This article appeared in The European Farrier's Journal #120 in July, 2006. It was in response to a "Letter to the Editor" which was related to our earlier article on Morphology.

In Response to the Comments of P. Grandjean

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Humans have prejudices that cause them to expect symmetry in the world around them. When Johannes Kepler (1571-1630) first described that planets followed elliptical paths around the sun, he was derided; at that time everyone accepted that the paths must be perfect circles. It is interesting to note that there are many such stories throughout human history.

Our article was merely pointing out that there are asymmetries in bones and hooves. We would be interested in learning of references to studies that show that foals start with symmetric bones and hooves – we don't think this is the case. It is certainly true that bones and hooves in adult horses show asymmetries. Further, there is a pattern to the asymmetries, for example, consider the long pastern bone (figure 1). This bone is not symmetric, and in our study of 34 horses, all showed this pattern to the asymmetry: the bone has a "built in" tilt to the lateral side.

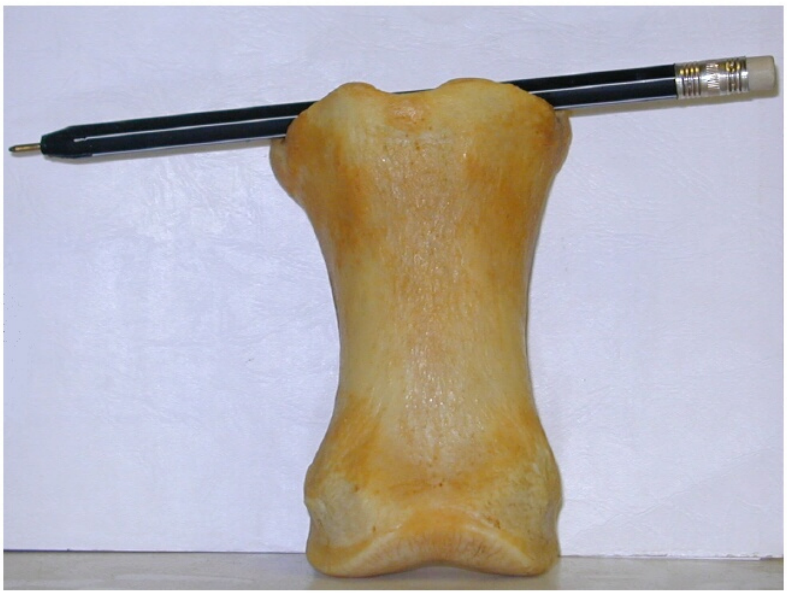

Figure 1: The long pastern (P1) bone from a right front leg. Pasterns have a built-in "tilt" in virtually all mature horses: the lateral side is lower.

Did foals start with symmetric pastern bones that became misshapen due to our poor trimming? We don't think so. If bones are not symmetric, then why wouldn't we also expect certain asymmetries in the hoof itself? Or perhaps people accept that the bones are not straight, but when you get to the distal end of the chain, they think that the hoof should have perfect symmetry? The same mother nature that designed non-circular planet orbits also designed the horse – and by lacking certain symmetries the horse's hoof is no less noble – it is an amazing structure.

As our article showed, in our study group, most hooves are narrower to the medial side as viewed from the solar aspect. It's not a large amount of asymmetry – but it exists – why is this difficult for some to acknowledge? Our article was primarily intended to debunk some pre-conceived ideas about the hoof. We are not the only ones who think that debunking is a positive thing in science [1].

The morphology of bones and hooves is the end result of a long evolutionary process, and all the influences that have come to bear are difficult to enumerate: mechanics, genetics, adaptations to environment, and the effects of man's care and use of the horse. It is true that bones, especially pedal bones, do "remodel" -- and not always for the better. But even before any "remodeling" happens (as the horse ages) we think there is an underlying intrinsic morphology of skeletal structures, some aspects of which include asymmetry.

Of course, we do need to have discussions about how the hoof should be trimmed and shod, our only point is that the discussion shouldn't start from an assumption of "innate symmetry".

The hoof capsule is highly adaptable structure and is very likely to change under the influence of different trimming and shoeing methodologies. The hoof capsule behavior and shape is also influenced by weather and soil conditions, and ultimately the biomechanics of a specific horse's motion and the type of training it undergoes.

The series of pictures in figure 2 shows the same hoof over a period of 14 months. In figure 2A this hoof was shod in metal shoes according the

American Farrier Association standard, in 2B it was shod in metal shoes according the Natural Balance standard, and in 2C it was shod using plastic glue on shoes. All pictures were taken at the end of a shoeing cycle (about 6 weeks.)

