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Natural balance trimming and shoeing: its theory and application

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The evolution of natural balance principles

The principles and techniques of natural balance trimming and shoeing are designed to optimize the efficiency and function of the foot. The basic guidelines have evolved in part from wild horse hoof imprint studies done in 1986 through 1987 and first presented in 1995 [1]. Further research has contributed to these principles and guidelines to make them applicable to domestic horses [2–4].

Before natural balance guidelines, the traditional approach to hoof balance often yielded undesirable results in performance and soundness. Using the external hoof capsule for distal phalangeal alignment had proven unreliable in light of the inconsistent parallel relation between the dorsal hoof wall and the dorsal surface of the distal phalanx. Repeated use of this approach often led to underrun heels in many cases, contracted heels in some cases, and vertical distal displacement of the distal phalanx within the hoof capsule in other cases.

Gene Ovnicek is the Chief Executive Officer, President, and a stock owner of Equine Digit Support System, Inc.. He has a financial interest in the sales and distribution of the Natural Balance Shoes that are discussed in this article. Barbara Page is Head of Research for the Equine Wellness Foundation, which is a nonprofit organization that sells the Metacarpal Level. She may indirectly have a financial interest in the sale of the Metacarpal Level mentioned in this article.

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On examining lateral projection radiographs using markers placed at the widest part of the foot at the ground surface, we have repeatedly shown that the widest part of the foot maintains a relatively constant position to the distal phalanx. Using this information during foot trimming, it is helpful to draw a line across the foot at its widest part. This provides a reliable static landmark to the distal phalanx and can be used as a guide for anterior/posterior balance. Horses that land toe first or have stumbling issues, interference problems, or caudal foot pain generally have a greater distance of foot mass forward of the widest part of the foot than behind the widest part of the foot. Many feet develop an appearance where there is a greater proportion or ratio of ground surface forward of this line than behind this line. Repeated natural balance trimming and shoeing help to reverse this abnormal ratio. A concomitant result is an improvement in the alignment of the phalanges (when seen before and after radiographs are taken).

We have also observed that when the hoof wall is worn to the level of the sole, the sole region that lies cranial to the frog apex and just caudal to the dorsal hoof wall exhibits a raised area. We refer to this raised portion as the sole callus. The sole callus outlines the ventral border of the distal phalanx. Those who are familiar with the equine bare foot see this raised area rapidly harden when the wall is worn to the level of the sole. This structure also responds quickly to environmental changes of moisture and dryness. When the ground is hard or soft, the sole maintains an optimal equilibrium of support and protection between the hoof wall and sole callus. The sole callus is an excellent reference for breakover placement for the foot because it seems to maintain a constant relation to the distal phalanx. It seems logical that the purpose of the sole callus is to protect the distal border of the distal phalanx and circumflex artery and vein.

It has been further observed that all horses, domestic or wild, having lifestyles that allow for foot self-maintenance wear their hoof walls to the level of the sole and equally from side to side. Preliminary dissection research has clearly shown that trimming the hoof wall in that same manner (equal height to the level of the live sole plane) is a reliable trimming technique that has proven to be helpful in simplifying and accurately achieving medial lateral balance (Gene Ovnicek, RJF, personal observations, 1999).

The accumulated results from these various studies [1–4] also support that a heel-first landing of the foot may be important for several reasons. Observations of the hooves of both wild and domestic horses reveal the normal presence of a natural buildup of nonsensitive frog material at the caudal portion of the frog buttress. This information, coupled with the findings of proprioceptors in this same anatomic area [2], strongly suggests that this buildup of material serves as a mechanism to assist proprioceptive function in this region. Related biomechanics research suggests potentially significant importance to this caudal frog buildup [4]. When heel-first

ground contact is coupled with selecting a breakover point associated with the distal dorsal border of the distal phalanx, optimal anatomic alignment of the phalanges seems to be achieved.

Natural balance trimming

The information and instructions for hoof maintenance that a farrier's work is based on have largely revolved around experiences with horses living in a domestic environment. All horses' feet essentially have the same anatomy and function similarly whether they are wild or domestic. The horse's foot (wild or domestic) requires stimulation to develop and perform optimally. The equine foot is a product of its environment, and the foot modifies and changes so that the basic requirements for health, function, and soundness can be met. This works well when the horse is roaming free in an area that is large enough for optimal foot maintenance. When we look closely at the feet of domestic horses that are used aggressively barefooted and the self-maintaining feet of horses in the wild, we see the same process of maintenance taking place. The sole, bars, and frog become callused and durable. Many horses do well barefooted, with the wall chipping and wearing in a manner that allows the wall at the toe to be worn to the same level as the sole. Feet managed in this self-maintaining manner are usually of good quality and are generally trouble-free and healthy.

Appearance of the self-maintained foot

The self-maintained feet of wild and the domestic horses have the same appearance. The wall is always worn down to the level of the sole callus in the toe region ahead of the frog apex. With horses that live in soft and sandy areas, the quarters are broken away at the widest part of the foot. This allows the dirt to compact only in the caudal region of the foot in the general area of the bars. Generally, the heels have grown beyond the height of the frog in these feet, which helps to form a trap for the dirt. The frog apex is generally in contact with the ground when the foot is loaded. It is common for that part of the frog to be enlarged and calloused as a result of its use. Radiographs show this area generally to be in the center of the distal phalanx. Distal phalanx support is presumed to be achieved in three parts. The wall and sole callus support the dorsal portion; the frog apex supports the axial (central) portion; and the frog buttress, bars, heels, and dirt compaction support the palmar portion.

Horses that are ridden or live in more abrasive areas (pavement or dry gravel) frequently have their heels worn shorter than the level of the frog. Again, the wall is always worn equal in height to the sole in the front part of the foot (Fig. 1). In a number of foot dissections, the thickness of the live sole callus (recognized as the functional epidermal sole tissue that extends beyond the dorsal distal border of the third phalanx) in the toe quarter and

Fig. 1. This imprinted feral foot shows that the wall is worn to the same level as the sole at the toe. This is typical of self-maintained feet of both feral and domestic horses.

the depth or thickness of the live sole at the heel quarters have been shown to be a consistent distance from the distal border of the distal phalanx (Fig. 2) (Gene Ovnicek, RJF, personal observations, 1999). Therefore, the live sole seems to be a reliable reference for medial/lateral balance. The wall can be trimmed or rasped to the same distance from the live sole on each side of the foot, and the coffin bone should be level with the ground.

