

# **LONG TERM STUDY OF REHABILITATION FROM LAMINITIS IN 25 HORSES UTILIZING COMPOSITE SHOES**

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## **Introduction**

Laminitis in the horse has long been considered to carry a grave prognosis. Many studies have given insight into the patho-physiology and treatment of laminitis yet mortality remains common.

There are many suggestions prevalent in the literature regarding the manner in which to best shoe the horse with chronic laminitis. However there is a paucity of long-term studies to support any of these methods. We present long-term evidence supporting our trimming, shoeing, and treatment methods in this paper.

Contributing factors to poor prognosis can be attributed to severe clinical symptoms, poor dietary habits (obese horses), metabolic problems (Cushing disease or insulin resistant (IR) horses) and lack of proper foot care.

There are differing opinions as to what constitutes the proper regimen for horses diagnosed with chronic laminitis. When rotation of the pedal bone is apparent, some practitioners add wedge pads to reduce tension on the DDFT to minimize further damage to the laminae, while other practitioners begin to trim down the heels to lower the amount of rotation back towards a more normal range. Hence we see that on this very basic issue of proper treatment, we have two groups of practitioners that adopt opposite approaches: one group raises the heel, one group lowers the heel. We adhere to the belief that the palmar angle should be restored to a normal or near-normal range as soon as possible.

The DDFT tenotomy is a procedure that can at times be used in the case of severe rotation of the pedal bone. Again we find a large divergence in opinion regarding when this procedure should be used. In our group of 25 horses, in only one DDFT tenotomy was performed.

Resection of the hoof wall is another technique sometimes used in treating founder cases. Again we find a large variance in how or if this technique is used, with some practitioners using it often, and others avoiding it totally. In our method, we tend to avoid resection of walls whenever possible.

Trimming methodologies play important parts in the outcome of treatment of laminitis, and the literature advances many proposed methods of trimming and shoeing in order to deal with the effects of founder. It appears clear that the proper shoeing system combined with frog and sole support play a central role in recovery from founder.

## **Materials and Methods**

Twenty five horses were followed in this study (mean age 12.8yrs), 9 QH, 6 Arabians, 2 Warmbloods, 4 TB, and 4 others, over an average of 21 months. All horses were clinically diagnosed with severe, bi-lateral, forelimb laminitis at the chronic stage. Additionally, 11/25 horses were diagnosed with insulin resistance and 2/25 with Cushing's syndrome. All horses entered rehabilitation and were treated with precisely monitored trimming of the hoof and the use of composite, glue-on shoes. This paper is a modified and updated version of [1].

There exist a set of measurable parameters that are regularly used in standard practice to assess the severity of founder. These measures are:

- palmar angle of the pedal bone
- sole thickness (generally under the tip of the pedal bone)
- proximal and distal HL zones [3]
- “P3 descent” or position of the extensor process in relationship to the coronary band.
- Heel height

These parameters may all be measured from a high quality lateral to medial radiograph, although the heel height is perhaps more easily and accurately measured from a lateral photograph of the hoof.

Calibrated radiographs and photographs were used in conjunction with the Metron hoof analysis software to make these measurements. The Metron software employs various calibration methodologies in order to ensure accurate measurements. A discussion of these details is beyond the scope of this paper, but has been independently verified by others [4].

All horses entered rehabilitation and were treated with precisely monitored trimming of the hoof and the use of composite glued-on shoes. Central to our technique is to trim to bring the P3 palmar angle into an acceptable range, increase weight bearing in the caudal portion of the hoof, and use shoes which closely match the mechanical properties of the biomaterials of the natural hoof [2].

The trimming methodology was based on a three dimensional (3-D) approach to trimming along with the use of composite shoes and packing material. Our 3-D approach to trimming uses landmarks taken from the bony column, and projects them orthogonally onto the sole. We use the same landmarks to assist us in choosing the shoe

placement. This method of ‘referencing to the bone’ is particularly useful in the case of foundered hooves which may be quite misshapen and may not allow the practical use of other landmarks so often cited in farriery literature (e.g. the widest part of the foot, the tip of the frog, etc [5]). When a hoof capsule is badly distorted, it becomes less reliable as an indicator of how to trim it --- the answer to this problem is to reference back to the bony column and make use of radiographs to see how to shoe relative to the bones. That is, we are simply suggesting that the use of landmarks that are related to the bony column of the leg and foot should be given a higher weight than landmarks taken from a hoof capsule, particularly when that hoof capsule may be severely distorted due to a laminitic episode. A full exposition of our approach to trimming is beyond the scope of this paper and will be published in the future.