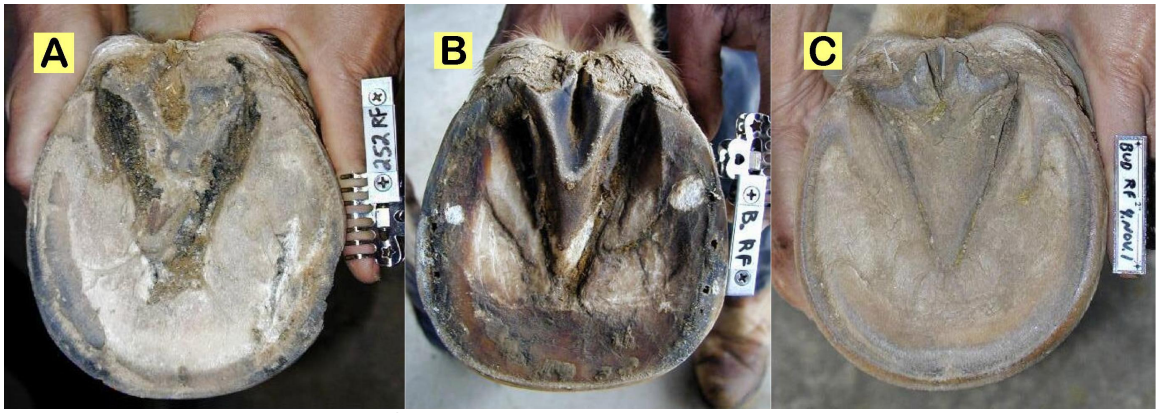

Figure 2: The same hoof over a 14 month period. Hooves change in shape depending on trimming, type of shoe, and other influences.

We do not think that a pad or packing can ever be the final answer to solving hoof problems, all these are just tools to help solve a particular problem. The main issue is how do you decide on your trim and when and how to apply these tools?

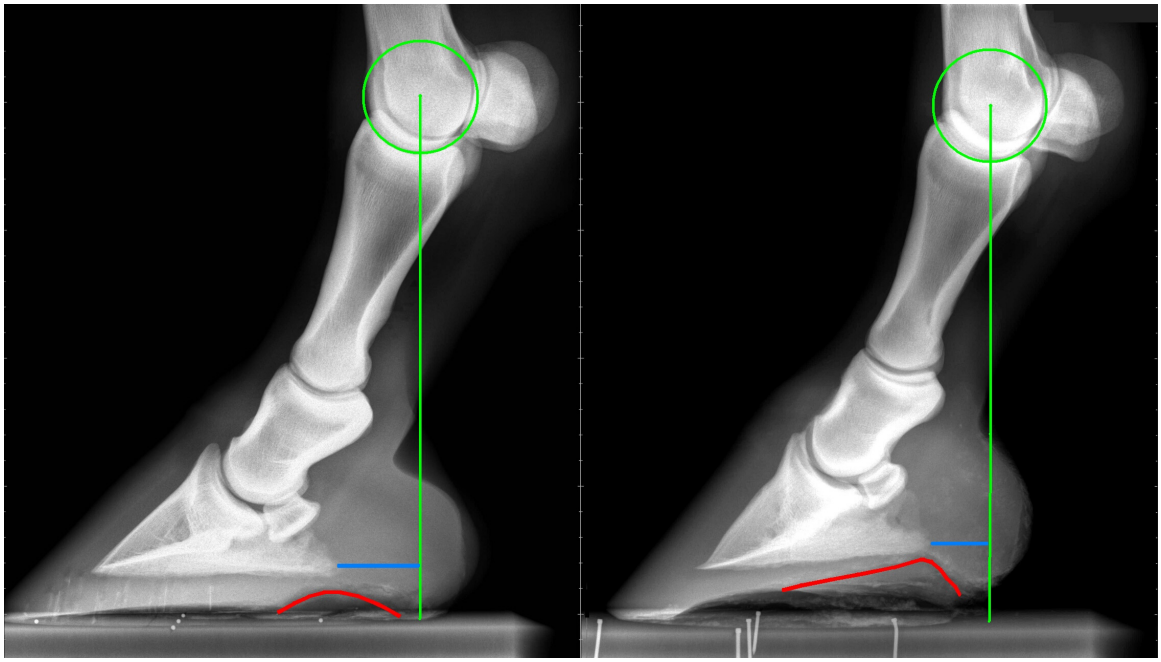

Figure 3: These two horses have very different attributes in terms of pedal bone shape and arch definition. The approach to shoeing will likely be quite different for these two cases.

