How to Restore Alignment of P3 in Horses with Chronic Laminitis  
S. E. O'Grady  
Northern Virginia Equine, The Plains, VA, USA.

Abstract  
Effective management of chronic laminitis involves restoring the alignment of the third phalanx (P3) relative to the ground, while maintaining an appropriate hoof-pastern axis. Good results can be achieved by trimming the heels, establishing breakover near the apex of P3, gluing the shoe parallel with the solar margin of P3, and raising the heels.

1. Introduction  
Chronic laminitis is a frustrating and, at times, disheartening condition to manage. The biggest challenge to the veterinarian and the farrier is to improve function in a foot that has substantial and possibly permanent structural changes. Chief among these is displacement of the third phalanx (P3), which is the underlying problem responsible for the clinical hallmarks of chronic laminitis: chronic lameness, recurrent foot abscesses, and abnormal hoof wall growth [1-3].

Rotation of P3 is the most common form of displacement and has several clinically important consequences. With rotation, weight bearing is concentrated at the apex of P3, which causes focal pressure on the solar corium in that area. Pain is the most obvious and most urgent consequence. Ischemia of the solar corium (and probably of the tip of P3) is also an important sequela, because it retards sole growth [4,5].

In addition to causing further damage to the laminar attachments in the dorsal hoof wall, rotation of P3 can lead to excessive pressure on the coronary corium by the extensor process. The resulting ischemia alters the rate and in severe cases, even the direction of horn growth from the coronary papillae in this area [6,7]. These problems can be ameliorated only by restoring the alignment of P3 relative to the bearing surface of the foot (i.e., to the ground surface). Therapeutic trimming and shoeing has long been the mainstay of treatment for chronic laminitis, and it will continue to be crucial for effective management. However, the principles must be thoroughly understood and skillfully applied. The objective is to restore P3 to its proper orientation in relation to the ground, while maintaining an appropriate hoof-pastern axis. Realigning P3 re-establishes weight bearing more palmarly, unloading the damaged laminae and relieving the compressed solar and coronary corium.

Several different methods may be used to achieve this goal. However, the effectiveness of many conventional techniques is often limited by inadequate sole depth and even prolapse of the sole in a foot with marked P3 rotation, and by individual foot conformation (e.g., inadequate heel mass in horses with under-run heels).

Glue-on shoe technology is ideal for this purpose. Attaching the shoe using polymethylmethacrylate has some important advantages over conventional shoeing techniques in horses with chronic laminitis. The procedure is atraumatic, because no nails are used. However, equally important, it allows the veterinarian or the farrier to adjust the angle of the shoe in relation to the foot (and thus, to the solar margin of P3) with precision; therefore, the technique can easily be tailored to the specific conformation and requirements of a particular foot. This paper describes the technique I use for restoring the alignment of P3 with glue-on shoes in horses with chronic laminitis.

2. Principles of Application  
When managing chronic laminitis, it seems to make little difference which shoeing system is used as long as the method achieves these key goals:

1. re-establish weight bearing along the entire solar surface of P3 (rather than being concentrated at the apex)
2. aid breakover by moving the functional breakover point palmarly
3. decrease tension in the deep digital flexor tendon (DDFT)
In the method described below, these goals are achieved by trimming the heels, applying a shoe that places the functional breakover point near the apex of P3, gluing the shoe to the foot so that the shoe and the solar margin of P3 are parallel, and raising the heels using wedge-shaped rails attached to the shoe.

Trimming the heels and applying the shoes as described below restores a more normal orientation of P3 relative to the ground and thus, more normal loading of the solar surface of P3. Moving the breakover point palmarly decreases the moment arm exerted on the distal interphalangeal joint (DIP) and therefore, decreases tension on the dorsal laminae. Removing more wall at the heels than at the toe during realignment, without also moving breakover back, increases tension in the DDFT and consequently, tension on the dorsal laminae. Thus, moving the functional breakover point more palmarly is an important element of this procedure.

Decreasing tension in the DDFT is achieved by raising the heels. By diminishing the pull of the DDFT on P3 and associated tissues, this part of the procedure reduces tension on the dorsal laminae and focal pressure on the solar and coronary corium. Thus, it reduces pain (immediately in most cases), limits further laminar damage, and makes way for more normal perfusion and horn growth.

Not only is pain relief important from an animal welfare perspective, but it is also important because it interrupts the vicious cycle of pain and increased tension in the deep flexor unit, which is one of the great challenges of managing these cases effectively. In my experience, raising the heels after realigning P3 yields better results in terms of comfort and hoof growth than simply realigning P3.

