Use of a Grading System to Facilitate Treatment and Prognosis in Horses with Negative Palmar Angle Syndrome (Heel Collapse): 107 Cases

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ABSTRACT

Negative palmar angle syndrome refers to the condition of progressive heel collapse and its consequences on gait and performance. Treatment and prognosis are facilitated by grading the severity of biomechanical disorder according to physical and radiographic features. Although negative palmar angle syndrome in grades I (mild) and II (moderate) can be corrected with trimming and routine shoeing, grades III (severe) and IV (complicated by flexor contracture) require more intensive mechanical intervention and patience—however, comfort and function can be improved immediately.

Keywords: Horse; Foot; Hoof; Palmar angle; Heel

Negative palmar angle syndrome (NPAS) is a new term and a new perspective proposed for an old problem: heel collapse and its consequences on structure and function of the equine foot. The name derives from a principal radiographic feature, in which the solar or palmar and/or plantar margin of the third phalanx (P3) has a negative angle in relation to the ground surface, and sole depth under the dorsal-distal margin (tip) of P3 is greater than that under the palmar processes (wings) when viewed on a lateral radiograph (Fig. 1). Although this condition can occur in either the fore or hind feet, for simplicity the term “palmar” will be used for both fore and hind feet in this article.

The typical foot with NPAS would be recognized by many as a “long toe, low heel” foot. For example, the overall shape of the hoof capsule in the foot depicted in Figure 1 is that of a long toe and low heel, with the heel bulb almost in contact with the ground. This shape is well accepted as being abnormal among farriers and veterinarians. However, little is known or understood about what lies beneath that simple descriptive label and what it represents.

To date, there has been no thorough exploration of this topic, and no effort to grade the severity of disorder for tailoring treatment and offering an accurate prognosis. In my experience, the “one size fits all” approach to managing these feet, wherein the same type of shoe or shoe-and-pad is used on all low-heel feet, has proven disappointing. That may be because the application of a shoeing system to feet with NPAS, without a complete understanding of the problem, provides at best only temporary relief, and fails to prevent the inexorable deterioration in heel mass that ultimately results in chronic lameness, labels such as “navicular syndrome,” and solutions such as neuroectomy, retirement, or even euthanasia.

The goal of this article is to define the NPAS, describe the functional consequences of the disorder on the gait and performance of the horse, offer a simple grading system, and discuss treatment approaches for each grade that have proven effective in my practice.

CLINICAL ASSESSMENT

Physical Characteristics

The external appearance of a foot with NPAS represents progressive weakening and ultimately collapse of the horn and soft tissues that comprise the heels and quarters. The appearance of the under-run, under-slung, or crushed heel and broken-back hoof-pastern axis should be familiar to all readers and requires no further description in the present article. However, the internal consequences might not be as familiar. As shown in Figure 2A–C, the horn of the wall and sole in the collapsed heel might hide areas of soft tissue damage that are indicative of chronic or recurrent trauma.

Figure 2A makes it easy to understand the reason of common occurrence of quarter cracks in feet with NPAS. The horn tubules at the heel (trimmed area) are running almost parallel to the ground, and laterally there is some separation between horn tubules (cracking within the hoof wall). As the load-bearing surface of the wall moves forward relative to the coronary band, the horn tubules become more and more slanted toward the horizontal. Horn tubules thus oriented are no longer set up for optimum weight-bearing capacity and are readily overloaded. This more acute heel angle becomes self-perpetuating because weakened heels are prone to further structural compromise and eventual collapse. In the process, the hoof wall...
unwillingness to stride out, a lack of desire to move forward, or resistance to cantering.

As the condition worsens, lameness ensues which is often diagnosed as “navicular syndrome” or simply “palmar foot pain.” The gait abnormality associated with moderate to severe NPAS is typical of what one might expect in a horse with sore heels. The horse appears unwilling to load the heels entirely, particularly during the initial part of the stance phase, so the horse avoids landing heel-first and instead lands toe-first, even to the point of toe-stabbing. Other gait abnormalities can include difficulty stabilizing the fetlock during initial loading, and difficulty making a simple turn in hand or breaking over at either the lateral or medial toe on a circle or tight turn (ie, loss of normal flexibility in the position of breakover). When the hind feet are affected, a stringhalt-type gait might also be observed.