In figure 3A, the hoof does not have a good arch definition, the palmar angle is negative and the last phalange P3 has shifted away from the bony column. The angulation of the coffin joint is quite different in the two images. Of course, this may affect the collateral ligaments to the navicular bone, and other structures. In figure 3A the static load at the pedal bone is shifted too far ahead of the bony column. Before applying any kind of support to the arch or the sole, it would be advisable to work with x-rays and to hoof test for signs of pain. We certainly would not address packing or support the hoof in figure 3A as we would in figure 3B. In figure 3B, the hoof capsule has a better arch definition and the pedal bone stands closer to the bony column. This is essentially a good hoof…at least as far as one can tell from the radiograph!

We think the internal stance is directly proportional to the quality of the stay apparatus (arch definition, angle of bars, and frog sulcus). Figure 4 shows a rendering of 3-D models of the bones created from the radiographs of figure 3, and shows their relative alignment.

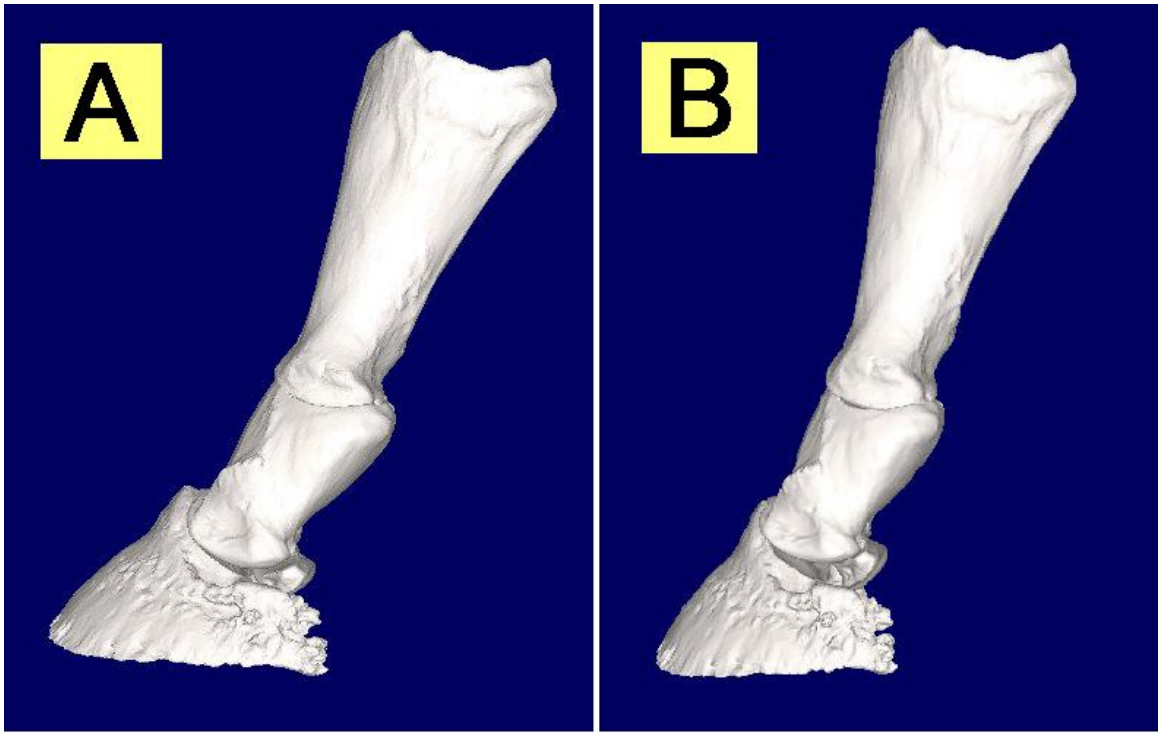

Figure 4: 3-D bone models and their relative alignment taken from the radiographs of figure 3.

The difference in static loading between the pedal bones shown in figure 4A and B will affect the health of the bones, the sole dermis and the keratinous sole. This may cause negative changes that could also create pain at the sole that have nothing to do with packing. Under normal conditions the whole hoof should be able to share load at the walls, the frog, the bars and the sole.