The quality of the frog and digital cushion also plays a major role in anterior/posterior balance of the foot. The natural healthy frog is designed to hold dirt in the rear of the foot between the bars and frog, and the dirt seldom exceeds the level of the frog. A recent study suggests that the frog (along with the dirt compaction) serves a function in foot biomechanics and is partially responsible for the alignment of the distal phalanx and the pastern [4]. It has become apparent that the frog, bars, and sole are all-important in weight bearing.

The hoof wall is part of the digit that wears or breaks away, whereas the sole and frog become callused and durable for the horse to walk on. With shod feet, natural wear and chipping of the foot do not occur. With hooves that are shod and where the wall is not prepared to an equal depth to the live sole plane from side to side, the coronary band distorts and quarter cracks and toe cracks are frequently experienced. Hooves that break and crush their heels or develop toe and quarter cracks are all experiencing a natural but crude deliberate way of trimming the foot so that the coffin bone maintains a parallel medial/lateral orientation to the ground. The hoof wall breaking and cracking is a function of the wall, which allows the frog, bars, and sole to contact the ground and fulfill their function in the life cycle of the equine digit.

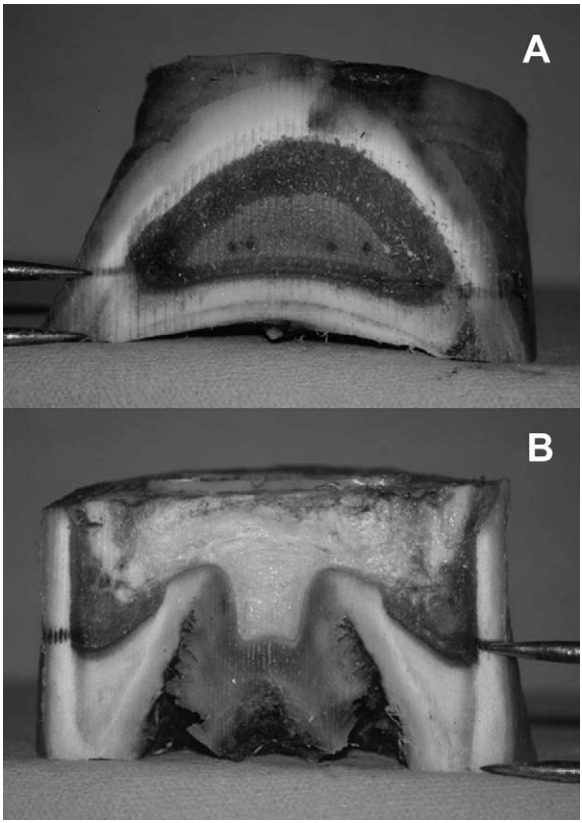

Fig. 2. In this study, the hoof wall was trimmed equal to the live sole (waxy-appearing surface) at the medial and lateral toe quarters and to the live sole just behind the widest part of the foot. The dissection cut was made across the foot through the toe quarters (*A*) and just behind the widest part of the foot (*B*). Measurements were taken from the ventral border of the distal phalanx to the ground at the exposed sites. In all samples, the distance was equal from one side of the bone to the other, meaning the ventral border of the distal phalanx was parallel to the ground.

Unfortunately, not all horses can be cared for in this self-maintaining fashion. If you want to maintain your horse barefooted but a large free-roaming area is unavailable, it may be useful to keep the horse's living area and exercising area the same. For example, if a horse is kept in a soft sandy pasture or large sandy paddock, it should be ridden daily in that same type of sandy terrain. The same is true for horses kept in dry rocky pastures. In addition to a consistent environment, regular activity is required. Riding or roaming around a pasture for a minimum of 5 miles (to as much as 25 miles) per day is generally what is required to maintain a foot that functions well barefooted under saddle for most disciplines. If these requirements for regular work and consistent environment can be met, a horse has a chance of self-maintaining its own feet.

An average of 5 to 20 miles of activity per day is something that few horses have privilege to these days. What makes being barefooted difficult for most horses is that they are housed in small confined stalls or paddocks that are often soft, wet, and nonabrasive. Their feet wear minimally and seem to adapt to the environment in which they reside. Some horses therefore have poor-quality substandard feet and need some type of protection when asked to perform in anything other than their own pasture or paddock.

Natural balance trimming for the barefooted horse

Natural balance trimming refers to preparing the feet of domestic horses in a manner that is consistent with those horses, domestic or wild, that self-maintain their feet through their environment and lifestyle.

Most horses' feet can be separated into four types. These include (1) what is generally considered a normal, nonproblematic, picture-book model foot; (2) those with underrun heels and long toes; (3) others that are clubbed or upright; and (4) those that are unusually flat. In all four groups of hoof types, the sole callus (Fig. 3A) is looked at as one of the primary support structures of the foot. The apex of the frog (see Fig. 3B) and the callused portion of the frog buttress (see Fig. 3C) are the other support structures of the foot.

The hoof wall that surrounds the sensitive bony structures of the foot is much like our own nails that protect the bone at the end of our fingers and toes. The wall is attached to the coffin bone by the laminae. The wall chips and wears away to the optimal level of the sole and frog when the horse lives

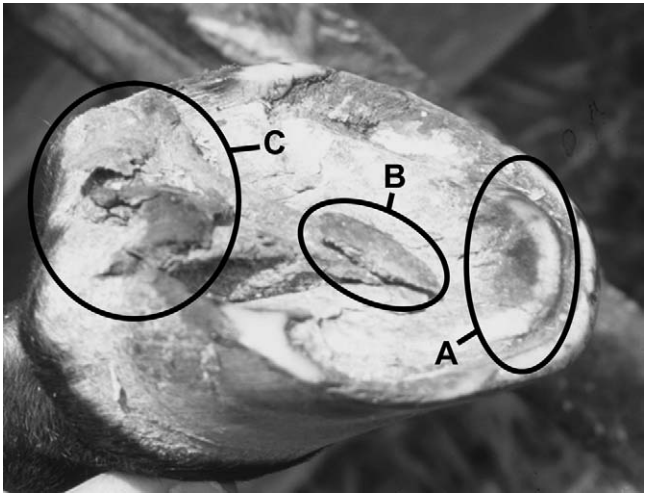

Fig. 3. The following foot components are all-important support structures of the equine digit: the sole callus (*A*), apex of the frog (*B*), and calloused portion of the frog buttress (*C*).

in its natural setting, much like our own fingernails when they get too long and get in the way of the functioning callused side of our finger. Again, comparing our own digit with that of the horse helps us to understand the horse's foot and its needs from a practical "form for function" point of view.