Radiographic Characteristics
Radiographic assessment of the low-heel foot is strongly recommended, as it is not always possible to know the extent of the biomechanical disorder just by observing the exterior of the digit. Diagnosis of NPAS is straightforward with a good lateral radiograph of the foot, taken with the beam centered just proximal to the bearing surface of the wall so as to ensure optimal superimposition of the two wings of P3. Specific measurements taken from the lateral radiograph that are used in the evaluation of an individual foot are summarized in Table 1 and illustrated in Figure 4.

The radiographic features of NPAS vary in severity, but include the following:

- The palmar angle (PA) is negative, thus sole depth under the tip (SDT) is greater than the sole depth under the wing (SDW) of P3.
- The distal interphalangeal (DIP) joint is hyperextended, bringing the extensor process of P3 closer to the dorsal articular margin of the second phalanx (P2).
- P3 is displaced dorsally in relation to P2 (ie, dorsal slippage of P3).
- With extension of the DIP joint and dorsal slippage of P3, the navicular bone is drawn proximally, toward the palmar surface of P2.

GRADING SYSTEM
The grading system described in the following paragraphs has proven useful in my practice for defining the extent of the problem, tailoring an appropriate treatment plan, and ensuring that the client has reasonable expectations for future soundness and duration of treatment. It combines both physical and radiographic characteristics and response to trimming.
Grade I (Mild)

The single most important feature that defines the grade I foot is that there is sufficient SDT of P3, such that a positive PA and normal digital alignment can be restored just with corrective trimming. (After trimming as described later, the typical grade I foot should have a SDT of 12 to 15 mm and a SDW of 15 to 18 mm, thus restoring a slightly positive PA). On initial presentation, these horses have a clumsy or guarded gait in which they try to avoid landing heel-first, but they are not lame, unless there is a concurrent but unrelated problem.

Figure 5 shows radiographs of a grade I bare foot before and after corrective trimming. It is noteworthy that despite the severity of the malalignment (Fig. 5A), there was sufficient SDT of P3 such that a positive PA and normal digital alignment could be restored with trimming alone (Fig. 5B). Also this foot shows a variation on the theme of “long toe, low heel”: rather than the toe being long in the horizontal plane and thus very sloped (inc, low hoof/toe angle), it was long in the vertical plane (ie, a tall toe or high hoof angle), giving a very steep slope to the coronary band from heel to toe (Fig. 5A). However, the heel was very low. The importance of a good lateral radiograph is highlighted by this foot because the severity of the interior disorder might not have been suspected just by observing the exterior.

Figure 6 shows radiographs of a different, and more typical, grade I foot which was trimmed as described later in the text, and then shod routinely. It should be noted that the rolled-toe shoe in the bottom image places breakover
just a few millimeters forward of the tip of P3 and supports the heels well, thereby supporting a normal PA and digital alignment.

Grade II (Moderate)

In grade II feet, sole depth at the toe is limited (typically, the SDT is only 8–10 mm), so the best that can be achieved with trimming is a PA of zero (ie, the palmar margin of P3 is horizontal, with SDT and SDW equal). Further digital realignment in these feet requires the use of a rocker shoe. These horses show the gait abnormalities described for grade I horses, and many are also mildly lame (Obel grade 1–2).

Figures 7 and 8 show lateral radiographs from two horses with grade II feet. It should be noted that these feet have very little SDT of P3, the characteristic which distinguishes the grade II from the grade I foot.

