Originally published in the European Farrier's Journal, 2020.

Tissue and Bone Stance Considerations During Hoof Manipulation

Monique Craig

Most hoof care professionals agree that the hoof should be aligned beneath the bony column and supported by a strong, structurally sound base, exhibiting well-defined sole arch characteristics (see Figure 1).

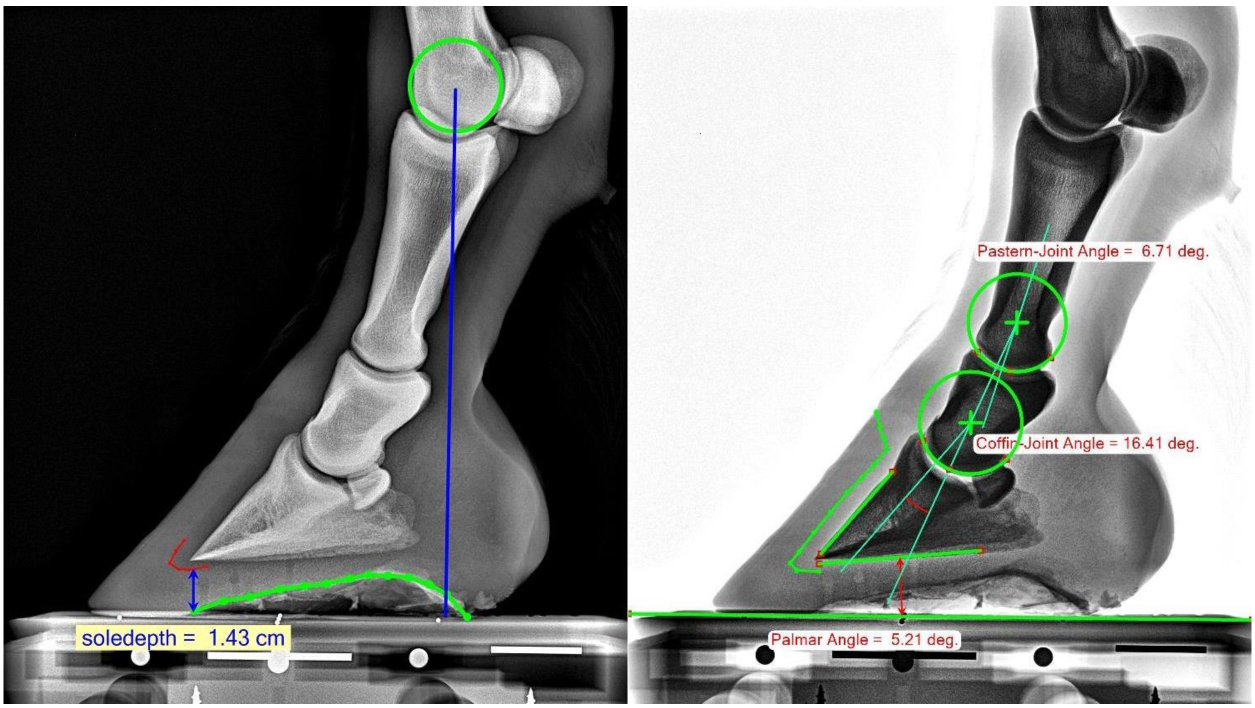

Figure 1: This radiograph is a good example of an adequate stance—meaning the hoof is standing under the bony column. The pedal bone is supported by a good sole arch. The sole depth, measured below the corium at the distal end of P3, is 1.43 cm. The palmar angle is 5.21 degrees. Both values are within range. The black-on-white radiograph displays the joint alignment, which is not straight, yet the hoof capsule is under the bony column with adequate sole arch, palmar angle, and sole depth.

Complications often arise when hoof care is guided by rigid formulas or unyielding dogma rather than by the unique anatomical and functional realities of the individual horse. While serious injuries, such as complete tendon ruptures, may necessitate more intensive forms of hoof manipulation, in my experience most cases do not require such drastic interventions through trimming or shoeing. It is essential to consider the hoof's inherent design, function, and biological limitations when determining an appropriate approach.