The pedal bone will lose its normal position as the arch loses its definition. In older horses we sometimes see partially collapsed bars and soles, and weaker digital cushions. In such horses, the position of the pedal bone changes – often starting to look more like the horse in 4A rather than the one in 4B. We feel that sole and arch support can be beneficial, especially in these cases. Obviously, there is a fine line between giving support and creating excessive pressure. Care and common sense must be applied when choosing and applying any kind of support to the sole and the arches. These days there are so many options with packing materials, the problem of creating painful pressure through packing should be avoidable. Finally, if there is already pre-existing pain in a hoof, it is unlikely that the pain will disappear overnight, especially when dealing with soft tissue and nerve damage.

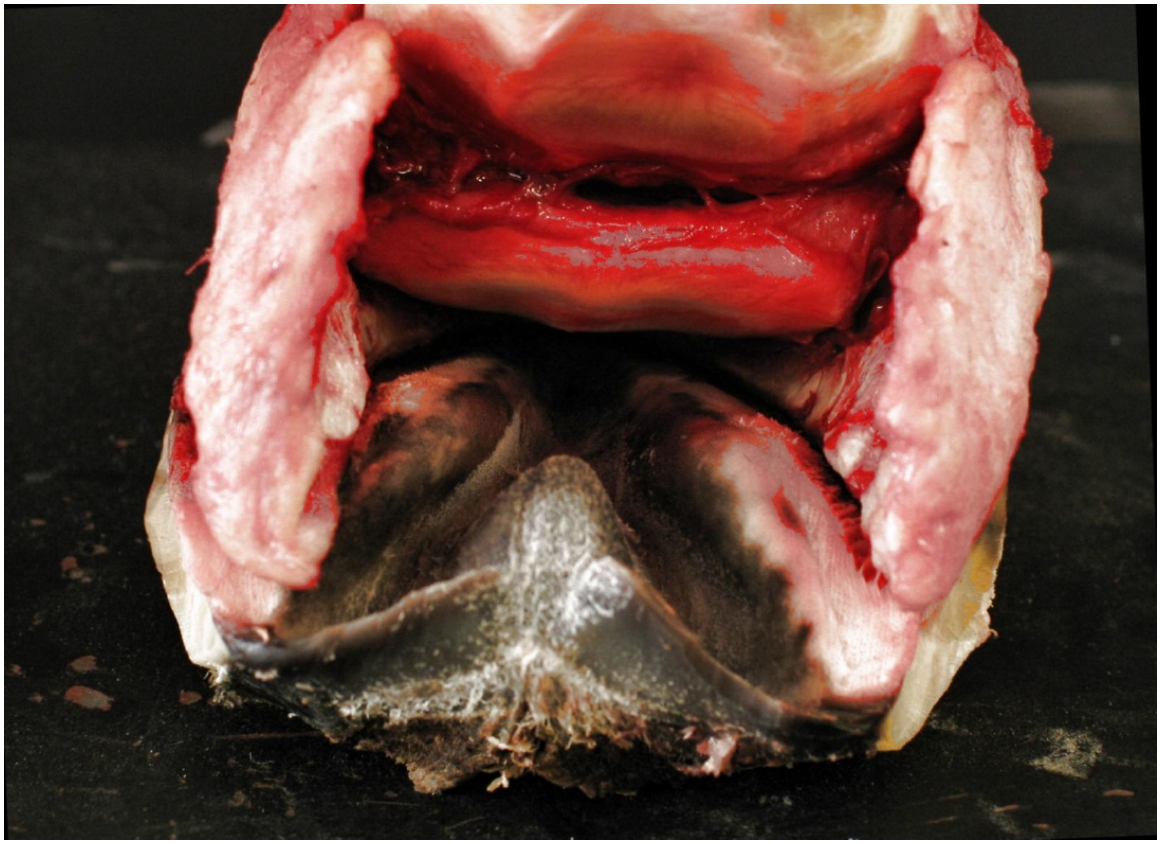

Figure 5: A view of the lateral cartilages. Rear view of dissected hoof with digital cushion removed. The prominent lobes on either side are the collateral or ungual cartilages.

Weak and/or collapsed internal structures need support to avoid further deterioration in the hoof. Note that negative changes in bone alignments within the hoof capsule also have an effect on the entire skeletal system and ultimately the general health of the horse. Everything is interconnected.