A commercially available rail shoe is a convenient and effective means of raising the heels in these horses. Alternatively, a rail shoe can be made from a standard aluminum shoe by welding or gluing a pair of wedge-shaped rails to the ground surface of the shoe (see below). Besides being necessary for realignment, trimming the heels maximizes the weight-bearing capacity of the heels, because shorter heels are stronger and less likely to contract than long heels; it also helps to move the weight-bearing surface of the foot more palmarly.

To further increase the bearing surface in the palmar portion of the foot, the area between the branches of the shoe is filled with an elastic yet resilient silastic polymer material. In this way, the entire ground surface in the palmar 50 - 60% of the foot (including sole, frog, and bars) is used to distribute the load.

**Capsular Versus Phalangeal Rotation**

When discussing rotation of P3, it is important to make the distinction between capsular and phalangeal rotation. With **capsular rotation**, the hoof capsule diverges from the dorsal surface of P3 (Fig. 1). The alignment of P3 in relation to the other phalanges may or may not be relatively normal in these feet. With **phalangeal rotation**, P3 is displaced in relation to the long axis of the first and second phalanges i.e., there is an abnormal degree of flexion in the DIP at rest (Fig. 2) [8]. Phalangeal rotation indicates functional shortening of the deep flexor unit.

**Figure 1. Capsular rotation.** Note that the dorsal hoof wall diverges from the dorsal surface of P3. The longitudinal alignment of P3 (relative to the other phalanges) is fairly normal. - To view this image in full size go to the IVIS website at www.ivis.org . -

**Figure 2. Phalangeal rotation.** The third phalanx is rotated relative to the long axis of the other phalanges, creating an abnormal degree of flexion in the distal interphalangeal joint. - To view this image in full size go to the IVIS website at www.ivis.org . -

In horses with capsular rotation and relatively normal longitudinal alignment of P3, realignment of P3 relative to the ground is easily achieved with trimming and shoeing alone. In horses with significant phalangeal rotation, a surgical release procedure (deep digital flexor tenotomy or inferior check desmotomy) generally is needed to facilitate realignment of P3. Trimming and shoeing alone is inadequate in many of these horses.

The severity and chronicity of the phalangeal rotation dictates which procedure (tenotomy or desmotomy) should be performed. Typically, more marked change in the angle of the DIP joint is achieved with tenotomy than with desmotomy. When a surgical release has been considered necessary, deep flexor tenotomy is the procedure I have used most often. I prefer to perform the surgery after applying the shoe.

One final preliminary comment: timing is important. These corrective procedures should not be implemented until the
condition is stable, the horse is relatively comfortable on minimal medication, and there has been no further radiographic deterioration for at least 10 days. In the meantime, the supportive therapy begun in the acute stage should be continued.

3. Materials and Methods

Equipment and Supplies

The following materials are needed:

- lateral radiograph of the foot (see below)
- aluminum shoe and two wedge-shaped rails (see below)
- denatured alcohol
- Equilox [a] or similar composite material
- two pieces of fiberglass mesh, 10 x 10 cm (4 x 4 in)
- non-sterile gloves (e.g., latex exam gloves)
- plastic wrap (sufficient to cover the foot)
- silastic polymer (e.g., Equilox Pink [a])
- plastic gutter guard (to hold the silastic polymer in place)

Lateral Radiograph

A high-quality lateral radiograph is critical to the success of this technique. The area of primary interest is the solar margin of P3. Thus, the radiograph should be taken with the X-ray beam directed horizontally at a point approximately 1 cm above the bearing surface of the wall, midway between heel and toe. A radiopaque marker on the upper surface of the wooden positioning block should be used to represent the ground surface in unshod feet. A thumb tack should be placed at the apex of the frog as a radiographic landmark.

Aluminum Shoe

Aluminum shoes are lighter than steel, easy to shape, and bond well to the composite. I primarily use a wide web aluminum shoe that is squared off and either rounded or beveled at the toe to set the breakover point back as far as possible. The shoe should be of sufficient size that, when fitted, the branches extend at least 1.5 cm (0.6 in) beyond the heels. Sizing and fitting the shoe this way increases the weight-bearing surface of the foot and moves it more palmarly.

Unless a commercial rail shoe is used, wedge-shaped strips of aluminum (rails) are glued to each shoe branch to elevate the heels. The rail is glued along the axial border of the shoe branch on the ground surface of the shoe (Fig. 3). (Note: The rails are applied after the shoe is shaped to fit the trimmed foot.)