The hoof capsule is composed of keratin, dermis (corium), ligaments, adipose tissue, fibrocartilage, synovial fluid, tendons, and bone—each contributing distinct structural and mechanical properties. Collagen, present in ligaments, tendons, skin, and bone, provides tensile strength and resistance to stretching, whereas elastin, primarily located in the dermis/corium, allows for elasticity and recoil. Although elastin constitutes only a small portion of the dermis, its fibers can stretch up to 1,000 times their original length without energy loss, returning efficiently to their original form.

Structurally, the hoof capsule represents a highly specialized form of skin. The keratinized wall exhibits one of the most complex architectures found among mammals, with a hierarchical design that extends from the external wall through to the corium. The sub-lamellar dermis comprises collagen bundles. These bundles originate from the parietal surface of P3 and interdigitate with primary dermal lamellae.

The sensitive tissues within the hoof are richly innervated. The digital cushion contains various mechanoreceptors and nociceptors (pain receptors). Both the epidermal and dermal laminae of the hoof wall house sensory myelinated nerves and Merkel cells [1]. These anatomical and neurological considerations are critical when determining trimming and shoeing strategies [2].

Mechanically, the hoof operates as a unified structure; isolating one component (such as walls or bone stance) from the rest misrepresents its functional integrity. Moreover, the hoof capsule exhibits remarkable adaptability, capable of altering its morphology in response to environmental conditions such as moisture, as well as mechanical influences like trimming and shoeing.

The following two images illustrate the effects of abnormal stance and loading on hoof structure. The horse used in this test had no pathologies and was not trimmed for six weeks. No trimming was done prior to this test.

