary corium (dermis) gives rise to elongated, distally directed papillae. Laminar (lamellar) corium
Figure 1.2. Bones of the left equine thoracic limb (lateral view).
forms a series of laminae that interdigitate with epidermal laminae of the stratum internum of the hoof wall. Shorter papillae extend from the perioplic, solar, and cuneate (frog) coria. The corium provides sensation as well as nourishment and attachment for the overlying stratified squamous epithelium comprising the ungual epidermis (hoof).

Three layers comprise the hoof wall: the stratum externum, stratum medium, and stratum internum (Figure 1.5). The superficial stratum externum is a thin layer of horn extending distad from the coronet a variable distance; this thin, soft layer, commonly called the periople, wears from the surface of the hoof wall so that it is present only on the bulbs of the heels and the proximal parts of the hoof wall. The bulk of the wall is a stratum medium consisting of horn tubules and intertubular horn. Horn tubules are generated by the stratum basale of the coronary epidermis covering the long papillae of the coronary corium. Intertubular horn is formed in between the projections.

Distal to the coronary groove, about 600 primary epidermal laminae of the stratum internum interweave with the primary dermal laminae of the laminar corium (Figures 1.6, 1.7). Approximately 100 microscopic secondary laminae branch at an angle from each primary lamina, further binding the hoof and corium together (Figure 1.6). There is some confusion concerning the terms “insensitive” and “sensitive” laminae. In the strictest sense the keratinized parts of the primary epidermal laminae are
nonpigmented equine hooves. Water content of the hoof significantly affects its mechanical properties. A very dry or extremely hydrated hoof wall is more likely to crack than a normally hydrated hoof wall.

The frog (cuneus ungulae) is a wedge-shaped mass of keratinized stratified squamous epithelium rendered softer than other parts of the hoof by an increased water content. Apocrine glands, spherical masses of tubules in the corium of the frog, extend ducts that deliver secretions to the surface of the frog. The ground surface of the frog presents a pointed apex and central sulcus enclosed by two crura. Paracuneal (collateral) sulci separate the crura of the frog from the bars and the sole. The palmar aspect of the frog blends into the bulbs of the heels.

The coronary and perioplic coria and the stratum basale of the coronary and perioplic epidermis constitute the coronary band. Deep to the coronary band the subcutis is modified into the

**Figure 1.4.** Dissected view of the relationship of the hoof to underlying regions of the corium (dermis).
Figure 1.5. Three-dimensional dissection of the coronary region of the hoof wall.
highly elastic coronary cushion. The coronary band and cushion form the bulging mass that fits into the coronary groove of the hoof. Part of the coronary venous plexus is within the coronary cushion. The plexus receives blood from the dorsal venous plexus in the laminar corium. Where the corium is adjacent to the distal phalanx, it blends with the bone’s periosteum, serving (particularly in the laminar region) to connect the hoof to the bone (Figure 1.7).

**INTERNAL STRUCTURES OF THE FOOT**

The medial and lateral cartilages of the distal phalanx (ungual cartilages) lie under the corium of the hoof and the skin, covered on their abaxial surfaces by the coronary venous plexus. They extend from each palmar process of the bone proximal to the coronary border of the hoof, where they may be palpated. The cartilages are concave on their axial surfaces, convex on their abaxial surfaces, and thicker distally where they attach to the bone. Toward the heels they curve toward one another. Each cartilage is perforated in its palmar half by several foramina for the passage of veins connecting the palmar venous plexus with the coronary venous plexus.

Five ligaments stabilize each cartilage of the distal phalanx (Figures 1.8, 1.9). Filling in between the cartilages is the digital cushion, a highly modified subcutis consisting of a meshwork of collagenous and elastic fibers, adipose tissue, and small masses of fibrocartilage (Figure 1.9). Only a few blood vessels ramify in the digital cushion. Dorsoproximally the digital cushion connects with the distal digital anular ligament. The apex of the wedge-shaped digital cushion is attached to the deep digital flexor tendon (DDFT) as the latter inserts on the solar surface of the distal phalanx. The base of the digital cushion bulges into the bulbs of the heels, which are separated superficially by a central shallow groove. The structure and relationships of the digital cushion indicate its anticoncussive function.
As the DDFT courses to its insertion on the distal phalanx, it is bound down by the distal digital anular ligament (Figure 1.10) and passes over the complementary fibrocartilage, a fibrocartilaginous plate extending from the proximal extremity of the palmar surface of the middle phalanx. Then the tendon gives off two secondary attachments to the distal aspect of the palmar surface of the bone (Figure 1.11). Continuing distad toward its primary attachment on the flexor surface of the distal phalanx, the DDFT passes over the navicular bursa (bursa podotrochlearis) interposed between the tendon and the fibrocartilaginous distal scutum covering the flexor surface of the navicular bone.