Our method to restore the palmar angle of P3 is to trim the heels lower by small amounts at each shoeing interval. While many details enter into the exact selection of the amount to trim at the heels, we would, on average attempt to lower the palmar angle by about 2 degrees every 5 weeks. The concept is to gradually lower the palmar angle so that the muscles and other soft tissue have time to readjust and heal without undue stress.

Our method to provide adequate caudal support is to use packing material along with a flexible shoe that has a good geometrical design to support the frog and caudal portion of the foot. The packing material in itself helps to support the arch of the sole. The helps maintaining structural integrity to the arches and prevent the pedal bone from further sinking (Fig. 1).

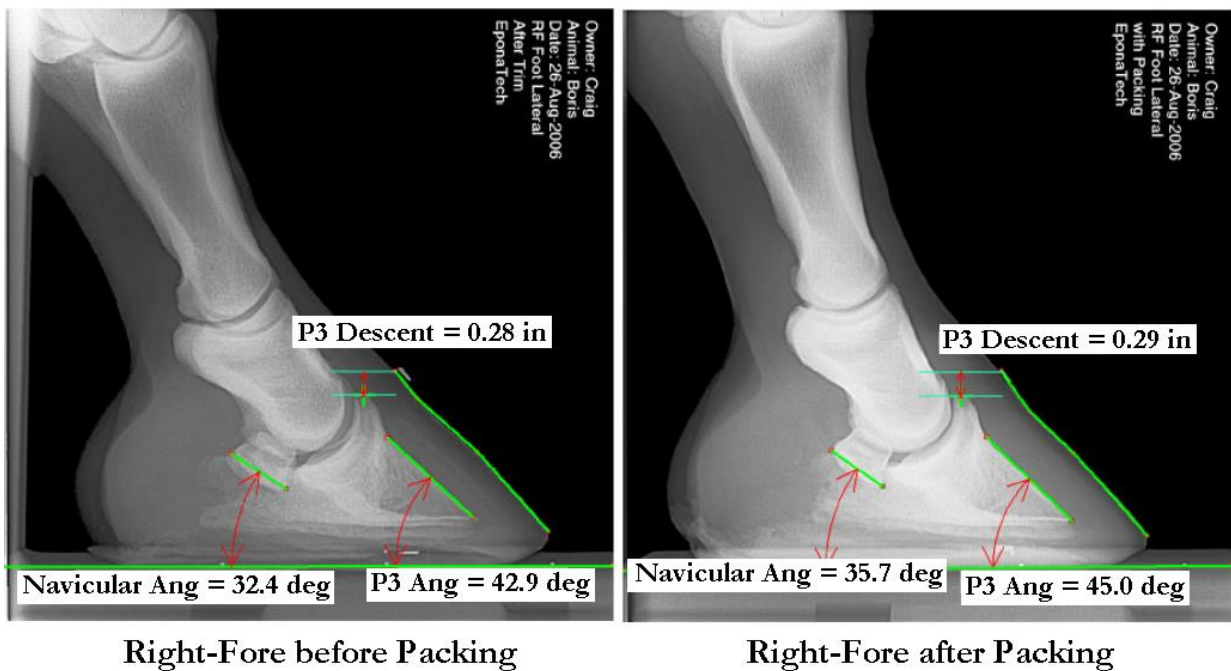


Figure 1: Adding packing in the caudal portion of the foot adds support and can change the angulation of the navicular and pedal bones.

The use of packing material to achieve arch and sole support was implemented for all the cases. The hooves were packed and supported with a packing material with a durometer of our design. When the state of the hoof allows, we trim so that the most caudal portions of the heels are level with the exfoliated and healthy frog. In this way, load is shared between the walls at the heel and the frog. When health of the foot does not allow this trimming, compensation is made with the packing and with glue.