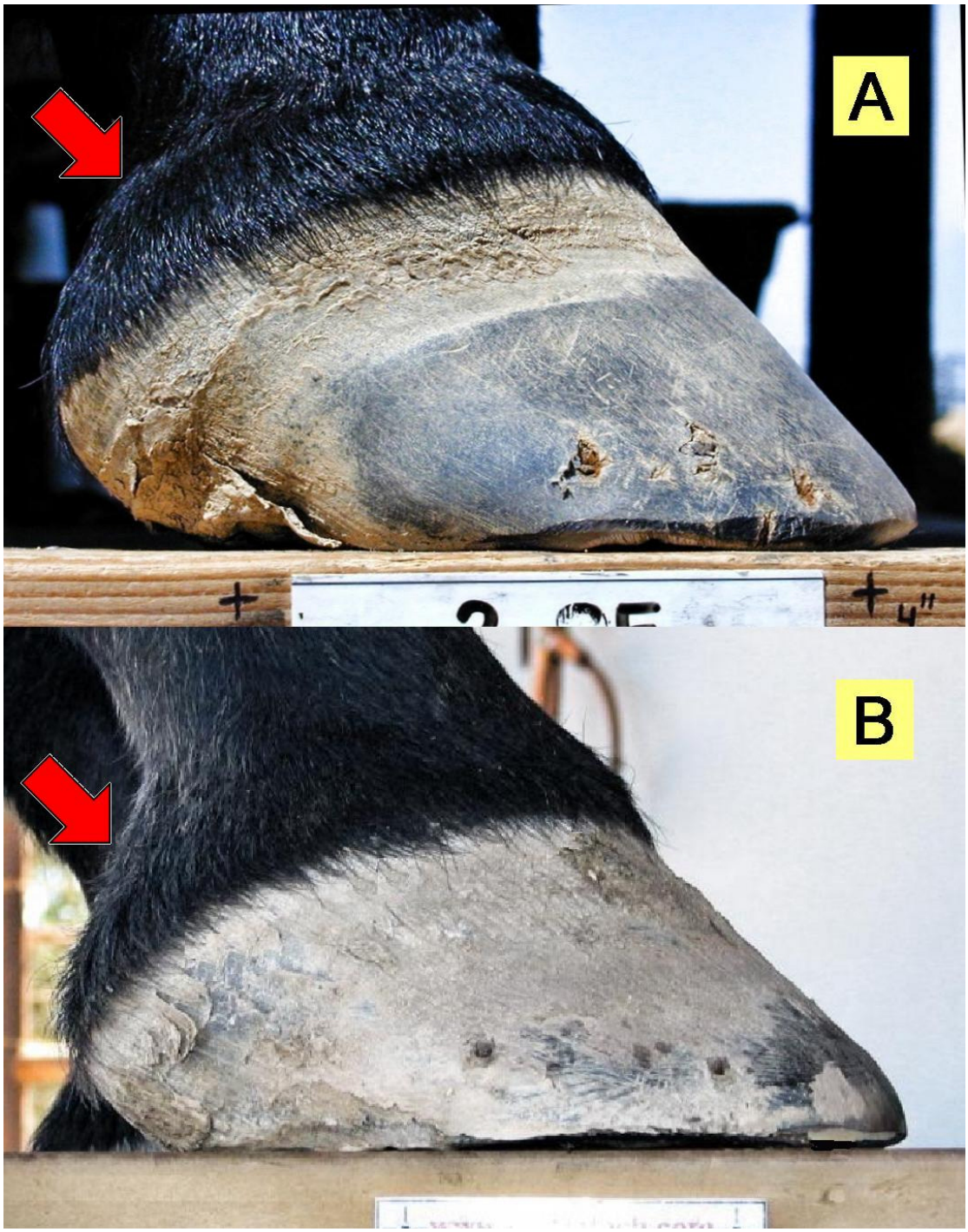

Figure 6: This is the same hoof before and after corrective trimming and shoeing. Both pictures were taken at the end of a six weeks shoeing cycle. On the topic of hoof pain and neurology -- what happens to the collateral cartilages as the arches lose their definition? Collateral cartilages are connected to the sole in the bar area, at least in 'normal' horses (fig. 5). The collateral cartilages can shift position within the hoof capsule as the shape of the arch changes.

Obviously capsular deformities do not only occur at the sole area. What happens when the walls of the hoof capsule have deformities? This may well also be affecting soft tissues, i.e. collateral cartilages, sensitive laminae, and the palmar nerves, arteries and veins (fig.6)

The hoof in figure 6A shows serious capsular deformities. Note also where the heels are in relationship to the bulbs. When a shoeing system changes there can be temporary pain and it is difficult sometimes to know whether the pain comes from "the change" or the new shoeing system. Sometimes a transition period must be allowed to see how the horse does in the new scheme. These issues often result in confusion or blame improperly assigned.

