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EVERY HOOF HAS A STORY: AN IN-DEPTH LOOK AT THE PHYSICAL EXAMINATION OF THE EQUINE HOOF

Debra R. Taylor, DVM, MS, Dipl. ACVIM (LAIM)
Auburn University
Auburn, AL, USA

Since we so commonly see “bad footed” horses, frequent observation of hoof abnormalities may create an altered sense of “normal”. Over time a clinician comes to accept “bad footedness” as “normal”. Close attention to the physical examination of the hoof can help us understand the history of the animal, the origin of lameness and enable us to be proactive addressing impending problems.

Symmetry

Visual evaluation of the distal portion of the limb relies heavily on recognition of asymmetry between the lateral and medial aspects of the same limb and between contralateral limbs. Digital asymmetry (laterality, high/low syndrome, mismatched feet, mild club foot) may be acquired as a consequence of decreased weight bearing caused by asymmetrical movement,[1,2,3] asymmetrical tension of tendons,[4] and pain.[5] The relatively overloaded (i.e., initially more sound) foot acquires a shallower angle of the dorsal hoof wall, low or under-run heel and lower palmar angle (angle of the solar margin of the distal phalanx relative to the ground surface), as well as a larger hoof circumference. In the relatively underloaded (i.e., lame or shorter strided) limb, the foot becomes more upright and narrow with a higher palmar angle.[4] Asymmetry may remain even after the original lameness has resolved. Although it is not always associated with lameness, asymmetry of the equine hoof should not be overlooked as an indication of previous, impending, or chronic lameness.[6]

Coronary band

Hair on the coronary band should lie flat against the hoof capsule; hair projecting horizontally may indicate excessive ground-reaction force on the associated hoof wall and may be correlated to pain within the foot. The coronary band is dynamic, and its shape can be affected by chronic overloading. When viewing the foot from the side, a healthy coronary band should be nearly straight with only a mild proximally directed arch. Asymmetry of the height of the coronary band in the heel region on one side is commonly known as a “sheared heel”, which is defined as instability between medial and lateral bulbs of the heel[7] and often a hoof capsule distortion resulting in proximal displacement of one quarter/heel bulb relative to the contralateral side of the foot.[8] Asymmetry of the heel region[9] often indicates medial-lateral imbalance during loading [4] and predisposes the horse to a spontaneous quarter crack on the side of the foot that has been displaced proximally. [10] Sheared heels often have a “fissure” between the heel bulbs[11] in which a chronically moist environment favors the development of thrush. [8]

The angle of the coronary band can be used to estimate the position of the distal phalanx within the hoof capsule. The angle of the coronary band of apparently normal front feet is 23.5 +/- 3 degrees.[12] If the coronary band angle is >30 degrees the horse is likely to have a negative palmar angle, and if the angle of the coronary band is >45 degrees, the horse undoubtedly has a negative palmar/plantar angle.[a,b,c] At the other extreme, a coronary band parallel to ground (as viewed from the side) is indicative of a high palmar angle, which is often associated with a club foot or laminitis. The coronary band angle and the solar angle of the distal phalanx (palmar angle) are correlated with the distal interphalangeal joint moment arm (DIP MA) or torque and the force exerted by the deep digital flexor tendon on the navicular bone.[12] As the coronary band angle increases (palmar/plantar angle decreases), both the DIP MA and the force exerted by the deep digital flexor tendon on the navicular bone increase.[12] A hind foot with a negative solar angle (plantar angle) will have a steep coronary band angle that when projected forward strikes the front leg above the carpus or as high as the chest or abdomen rather than at the carpus or below.[13,c] A distally directed arch in the coronary band in the dorsal portion of the foot may indicate remodeling of distal phalanx. A distally directed arch in the heel region indicates a weak heel.

Hoof Wall

The normal healthy hoof wall should be smooth, have a light sheen, and be free of flares, cracks, and prominent growth rings. Growth rings are horizontal ridges of the hoof capsule that are formed by tubular horn distortion that occurs when perfusion of the coronary corium is altered by abnormal hoof loading, changes in diet, intensity of exercise, or by systemic disease.[14] When growth of the wall becomes retarded as the result of uneven circulation, alterations in growth ring width are evident at the proximal margin of the hoof capsule. Uneven rings in some areas indicate that circulation of the coronary corium has been decreased in the narrow region. Wall growth is generally inversely related to load.[15] A hoof that exhibits growth rings that are narrower in some regions likely has chronic overload and/or under-perfusion of the coronary corium in the region of narrow rings. Narrow growth rings are commonly seen in the toe region of horses with chronic laminitis.[16] Narrow growth rings can be seen in the medial quarter of the forefeet of some athletic horses presented for lameness evaluation. The coronary band of these horses is usually displaced proximally similar to the coronary band of horses with sheared heels and is likely caused by similar unequal distribution of vertical forces.[10] The growth rings of a horse with a negative palmar/plantar angle are often wider in the toe region and narrower in the heel region due to overloading of the heel region.