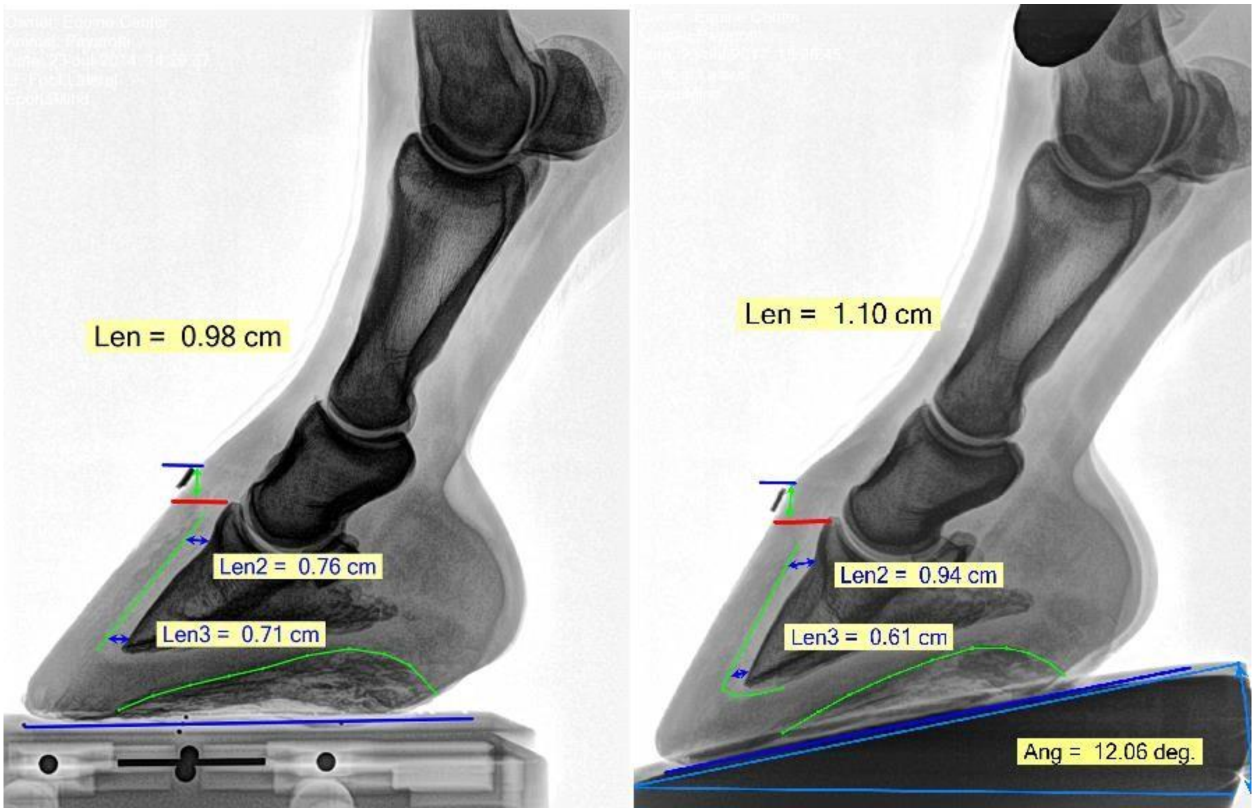

Figure 2: This left hoof is the "low hoof" of this horse. The radiograph on the left shows the hoof on a flat surface, but in the image on the right, a wedge of 12 degrees has been added. When comparing the two images, it is interesting to notice the position of the extensor process as it relates to the coronary band. The image with the wedge pad on the right displays a small numerical increase in vertical distance from the coronary band to the extensor process—changing from before lift (0.98 cm) to after wedge (1.10 cm). The extensor process position has also shifted toward the proximal wall after wedging the hoof. The dermal zones change before and after wedging. The dermal zone is the measurement of the sensitive lamina width. An increase in space in the proximal dermal zone and a decrease in space in the distal dermal zone is noticeable after wedging. The proximal dermal zone before wedging was 0.76 cm and after wedging was 0.94 cm. The distal dermal zone went from 0.71 cm to 0.61 cm. Note that no trimming was done at the time of the radiographs. The stance is altered to the point that the phalanges are no longer in normal joint positions. The sole is also being crushed down.