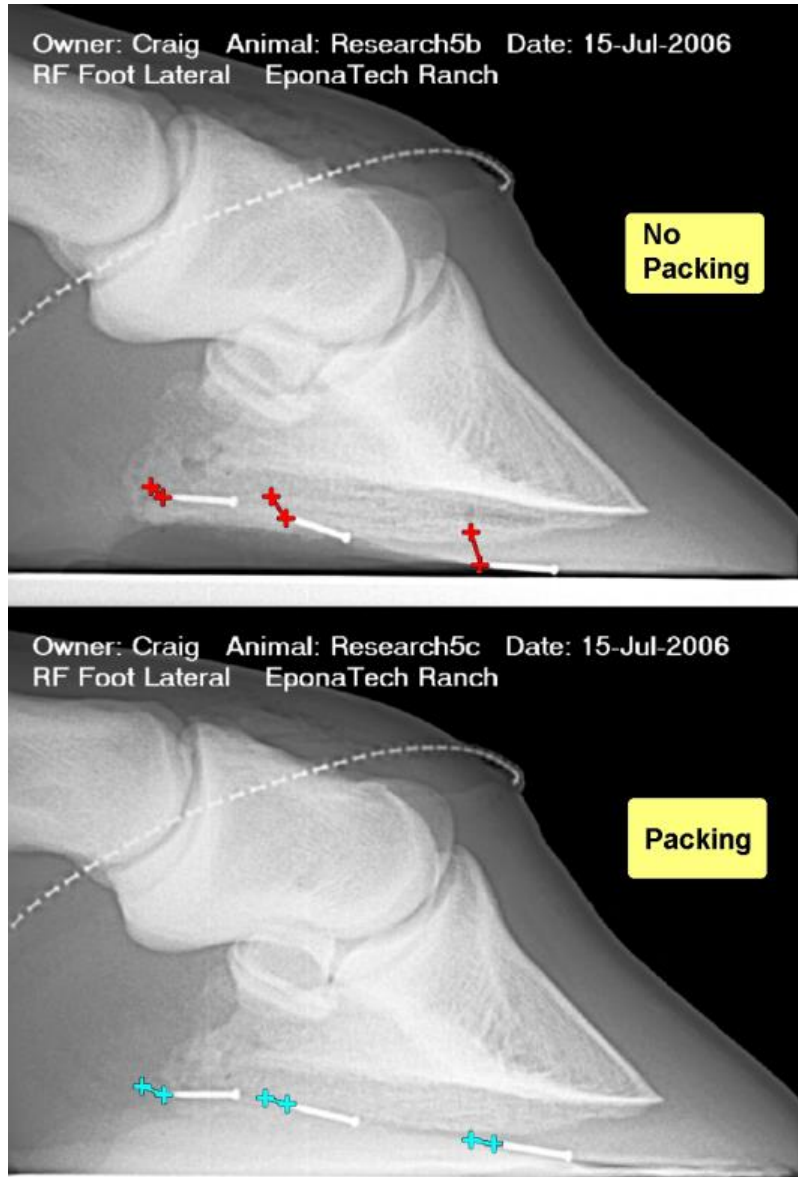


Figure 2: Small nails, glued to the underside of the sole, are marked before and after loading. The presence of packing in the commissures of the frog significantly reduces the vertical flexing of the sole during loading. A thin metal chain was placed along the hairline.

In our own compression tests on cadaver legs, we could note the large change produced by the addition of packing concerning the motion of the sole under load (Fig. 2). Of

course, the details of this motion depend on the thickness of the sole, how the foot was trimmed, and other factors.

In the case of a seriously dropped sole we often increase the thickness of the glue layer as needed to ensure that the load on the sole is not too great. Sometimes in these cases we introduce a thin layer of compressible foam rubber between the sole and the shoe – used mostly as a standoff to ensure that direct pressure is not on the sole, yet allowing some reduced amount of load on the sole. A dropped sole can also make the judgment of proper medial-lateral balance difficult, and our method is to key off of a DP radiograph and attempt to set the shoe, using glue as needed, so that the coffin-joint axis is parallel to the ground (Fig. 3).

