

# Structure and Function of the Equine Digit in Relation to Palmar Foot Pain

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## 1. Introduction

The palmar one-half of the foot is palmar to the frontal or dorsal plane that divides the foot into approximately dorsal and palmar halves. The term "heels" simply refers to the palmar-most portion of the foot. As befits such a vague description, the heels are arbitrarily determined to extend palmarly from their junction with the quarters. The heels include the angles of the sole, the inflexion of the wall, and the bulbs as well as all the tissues that encase by them (Fig. 1); however, for the clinician, the definition of what structures constitute the heel is not usually derived from an anatomy book. Rather, it is defined by those structures that are desensitized with a palmar digital nerve block, because the gamut of injuries that are identified in this manner constitute the causes of "heel pain."

Neither anatomy nor function of the heels can be divorced from anatomy and function of the remainder of the foot because of the interdependence between them. Consequently, this discussion is inevitably somewhat broader in nature than the title might suggest, and it will be focused on those structures that are generally considered to give rise to heel pain in lame horses. Structures that are considered within or bordering on the heels include the navicular bone, palmar aspect of the distal pha-

lanx, ungual cartilages, navicular bursa, palmar aspect of the distal interphalangeal joint, distal deep digital flexor tendon, associated vessels and nerves, and hoof. Because heel pain is common, the heels have always warranted attention. Recently, advances in diagnostic imaging have enabled the identification of injuries, particularly those of soft-tissue structures, that were previously impossible except at a post-mortem examination. This has increased our need to understand the detailed structure of the palmar aspect of the foot, because the extended range of diagnoses that are now feasible requires similar advancements in treatment. Paralleling our increased ability to diagnose diseases of the heel has been an increase in the understanding of the function of the foot. As such, the mechanics of weight bearing and associated stresses are now beginning to be understood. Because abnormal stresses are the cause of the majority of lameness occurring in the heels, the dual development of increased diagnostic capabilities and increased understanding of function are likely to lead to more effective treatment strategies.

To better understand the foot, the clinician must build a mental model of the structures that form the distal limb and envision how they interact with each other both at rest and in motion. Additionally, it is

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## NOTES

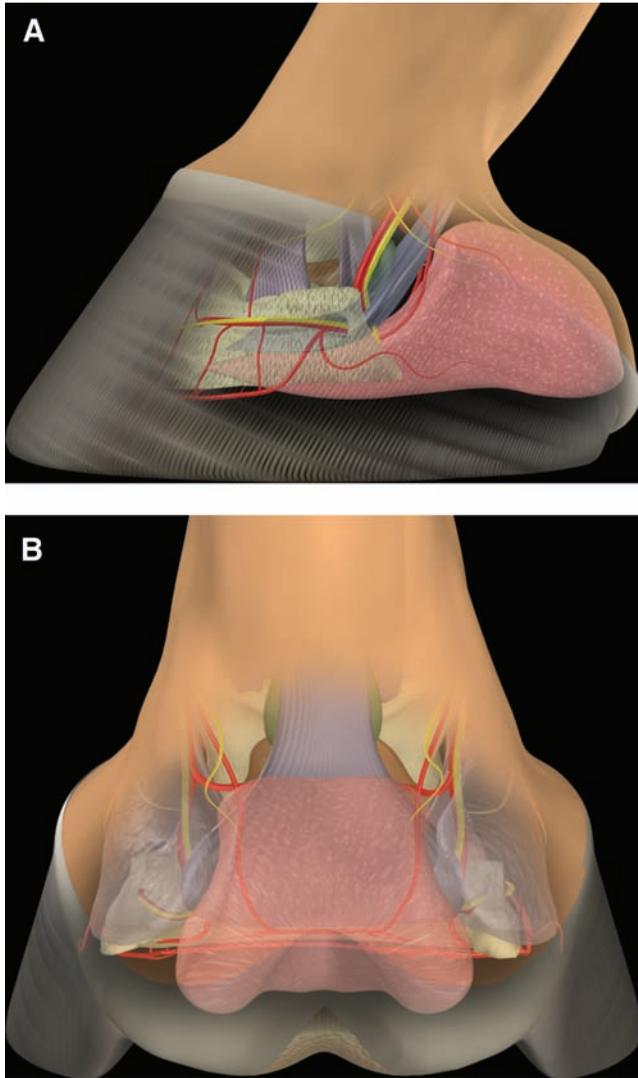


Fig. 1. (A) Lateral and (B) palmar schematic representations of the structures of the palmar aspect of the foot.

advantageous to have at least a qualitative idea of the distribution of the stresses within the distal limb to decide what measures must be taken to reduce stresses that are considered injurious. Although a qualitative idea of stresses within the digit is frequently enough to guide treatment by intelligent trial and error, completely ignoring the quantitative distribution of stresses within the limb may cause a clinician to overestimate or underestimate the benefits of therapy.

## 2. Anatomy of the Heels

The palmar aspect of the distal phalanx includes the palmar articular surface that articulates with the congruent surface of the middle phalanx and a smaller articular surface perpendicular to the principal joint surface that articulates with the navicular bone (Fig. 2). The flexor surface forms the palmar aspect of the solar surface of the distal pha-