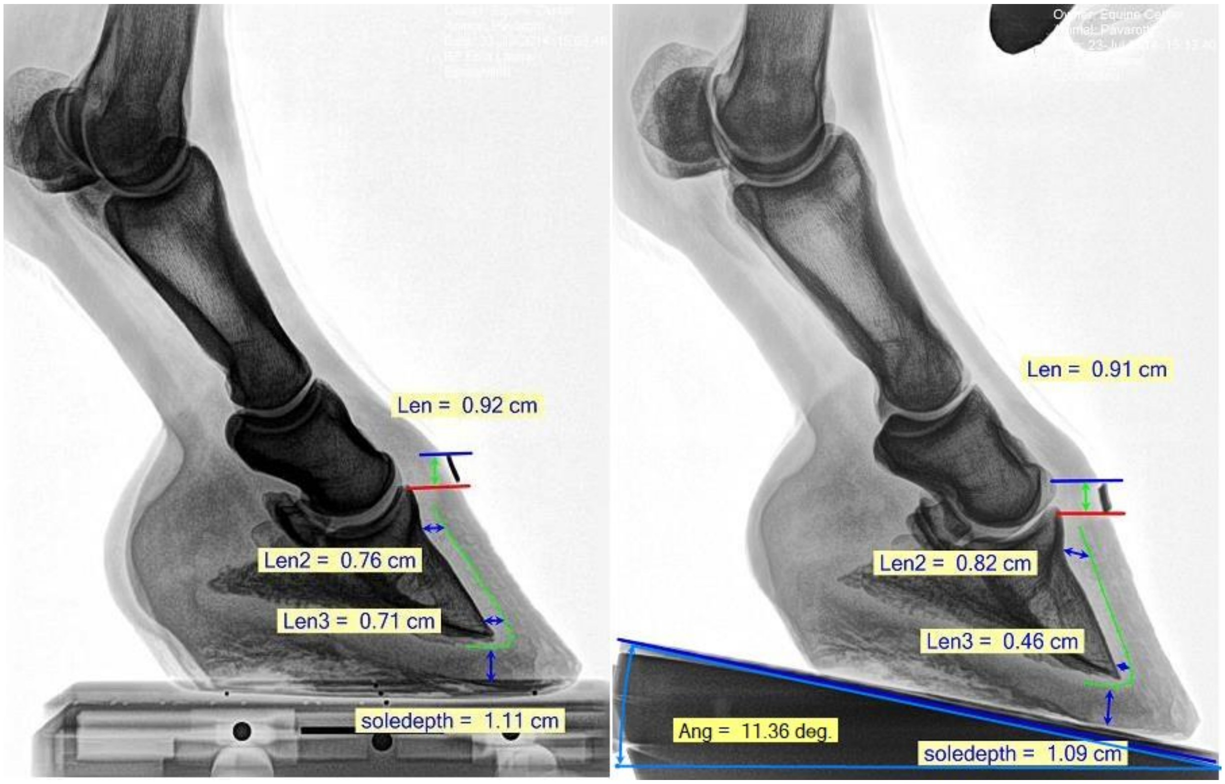

Image 3: This is the right front hoof of the same horse. Interestingly, this hoof already has an inadequate stance, being a bit too upright. However, when this hoof is wedged to 11.36 degrees, similar issues arise—namely with the dermal zones. The proximal dermal zone prior to wedging is 0.76 cm and after wedging measures 0.82 cm. The distal dermal zone prior to wedging is 0.71 cm and after wedging drops to 0.46 cm. The sole depth is slightly decreased, as well as the sole arch definition. After wedging, the original stance has degenerated further.

We need to consider the pros and cons of manipulating hooves via trimming and shoeing since it affects soft tissue health and proprioception. We must also consider the long-term effects of such shoeing decisions. Horses are masters at compensating, but this is not always for the better.

One thing I find intriguing is the notion of raising heels exceedingly in the treatment of laminitis. The rationale that raising heels reduces stress on the lamellar junction contains flaws when considering the abnormal repositioning of soft tissues along with faulty stance. Noted in a research paper [3]:

"… raising the palmar angle increases the load on the dorsal lamellar junction; therefore, hoof care interventions that raise palmar angle in order to reduce the dorsal lamellar load may not achieve this outcome…"

When it comes to the increased blood flow seen in venograms, one might ask: Is it due to the large wedge pad, or might it be due to the increased pressure due to faulty stance and soft tissues being stretched and compressed?

The next set of radiographs were obtained prior to and after trimming and shoeing done on the same day. The horse was not lame but needed a checkup due to early issues with thin soles. The pre-shoeing radiograph was taken after a six-week cycle and was obviously due for re-shoeing. Upon reviewing the radiograph, the attending veterinarian decided to change the prescription. In this instance, the chosen prescription was to obtain a 50/50 balance around the center of articulation and to achieve a straight phalangeal alignment. The post-trimming and shoeing radiograph achieved that goal—but at what cost? The right radiograph (Image 4) shows a hoof trimmed and shod to a rigid formula. Note that I am not against reasonable use of wedge pads; one needs to assess what can be done safely. The formulaic approach increased the lever and resulted in stressing tissues in a very similar manner to that presented in Images 2 and 3. The sole depth was reduced also.