The good-quality functional foot

This is the trimming sequence for those horses that have normal feet and are left barefooted without suitable activity to wear their own feet to the natural hoof shape.

Once the dirt is removed from the foot, the sole callus is identified in the toe area of the foot. The "sole callus" is the functional epidermal tissue that extends beyond the dorsal distal border of the third phalanx and is seen as the raised area just inside the hoof wall in the front part of the foot (see Fig. 3A). The sole callus maintains its relation with the distal phalanx in the toe quarters (10:00 o'clock and 2:00 o'clock positions) and adapts quickly to changes in the environment to offer protection and support to the distal phalanx. The "live sole" is described as the functional epidermal sole tissue that extends beyond the ventral border of the distal phalanx and has a waxy surface appearance. If the sole is extremely flaky and loose, only enough of this chalky sole material is removed so that the depth of the live sole and the sole callus can be seen (Fig. 4). The same is true for any extremely loose sole material that is found in the quarters behind the widest part of the foot. Most horses left barefooted have little to no sole that needs to be exfoliated

Fig. 4. Only chalky sole material that trims away easily is removed. Live sole (waxy appearance) is left for protection and support.

or removed (see Fig. 3). Without the protection of a shoe, the sole is somewhat exfoliated on its own as necessary.

Once the live sole has been identified, an imaginary line is drawn across the toe at the back edge of the sole callus in the center of the toe (see Fig. 3A). This is the place where natural breakover occurs in the self-maintained foot. With the normal foot, the wall at the toe quarters is firmly attached to the sole callus at the ground level. The sole callus on most normal bare feet is narrow and well defined, which differs somewhat from those feet that are flat or clubbed. This is because in flat or clubbed feet, the tip of the distal phalanx is closer to the ground. Be conservative when the hoof wall is rasped or nipped to the back edge of the sole callus. The rocker or roll prepared in the foot should not exceed 10° to 15° from the flat plane of the sole or, in simple terms, what is normally found on a well-worn shoe. Next, the wall is rasped or nipped down to the level of the sole callus on each side of the toe behind the rockered portion. The hoof wall should be trimmed so that the height of the sole callus and wall is equal. The length of that flattened area depends on the size and type of the foot and sole callus (approximately 1–1.5 inch) (Fig. 5).

Once the wall is trimmed to the height of the sole callus, the wall behind the toe callus is trimmed to the level of the live sole through the quarters. The heel that remains is flattened off so that the heels are equal in height to

Fig. 5. The flattened area of the wall caudal to the point of breakover should be 1 to 1.5 inch in length and parallel to the ground. The sole callus and hoof wall at the cranial aspect of the flattened area should make equal ground contact, even when the caudal portion of the sole callus is not equal in height to the wall (see Fig. 1).

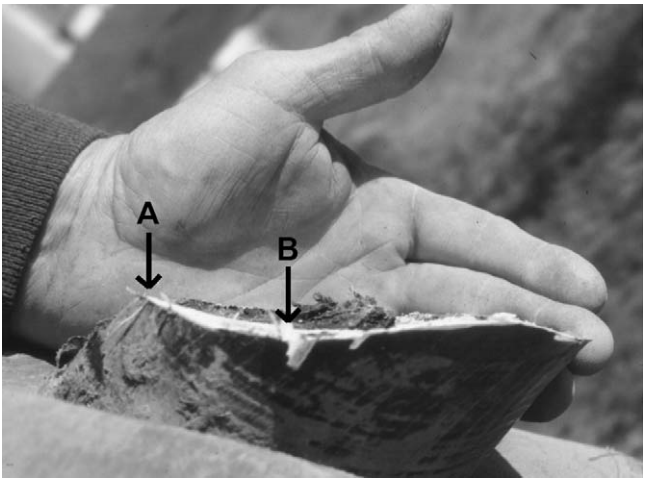

Fig. 6. (*A*) The heels are trimmed level with the frog or slightly lower and then flattened off so that they are equal in height to each other. (*B*) By lowering the quarter region of the hoof wall to the sole, the frog apex can be exposed to the ground and only allows dirt to fill the foot in the caudal region.

each other and at the same level or slightly shorter than the frog buttress (Fig. 6A). This generally means that the quarters are relieved or floated somewhat through the widest part of the foot between the sole callus and the heels (see Fig. 6B).

The main area of the frog that is routinely trimmed is the cleft of the central sulcus. Keeping this area open seems to lessen the chance of bacteria forming in horses that are less active. The rest of the frog should not be trimmed unless it separates easily from the chalky layer or has parts that are hanging by a small attachment from the live frog structure.

The bars are trimmed only when they become curved or roll over and become flat to the sole. If the bars become cracked or diseased with a black substance under them, they must be removed enough to encourage straighter and more upright regrowth.

If flares exist on the outer hoof wall, the most prominent growth ring near the middle of the dorsal hoof wall is identified, and only enough is removed to make the wall straight from top to bottom. On badly flared feet, the wall is never rasped beyond the white zone. The white zone is the lighter colored part of the wall that is next to the laminae. Once the outer hoof wall is dressed, the outer rim of the hoof wall that is closest to the ground is rounded (chamfer the rim).

Flat feet

Horses with feet that are extremely flat and often sensitive when they cross gravel or rocky areas are difficult to leave barefooted when they are

used for trail riding and multiple terrain activities. Flat feet are often found on Thoroughbreds. The sole is thin and is separating from the wall at the ground level. When horses reach this condition, they are experiencing laminar tearing at the ventral aspect of the distal phalanx as well as sensitivity from the thin flat sole. With the sole callus used for weight bearing, the outer wall is removed in a dubbed vertical manner so as to lessen the pull on the wall when it is flared. The upper portion of the flares are not rasped back to a straight line from the hairline for cosmetic reasons. Instead, the foot has an appearance similar to that of a roughshod ranch horse. The wall is brought back close to the edge of the sole on the ground side so that no dirt packs under the wall next to the sole. The sole of the foot is never touched with the knife or rasp. Feet of this type never need exfoliating but require more sole thickness below the distal phalanx. This is gained once the wall is reattached closer to the ground surface of the sole. To overrasp the flares weakens the area of the wall above the fragile border of the distal phalanx. This could allow the distal phalanx to twist and bend when the horse walks on uneven or rocky ground. When the wall is left to full thickness in the lower 1.25 to 1.5 inch of the hoof wall, the distal border of the distal phalanx is supported from above by a stable wall structure. The sole callus has a better chance of becoming more durable and develops dense protective tissue once the laminae are not being torn by the wall pulling away from the sole. Also, the wall above the distal phalanx is stable enough to support the border of the bone when the horse encounters rough ground.