Grade III (Severe)

The grade III feet have severe compromise of the heels, bars, digital cushion, and bulbar cushion, and the horse

<table>
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<tr>
<th>Measurement</th>
<th>Description</th>
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<tr>
<td>Palmar angle (PA)</td>
<td>Angle of the solar margin of P3 in relation to the ground surface (blue lines)</td>
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<tr>
<td>Bone angle (BA)</td>
<td>Angle between the dorsal and solar surfaces of P3 at its tip (shorter curved green arrow)</td>
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<tr>
<td>Hoof angle (HA)</td>
<td>Angle between the dorsal and solar surfaces of the hoof capsule (longer curved green arrow); also called the dorsal hoof or toe angle</td>
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<td>Sole depth at the tip of P3 (SDT)</td>
<td>Vertical distance between the dorsal-distal extent (tip) of P3 and the outer surface of the sole (long yellow arrow)</td>
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<tr>
<td>Sole depth at the wings (SDW)</td>
<td>Vertical distance between the solar margin of the palmar process (wing) of P3 and the outer surface of the sole (short yellow arrow)</td>
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<td>Extensor process to coronary band (EP-CB) distance</td>
<td>Vertical and horizontal distances between the proximal extents of the dorsal hoof wall and the extensor process of P3 (red arrows); a radiopaque marker that accurately indicates the proximal extent of the hoof wall is needed</td>
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<td>Horn-lamellar zone (HLZ) width</td>
<td>Distance between the dorsal surface of P3 and the dorsal surface of the hoof wall, measured perpendicular to the hoof wall; measurements are made just distal to the extensor process and just proximal to the tip of P3 (straight green arrows); in a healthy foot, the HLZ should be the same at both locations (eg, 17/17 mm), but in many feet with NPAS, the distal measurement is smaller (eg, 17/15 mm), as P3 is cocked up at the toe</td>
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<td>Digital alignment (DA)</td>
<td>Alignment of the individual phalanges relative to each other; the DA in a healthy digit should be approximately 180°, or a straight line; in a foot with NPAS, the abnormal PA usually is about the same order of magnitude as the abnormal DA</td>
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*Please refer to Figure 4 for illustration of these measurements.*
is lame (usually Obel grade 2–4). Digital realignment is impossible without a special trim (described later) and a rocker shoe. Figure 9A–D shows a grade III foot before treatment began and immediately after corrective trimming and shoeing. This horse had been lame (Obel grade 4) for the past 5 years. The absence of solid heel mass under the wings of P3 in the pre-treatment radiograph (Fig. 9B) is noteworthy.

This case illustrates that it is the severity of heel collapse which most distinguishes the grade III foot from the grade I or II foot. There is simply very little heel mass left in these feet for digital alignment to be restored just with trimming and routine shoeing.

Grade IV (Contracted)

This category is unique beyond the severity of heel collapse because these horses also have flexor contracture, giving them a post-legged appearance (Figs. 10–12). Presumably, the flexor contracture is the body’s attempt to relieve the excessive tension in the DDFT as a result of utter collapse of the heel area and extreme DIP hyperextension. Treatment of these cases requires great patience and intensive biomechanical manipulation.

Although the foot depicted in Figure 11 would appear to have adequate SDT of P3, the feature that distinguishes this grade IV foot from grade I foot shown in Figure 5 is the vertical orientation of the proximal and middle phalanges and severe hyperextension of the DIP joint. As noted in Figure 12, the post-legged stance was not corrected even after the foot was trimmed to create a zero PA.

**TREATMENT**

**All Grades**

Treatment for all grades begins with a proper trim. The goal of trimming for all grades is to restore a normal PA and digital alignment, or at least to make as much improvement in both as is possible with the available hoof mass. For horses with grade I feet, the solar surface is trimmed in a single plane to restore a positive PA. Using the lateral radiograph as a guide, more depth is removed at the toe than at the heel, thereby recreating a normal PA and digital alignment (Fig. 5B).

For horses with grade II or more, inadequate sole depth at the toe and/or severe digital malalignment necessitates a modified trimming strategy. Although the goal is still the same, the technique must be modified to avoid excessive removal of sole at the toe. Figure 13 illustrates the basic trimming technique for these feet. Observing the solar surface, the foot is found to be mentally bisected into two halves: toe (from the quarters forward) and heel (from the quarters back). The solar surface at the toe is rasped as illustrated by the red line, to create a PA of 0 to +3°. Next, the solar surface at the heel is lightly rasped as illustrated by the green line to move the bearing surface of the wall back to the widest part of the frog. The result is a solar surface that has two slightly different planes, with the intersection forming a small high spot at the quarters.