The presence of hoof wall flares or cracks are often caused by chronic, excessive overloading of the hoof wall in the region where these defects are found.[8,10,17] Cracks in the quarter are more likely to involve the dermal layers of the hoof than cracks in other regions.[17] Horizontal cracks are usually the result of a disruption of production of horn caused by coronary band trauma or when an abscess opens ("gravels out") at the coronary band. These cracks are seldom a cause of lameness once the abscess has resolved.[17]

Frog

The frog is highly dynamic and its morphology changes relative to current hoof demands and terrain.[18] The width of a healthy frog should equal 50 - 66% of its length.[11,19,20] The frog of a healthy hoof has sufficient depth at its dorsal aspect to reach the bearing surface.[21,22] If this portion of the frog does not engage the ground, fibrocartilage in the palmar portion of the foot develops poorly or atrophies contributing to a weak heel.[22] The central sulcus should be wide and shallow so that the index finger or ring finger fits easily into it. Contracture of the central sulcus is commonly observed. Contraction of the central sulcus can create an anaerobic environment that is ideal for development of thrush.[18] When the frog tissue entrapped by the contracted sulcus becomes infected, the dermis at the deepest aspect of the sulcus often becomes eroded. The horse may exhibit lameness and show significant signs of pain when the sulcus is cleaned with a hoof pick. The pain caused by thrush in the central sulcus may cause some horses to land toe first to avoid loading the inflamed soft tissues of the heel. Landing toe-first may cause the heel to contract and atrophy more, perpetuating the infection and lameness. Severe central sulcus thrush in an entire group of horses may be an indication of mineral imbalance in the diet.

The relationship of the untrimmed frog to the sole indicates the position of the distal phalanx within the hoof capsule (i.e., the palmar angle).[23] For instance, if the apex of the frog is deeply recessed and the frog appears to be angling toward the coronary band at the toe, the distal phalanx is probably similarly positioned, having a negative palmar angle.[23]

Collateral Grooves or Sulci

The depth of the collateral grooves may provide an accurate anatomical reference for predicting the relationship between the internal and external structures of the foot and the bearing surface. This is useful because the depth of the collateral grooves is not altered by any method of hoof care,[24] whereas the plane of the frog can be altered by a hoof knife.[25] Based on dissection studies of the foot there appears to be a constant relationship between the collateral grooves and hoof conformation/structure.[a,b] Foot structure that can be predicted based on characteristics of the collateral grooves includes: sole depth, distance of the distal phalanx from the ground, and the palmar/plantar angle. The collateral grooves run parallel to and a fixed distance (10-11mm) from the solar surface of the distal phalanx in the dorsal half of the foot and a similar same distance from the collateral cartilages in the palmar half of the foot. In the healthy foot with adequate sole depth, the collateral groove at the apex of the frog is 10 – 20 mm from the ground.[25] This indicates that the distal phalanx is positioned an adequate distance from the ground, because the concave aspect of the distal phalanx is positioned 10-11 mm proximal to the deepest part of the collateral groove [a,b]. This relationship of central sulcus depth at the apex of the frog to radiographic sole depth has recently been validated.[26] Collateral grooves of some horses have a stair-step or undulating shape where the groove dips or curves to become substantially deeper in the heel region. Collateral grooves that exhibit this type of conformation are an indication of poor development of the internal structures of the heel. A foot that has collateral grooves with this deep curvature in the heel region also commonly have a long toe and under-run heels. Hooves with this confirmation should be examined radiographically to confirm digital alignment and orientation of the distal phalanx to the ground (palmar angle). This conformation in the hind feet may be associated with pain in the hocks, suspensory ligaments, and lumbar regions.[27-29]

Heels

During examination of the foot, the “heel base” of the hoof capsule, the collateral cartilages and the digital cushion should be evaluated. The “heel base” of the hoof capsule includes the hoof wall, the buttress, angle of the sole and the bars.[30] The heel tubules should be straight and have an angle of incidence with the weight bearing surface within 5 degrees[9] of the tubules in the toe region. Ideally, the most palmar extent of the bearing surface of the heel tubules would be at the base of the frog and very near a vertical line drawn thru the middle of the third metacarpal/metatarsal bones.[30] Under-run heels that grow forward toward the widest part of the foot often collapse under the weight of the horse causing heel tubules to run nearly ground parallel. The bars and the angle of the sole may be crushed, deformed or injured as a consequence of the severely under-run heel. Horses with under-run or collapsed heels generally have thin (less than 2 inches[9]) digital cushions that are easily deformed with finger pressure.