The rest of the foot requires little work. The heels are rasped back to a solid horn structure, and the frog is left full and untouched because it supports the back of the foot. The toe is not rockered until the wall attaches more normally to the sole at the ground level. By leaving the sole and dubbing the wall back repeatedly, the gap between the sole and wall disappears, and, eventually, the callus at the toe quarters tightly bonds with the wall. A concavity is then seen to come back into the foot.

Clubbed feet

The management of clubbed feet has been discussed and theorized by farriers and veterinarians for many decades. Treatment and management of clubbed feet are still divided into many groups. The frequency at which clubbed feet are noticed seems greater in the last 20 years than in previous years. Upright feet also seem to be more apparent in some breeds (eg, Arabians and Quarter Horses) and in certain areas across the country that are more populated (eg, West Coast). It has become more common to see horses with one foot that is more upright than the other, and the condition varies from mild to severe (Fig. 7).

This type of hoof conformation is not bad or life threatening until an attempt to change the appearance of the hoof is made so that it looks more like the opposite foot. We should have some solid answers about this mismatched foot issue in the next few years. Until then, some good

Fig. 7. Clubbed feet are easily identified by their extreme upright appearance. The proximal dorsal aspect of the hoof wall is more vertical than the ventral aspect, and the heel is noticeably more vertical as well.

suggestions on how to manage the upright foot have been gleaned from observations of the wild horse hoof.

Almost all farriers have at some time been pressured by a horse owner or trainer to make mismatched front feet look alike. Most of these farriers have been fired because of their inability to get the feet to be the same. One author (G.D.O.) would remove the heel on the upright foot and leave the toe longer to replicate the foot next to it. If he continued, the foot would become even more deformed as time went on, and he would sometimes lose the account. A new farrier would get hired and fired trying to accomplish the same goal. Generally, the farrier who ultimately succeeds in satisfying the horse and the customer is the one who does not try to change the upright foot but treats it as an individual foot instead. In time, the foot becomes more like the foot next to it when we do not try to change it. The secret lies in using the same guidelines as for any other normal foot. The sole callus is located at the toe to determine the point for breakover, the live sole in the heel region is used as a guide for trimming the heels, and, especially with clubfeet, the sole is left full thickness to protect the distal border of the coffin bone. It is important to understand that most clubbed or upright feet are smaller and will never be the same size as the opposite foot.

In my opinion, the most fragile part of the horse's foot is the distal border of the distal phalanx. The upright foot commonly has margin fractures and bone remodeling at the rim of the distal phalanx. The upright angle is responsible for part of that pathologic change. Lowering the heel excessively and leaving the toe longer increase the tension on the deep digital flexor tendon (DDFT) both statically and dynamically. The upright foot also has a

unique heel position that sets it apart from the normal or underrun foot (Fig. 8A). The heel buttress (end of heel) of the upright foot has an abrupt curve with bars that are quite straight. The heel also ends close to the back of the frog, whereas the normal foot has an even curve to the outer hoof wall at the heel buttress as well as an even arch to the bars, with the heel buttress terminating slightly ahead of the back of the frog (see Fig. 8B). The bars on the clubbed foot are not curved the same as the heel buttress. Farriers have found that the optimal place for the heel of all feet to end is close to the back of the foot near the frog buttress. To achieve this rearward heel position, trimming or rasping heels down some positions the heel buttress closer to the back of the frog. The clubfoot already ends well to the back of the frog, however, and removing the heel does not increase the base of support; it only increases the tension on the ddft. Excessive removal of the heel on a

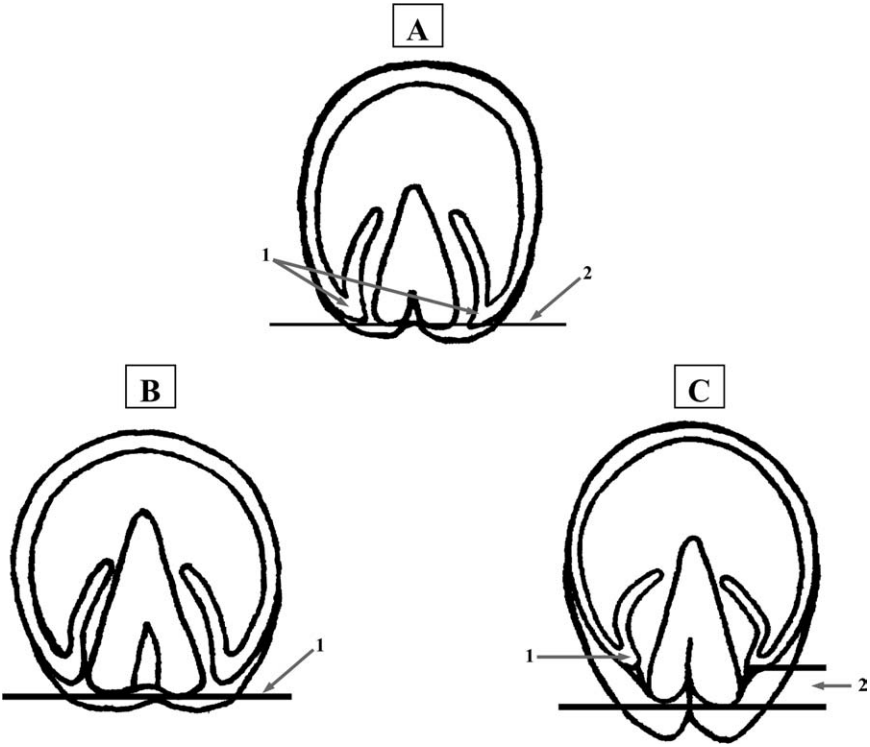

Fig. 8. (*A*) Clubbed feet have unique characteristics when viewed from the bottom. The hoof wall at the heel buttress is curved abruptly (*1*) and is positioned in line with the back of the frog (*2*). The bars have a normal gradual arc to them. (*B*) The ventral view of normal feet has heels that terminate anterior to the back of the frog (*1*), and the heel buttress has a gradual arc that corresponds to the similarly shaped bars. (*C*) The long toe–low heel (or underrun heel) is seen with heels terminating substantially ahead of the back of the frog (*2*). The heel buttresses (*1*) have an abrupt curve to them, as do the bars.

club foot does not allow the horse to land heel first and increases the chances of distal phalanx trauma from landing toe first.