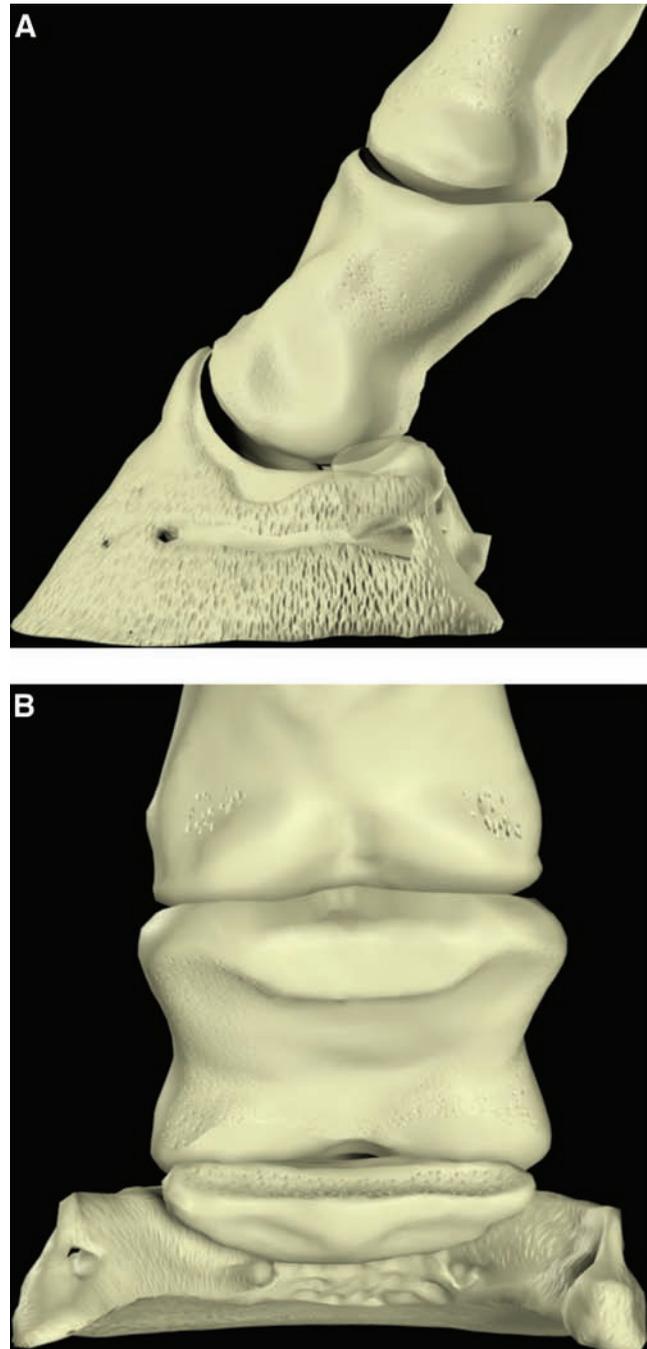


Fig. 2. (A) Lateral and (B) palmar schematic representations of the phalanges.

lanx into which the deep digital flexor tendon and distal sesamoidean impar ligament insert. The two palmar processes extend palmarly and abaxially from the body of the bone.<sup>1,2</sup> The distal sesamoid or navicular bone is a shuttle-shaped bone with two surfaces; the articular surface articulates with the distopalmar aspect of the middle phalanx, and the secondary smaller articulation with the distal phalanx and a flexor surface forms the distal scutum

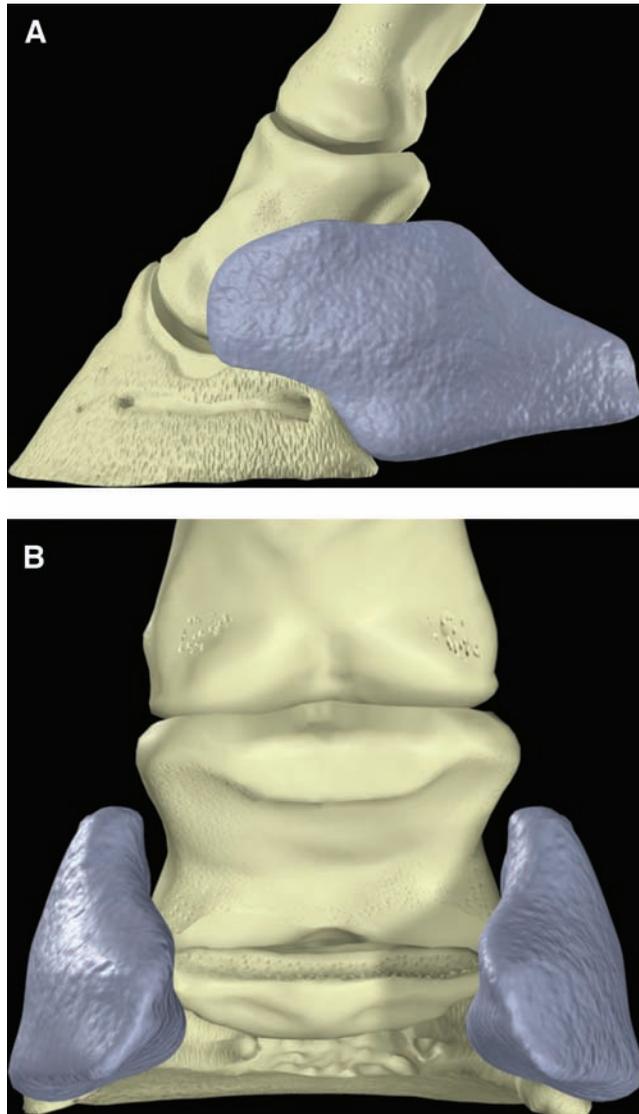


Fig. 3. (A) Lateral and (B) palmar schematic representations of the ungual cartilages.

through which the deep digital flexor tendon passes. It also has two borders—a proximal border to which the collateral sesamoidean ligaments attach and a distal border from which the distal sesamoidean impar ligament arises. It also has two extremities abaxially<sup>1,2</sup>: the ungual cartilages are rhomboid-shaped plates of hyaline cartilage that attach to the palmar process on either side of the distal phalanx such that approximately one-half of their mass is dorsal to the palmar extent of the distal phalanx and one-half of their mass is dorsal to it (Fig. 3). Additionally, these cartilages are approximately one-half within the hoof capsule and approximately one-half proximal to the hoof capsule.

The distal interphalangeal joint is complex and is formed by the articular surfaces of the head of the middle phalanx, distal phalanx, and navicular bone.