The proximal border of the navicular bone presents a groove containing foramina for passage of small vessels and nerves. The distal border of the bone has a small, elongated facet that articulates with the distal phalanx. Several variously enlarged, foramina-containing fossae lie in an elongated depression palmar to that facet (Figure 1.12). Two concave areas on the main articular surface of the navicular bone contact the distal articular surface of the middle phalanx. The navicular bone is supported in its position by three ligaments comprising the navicular suspensory apparatus. A collateral sesamoidean (suspensory navicular) ligament arises from the distal end of the proximal phalanx (Figures 1.10, 1.11). These collateral sesamoidean ligaments sweep obliquely distad, each ligament crossing the pastern joint, and then giving off a branch that joins the end of the navicular bone to the cartilage of the distal phalanx. Each collateral sesamoidean ligament terminates by attaching to the proximal border of the navicular bone and joining with the contralateral ligament. Distally, the navicular bone is stabilized by the distal sesamoidean impar ligament, a fibrous
Functional Anatomy of the Musculoskeletal System

The synovium has a complex relationship on its palmar side to the ligaments and tendons that are found there. The proximal portions wrap around the distal ends of the collateral sesamoidean ligament and the distal palmar pouch forms a thin extension between the articulation of the navicular bone and the distal phalanx. Distally, this pouch’s synovial membrane surrounds the distal sesamoidean impar ligament on each side where the DIP joint is closely associated with the neurovascular bundle that will enter the distal phalanx. Although a direct connection between the DIP joint and the navicular bursa is rare, passive diffusion of injected dye, anesthetics, and medications is thought to occur.

The distal articular surface of the middle phalanx, the articular surface of the distal phalanx, and the two articular surfaces of the navicular bone form the coffin joint, a ginglymus of limited range of motion. Short collateral ligaments arise from the distal end of the middle phalanx, pass distad deep to the cartilages of the distal phalanx, and terminate on either side of the extensor process and the dorsal part of each cartilage.

The synovial membrane of the coffin joint has a dorsal pouch that extends proximad on the dorsal surface of the middle phalanx under the common digital extensor tendon nearly to the pastern joint. The synovium has a complex relationship on its palmar side to the ligaments and tendons that are found there. The proximal portions wrap around the distal ends of the collateral sesamoidean ligament and the distal palmar pouch forms a thin extension between the articulation of the navicular bone and the distal phalanx. Distally, this pouch’s synovial membrane surrounds the distal sesamoidean impar ligament on each side where the DIP joint is closely associated with the neurovascular bundle that will enter the distal phalanx. Although a direct connection between the DIP joint and the navicular bursa is rare, passive diffusion of injected dye, anesthetics, and medications is thought to occur.

Figure 1.9. Sagittal section of the equine fetlock and digit.
Figure 1.10. Sesamoidean ligaments. Dashed lines indicate positions of the proximal sesamoid bones embedded in the metacarpointersesamoidean ligament. Numbers indicate cut stumps of (1) palmar anular ligament, (2) proximal digital anular ligament, (3) superficial digital flexor, and (4) deep digital flexor tendon.
Pastern

Deep to the skin and superficial fascia on the palmar aspect of the pastern, the proximal digital annular ligament adheres to the superficial digital flexor tendon (SDFT) and extends to the medial and lateral borders of the proximal phalanx (long pastern bone). This fibrous band of deep fascia covers the SDFT as it bifurcates into two branches that insert on the proximal extremity of the middle phalanx just palmar to the collateral ligaments of the distal interphalangeal (PIP; pastern) joint. The DDFT descends between the two branches of the SDFT and the digital flexor tendon sheath (DFTS) enfolds both tendons as far distally as the so-called “T ligament” (Figure 1.9). The latter is a fibrous partition attaching to the middle of the palmar surface of the middle phalanx.

Deep to the digital flexor tendons a series of ligaments referred to as distal sesamoidean ligaments (DSLs) extends distad from the bases of the two proximal sesamoid bones. The superficial straight sesamoidean ligament attaches distally to the fibrocartilaginous plate on the
The distal extremity of the cannon bone, the proximal extremity of the proximal phalanx, the two proximal sesamoid bones, and the fibrocartilaginous metacarpointersesamoidean ligament in which the proximal sesamoids are embedded form the MCP joint. A somewhat cylindrical articular surface on MCIII/MTIII is divided by a sagittal ridge, and this surface fits into an accommodating depression formed by the proximal phalanx, the proximal sesamoid bones, and the metacarpointersesamoidean ligament. Collateral ligaments of the fetlock joint extend distad from the eminence and depression on each side of the third metacarpal bone. The superficial part of each ligament attaches distally to the edge of the articular surface of the proximal phalanx; the shorter, stouter deep part of the ligament attaches to the abaxial surface of the adjacent proximal sesamoid and the proximal phalanx.

The palmar part of the fetlock joint capsule is thicker and more voluminous than the dorsal part. A palmar recess (pouch) of the fetlock joint capsule extends proximad between the third metacarpal bone and the suspensory ligament. This pouch is palpable and even visible when the joint is inflamed, distending the palmar recess with synovial fluid. The joint capsule is reinforced on each side by the collateral ligaments and dorsally by fascia attaching to the common digital extensor tendon.

In the standing position, the fetlock and digit are prevented from non-physiologic hyperextension by the suspensory apparatus of the fetlock (interosseus muscle, intersesamoidean ligament, and distal sesamoidean ligaments), the digital flexor tendons, and the collateral ligaments of the joints. During flexion of the fetlock and digit, most of the movement is in the fetlock, the least amount of movement is in the pastern joint, and movement in the coffin joint is intermediate. Contraction of the common and lateral digital extensor muscles brings the bones and joints of the digit into alignment just before the hoof strikes the ground. The neurovascular supply to the digit and fetlock are illustrated in Figures 1.13 to 1.15.

Metacarpus

The equine metacarpus consists of the large third metacarpal (cannon) bone, the second (medial) and fourth (lateral) small metacarpal bones (sincipital bone), and the structures associated with them. The shaft of each small metacarpal
Figure 1.13. Arterial supply to the digit of the forelimb.
Figure 1.14. Medial aspect of the distal metacarpus, fetlock, and digit with skin and superficial fascia removed. Inset: schematic of the distribution of major nerves; dashed lines indicate variant branches.