The sole callus on a clubfoot is also slightly different from that of a normal foot. There is usually a broad raised formation to the sole seen just ahead of the frog apex. The callus on each side of the frog apex is usually more prominent and extends well behind the tip of the frog. The natural place for breakover is closer to the frog apex because of the position of the sole callus. Therefore, the wall is rockered ahead of the sole callus just as with a normal foot. The live sole in the back part of the foot often seems unusually deep, so the hoof wall at the heel is not trimmed equal to the live sole. The sole does not recede at the widest part of the foot as commonly seen with other types of feet. Instead, the sole callus continues caudally to the widest part of the foot and beyond, giving the appearance of a flat thick sole from heel to heel. In some cases, when the dorsal hoof wall is severely flared and not attached well at the ground level in the front and strongly resembles a foot with chronic laminitis, you can be more aggressive about removing the dorsal flare. Once the flares are removed, the wall is radiused around the foot to keep it from chipping.

Feet with long toes and underrun heels

This procedure for trimming feet that are long in the toe and have long heels that grow forward under the foot (also called a long-toe–low-heel [LT-LH] foot) is slightly different than for the other three hoof types. Heel pain and soreness through the middle of the frog are not uncommon with this type of hoof deformity. The underrun foot has a sharp curve in the heel (see Fig. 8C), and the underrun heel also ends well ahead of the frog buttress (see Fig. 8C), with bars that are curved similar to the end of the heel. This heel conformation is abnormal and is often painful. Natural balance trimming helps to restore the foot to a near-natural shape, and a high level of soundness normally follows. With LT-LH feet, the frog and sole can also become stretched forward. These feet can be trimmed aggressively with good results. The narrow elongated frog apex is a sure sign of potential problems. The sole callus looks similar to that of a clubbed foot. It is broad and looks more like a small mound around the sole directly at the apex of the frog. If the horse can be kept in a dry soft area for 1 or 2 weeks, the toe can be aggressively rockered ahead of the callus, leaving the sole callus for the horse to walk on. The heels need to be trimmed back below the level of the frog if the bars and heels are severely curled and appear to end forward of the back of the frog. You should never trim the heel down past the live sole to the point where the foot is extremely sensitive or bleeds. The wall is finished in accordance with what is done with the other hoof types. This aggressive trimming procedure rapidly starts to repair the deformed feet. You may approach this task more slowly if you like, but it can be done quickly and successfully as long as you harden and protect the bottom of the foot with hoof and sole

hardeners. It is also a good idea to treat the bottom of the foot even when you know the ground is soft.

A less aggressive approach would be to leave a little more wall at the medial and lateral sole callus so as not to overload the sole callus. The foot responds well with each trimming. Remember to be respectful of the sole callus, leaving it full sized, and harden it some if necessary.

Natural balance shoeing

It is a well-known fact to those who have horses and have thought much about their natural evolution that horses were never intended to wear shoes. We know that a horse's feet normally do better when they are left bare. In fact, many times when treating chronic recurrent lamenesses, some suggest pulling the shoes and turning the horses out. Amazingly enough, a large percentage of these horses improve, and some even recover completely. There is now some scientific support [2–5] for why this might work. The point is that conventional shoes (nonorthopedic) can stand in the way of the hoof's natural function. We have described the natural self-maintained bare foot and how it functions. We have also discussed the method for barefooted management of domestic horses that cannot maintain their own feet. For those horses that are unable to be left barefooted, we provide some information on how to prepare the feet and how to modify conventional keg shoes and apply them to the horse's feet. We can also show you how to apply Natural Balance Shoes (Equine Digit Support System, Inc, Penrose, CO) to the same properly prepared feet.

With the natural bare foot, the hoof wall breaks away to let the sole, frog, and bars accept some of the load. This allows two things to happen. The distal phalanx becomes flat to the ground from a medial lateral plane when the wall is removed by natural wear. Also, there are no flares or hoof wall extending outside the white zone (inner part) of the hoof wall. This means that the ground surface of the natural foot's wall is rounded and extends little beyond where the nail would be placed. These simple hoof features have important implications for the way horseshoes could be designed. When horses need to be shod, it is important to remember these hoof patterns as the natural process has sculpted them. When the horse is shod and the shoe is not properly oriented to the natural hoof wall and distal phalanx, or when extra width or extra length is added to the ground surface perimeters of the hoof, unreasonable forces are added to the hoof wall, laminae, joints, and overall body structure. Therefore, it is important for farriers, veterinarians, and horse owners to become familiar with the natural foot shape and how it relates to the distal phalanx. Self-maintaining feet give us that information. For instance, the sole callus mimics the shape of the ventral border of the distal phalanx. It modifies rapidly to adjust for changes in the environment. It protects the circumflex artery and vein as well as the ventral aspect of the distal phalanx. The sole callus also regulates the

amount of wear on the hoof wall so that load sharing takes place between the hoof wall and sole callus on the ground surface.

With feet that are self-maintaining, the toe is always worn back to a consistent distance from the tip of the distal phalanx. The sides of the hoof are always worn back near the sole to an equally consistent place as well. Because of this, it is extremely important for the shoe to mimic the natural hoof wall pattern as it relates directly to the distal phalanx in both length and width, especially with breakover. The breakover is determined by drawing a line across the foot at the inside (back) edge of the sole callus. This is approximately 1 to 1.5 inch ahead of the tip of the frog apex, depending on the size of the foot.

Hoof preparation is the most important part of horseshoeing, because once the foot is prepared and the shoe is attached, nature has little control over keeping the foot flat to the ground by the natural means of chipping and breaking the hoof wall. The hoof shape as it relates to the distal phalanx is crucial. Equally important are the sole callus depth and a genuine respect for all the other sole structures.

Before removing the chalky sole, the back edge of the sole callus can be found by passing your thumbs forward from the frog apex. The distance from the back edge of the sole callus to the frog apex can help you to match the shoe's breakover with the natural position for breakover.