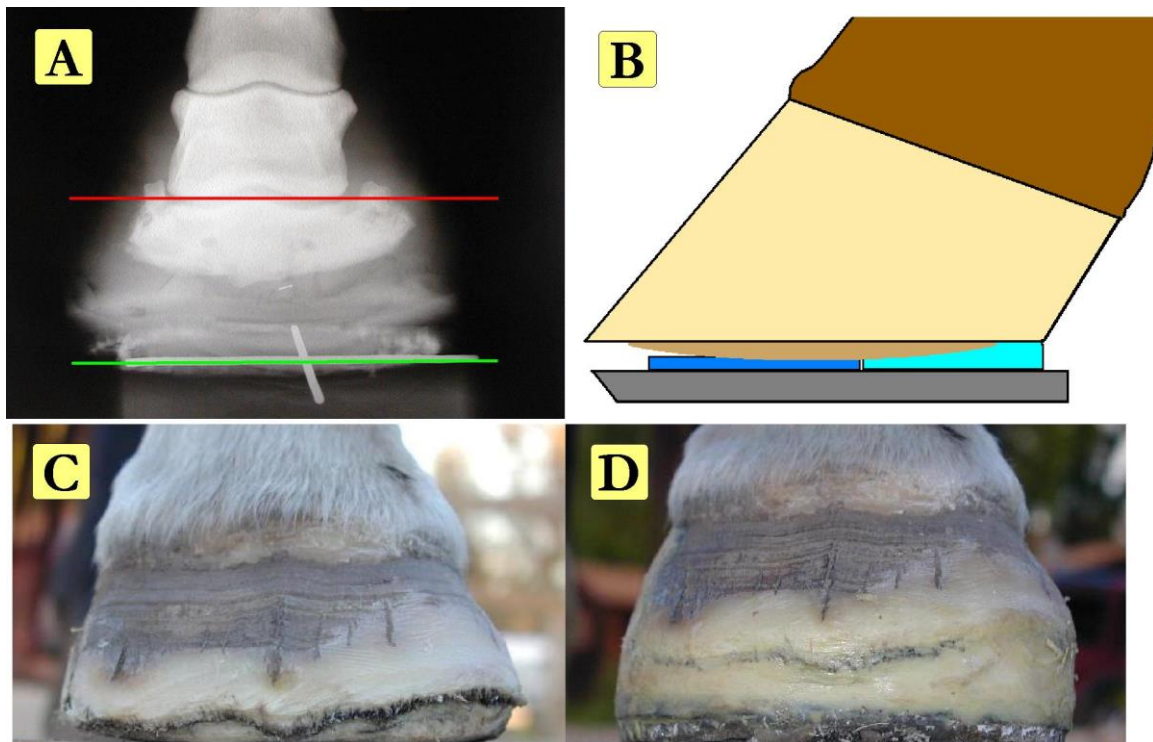


Figure 3: A foam spacer (dark blue in (B)) and packing material (light blue in (B)) are used to load the foot as needed. Glue is used to attach the shoe and to deal with a ‘dropped sole’ (D). This is done with reference to a DP radiograph so that the axis of the coffin joint is made to be parallel to ground (A).

## Results

Assessment of outcome of rehabilitation was judged at the end of rehabilitation by monitoring Obel grade lameness, standard parameters on the lateral to medial digital radiograph and photograph of the distal limb [3]. Within a mean of 4.3 months, 21 of 25 horses improved to an Obel grade 0; the remaining 4 had an Obel grade 1. Two important measures, sole depth and palmar angle, improved in all horses in the study. One horse in the study was euthanized for complications not related to laminitis,

however, 24/25 horses returned to use. In this study horses affected with severe chronic laminitis had a favorable prognosis for survival, and surgery was required on only 1 out of 25.