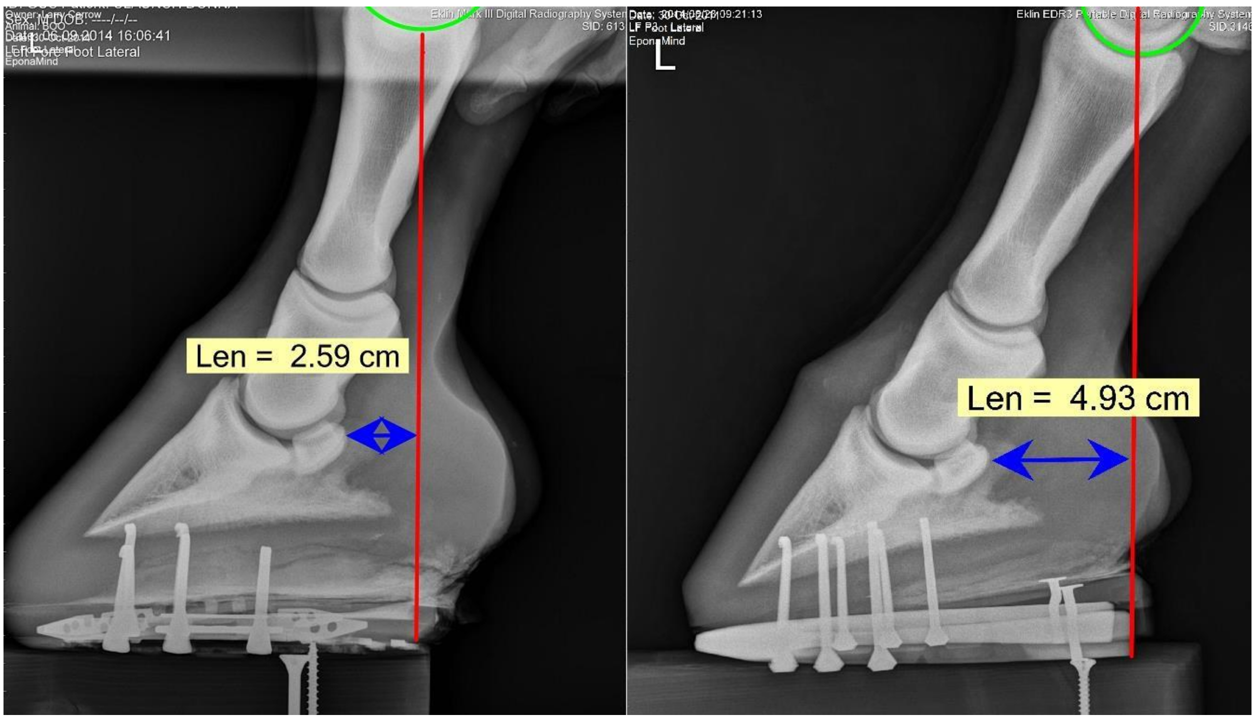

Image 4: A "before" and "after" shoeing on the same day. The before image on the left needed some correcting—but by how much, and according to which formula? A straight phalangeal alignment was obtained via a wedge pad and trimming to a 50/50 capsule position. This shoeing formula increased the lever arm.