When preparing the sole surface for a shoe, the frog, bars, and sole are prepared conservatively, similar to feet that are left bare. Bare feet that are on hard ground exfoliate reasonably well on their own, even with minimal exercise. Feet that are shod do not exfoliate effectively on their own; therefore, a conservative effort should be made to remove the sole material that is showing cracks in the sole and is chalky and crumbles when it is cut with a knife. It is critical to remove only the exfoliating material. When the sole and frog material changes from a chalky crumbly state (as you remove it) to a waxy-appearing surface, the live or functional sole and frog have been reached, and absolutely no more cutting should be done. The live functional sole at the toe quarters and the live sole at the heel quarters (behind the widest part of the foot) are references to the ventral border of the distal phalanx. Trimming the wall to these live functional structures offers the best guide to attain accurate medial/lateral and anterior/posterior balance. These live sole structures are generally easy to find on most horses.

Hoof preparation procedure

The true apex of the frog is identified either by probing or by removing a small amount from the tip of the frog pad. This should give you a mental image of where the live functional sole is for that part of the foot. Next, all the chalky sole around the frog apex that presents with small cracks is removed. If the cracks are large and deep, removal starts at the frog apex

and continues outward to the toe quarters. One blade of the nippers can be placed in the cracked chalky sole, and large chunks can then be lifted or pried out. From there, the search for live sole can continue using the hoof knife. In some cases, the sole material that is left is difficult to identify from the live functional sole. If there are any doubts, one should return to the frog apex and work back out to the outer edge of the sole, progressively searching for chalky layers. With those feet that present greater difficulty in determining the difference between live and dead sole, the conservative approach should be taken, using hoof testers to ensure that you do not get too close. If the foot is properly shod over time, these sole references are easy to find. It is better to be too long than too short. Exfoliating the rear of the foot is also done with the knife, again removing the chalky material and leaving the functional live sole that is waxy. The upright healthy structure of the bars should also be retained.

When the foot is properly exfoliated, the slightly raised area of the sole next to the wall should be seen. That raised area is the sole callus and should blend in gradually to the wall, with no ledge. Once you become familiar with the sole callus, you can clearly see the distal phalanx references that you need to trim the foot accurately as well as recognize the place on the sole for breakover.

For final foot preparation for shoe application, remember that the four corners of the distal phalanx are the part of the horse's anatomy we are trying to put in balance with the ground. Once the foot is exfoliated and the live functional sole is identified, the key points of reference are easy to find. It is best to prepare the back part of the foot first. From a line drawn across the foot at the frog apex, rasp or nipper the heel so that the height of the wall behind the widest part of the foot in the heel quarters is approximately 0.125 inch in vertical depth to the live functional sole (Fig. 9). The medial and lateral sides of the hoof wall in the heel region should be exfoliated and prepared equally.

The front or toe area is prepared next. Again, the sole callus is a major support structure for the distal phalanx. Therefore, excessive removal of the callus allows the coffin bone to settle or sink more than normal when the foot is loaded (Gene Ovnicek, RJF, and Barbara Page, DVM, personal observations, 1997) Remember that self-maintaining feet of domestic or feral horses are found to have the sole (inside of the hoof wall) on the ground in the toe quarter level with the hoof wall. Be conservative when removing the hoof wall at the toe, and do not make contact with the live sole with your initial nipper cut. Bring the wall down to meet the sole by rasping the wall into the sole callus at the two toe quarters until flattened areas appear equally on both sides. The width of these areas, measured from the laminae inward, should be approximately 0.25 inch. This ensures that there is optimal sole thickness below the distal phalanx for protection and support (Fig. 10). With ground contact the same, the dorsal aspect of the distal phalanx is equidistant to the ground from side to side. Farriers experienced

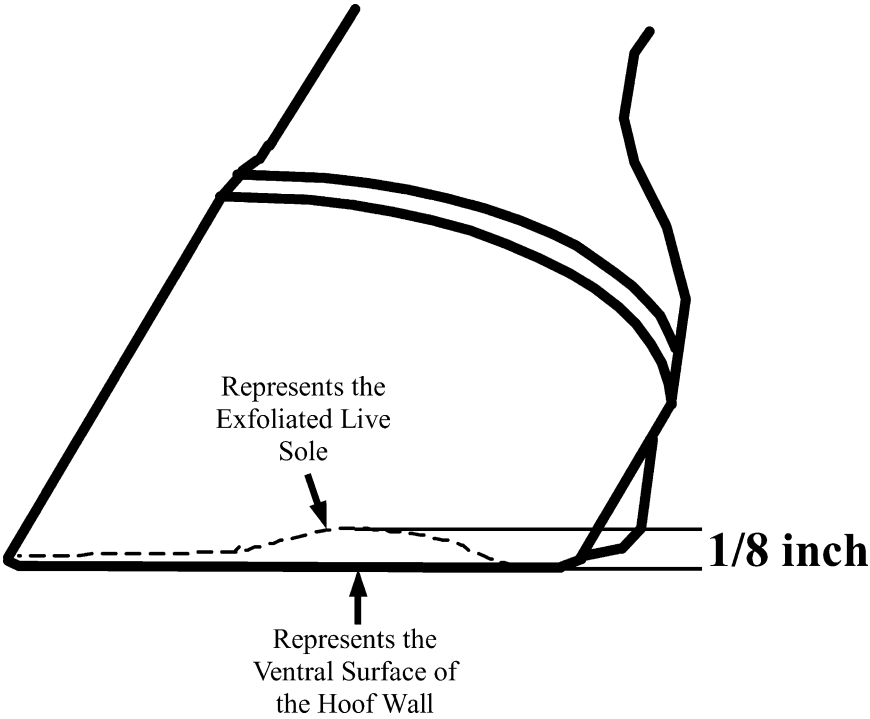

Fig. 9. When preparing the foot for a shoe, the vertical depth between the ventral surface of the hoof wall and the exfoliated live sole should be approximately 0.125 inch (behind the widest part of the foot in the heel quarters).

in this technique find some variations in this measurement of sole callus width in feet that are affected by previous trimming practices, individual hoof types, or extremes in general hoof condition.

The bottom surface of the foot is finished flat when the foot is prepared for shoeing (not relieved in the quarters as when trimmed to be left barefooted) and is hot seated if possible. Vigorous hot seating helps to dehydrate and strengthen the sole callus. It also pulls the sole proximally from the ground level so as to eliminate sole pressure.