The data we collected consists of 12 numbers per hoof, for 25 horses, and there are 'before' and 'after' numbers, for a total of 600 numbers. This entire data set is available upon request, and is not reproduced in this article. We can summarize these data in the simplest way by giving the change in average values between the 'before' data and the 'after' data:

Measurement	Value Before	Value After
Palmar Angle	10.0 degrees	4.3 degrees
Sole Thickness	10.5 mm* ( 0.41 in. )	13.8 mm ( 0.54 in. )
P3 Descent	12.9 mm ( 0.51 in. )	9.8 mm ( 0.39 in. )
Heel Height	28.4 mm ( 1.19 in. )	20.8 mm ( 0.82 in. )
HL Zone Difference	20.3 %	8.6 %

\* If we exclude 4 horses that came to us long overdue for trimming and with excessive sole, the average Sole Thickness 'before' would drop to 8.3 mm ( 0.33 in.), meaning that for most horses an average of 5.5 mm ( 0.22 in. ) of sole thickness was gained.

On average, the palmar angle was lowered from a value generally considered too high (10.0 degrees) to a value that can be considered normal (4.3 degrees). The sole thickness at the tip of the P3 bone increased on average by 3.3 mm for all horses, but excluding 4 horses showed an increase of 5.5 mm. The 'P3 Descent', which is a measure of 'sinking' within the hoof capsule, improved by 3.1 mm on average. The heel height was lowered by an average of 7.6 mm. This change was greater for horses which suffered large P3 rotations, and smaller for horses who showed less rotation but more 'sinking'. Finally, the disparity in the proximal and distal HL zones was reduced by an average of 11.7%.

## Discussion

A key objective of our study was to follow a large group of laminitic horses over a period of time long enough to judge the efficacy of our treatment. We believe that our protocol has been successful because one of our main goals was to allow the hoof to behave as naturally as possible by choosing shoeing medium that is synergetic with the hoof capsule mechanical properties [2].

The trimming method was also of great importance. We believe in following bony landmarks rather than solely the hoof capsule. Laminitic horses have often very deformed capsules thus making it very difficult to use some traditional cues for trimming landmarks.