Preparation - The procedure essentially involves trimming the heels and attaching the shoe in such a way that the shoe is parallel with the solar margin of P3. In a foot with significant phalangeal rotation, there will inevitably be some divergence of the shoe from the bearing surface of the hoof in the toe area. Before applying the shoe, it is necessary to determine what the relationship between the hoof and the shoe will be when the shoe is positioned parallel with the solar margin of P3. The lateral radiograph is used to guide trimming of the hoof and alignment of the shoe (Fig. 4) [9].

First, a line is drawn 20 mm distal to, and parallel with, the solar margin of P3 (line 1); this is the plane to which the ground surface of the foot should be trimmed. Any horn at the heels and quarters that extends below this line is removed before the shoe is applied. A distance of 20 mm is required to ensure an adequate distance between the solar margin of P3 and the
ground surface. Next, a line is drawn 15 - 18 mm dorsal to, and parallel with, the dorsal surface of P3 (line 2). Where lines 1 and 2 intersect (point A) is the dorsal-most point that the shoe should be positioned at relative to the ground surface of the foot, although it may be positioned more palmarly. Lastly, a short line is drawn from the tip of P3 to meet line 1; this line should be perpendicular to line 1 (rather than vertical). A mark (point B) is made at the ground surface approximately 6 mm dorsal to where these lines intersect; this is the preferred location for breakover [10]. Alternatively, a vertical line can be dropped from the apex of P3 and a mark made where that line meets the ground surface of the foot [10]. In most cases, both methods place point B in approximately the same location. To guide shoe placement, a mark is then made on the sole of the foot to indicate the location of point B, using the apex of the frog as a reference point. When there is significant phalangeal rotation, line 1 and the bearing surface of the hoof will diverge, creating a wedge-shaped air gap at the toe. The distance between the bearing surface of the hoof and line 1, which represents the upper surface of the shoe, indicates how much Equilox will be required to fill the gap between the shoe and the hoof.

**Note** - When bonding the shoe to the foot, the Equilox will not extend further forward than the apex of the frog, so only the caudal part of the gap will be filled. It is useful to measure the distance between line 1 and the bearing surface of the foot at the apex of the frog (thumb tack) on the lateral radiograph. This measurement determines how thick the composite should be at its widest point when bonding the shoe to the foot.

**Procedure**

Prepare the foot and apply the shoe as follows:

1. Trim the bearing surface of the foot to match line 1 (i.e., remove the horn that extends below line 1 on the radiograph). If possible, trim down to solid horn; explore any tracts or areas of hoof wall separation before applying the Equilox. (With severe phalangeal rotation, trimming the heels to realign P3 with the ground surface will result in an unlevelled bearing surface [i.e., bearing surface at the heels and quarters on a different plane from the bearing surface at the toe]. This is not a problem, because the shoe does not need to contact the bearing surface at the toe; additionally, the composite will fill in and negate the change of angle.)
2. Shape and fit the shoe to the foot.
3. Cut a piece of plastic gutter guard to match the size of the shoe.
4. Prepare the composite (3 - 4 oz, depending on the size of the foot) according to the manufacturer's directions. Wear gloves when working with the composite.
5. Attach the rails to the shoe using approximately 1 oz of composite.
6. Take each square of fiberglass mesh and tease it apart to separate the fibers; keep the two piles of fibers separate. Mix an equal amount of composite with each pile of fiberglass, and roll each pile of composite-fiberglass mix into a solid cylindrical structure.
7. Clean the trimmed area of hoof and the matching surface of the shoe with denatured alcohol, allowing it to dry completely.
8. Apply a thin layer of plain composite to the bearing surface of the wall, from frog apex to heel, and work it into the hoof surface.
9. Place a composite-fiberglass roll along the bearing surface of the hoof wall on each side of the foot, beginning at the apex of the frog and extending back beyond the heels (Fig. 5).

![Figure 5](https://www.ivis.org)

10. Place the shoe with gutter guard over the composite rolls, using the mark made on the sole to guide shoe placement. Note: The gutter guard is placed between the hoof and the shoe.
11. Press the shoe into the composite until the angle between hoof and shoe determined on the radiograph is achieved (Fig. 6). In most cases, the shoe will be separated from the hoof by only a thin layer of composite at the heels but by several millimeters of composite at the level of the frog apex. Take care to ensure good lateral-medial balance when setting the shoe into the composite. [Divergence of the shoe from the hoof results in a space between shoe and hoof.
at the toe (Fig. 7)]. This configuration is to be expected in a foot with significant phalangeal rotation, because the shoe is positioned to be parallel with the solar margin of P3 rather than with the hoof. In addition to restoring P3 alignment, it unloads the laminar and solar corium at the toe, and it prevents contact between the shoe and the sole in this area. Having pre-measured the distance between line 1 and the bearing surface of the hoof at the frog apex on the radiograph is very helpful during this step.