The hoof wall supports the distal phalanx via the laminae. The laminae attach the distal phalanx to the inner face of the hoof wall. The hoof wall laminae, together with the sole callus, provide for the support of the distal phalanx in the front part of the foot. The frog and bars, via the digital cushion and lateral cartilage, serve to cushion and support the rear of the foot. All these structures must be left full strength, with only exfoliating and dead material being removed.

Flares should only be removed from the midportion of the hoof wall to the ground. The amount of wall that is rasped away should never exceed the

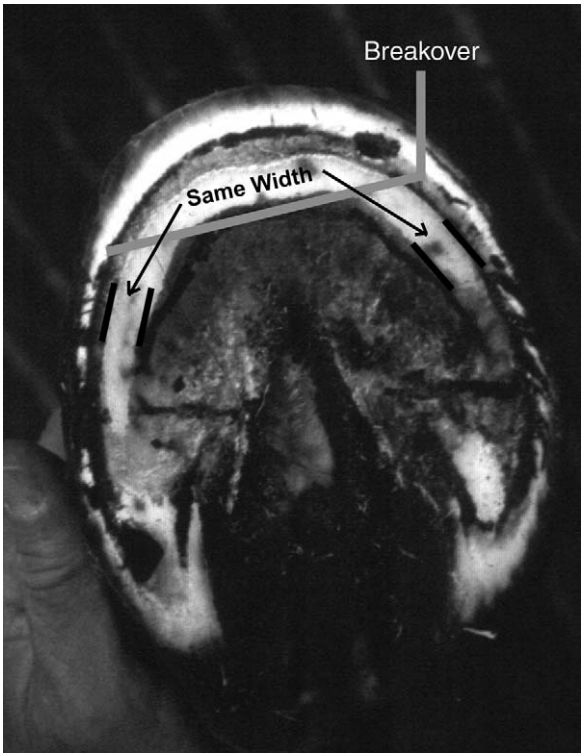

Fig. 10. The sole callus at each toe quarter is rasped to an equal width (approximately 0.25 inch). This ensures proper medial/lateral balance and optimal sole thickness below the distal phalanx.

outer layer (stratum externum). When the white zone appears at the ground level, wall flare removal should cease. In cases where the wall extends beyond the shoe at the toe, remove only what is beyond the shoe by undercutting (with a rasp) at approximately 45°. With extremely flat feet, flares have the wall pulled away from the sole at the ground level. These flares should be removed in an abrupt dubbed fashion.

Shoe placement and application

Shoe selection is important if you wish to meet the natural breakover requirements. Wide-web rim type shoes work best for easy modification. The outer rim is normally tapered in to the nail groove, which is helpful and somewhat mimics the way the bare foot naturally wears. That same feature is equally helpful at the toe when the shoe is squared somewhat and positioned on the foot so that the breakover point of the shoe fits directly over the back edge of the sole callus at the center of the toe (Fig. 11). The

Fig. 11. The wide-web rim shoe is broadened at the toe and tapered from the inner rim to the toe between the toe quarters. The shoe is placed on the foot so that the inner rim (point of breakover) is over the inside edge of the sole callus.

heel of the shoe should extend the full length of the frog. A good reference for that position is the back of the crease in the central sulcus (see Fig. 11; Fig. 12). Radiographs can be used to determine the natural position for the point of breakover [4] and are discussed later.

When premade aluminum or steel Natural Balance Shoes are used, the same criteria of shoe placement for breakover as well as heel length should be followed. The Natural Balance Shoe instructions suggest a varied distance from the frog apex to the inside edge of the shoe for placement. That distance is regulated with the heel position. Remember, the hoof preparation is exactly the same for both modified and Natural Balance Shoe application.

In Fig. 11, there is a line drawn across the widest part of the foot where the bars end. One third of the foot mass should be ahead of this line and up to the point of breakover. Again, the breakover point is at the inside edge of the sole callus in the center of the toe, approximately 1 to 1.5 inch ahead of the frog apex. The back two thirds of the shoe extend to the back of the crease in the central sulcus of the frog.

Fig. 12. The steel Natural Balance Shoe is designed to be applied with 0.25 to 0.5 inch (depending on the foot size) of distance from the frog apex to the inside edge of the shoe at the toe. This placement closely meets breakover requirements with respect to the sole callus. The seated out reverse arch on the inside border of the shoe at the toe helps to protect the distal border of the distal phalanx from sole pressure.

Radiographic technique and interpretation

A consistent radiographic technique with the use of radiopaque markers can help to confirm a low or high hoof-pastern axis and accurately assess the location of the distal phalanx in a dorsopalmar/plantar, proximodistal, or mediolateral direction. The proximodistal position of the navicular bone (NB) can also be assessed. Further information can sometimes be gleaned regarding the cause of caudal heel pain, and changes in position of the distal phalanx and the NB can be determined after application of therapeutic trimming and shoeing [4]. Although numerous useful measurements can be made, we principally address the use of radiographs to help determine proper breakover position in this article.

Lateral radiographs

Three markers are used: (1) a thumbtack at the true apex of the frog, (2) a wire along the dorsal aspect of the hoof wall, and (3) a wire imbedded in the block [6].

After removing dirt from the sulci, a thumbtack is placed into the true apex of the frog. The true apex is defined as the location where the frog blends with the sole. This area has a color and texture difference and is an easily identifiable standard for farriers and veterinarians. Often, the superficial layers of the frog grow over the true apex, necessitating the use of a sharp hoof knife to remove any overgrowth of the apex of the frog so as to allow identification of the true apex.

A wire is also placed on the dorsal hoof wall, with the most proximal aspect of the wire at the coronet where the last hair leaves the skin. Several materials may be used. Baling wire can be used but is not extremely malleable, lead from radiography aprons is malleable but less obvious on the radiograph, and barium paste is malleable and obvious but less easy to position accurately. A wire is also embedded into the center of one of the long sides of the block that the hoof is positioned on for radiography.

Horses are stood with both limbs on blocks and fully weighted. The blocks are of a height so that the x-ray beam intersects 0.375 to 0.625 inch (0.9–1.5 cm) distal to the coronary band. Blocks measuring 7 inches long and 6 inches wide give a good surface area for support of the foot yet are not too bulky. The foot to be radiographed is placed at the edge of the block so as to ensure that the cassette touches the hoof capsule. The limb is placed so the large metacarpal or metatarsal (cannon) bone is perpendicular to the ground, which is done by using a Metacarpal Level (Equine Wellness Foundation, Littleton, Co) placed at the midcannon position.