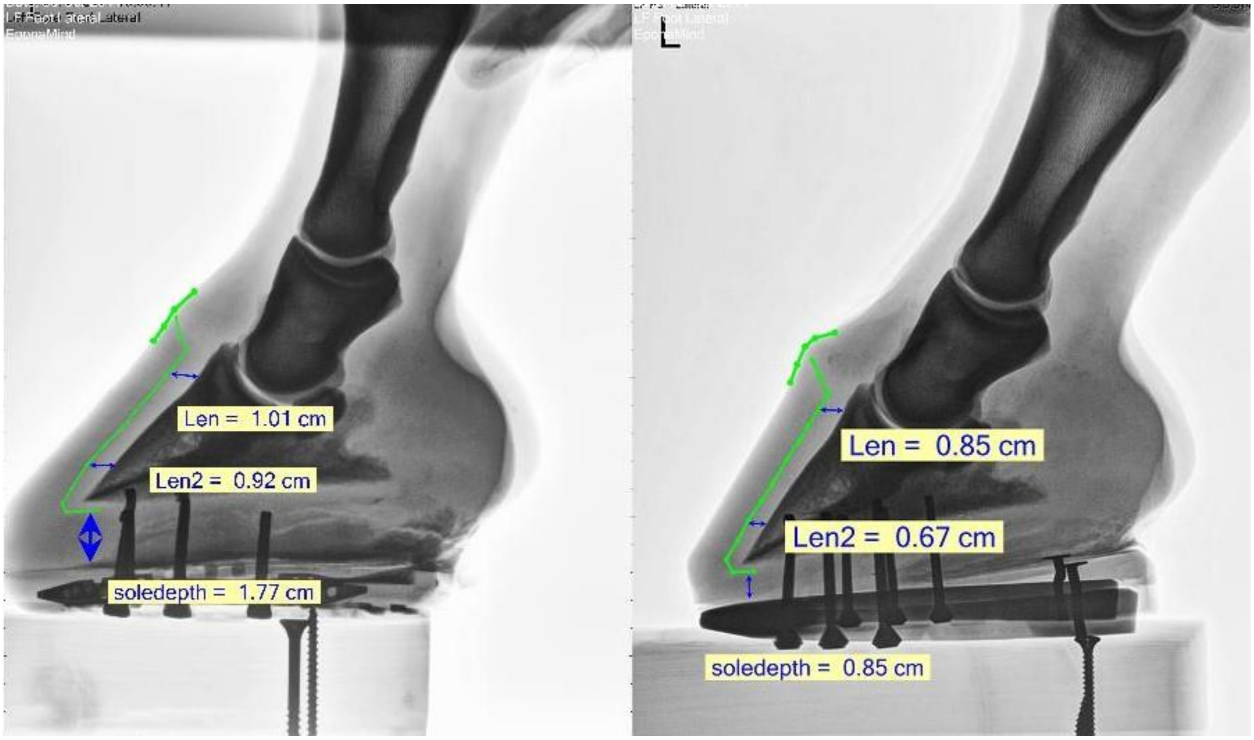

Image 5: The same images as in Image 4. The pre-wedge pad and trim radiograph show no signs of dermal zones being significantly altered, whereas the post-wedge image shows similar patterns of dermal zone shifts as in Images 2 and 3—namely, an increase in the width of the proximal dermal zone with a decrease in the distal dermal zone.

Finally, it is important that bones “seat together” at joints in a natural way as specified by their condylar morphology. It is not clear that the phalanges being in a perfectly straight line is natural in the standing horse. Further, it is detrimental to any bone to be forcefully set out of joint (see Image 6). Bones have different morphologies, and no one at this stage has produced enough research on dynamic modeling of joint kinematics to give provable assertions in these matters. Hence, it would be wise to proceed with caution when deciding to change stance radically.