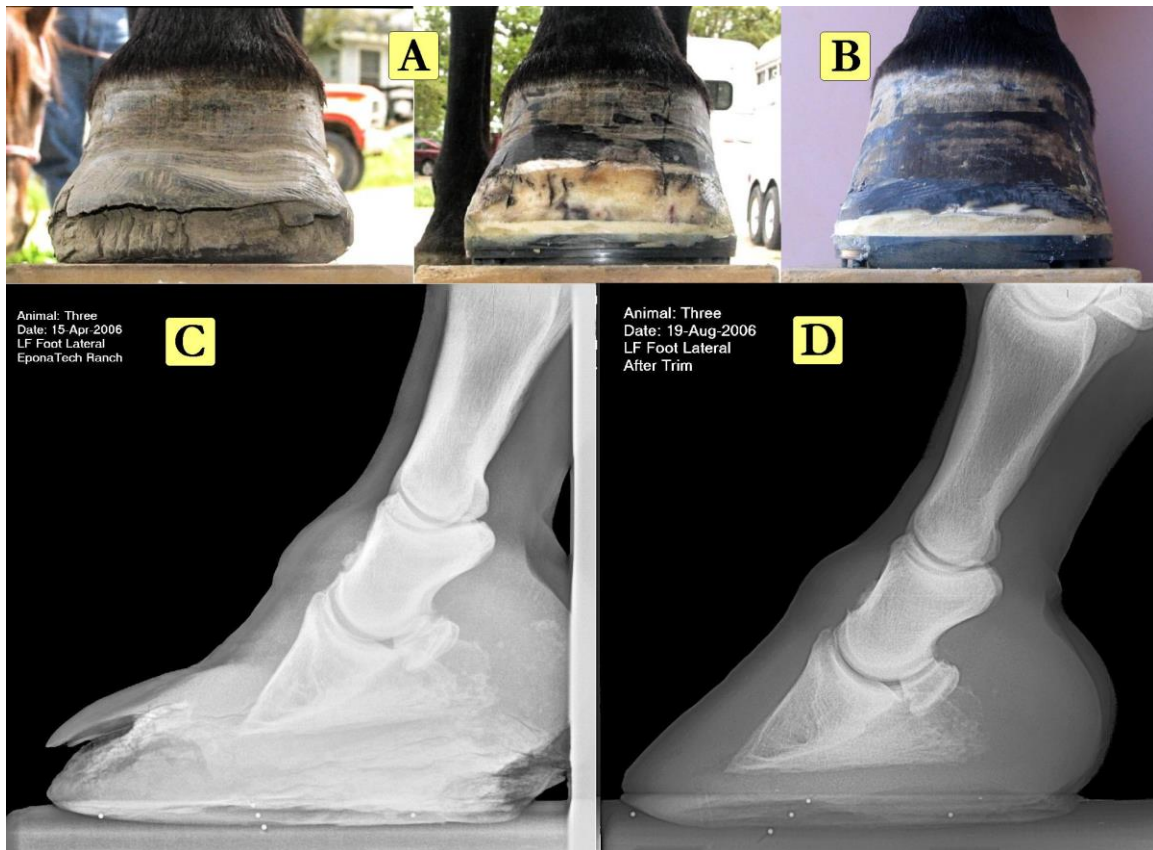


Figure 4: Photos before and after trimming (A), and 4 months later (B). Radiograph before (C) and 4 months later (D).

Placing the shoe to the bony landmarks rather than the capsular distortions helps to provide proper support to the bony column. We also aim to shoe the entire hoof and to allow it to function dynamically. By doing this, we not only help the blood flow [6] but we also allow the entire hoof capsule to regenerate itself. Skin stem cells do not proliferate and differentiate at a constant rate but rather are generated as needed and in response to stimulation. There is a very complex system of molecular signals that regulate stem cell production whether for repair or to respond to rough usage [7]. It is interesting to note that it is crucial for these cells to have the sufficient stimulation to help in the repair process. Allowing the hoof capsule to flex would seem important for its regeneration.

Our other goal is to rehabilitate tissues while working in a synergetic manner with the hoof. We try to refrain whenever possible from invading the hoof capsule either by dremelling or resecting. The exact mechanism under which a hoof is able to restructure itself is poorly understood at this stage but suffice to say that the hoof is amazing in its capability to regenerate itself when allowed to do so. The old-fashioned notion that the wall grows down from the corium seems not to be strictly true; there is some amount of new wall growth from within the hoof capsule [8]. Deep resection can cause permanent change to molecular structure of the hoof keratin [9], this means that the biochemical and

biomechanical stability of the horn may become compromised. We suspect that any long term aggressive trimming of the horn will eventually cause loss of its mechanical integrity.