Figure 6. The shoe is pressed into the composite until the angle pre-determined on the radiograph is achieved. - To view this image in full size go to the IVIS website at www.ivis.org.

Figure 7. Side view of completed realignment. (In horses with significant phalangeal rotation, there will be a gap between the hoof and the shoe at the toe when the shoe is correctly applied). - To view this image in full size go to the IVIS website at www.ivis.org.

12. Cover the foot with plastic wrap and continue to hold the foot off the ground until the composite cures, which usually takes 2 - 3 min. Then remove the plastic and set the foot down.

13. Mix the silastic polymer, and apply it to the solar surface of the foot (from frog apex to heels) to fill the space between the shoe branches. Press it into the gutter guard to hold it in place.

In horses with bilateral laminitis, the same procedure is performed on the opposite foot. As mentioned above, if a surgical release procedure is deemed necessary, it is performed after the shoe is applied.

Aftercare - The horse is confined to a stall for the first 3 wk. Short periods of hand walking can begin after this time. Non-steroidal anti-inflammatory drugs are administered as needed. In most cases, the shoes are reset every 4 - 5 wk. The shoe is easily removed using hoof nippers, beginning with one or two "bites" through the composite at the heels. The rails are lowered at each reset; typically, rail shoes are needed for only two or three shoeings. This glue-on system is continued until there is sufficient hoof wall growth for alignment of P3 to be maintained just with trimming and conventional shoeing.

4. Results
Records were reviewed for 32 horses with chronic laminitis in which this technique was used. In all cases, the condition had been present for >3 mo, the amount of P3 rotation was significant, the hoof tester response was positive, and the lameness severity was at least Obel grade II on a scale from I (mild) to IV (severe). All horses underwent the above procedure for realignment of P3. In addition, deep flexor tenotomy was performed on nine horses and inferior check desmotomy was performed on two horses.

At the first reset (5 wk after the shoes were first applied), there was a decrease in lameness by at least one grade, a notable increase insole thickness and hoof wall growth at the toe, and an absence of hoof tester in all 32 horses. The average increase in sole thickness was 3 - 5 mm. By the third reset, hoof wall and sole growth were sufficient for continued realignment of P3 to be accomplished simply by trimming the hoof capsule. At this and subsequent resets, the shoes were attached in a conventional manner using nails.

No adverse effects of the procedure have been noted to date. In all cases, the lameness was sufficiently improved to the point that controlled turnout could be tolerated. Of the total, 20 horses (62.5%) returned to some level of usefulness, although below their former level of athletic ability. The two cases that underwent inferior check desmotomy were in this group. The remaining 12 horses (37.5%) were pasture sound. The nine cases that underwent deep flexor tenotomy were in this group.

5. Discussion
This glue-on technique for shoeing chronically laminitic horses is quick, simple, atraumatic, inexpensive, and logical. Using radiographic guidance, the shoe is bonded to the foot in a manner that realigns P3 relative to the ground surface. By also raising the heels, this approach re-establishes weight bearing over the entire solar margin of P3, minimizes tension and leverage on the dorsal hoof wall during breakover, and relieves focal compression of the solar and coronary corium, which
in turn reduces pain and promotes horn growth. This procedure is more effective and allows greater flexibility and precision in realigning P3 than any other technique I have used. It can be tailored to the specific requirements of each foot simply by using more or less of the composite as needed.

The importance of having a good lateral radiograph from which to work cannot be overstated. Without a lateral radiograph, it is impossible to determine the precise orientation of P3 and thus, the degree of intervention necessary to realign P3 with the ground surface. The primary reason this glue-on shoeing technique may be less than satisfactory in inexperienced hands is failure to achieve the desired angle between the shoe and the hoof and thus, realignment of P3. This mistake can be avoided by studying the lateral radiograph and deciding how to orient the shoe in relation to the bearing surface of the hoof before commencing.

Although few of the horses with chronic laminitis returned to their former level of athletic use, all horses treated with this technique have become more comfortable. All are at least pasture sound and able to move about freely with minimal analgesic medication. (In many of the laminitic horses treated in this practice, permanent vascular and structural damage within the foot prevents full recovery, regardless of which technique is used to realign P3 and support the foot.)

In summary, effective management of chronic laminitis involves restoring the alignment of P3 relative to the ground surface. Clinical experience has shown the glue-on shoeing technique described here to be a simple and atraumatic method of effectively realigning P3 and thus, improving comfort and hoof growth in horses with chronic laminitis.

Footnote
[a] Equilox International, Pine Island, MN 55963, USA.

References


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