They form three separate articulations: between the middle and distal phalanx, between the middle phalanx and navicular bone, and between the distal phalanx and navicular bone. However, the articulation between the distal phalanx and the navicular bone moves very little so that the distal phalanx and the navicular bone essentially function as a single articular surface to articulate with the head of the middle phalanx. The two condyles of the head of the middle phalanx, separated by a shallow groove, are congruent with the corresponding surfaces on the distal phalanx and navicular bone. As such, this joint is a hinge that permits flexion and dorsiflexion. The configuration also permits considerable rotation and thus, is also called a saddle joint. Slight mediolateral translocation of the distal phalanx in relation to the middle phalanx may also occur. These movements out of the primary plane of motion allow the foot to temporarily accommodate the irregularities in the ground surface. The shape of the joint capsules reflects the direction of motion within the joint and the position of restraining ligaments (Fig. 4).

The relationship between the three bones is maintained by the collateral ligaments of the distal interphalangeal joint, the collateral sesamoidean ligaments, and the distal sesamoidean impar ligament (Fig. 5). Several other ligaments within the foot attach the ungual cartilage to all three phalanges, the navicular bone, the deep digital flexor tendon, and its contralateral counterpart.<sup>3,4</sup>

Within the middle of the pastern, the deep flexor tendon is relatively narrow. After passing distally over the middle scutum on the proximopalmar aspect of the middle phalanx, the tendon broadens to pass over the distal scutum formed by the flexor surface of the distal sesamoid bone (Fig. 6). The navicular bursa is interposed between the deep digital flexor tendon and the distal scutum (Fig. 7). The deep digital flexor tendon inserts on the flexor portion of the solar surface of the distal phalanx. The digital flexor sheath encases the deep digital flexor tendon through most of its course in the palmar pastern region and terminates approximately at the level of the middle of the middle phalanx.<sup>5,6</sup>

The hoof is the integument of the foot. Like skin, the integument of the foot has three layers, namely the epidermis, dermis, and SC tissue. The epidermis is further subdivided into the stratum basale, stratum spinosum, and stratum corneum. The stratum basale and stratum spinosum are frequently referred to collectively as the stratum germinativum. Each of these layers is highly specialized. In brief, the SC tissue forms the digital and coronary cushions and the perichondrium and periosteum of the adjacent surfaces of the distal phalanx and ungual cartilage. The dermis and germinal layer of the epidermis interdigitate to form dermal and epidermal lamellae in the parietal part of the hoof and dermal papillae and epidermal pegs elsewhere. These relate directly to the tubular and

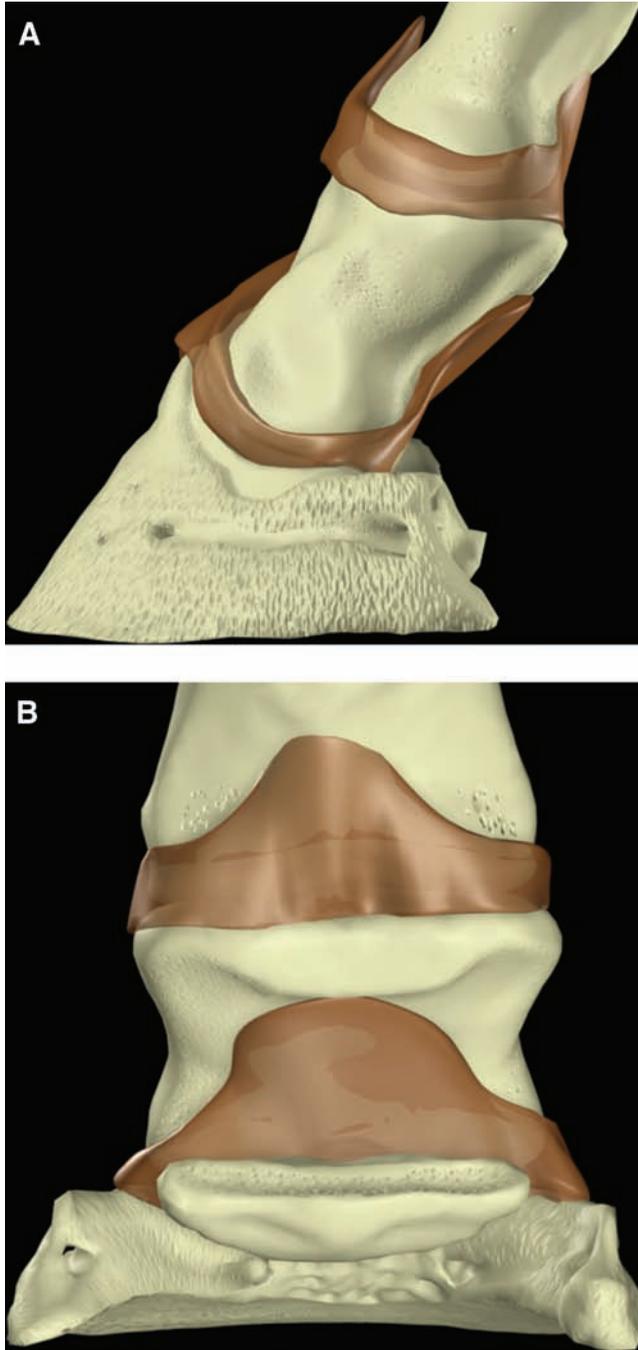


Fig. 4. (A) Lateral and (B) palmar schematic representations of the capsules of the interphalangeal joints.

lamellar patterns of horn that develop in the stratum corneum. The stratum corneum forms the hoof capsule. The hoof capsule is composed of the wall, sole, frog, and bulbs. The wall of the hoof capsule forms a curved plate that encapsulates the foot from heel to heel; this is thickest at the toe and thinnest at the heels. Inflexions of the walls at the heels form the bars. The sole has a body and two crura, and the overall structure is a concave plate.