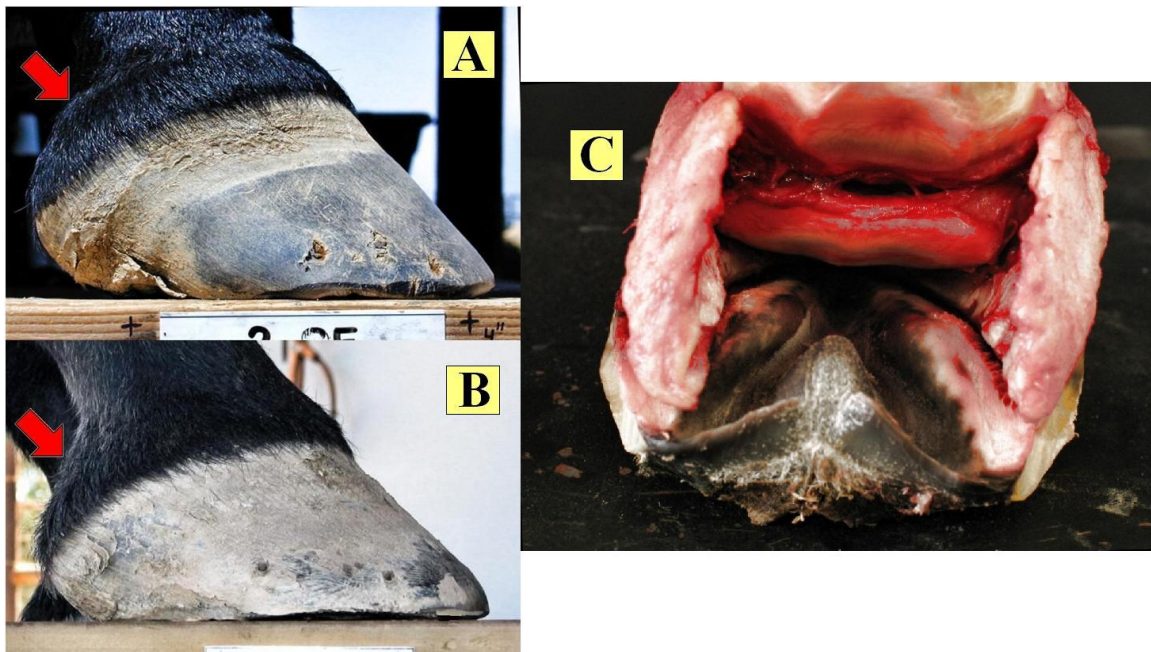


Figure 5: Soft tissue changes are apparent from ‘before’ (A) to ‘after’ (B) over about 4 months. Such changes in the region of the lateral cartilages (C) can have repercussions on blood flow [6] and other issues.

Finally, we aim to make the foundered horse comfortable so that the horse resumes ‘reasonably normal’ motion and exercise. This may help the tendons and ligaments regain their flexibility. It is also crucial to understand the mechanical properties of tendons and ligaments, especially how they react after immobilization. Tendons and ligaments will lose their flexibility if not put to work [10,11]. It is harder to return a high palmar angle down to within a normal range on a foundered horse that does not get sufficient exercise. In the case of tendons, the muscles to which they attach are the real issue – it is these muscles that need to stretch and come back to some normalcy. It is often the case that foundered horses kept on artificial high heels will eventually have to have tendon or ligament surgery to correct this problem. In human medicine, it is known that surgery to tendons and ligaments often has a side effect of irreversible damage to proprioceptors [12, page 310]. We believe the same is true for the horse, and in our opinion, such tendon and ligament surgery should only be used as an absolute “last resort”. We aim to return horses to riding or at least comfort and quality of life.

There are widely varying opinions about the nature of the hoof flexing, from those who don’t believe it flexes at all, to those who think the hoof can flex just fine in a metal shoe. It’s true that, with nails kept forward, the rear walls of the hoof can slide in and out slightly on top of a metal shoe, but this is the only sense in which a hoof can flex in a metal shoe. An unshod hoof can flex in various ways, for example one heel could be

deflected upwards (when stepping on a rock, for example) while the other heel is down lower. The whole capsule can flex in various ways, and when we put a flexible shoe on, it does not impede this natural flexing. The glue, if used, must also be flexible so the whole combination can flex. Unless there is a good reason to attempt to restrict the natural flexing of the hoof, we should not do so. We have seen hooves restore very quickly (Fig. 4) and we attribute this to the proper support of the sole, bars, and frog, and to the ability of the shoeing system to flex.

We believe that this protocol has been successful for the following reasons:

- By tracking the hoof and bone morphologies by means of calibrated photos and radiographs, we can be more precise in our trimming and shoeing protocol and in tracking progress.
- By utilizing bone-referenced landmarks, we do not follow distortions of the hoof capsule when trimming and placing the shoe, rather we achieve a trim and shoe placement relative to the bony column.
- Certain cell growth and repair mechanisms require sufficient physical stimulation to be fully realized. Our use of a flexible shoe allows this possibility.
- Immobilization causes atrophy in muscles, tendons, and ligaments. The comfort afforded by our system allows the animal to return to physical activity sooner in order to minimize these issues. [10,11]
- We work with a shoeing medium that is synergetic with the hoof capsule (keratin) mechanical properties.
- The use of packing and the shoe design promote weight bearing in the caudal portion of foot, off-loading the dorsal hoof wall (which may be damaged as a result of founder) while supporting the pedal bone.
- The composite shoe's flexibility, along with the support of the caudal portion of the hoof, yield positive benefits regarding blood flow. [6]
- Composite shoes can be easily beveled when as needed to reduce biomechanical stress on the DDFT during locomotion.
- Use of the glue-on system avoids nails where painful or impossible due to missing or damaged walls, and allows partial rebuilding of missing walls.

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