

Equine Foot Function beliefs called into Question by New Research

I have questioned the simplicity of conventional foot function theory for much of the 25 years of my professional career. The equine foot is commonly treated with little regard given to the collective functions of its sensitive internal structures, this is irresponsible at best. To teach hoof care using anecdotal antiquated theory as a foundation, and then in some cases to label it as *Natural*, is ludicrous.

Today there are a great number of studies on the equine foot that could fall under the category of evidence based medicine; there are also several that do not. Sifting through the thousands of pages of text available on the equine foot did reveal one important fact; that a large percentage of today's hoof care professionals, whether labeled natural or traditional are comfortable, even complacent in their acceptance of the simplest of foot function theories.

My own anatomical studies and on-going research have revealed the importance of otherwise overlooked structures, vital to the proper function of the equine foot. I have gone so far as to develop theories that support the science of Energetics. Energetics defines a science that goes beyond simple bio-mechanics, and embraces physiology as a component of the whole.

The Suspension Theory of Hoof Dynamic™, Internal Arch Apparatus theory™, and my Hoof Growth theories will answer many of the questions facing today's researcher, horse owner, and hoof care professional. At the very least, these theories provide us with a starting point from which we may move ahead, this in contrast to the accepted simplistic explanations that provide us comfort in our current treatment of the equine foot.

What follows is a brief outline of my theories on energy management within the equine foot. It has been created to help reduce the anxiety of those who find themselves questioning the more vocal foot experts.

Energy Management within the Equine Foot (Foot function) by KC La Pierre

Close examination of the digital cushion and the relationship it holds with the lateral cartilages and surrounding tissue calls into question their functions. There are several theories that account for the function of the digital cushion-cartilage anatomy.

The *depression theory* holds that pastern movement into the digital cushion during the impact phase of the stride causes the digital cushion to force the cartilages of the foot outward, aiding in circulation and energy management. The *pressure theory* utilizes ground (solar) contact, with the frog stay pushing upwards into the digital cushion forcing the lateral cartilages to move outward. Both theories speculate that the digital cushion and the vasculature that accompanies it play a role in energy management, with the digital cushion absorbing the energy. Attempts to define haemodynamic function of the digital cushion have also suggested that during ground impact, the outward expansion of the cartilages of the foot occurs through the bars contact with the axial projections of the cartilage, and the downward movement of the bony column into the digital cushion. When this occurs, it is hypothesized that venous blood within the vessels of the palmar aspect of the foot is forced into the micro venous vasculature within the vascular channels of the ungular cartilage of the foot. Hydraulic resistance to flow through the micro vasculature dissipates the high energy. It is thus hypothesized that foot haemodynamic action accounts for the negative pressure recorded at mid stance, stating that the negative pressure would allow for refilling of the vasculature before next foot fall. It is further hypothesized that the negative pressure is the result of rapid outward movement of the cartilages of the foot. 2

Research into those structures that join with the cartilages of the foot, and the digital cushion provide evidence that may contradict the pressure and depression theories and support several aspects of the *Suspension Theory of Hoof Dynamics*.

Examination of those structures that may work in concert with the cartilages and digital cushion is necessary to formulate a working hypothesis for foot function. We also need to look to areas that may have otherwise been over looked in previous attempts to understand foot function.

The *coronary band* and its attachment are very poorly defined, when compared to those of the ligaments, cartilage, and digital cushion of the foot. Its attachment to the ungular cartilages and extensor process could prove to be a vital piece of the puzzle in the search to define proper foot function. The coronary band (Pulvinus coronae) lies in the coronary groove immediately distal to the periople corium, proximal to the parietal surface of the distal phalanx, and abaxial of the ungular cartilages of the foot. In vitro studies of the coronary band suggest that its relationship to the ligaments of the foot and cartilages of the foot may play a significant role in haemodynamic flow.

The Suspension Theory of Hoof Dynamics hypothesizes that during the ground impact phase, the pastern begins to descend, causing the lateral cartilages of the foot to move outward. This occurs as a result of ligament, fibrous and fascia attachment influences, and displacement caused by the second phalanx, as opposed to digital cushion displacement. Though digital cushion displacement does occur, new studies indicate that its function is interdependent upon the frog spine. The frog spine effectively directs the energies/pressure medial and lateral to the ungular cartilages. Pressure exerted on the vasculature of the foot by the displacement of the cartilages by the distal palmar movement of P2, displacement of the DC as directed by the frog spine, and the *resistances provided by the coronary band and its attachment effectively restrict* venous blood flow. This restriction would allow for the dissipation of excess energy, and provide the optimum stimulus needed for correct foot function

The Suspension Theory of Hoof Dynamics™ further hypothesizes that just prior to mid stance, the pastern begins to ascend, this releasing venous blood now *under pressure*. This rapid exchange of blood *under pressure* from the ungular cartilage, and coronary vasculature to the proper palmar digital vein would result in a negative pressure in the foot. This action would presumably cause rejection of both the pressure, and depression theories, as well as dispel the concept that hoof expansion was responsible for finding negative pressure within the digital cushion at mid stance.