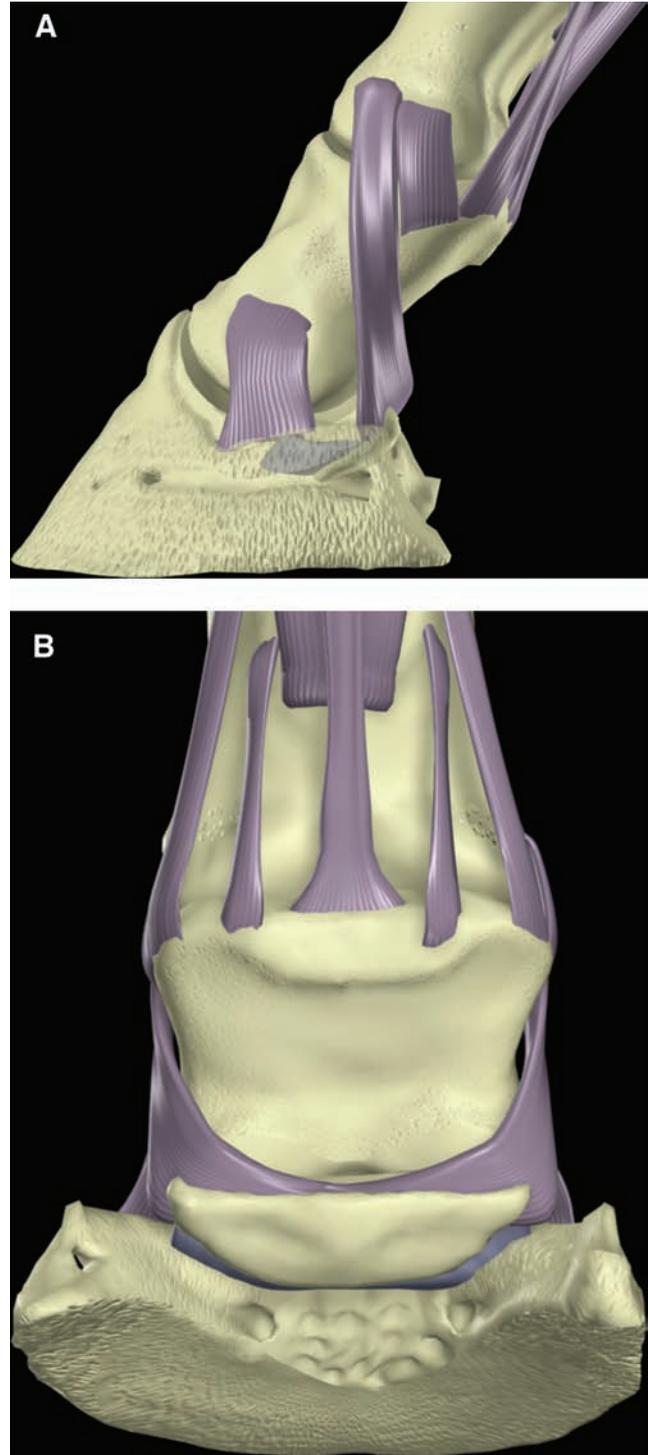


Fig. 5. (A) Lateral and (B) palmar schematic representations of the ligaments of the distal digit.

The crura of the sole abut the walls between the quarters and heels abaxially and the bars and frog axially. The horn of the wall is comparably strong around the circumference of the foot, but because the wall at the heels and quarters are thinner than at the toe, the palmar part of the hoof capsule is

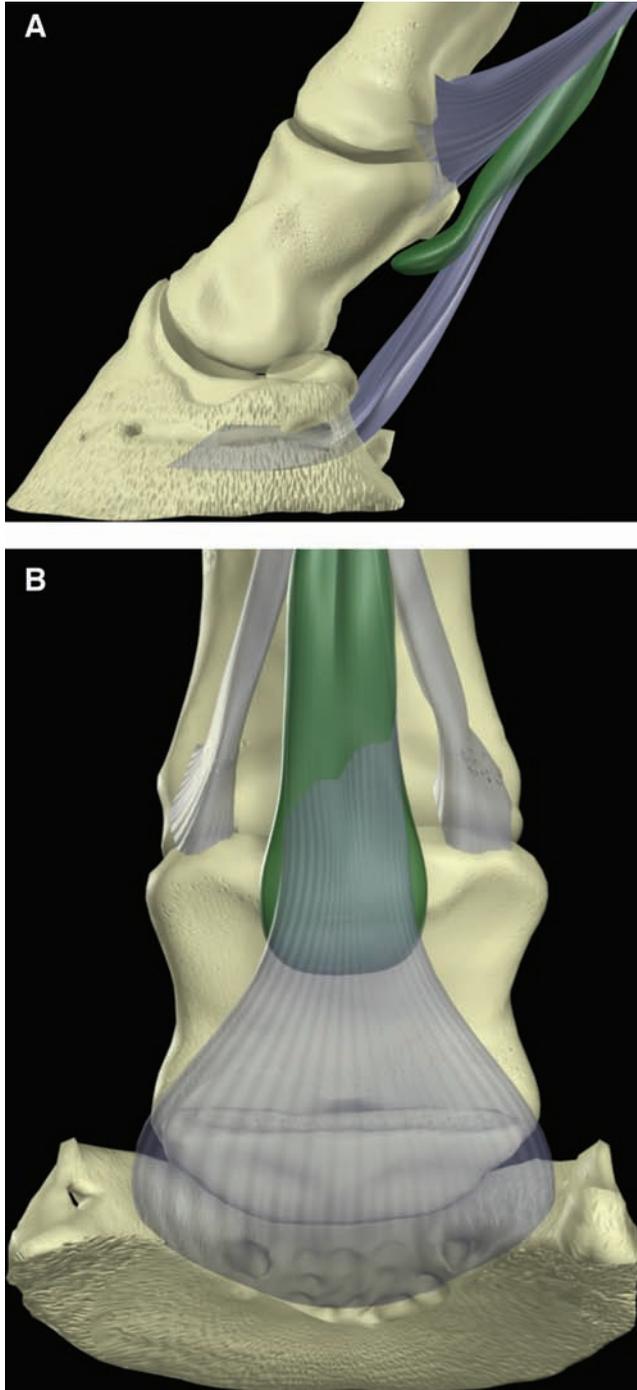


Fig. 6. (A) Lateral and (B) palmar schematic representations of the distal portions of the deep and superficial digital flexor tendons.