Solar proportionality
When viewing the solar aspect of a healthy hoof, the ground surface should be approximately as wide as it is long.[20] This creates a relative proportion from the front of the foot to the palmar aspect that is related to alignment of the center of articulation (of the distal interphalangeal joint) in the middle of the foot, or when shod, the middle of the shoe.[31] The normal solar surface of the foot may be wider laterally than medially.[20,24]

Sole
The healthy sole tends to be callused and between 10 to 15 mm thick[25] beneath the distal rim of the distal phalanx. This sole thickness protects the distal phalanx from trauma associated with impact.[4,25] Sole depth can be predicted by placing a ruler calibrated in millimeters within the collateral groove at the apex of the frog to measure the distance between the deepest part of the groove and the plane of the outer perimeter of the sole. This measurement predicts the height at which the distal phalanx is suspended above the ground and can be used to predict solar depth. It is common to find thin soled horses in which the depth of the collateral grooves measured at the apex of the frog is essentially zero millimeters from the ground (i.e., no space). These thin soled horses that have zero collateral groove depth at the apex of the frog, generally have less than 7 mm of solar depth along the rim of the distal phalanx[25] predisposing them to solar bruising, subsolar infection, P3 remodeling and rim fractures. The opposite situation is true of feet with deep collateral grooves at the apex of the frog. These feet have sufficient solar depth and/or solar concavity to elevate and protect the distal phalanx from the trauma associated with impact.

Hoof Palpation
Examination by palpation should start with assessment of the temperature of the hoof wall, the coronary band and the heel bulbs by using the palm or the back of the hand. The hand can detect temperature differences in tissue of 1 to 1.5° C.[32] Elevated temperature of a foot may indicate the presence of inflammation. Decreased temperature of the coronary band may indicate poor perfusion of the coronary corium as often occurs with subacute-chronic laminitis. Some clinicians and hoof-care professionals use inexpensive infrared thermometers to increase their ability to objectively evaluate temperature of the hoof and coronary band.
The coronary band of a healthy hoof should feel thick and spongy[33] and should have no evidence of a "ledge" where a finger can be placed behind the proximal aspect of the hoof capsule. A prominent ledge or depression indicates there is excessive distance between the coronary band and the extensor process.[33] The dorsal aspect of the coronary band and the region immediately proximal to it should be palpated for effusion in the dorsal pouch of the distal interphalangeal (DIP) joint.

Heel
In recent years, inadequate development of fibrocartilage in the palmar/plantar portion of the foot has been recognized as a precursor to tissue injury and lameness.[22,34] Horses with under developed heels typically have a poorly formed digital cushion and thin collateral cartilages. It is these structures that determine the overall conformation of the palmar/plantar portion of the foot. Clinicians should gain an appreciation for variation in the consistency and overall size of the digital cushion and collateral cartilages. The digital cushion can be palpated between a thumb placed between collateral cartilages and the fingertips placed on the frog. A sense of normal can be learned by palpating the digital cushions of sound horses with "good feet" and comparing those findings with those of horses with poorly conformed feet.[22,34,35] The depth of the combined tissues of normal digital cushion and frog should be 2 inches.[4] Horses with underdeveloped digital cushions or "flimsy" collateral cartilages[33] typically have under-run heels, heels that can be easily moved up and down independently, and frogs that can be deformed with finger pressue.[22,25] Horses that have been chronically stalled, are likely to have weaker heels in the hind feet as compared to the front feet.
The thickness, density and pliability of the collateral cartilages should be noted[33] Inflexible collateral cartilages are often found in an upright foot whereas "flimsy" cartilages are commonly found in feet with a collapsed heel.[33] Horses with narrow heels (less than 2 fingers width between the collateral cartilages) or low poorly developed heels may be predisposed to injury of the navicular bone and deep digital flexor tendon.

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