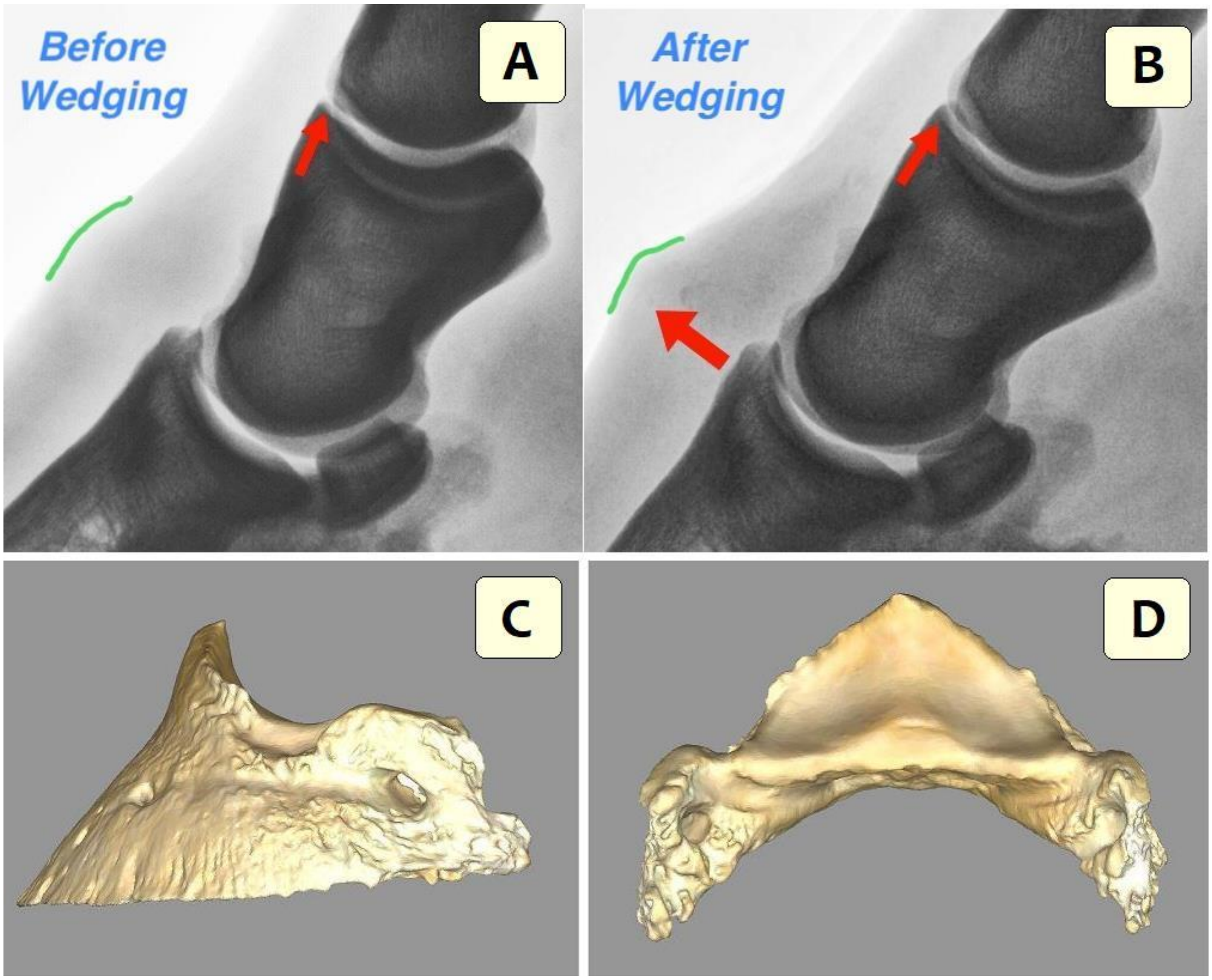

Image 6: This is a close-up of the radiographs in Images 4 and 5. Note the difference in bone stance prior to and after wedging. In the "after," the extensor process is forced onto the dorsal wall; note the bulging at the coronary band. The extensor process is not as small as it may appear in a lateral view (C) — in (D) we see it is quite broad. Any time it is pushed out of place, it affects a large portion of the coronary band.

In our published study [4] of 2,388 radiographed hooves, we found that the median coffin joint angle was 10.1 degrees, and the median pastern joint angle was 4.9 degrees in the standing horse. "Phalanges aligned" would be when these numbers are both 0.0. Summing them, we found that the average horse stands 15 degrees "to the upright side" of aligned. So, we believe this slightly broken-back stance is, in fact, normal. It is left for experts in the field to argue what is "ideal," which may differ from what is "normal." Although many references argue for "phalanges aligned" as the "ideal," we are still looking for a cogent biomechanical rationale for why that is believed to be so. In our further (and so far, unpublished) work, we have expanded the number of hooves in this study to over 7,000, with almost identical statistical results.

References

[1] Robert M. Bowker, VMD, PhD, Lisa S. Lancaster, DVM, PhD, and Diane A. Isbell, DVM, "Morphological evaluation of Merkel cells and small lamellated sensory receptors in the equine foot." *AJVR*, Vol. 78, No. 6, June 2017.
[2] Robert M. Bowker, VMD, PhD, Patrick J. Atkinson, PhD, Theresa S. Atkinson, PhD, Roger C. Haut, PhD, "Effect of contact stress in bones of the distal interphalangeal joint on microscopic changes in articular cartilage and ligaments." *AJVR*, Vol. 62, No. 3, March 2001.
[3] Ramsey, G.D., Hunter, P.J., and Nash, M.P., "The effect of hoof angle variations on dorsal lamellar load in the equine hoof." *Equine Veterinary Journal*, BEVA, Vol. 43, Issue 5, March 2011.
[4] Monique Craig, BSCE, APF, Tracy Turner, DVM, and John Craig, PhD, "Do horses stand with phalanges aligned?" *BFBA UK Forge Magazine*, Vol. 5, No. 5, September 2021.
[5] Pollitt, C., *The Illustrated Horse's Foot.* Elsevier, 2016.