more flexible. The digital cushion is a specialization of the SC tissues that underlies the frog. It is bounded medially and laterally by the unguis cartilages, dorsoproximally by the deep digital flexor tendon, palmaroproximally by the more superficial layers of the integument proximal to the coronary

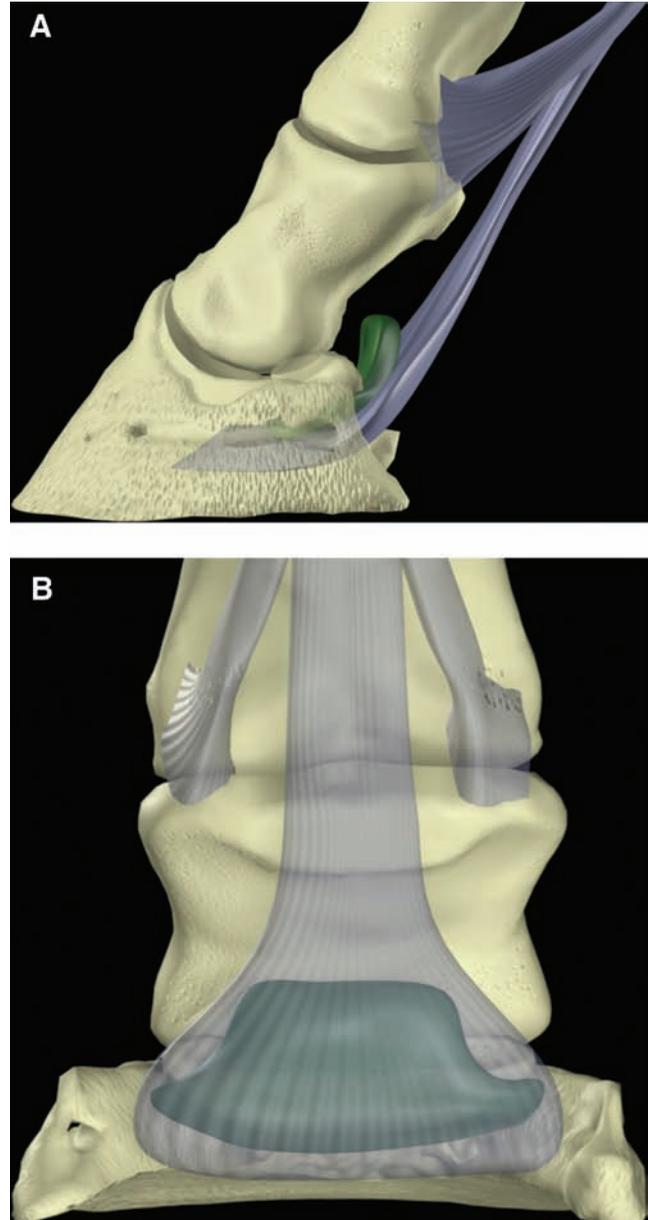


Fig. 7. (A) Lateral and (B) palmar schematic representations of the navicular bursa.

band, and distally by the dermis and epidermis of the frog (Fig. 8).<sup>7,8</sup>

### 3. Function of the Heels

An approximate idea of the function of the equine heels must be pieced together by examination of the gross anatomy of the foot. This helps clinicians form hypotheses regarding function, determine results of functional studies that show the role of the heels in landing and weight bearing, and correlate the conformation with diseased and “healthy” feet. The majority of information available regarding the function of the heels pertains to the forelimbs.

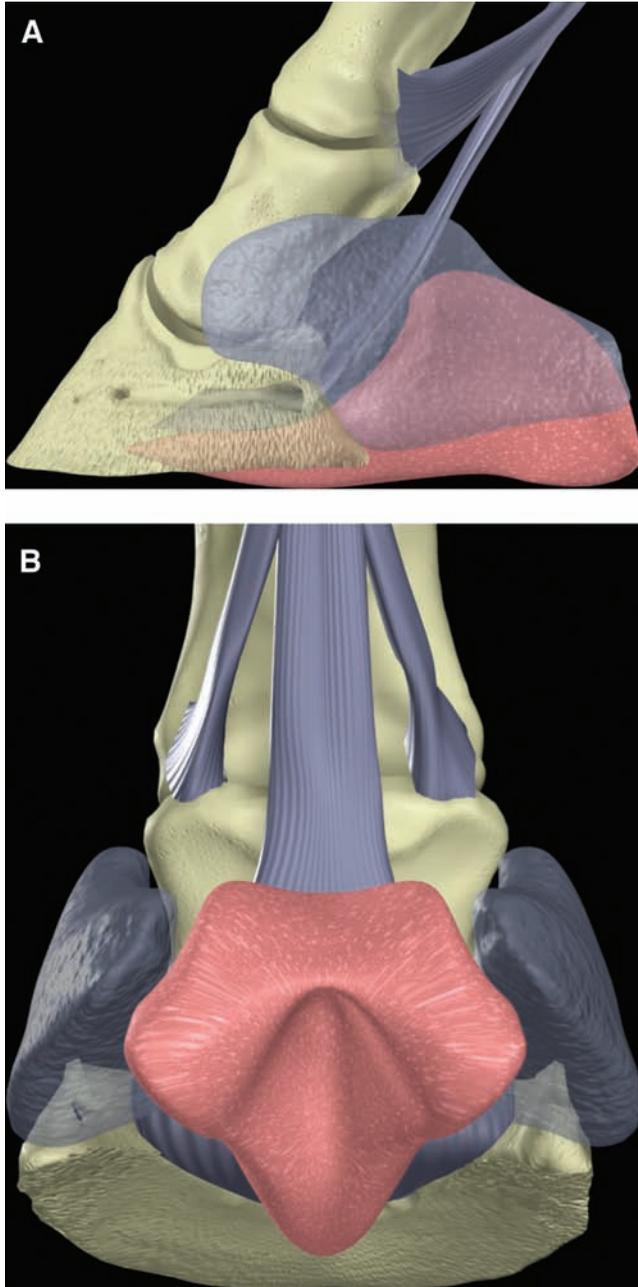


Fig. 8. (A) Lateral and (B) palmar schematic representations of the digital cushion (the ungual cartilages are ghosted).