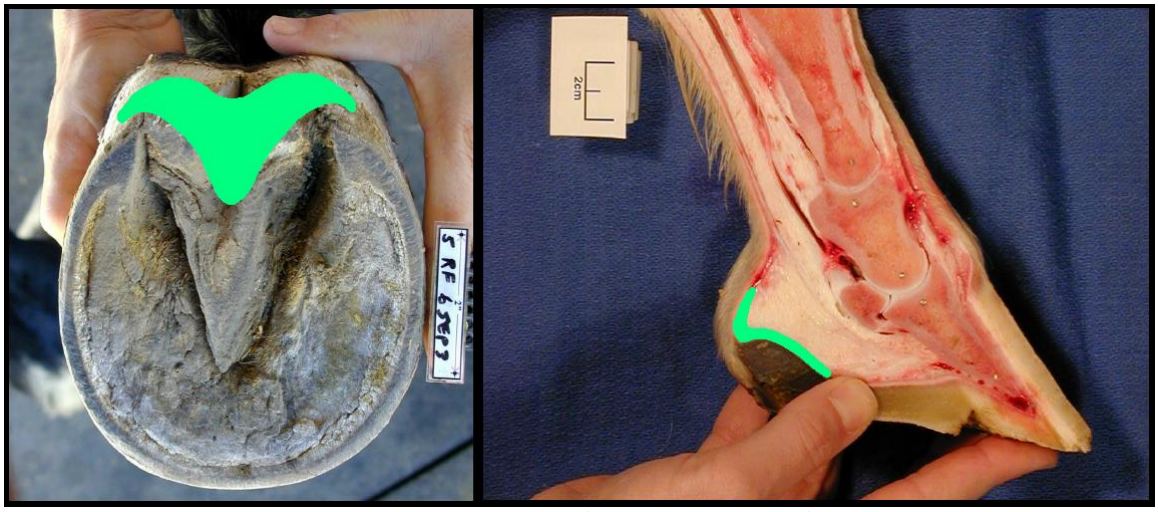

Figure 7: The approximate location of the majority of sensors and receptors is highlighted in green.

In the Eocene era, 55 million years ago, the first horse (Eohippus) had four toes in the front and three in the back. Eohippus was walking on pads more like a dog than the hooved animals we recognize today. The interesting thing with pads is that they contain subcutaneous pressure/touch sensors (pacinian corpuscles) and subcutaneous pain receptors. All mammals have such sensors and receptors in their skin, they can be found for instance in human finger tips and in dog paws. The modern horse has evolved to a hooved single digit animal but one can still find the vestigial digits in the splint bones and chestnuts. Pacinian corpuscles and pain receptors have also been found in the caudal region of the hoof [2], see figure 7.

The frog, it seems, is related to the pads of the dog's foot, and such structures in other animals. It is not too far fetched to note that the latter part of the frog and bulbs is essentially a pad [3,4].

On a final note, the digital cushion can vary in structure and quality, from being made of mostly fatty tissues to fatty tissues with large amount fibro-cartilages [5]. These differences in digital cushion will affect the durometer (hardness measure) of the digital cushion. Hence, it is probably not appropriate to characterize the digital cushion by a single value (e.g. 18 Shore A durometer).

References

[1] Gould, Steven J., "The Mismeasure of Man", 1981, 1993.
(This is not necessarily about horses but it is an interesting book about science, prejudice and misuses of data. The late S.J. Gould presents the idea of "debunking" as positive science!)

[2] Bowker RM, Brewer AM, Vex KB, Guida LA, Linder KE, Sonea IM, Stinson AW. "Sensory receptors in the equine foot." Am J Vet Res. 1993 Nov;54(11):1840-4. A.E.P., pp 405-406

[3] Gould, S.J. 1983. "Hen's Teeth And Horse's Toes", 1991.

[4] Thomason, J.J. 1986. The functional morphology of the manus in the tridactyl equids *Merychippus* and *Mesohippus*: paleontological inferences from neontological models. J. Vert. Pal. 6(2):143-161.
(Analysis of the pad-foot to spring-foot transition.)

[5] Bowker, R.M., "Contrasting Structural Morphologies of 'Good' and 'Bad' Footed Horses" in proceedings of the 49th Annual Convention of the AAEP, 2003, New Orleans, Louisiana.

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