The suspension theory redefines haemodynamic function, to include haemodynamic response, and the resulting neurological response. The amount of resistance that the venous blood meets during the stance phase would depend upon several factors including, health of internal arch apparatus, pastern movement, and amount of force. The greater the force, the greater the pastern movement, the greater the resistance the coronary band would need to provide. The amount of pressure within the foot during the impact and stance phase will be in direct ratio to pastern movement, and the resistance to expansion provided by the cartilage, coronary band, digital cushion/frog spine, and hoof capsule. It then becomes the amount of pressure, and the health of hoof capsule, connective tissue, ungular cartilages, and digital cushion/frog spine that will determine haemodynamic response and energy utilization/dissipation.

All directional movement of the ungular cartilages, coupled with distal palmar movement of P2 would result in a variable restriction of blood flow proximally from the foot. It is likely that medial-lateral and proximal-distal movement of the palmar axial projection of the lateral cartilages would be influential in the timing, and the ratio of "force to pressure "occurring during the impact and stance phases of the stride. It can easily be understood why the coronary band has been overlooked as an important component in energy management, with the coronary band being commonly viewed as elastic in nature.

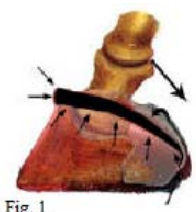


Fig. 1

Figure 1 illustrates the function defined by the relationship of the coronary band (Pulvinus coroneae) to that of the cartilages of the proximal palmar aspect of the foot, upon impact. The anatomical evidence pictured supports the *Suspension Theory of Hoof Dynamics™*.

Timing is crucial to proper function, with timing being determined by pastern movement. Pastern movement is determined by the balance of the hoof capsule around the axis of the foot, and placement of the distal most surface of the angle of the bar/wall. Position of heel purchase is defined by the conformation of the cartilages.

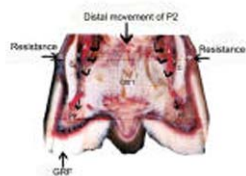


Fig. 2

- A. Proper palmar digital artery
- V. Proper palmar digital vein
- C. Ungular cartilage
- CC. Pulvinus coroneae
- PP. Palmar processes
- DC. Digital cushion

Figure 2. In the transverse section illustrated, the digital cushion would have little effect on the mechanisms responsible for cartilage movement as described by the Suspension Theory of Hoof Dynamics. Anatomical evidence does support the hypothesis of a *functional internal arch apparatus*, where all structures work in concert to regulate haemodynamic flow, haemodynamic response, and energy management.



Fig. 3



Fig. 4

Figure 3 & 4 illustrate the importance of the frog spine, and how its health would affect the distribution of pressures in the caudal foot. Heel, cartilage, and digital cushion integrity would be in direct ratio to frog and frog spine health.

These hypotheses would seem to negate the simplistic belief that the frog's primary function is to pump blood, or to act as a vehicle for the necessary displacement of the digital cushion, as outlined in the pressure, and depression theories. The Suspension Theory of Hoof Dynamics defines the angle of the bar/wall as the primary instigator of pastern movement upon impact, and would explain why performance horses are capable of dealing with the energies created at speed, with less than healthy frogs. Injury appears to occur more often in the foot with poor heel conformation, than in those that have unhealthy frogs, although unhealthy frogs often accompany poor heel conformation. Research does provide evidence to support the belief that the frog spine is responsible for directing pressure to the ungular cartilages, and thus providing the stimulus needed to develop healthy heel conformation. An unhealthy frog would define an unhealthy frog spine, and a foot that lacks the ability to produce the healthy cartilage needed for correct heel conformation. This process can only occur however, if the foot is allowed to distort three dimensionally.

Whereas shoeing will support the depression, pressure and haemodynamic theories, it will not support the Suspension Theory of Hoof Dynamics. The depression, pressure, haemodynamic theories require only expansion and contraction of the palmar aspect of the foot, where the suspension theory requires three dimensional distortion of the palmar aspect of the foot, only then can stimulus be distributed and utilized correctly.

For more information on foot function and this energy management theory please visit www.appliedequinepodiatry.org

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