Both macroscopically and microscopically, the very structure of the foot suggests its functions. The classical example is that of the frog; the position and shape of it suggest that when pressure is applied, it should cause an increase in pressure in the digital cushion. In turn, this suggests that the increased digital-cushion pressure forces the walls between the quarters and heels abaxially. Alternatively, the position of the frog between the bars and crura of the sole suggests that the frog could also act passively as an expansion joint that permits the heels to expand by some other mechanism. Form per se cannot be used to infer

function, but rather, it can be used to formulate hypotheses about function that can be tested with physiological studies.

To understand the function of the heels, it is necessary to explore the kinematics of the stride as it pertains to the foot and the distribution of forces exerted on the structures of the foot. The stride is divided into two primary phases—suspension and stance; the suspension phase involves movement of the limb off the ground, and the stance phase is the period that the limb is in contact with the ground. The stance phase of the stride is subdivided into initial contact, impact, stance, and breakover.<sup>9</sup>

When moving in a straight line, most horses land on the lateral side of the foot, either at the heel or quarter.<sup>10</sup> Landing flat is less common, and landing medially is rare. The foot becomes flat within a few milliseconds and remains so for the duration of the stance phase until the beginning of breakover, which begins the moment the heels leave the ground and ends as the toe leaves the ground. Research suggests that the angle at which the foot initially impacts the ground is determined by proprioceptive feedback that regulates the angle of the distal phalanx to the ground but not the angle of the ground surface of the hoof capsule. Presumably, this works through receptors in the joint capsules and tendons.<sup>9</sup>

Much of the movement and loading of the distal limb are passive. The distal limb advances during the protraction phase of the stride primarily because of the momentum generated by the proximal limb; the foot is positioned at the appropriate angle for impact. As the limb is loaded by the weight of the horse accelerating toward the ground, the metacarpophalangeal joint dorsiflexes, and the interphalangeal joints flex. The tension in the flexor tendons increases as they lengthen and store energy.<sup>11</sup> Because the metacarpophalangeal and interphalangeal joints rotate in opposite directions during loading, the increase in tension in the deep digital flexor tendon that inserts on the distal phalanx is less than that in the superficial digital flexor tendon and suspensory ligament that insert on the proximal and middle phalanges during loading. However, during the second one-half of the stance phase, the metacarpophalangeal joint moves dorsally and the distal interphalangeal joint also dorsiflexes so that the tension in the portion of the deep digital flexor tendon distal to the insertion of its accessory ligament increases.<sup>9</sup> Increased tension in the deep digital flexor tendon causes increase pressure on the navicular bone.<sup>12</sup> Additionally, during the normal walk, slight amounts of collateromotion and rotation between the phalanges is normal, primarily at the beginning and end of the support phase of the stride.<sup>10</sup>

The weight-bearing interaction with the ground is described in terms of the ground-reaction force that is represented as a vector (i.e., it has a magnitude and direction). Additionally, it has a point of action

called the center of pressure or point of zero moment. The ground-reaction force vector is divided into three components—vertical, mediolateral horizontal, and cranio-caudal horizontal components. Albeit somewhat simplified, the vertical component represents the weight on the limb, and the cranio-caudal component is braking (deceleration) and propulsion (acceleration).

The center of pressure is initially at the point of initial contact, and it rapidly moves to the approximate center of the ground surface of the foot where it remains for most of the weight-bearing phase of the stride before it begins to move toward the toe approximately 75% of the way through the stride.<sup>13</sup> The force-time curve during the weight-bearing phase of the stride at a trot looks like an inverted U.<sup>9</sup> Therefore, the magnitude of the vertical component of the ground-reaction force is low at initial contact and at the end of breakover, and it peaks in the middle of the stride. Thus, at the time when the center of pressure is at the heels, the vertical ground-reaction force is low, and by the time the ground-reaction force is high, it is centered in the ground surface of the foot. However, in addition to the overall force on the limb, the ground-reaction force undergoes high-frequency vibrations during the impact phase that take ~50 ms to disappear.<sup>9,14</sup> It is these oscillations associated with impact in the ground-reaction force that are thought to be the greatest source of injury in equine and human athletes.

It has been known for a long time that the hoof expands as it is loaded during weight bearing. Maximal expansion of the foot occurs during ~33% of the overall stance phase of the stride. This occurs after the oscillations of impact have subsided and the center of pressure is near the middle of the ground surface of the foot but before the vertical component of the ground reaction force is maximal.<sup>15</sup> The width of the heels has return to pre-expansion dimensions by 75% of the stance-phase duration after which the heels contract to coincide with the movement of the center of pressure toward the toe.<sup>15</sup> It has also been shown *in vitro* that the majority of the dampening of the vertical component of the ground-reaction force occurs between the hoof and the distal phalanx.<sup>16</sup> Thus, the expansion of the palmar one-half of the foot seems to be related to the absorption of the energy from the vertical component of the ground-reaction force before the rate of loading tapers off in the middle of the stance phase of the stride; however, the mechanism by which the foot expands is incompletely understood. Traditional hypotheses suggest that the pressure in the digital cushion is increased either by descent of the middle phalanx toward the digital cushion or by upward pressure from the frog as it contacts the ground; this increase in pressure is thought to force the abaxial movement of the hoof. Research studies have provided either inconclusive or conflicting results. One showed no consistent relationship be-

tween frog pressure and hoof expansion.<sup>17</sup> Another showed increased hoof expansion with increased frog pressure, but the hoof expanded to a lesser extent when no frog pressure was present.<sup>15</sup> A third study showed that the pressure in the digital cushion dropped during weight bearing, which suggests that foot expansion was not dependent on frog pressure and that it was the expansion of the hoof by some other mechanism that caused the drop in frog pressure.<sup>18</sup>

There are significant differences in the landing of the horse, the movement of articulations, and the distribution of stress within the distal limb when a horse turns in a tight circle compared with when a horse moves in a straight line.<sup>19</sup> When a horse moves in a tight circle, the limb to the inside of the circle is abducted before contacting the ground. The foot is more likely to land flat or toe first. The load, as evidenced by increased strains in the hoof wall at the lateral quarter and reduced strains in the medial quarter, moves toward the lateral wall.<sup>20</sup> As the limb is retracted during the stride, the distal interphalangeal joint rotates medially during the stance phase. This places considerable stress on the collateral ligaments of the distal interphalangeal joint and the suspensory ligaments of the navicular bone.