**Grade II**

In the grade II foot, the high spots at the quarters are rasped down to merge the planes of the toe and heel regions into one level solar plane from heel to toe. If the horse is to be shod, then the shoe should be selected and applied such that both breakover and heel support are optimized, and a positive PA and normal digital alignment can be maintained. A rocker shoe is ideal for this purpose. The “after” radiograph in Figure 8 illustrates proper shoe application for optimal digital mechanics in these feet.
Grade III

In the grade III foot, the high spots at the quarters are left intact for the purpose of shoe placement. The forward portion of the foot, from quarters to toe, is used as a platform for setting and nailing the shoe. The shoe is placed flat against this portion of the foot and the nails are confined to the wall in this area forward of the quarters (Fig. 9C). A rocker shoe is used to further correct the digital malalignment (Fig. 9C and D).

These feet have severely compromised heels, so this trimming and shoeing strategy allows the painful heels to be floated above the shoe and supported by a soft yet resilient composite material, such as Equi-Pak (Vettec, Inc. Oxnard, CA, USA). The material is used to fill the gap between the trimmed heel and the shoe while the damaged heels slowly regenerate (Fig. 9C). The composite is softer than hoof wall, and so it does not further damage or crush the heels, but rather it allows proper weight-bearing across the heels and even seems to promote healthy heel growth.

As noted in Figure 9D, the PA and digital alignment are improved with the first shoeing using this approach. The horse had been lame for several years, but moved comfortably after the first shoeing.

Grade IV

As mentioned previously in the text, treatment of these cases requires considerable biomechanical intervention. Correction of the flexor contracture is addressed for the first several shoeings by trimming and shoeing as described previously for the grade III foot (including the use of composite material to support the heels) and adding 5/8 of heel elevation with a full wedge pad to decrease tension in the DDFT and allow restoration of a more normal fetlock angle (Fig. 10). In cases of extreme flexor contracture, the combination of a 5/8-wedge pad and a 5/8 rail shoe (Nanric, Inc. Lawrenceburg, KY, USA) can be used.

However, caution must be exercised here because heel elevation extending to several months will result in further weakening of the heel area. The goal is always to discontinue heel elevation as soon as possible, by lessening the amount of elevation at each successive shoeing. Throughout, the PA and digital alignment are addressed with...
trimming, shoeing, and the use of composite support material at the heels, as described previously for the grade III foot.

CLINICAL OUTCOMES

Till date, 107 horses with NPAS have been treated in our clinic. Of note, all of the grade IV horses were halter-bred American Quarter Horses. For all other grades, a variety of breeds were represented, including Thoroughbreds, Quarter Horses and related western breeds (American Paint Horse, Appaloosa), and Warmbloods. The outcomes are summarized in the following paragraphs.

Grade I

A total of 43 horses in this category have been treated as described earlier. The reasons for presentation included clumsiness, tripping, resistance to the rider, and/or unwillingness to pick up a particular lead or change lead at the canter. After the first corrective trimming and/or shoeing, all presenting complaints were resolved and all owners were satisfied with the outcome.

Grade II

Thus far, 52 horses with this grade were treated as described earlier. All were able to return to their previous level of performance after the first shoeing. Not only were the horses no longer lame, but most of the owners commented that the performance of the horse had improved.

Grade III

To date, only six horses in this category have been treated as described earlier. In all, the lameness disappeared after the first or second shoeing, but it took a maximum of 2 years before healthy heels, bars, and digital cushion were restored in these feet. Although these cases take a long time to fully recover, prompt resolution of the lameness and return to ridden work during the healing process can be expected with this treatment approach.

Grade IV

A total of six horses with this grade were treated as described earlier. Five eventually became sound and one developed a quarter crack and was lost to follow-up.