The evidence from the aforementioned studies suggests that the principle function of the heels is to dissipate energy during the impact phase of the stride. Therefore, it follows that any conformation or imbalance that impairs this natural function is likely to result in disease, because the majority of lameness associated with the heels are related to stress-induced injuries. Stress-induced injury is both a function of the structure of the heel and the severity of work performed. That is, injury may occur in any horse if the insult is severe enough, but if there is an anatomical pre-disposition because of abnormal balance or conformation, or a farriery manipulation that focuses stress, then injuries will be more likely to occur at submaximal work. If disease is the result of abnormal stresses and impaired function and poor structure pre-disposes the horse to disease, it follows that comparison of structures of the feet of horses with and without disease should indicate what good conformation is and have implications for function.

There are many assumptions about what constitutes a healthy foot based on clinical experience, and the characteristics that are generally considered desirable usually relate to the surface structure of the foot. These characteristics include a straight foot-pastern axis, short upright heels, a foot that is approximately symmetrical about the frog, and a foot that is about as wide as it is long. Additionally, the width of the frog at its base (i.e., its widest and palmar-most aspect) is approximately one-half to two-thirds of its length.

Examination of the palmar one-half of the foot shows that the internal structures are similar be-

tween horses at skeletal maturity, regardless of breed or type.<sup>21</sup> Some horses feet continue to develop, probably under the influence of some stimulation related to exercise and weight bearing, whereas others do not. It is the former category of internal development that correlates with the external appearance of the archetypal "healthy" foot. Such horses develop thicker unguis cartilages with fibrocartilagenous extensions that merge into the digital cushion, and the digital cushion contains more fibrocartilage. The thickened unguis cartilages contain numerous foramina of which each contains a central vein and a substantial microvascular network that includes numerous vascular anastomoses. The digital cushions that contain fibrocartilage are better at absorbing energy than those that contain predominantly fat and elastic tissue. The elaborate network of veins and microvasculature associated with the axial aspect of the unguis cartilages is compatible with a hydrodynamic mechanism for dampening the stresses associated with the impact phase of the stride. In contrast, "unhealthy" feet are associated with thin unguis cartilages with few to no vascular foraminae and digital cushions primarily composed of fat and elastic tissue. This provides both additional evidence for the impact-dampening function of the heels and a potential hydrodynamic mechanism for it.<sup>21</sup>

#### 4. Conformation, Balance, and Shoeing

The definitions of conformation and balance in relation to the equine foot are frequently ambiguous. Therefore, for the context of this review, the author considers the term conformation to refer to the shape of the limb, and as such, it refers strictly to the limb at rest (if the hoof is excluded, it changes little and slowly in adult horses). In contrast, the author considers the term balance to refer to the way the hoof relates to the underlying structures in the foot and to the limb proximal to the coronary band with respect to its position, size, and shape as well as the way the hoof relates to the ground both at rest and in motion. Because the hoof is constantly growing and because of the viscoelastic nature of the hoof capsule, foot balance can change rapidly in adult horses. Few studies have examined the effect of conformation with a "normal hoof" on foot function. One such study examined the relationship between slope of the foot-pastern axis and the distribution of force during the weight-bearing phase of the stride; a higher percentage of weight is borne by the palmar one-half of the foot in horses with sloping foot-pastern axes compared with horses with upright foot-pastern axes.<sup>22</sup> The implication is that the dorsal structures are more prone to concussion if the pastern axis is upright and vice versa.

There are many variables associated with balance that may influence the vibrations during the impact phase of the stride or the magnitude and position of the ground force; our knowledge about how these

impact the function and structural integrity of the heels is far from complete. However, intuitively it would seem that any particular pattern of conformation or balance that either increases the vibrations associated with initial impact or moves the point of force palmarly during the weight-bearing phase of the stride has the potential to damage the structural integrity of the palmar one-half of the foot and thus, alter function.

The influences of balance and shoeing on foot function have both been examined extensively. To alter the angle of the hoof to change either dorsopalmar or mediolateral imbalance, a wedge pad is applied; because a wedge pad is a shoeing manipulation, this aspect of shoeing is considered in conjunction with balance. Probably no external manipulation has been examined more than the effects on foot function of altering the angle of the hoof, particularly elevating the heels, because it is a time-honored method of treating horses with heel pain, and the simplest way to study the effects of altered dorsopalmar hoof balance. At rest, elevating the heels causes the interphalangeal joints to flex (the distal joint more so than the proximal one) and the metacarpophalangeal joint to dorsiflex modestly.<sup>23</sup> The opposite response occurs if the toe is elevated. The center of pressure remains in approximately the same position if the heels are elevated<sup>13,24</sup>; however, it has been pointed out that this results in a small ground-surface area that theoretically could lead to injury, because the same force is distributed over a smaller area.<sup>25</sup> The clinical observation that elevating the heels decreases the growth of the wall at the heels supports this contention, because wall growth is generally inversely related to load. Elevating the heels decreases the tension in the deep digital flexor tendon.<sup>26</sup> It also increases the intra-articular synovial fluid pressure.<sup>27</sup> Additionally, silicone-casting studies of the distal interphalangeal joint show that the contact between the head of the middle phalanx and the articular surfaces of the distal phalanx and navicular bone is no longer as even with heel elevation; the contact is concentrated more dorsally.<sup>27</sup>

In motion, elevating the heels increases the likelihood of heel-first contact and causes the distal phalanx to roll forward more after first contact before the foot becomes in stable contact with the ground.<sup>28,29</sup> During the second one-half of the stance phase of the stride, elevating the heels delays the movement of the center of pressure to the toe at breakover and thus, their unloading.<sup>13</sup> Additionally, either elevating the toe or the heel is reported to increase the impulse (area under force  $\times$  time curve) during the total weight-bearing phase of the stride.<sup>28</sup> It has little impact on motion within the distal interphalangeal joint outside the sagittal plane.<sup>29</sup>

It has long been held that the foot-pastern axis should be straight (i.e., 180°), but the evidence to confirm that this is the least injurious is limited. However, the evidence of optimal congruency of the

contact between the middle phalanx and the distal phalanx and navicular bone and the lowest impulse during motion with a straight foot-pastern axis support this concept. Another clinical feature considered indicative of poor dorsopalmar balance, namely collapsed heels, has recently been shown to be unrelated to the force applied to the navicular bone; however, the angle of the solar margin of the distal phalanx to the ground does correlate with the force on the navicular bone.<sup>30</sup>

The effect of changing mediolateral balance has been investigated in both stationary and moving horses in a similar fashion to dorsopalmar balance by adding medial or lateral wedges to a foot. Elevating one-quarter to induce imbalance causes rotation, collateromotion, and sliding between the phalanges.<sup>31,32</sup> It also shifts the landing pattern and the center of pressure during the stance phase of the stride toward the elevated side.<sup>12</sup> Logically, this would induce stresses in the collateral and collateral sesamoidean ligaments as well as the articular surfaces themselves. The challenge, of course, is to relate these deeper structural changes to superficially detectable changes. Optimal static-mediolateral balance based on external landmarks has been related to symmetry of the hoof and distal limb; however, radiography is a useful if not indispensable adjunct to assessing mediolateral balance. As such, mediolateral balance has been related to both parallelism of the articular surface of the distal phalanx with the ground and parallelism of the articular surfaces of the distal and proximal interphalangeal joints.<sup>33</sup> It is hard to imagine a beneficial situation in which the articulations are uneven, so the latter takes precedence over the former.

Steel shoes attached with nails are known to diminish the natural dampening mechanisms of the distal limb compared with unshod feet.<sup>14</sup> Specifically, shoeing with plain steel shoes increases the frequency and amplitude of the oscillations in the ground-reaction force during the impact phase of the stride and decreases the expansion of the quarters and heels during the stance phase. Certain plastic shoes used with synthetic viscoelastic pads reduce both the frequency and magnitude of the vibrations associated with the foot's impact with the ground.<sup>14</sup> Additionally, finite element analysis suggests that the nails, particularly those placed most palmarly in the foot, cause concentration of stress in the wall.<sup>34</sup> Egg-bar shoes, which function as a short palmar extension of the shoe, are probably the next most frequently used shoe for the treatment of heel pain. Studies have primarily examined the effect of egg-bar shoes when the horse is standing or moving on a firm, flat surface. At rest, they move the center of pressure palmarly in relation to the toe; this is considered beneficial for the deep digital flexor tendon and navicular bone but is potentially harmful to the hoof capsule at the heels.<sup>24</sup> Extreme heel extension combined with elevation, as seen in the use of Patten shoes that are used to treat

horses with deep digital flexor tendon injuries, shortens/deforms the heels; at the same time, it causes the toe to lengthen and become more convex and the sole to become more concave.

## 5. Conclusion

The equine foot is an intricately designed structure that accommodates the weight-bearing and propulsive functions of the foot at rest and during locomotion. It seems that the function of the various structures of the heels varies with the phase of the stride. At impact, they dampen the damaging high frequency of the rapidly accelerating and decelerating forces. During the stance phase of the stride, they facilitate the expansion of the hoof as increasing weight is borne by the foot and the flexion of the interphalangeal joint. At breakover, they participate in the extension/dorsiflexion of the distal interphalangeal joint. Consequently, it follows that if the heels are unduly loaded during the stance phase of the stride because of either poor conformation or improper farriery practices, then the additional load is likely to cause injury, damage these structures, and impair their function. During the second one-half of the stride, particularly at breakover, the navicular apparatus is under the greatest amount of stress. Consequently, it follows that either poor conformation or farriery practices that increase these stresses are injurious to the navicular bone, its associated ligaments, and the deep digital flexor tendon.

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Purinergic pathways are considered important in pain transmission, and P2X receptors are a key part of this system which has received little attention in the horse. The aim of this study was to identify and characterise the distribution of P2X receptor subtypes in the equine digit and associated vasculature and nervous tissue, including peripheral nerves, dorsal root ganglia and cervical spinal cord, using PCR, Western blot analysis and immunohistochemistry. mRNA signal for most of the tested P2X receptor subunits (P2X1-5, 7) was detected in all sampled equine tissues, whereas P2X6 receptor was not. *Structure and Function of the Equine Digit in Relation to Palmar Foot Pain*. Reprinted with permission from the American Association of Equine Practitioners. Originally printed in the 2006 AAEP Convention proceedings. Andrew Parks. © 2006 AAEP. 1. Introduction. The palmar one-half of the foot is palmar to the frontal or dorsal plane that divides the foot into approximately dorsal and palmar halves. The term "heels" simply refers to the palmar-most portion of the foot. As befits such a vague description, the heels are arbitrarily determined to extend palmarly from their junction with the quarters. The heels include the angles of the sole, the inflexion of the wall, and the bulbs as well as all the tissues that encase by them (Fig. Encasing the palmar/plantar surface of the foot is the sole, which is concave and has a similar, but softer and more flexible, composition to the hoof wall [10]. The bones of the equine foot comprise the third phalanx (P3; also called the distal phalanx), the second phalanx (P2), and the navicular bone. The solar corium is similar in structure and function to the coronary corium, with papillae enabling the growth of the sole [8]. The lamellae of the lamellar corium, commonly referred to as the sensitive or the dermal lamellae, form, together with the epidermal/insensitive lamellae of the inner hoof wall with which they interlock, the suspensory apparatus of the third phalanx, suspending.