DISCUSSION

This syndrome characterized by a negative PA to P3 is essentially about chronic overload and eventual collapse of the horn and soft tissues which support the palmar and/or plantar aspect of P3 and the DIP joint from below. Although it is arguably an overused term, the word syndrome is valid here, as the word’s origin literally means “run together”. In medicine, the term is most often used to refer to a combination of recognizable features that so often occur together as to constitute a distinct clinical picture, and the presence of one feature alerts the clinician to the presence of others. In the case of NPAS, the presence of low or collapsed heels should alert the clinician to the likelihood of a negative PA and associated skeletal and soft-tissue abnormalities, both present and potential.

Before implementing this grading system, no protocol for evaluating and managing collapsed heels that yielded consistently good results was available. Treating every low-heel foot the same way was too often disappointing, as was taking an ad hoc approach in which every low-heel foot was treated differently. By classifying each horse
with heel collapse into one of the four grades described in
this report on the basis of both physical and radiographic
findings, and managing the foot according to the degree
of biomechanical disorder present, it has become possible
to restore comfort and function to the majority of horses
with heel collapse. The main limiting factors have been
the client’s budget and patience, as the grade III or IV
feet in particular take considerable time and attention to
restore.

An essential component of this grading system is evalua-
tion of a lateral radiograph of the foot. Although it might
be possible in many cases to deduce the approximate posi-
tion and orientation of P3, the angle of the DIP joint, sole
depth, and other relevant internal features just by examin-
ing the exterior of the hoof capsule and digit, the illustra-
tions presented here show that quite severe abnormalities
might be hidden by a hoof capsule that appears only mod-
erate abnormal.

In fact, the low-heel foot shape is so common that many
of us have come to view it with the dismissive contempt of
long familiarity. It is hoped that this report will promote
the realization that the grade I foot with mild NPAS is al-
ready revealing pathology and represents the top of a slip-
pery slope. Prompt and appropriate action at this early
stage can forestall further deterioration in heel mass and
resolve any associated gait abnormalities and performance
issues. By failing to identify or correct the disorder at this
delayed stage, we ignore it at our peril—or more precisely,
at the horse’s expense—and we make its subsequent treat-
ment more complicated and recovery more protracted.

Before concluding, it is noteworthy that heel wedges are
not a prominent component of my treatment approach for
NPAS. I use heel wedges in only the grade IV feet, and for
only as long as necessary to correct the accompanying
flexor contracture in these limbs. In my experience, al-
though heel wedges might improve the horse’s gait in
the short-term, they are counterproductive in the long-
term because they can contribute to the further overload
of already distorted and collapsing and/or collapsed heels.
Instead, a rocker shoe is used when trimming alone is

Figure 9. Grade III foot. (A) Solar view at initial presentation. (B) Lateral radiograph at initial presentation. The palmar
angle (PA) was -5°. (C) Immediately after treatment (corrective trimming in two planes and a rocker shoe with
composite filler supporting the heels). (D) Radiograph taken immediately after shoeing.
insufficient to restore and maintain a normal PA and digital alignment.

In summary, grading the severity of heel collapse and its biomechanical consequences using physical and radiographic features greatly facilitates the treatment of NPAS. Using this approach, many horses that might have been otherwise lost to chronic lameness, have been returned to athletic usefulness. It is hoped that this grading system will facilitate communication among veterinarians and farriers, and lead to the prompt and appropriate treatment of

**Figure 10.** Grade IV foot, immediately following corrective trimming and shoeing aimed initially at correcting the flexor contracture (see text).

**Figure 11.** Lateral radiograph of the horse shown in Figure 10, before corrective trimming and shoeing.

**Figure 12.** The same case as shown in Figures 10 and 11, following a trim to create a zero PA.

**Figure 13.** The trimming technique used for horses with NPAS of grade II or more. The red line depicts the plane trimmed from the quarters forward to the toe, to create a PA of 0° to 3°. The green line depicts the light trim that is performed from the quarters to the heels, to move the loading surface back to the widest part of the frog.
horses with this problem. Treating advanced NPAS takes time, patience, and practice. There is a learning curve, in particular with the higher grades, but the rewards are well worth the effort. However, the prevention of advanced NPAS through early identification and intervention is better.

REFERENCES
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