The focal-field distance is important and needs to be consistent, because measurements from the radiographs are transferred directly to the solar aspect of the foot. It is therefore critical to know the focal-field distance for the machine being used. To determine the focal-field distance that does not have any magnification for your machine, the following simple procedure can be used. Embed two penny nails 2 inches apart into the block the foot is placed on for radiography. Ensure that the cassette touches the hoof. Radiograph the foot, and measure the distance between the penny nails on the radiograph. If the distance measured on the radiograph equals the distance measured between the nails on the block, there is no magnification with that focal-field distance. The Min-Ray machine (Min X Ray, Inc., Northbrook, IL) (80 or 100 KvP), with a focal-field distance of 28 inches, has no significant magnification.

In taking the radiograph, ensure that the x-ray machine is parallel to both heel bulbs so that the wings of the distal phalanx are superimposed on the radiograph. To facilitate this, we use an extendable/retractable pointer held along the side of the x-ray machine that extends to the heel bulbs. The center of the x-ray beam is positioned about 0.5 inch below the coronary band and 2.5 to 3 inches dorsal to the heel bulbs. This position centers the beam over the NB. The film/cassette combination we have found to have the most detail and practicality is the 3-M Ultra-Detail Plus film (3M Animal Care Products, St. Paul, MN) in 3-M Veterinary EQ 2/6 rare earth screens or

Kodak Lanex Regular screens (Eastman Kodak, Rochester, NY). We use a distance of 28 inches at 64 KvP, and the time is 0.06 seconds.

From the radiograph, a line is drawn perpendicular to the ground, intersecting the tip of the distal phalanx. A second line is drawn perpendicular to the ground, intersecting the breakover location. (Breakover is defined as the most dorsal aspect of the hoof capsule or shoe that contacts the ground). The distance between these two lines is the dorsopalmar/plantar position of the distal phalanx with respect to the hoof capsule (Fig. 13).

Distances from the tip of the distal phalanx to breakover have varied from 0.5 to 7.0 cm. In our studies, a breakover of 0.6 cm dorsal to the tip of the distal phalanx in the front limb of horses weighing between 400 and

Fig. 13. Radiograph of a foot with measurements made to identify breakover. (*A*) Location of the thumbtack placed at the true frog apex. (*B*) Location of the dorsal tip of the distal phalanx. (*C*) A line is drawn at a distance of 0.6 cm (0.25 inch) dorsal to the dorsal tip of the distal phalanx. The distance from A to C is marked on the side so as to identify the breakover point for the shoe.

500 kg has been shown to be optimal. In the hind limb, the similar optimal location is 0.3 cm. The distances are increased 0.6 cm for warmbloods and 1.2 cm for draft horses.

For phalangeal alignment, a line is drawn along the dorsal aspect of the distal phalanx. The proximal phalanx is then bisected by measuring the midpoint of the proximal and distal shafts, and the two points are connected. The angle formed by the two lines is measured (Fig. 14). Angles vary from 0° to 36°. In horses in our studies having an angle between 0° and 10°, no lameness is noted. Horses with angles between 10° and 20° show varying lameness, and horses with angles greater than 20° often have changes in the shape of the hoof capsule in addition to lameness.

Application from marked radiographs to the hoof capsule

The lateral radiograph can be used to locate shoe placement for optimal support. To make this application, place the radiograph on a viewing screen and draw a line on the radiograph perpendicular to the ground, touching the tip of the coffin bone. Measure 0.25 inch (0.6 cm) dorsal to this line, and draw a second line parallel to the first. The location where the most dorsal

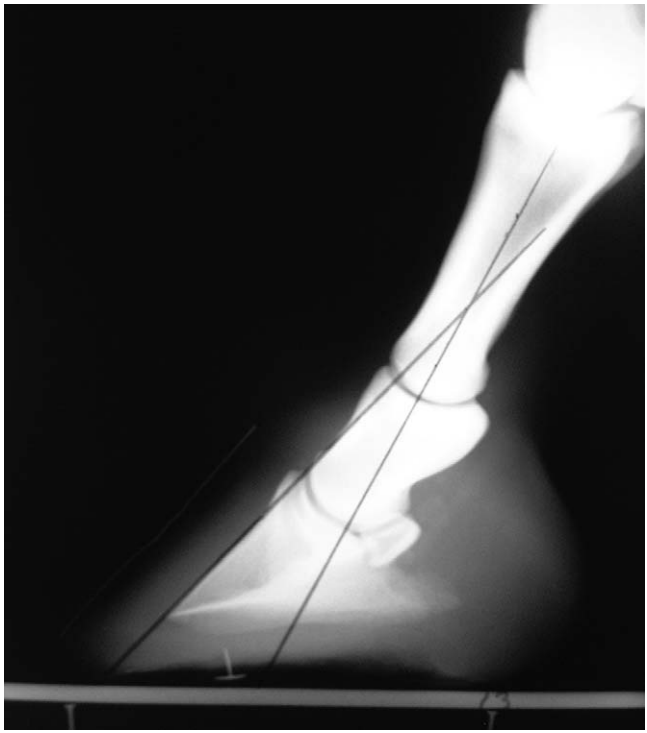

Fig. 14. Radiograph showing an alignment angle of the proximal and distal phalanx of 15°.

line meets the sole is the location of breakover (see Fig. 13). On the solar surface of the foot, use the measurement from the lateral radiograph and measure from where the thumbtack was placed at the true apex of the frog dorsally toward the toe. This location on the solar surface is where the breakover or roll in the shoe is located (Fig. 15).

Review

Review of general principles for natural balance trimming in barefoot horses

Always remember the following:

1. Never trim the sole callus.
2. Rocker the toe first if you are going to do so.
3. Do not remove any sole or frog that does not come easily.
4. The bearing points on the bottom of the foot should be long and broad rather than pointed.
5. The bearing points should incorporate the inner wall and the sole callus.
6. The heels should be left trimmed close to the height of the frog if possible.

Fig. 15. Measurements are transferred to the foot for shoe application. (*A*) Thumbtack at the true apex of the frog. (*C*) The position for the breakover point on the shoe (this varies depending on the shoe used but is often in the middle of the shoe web). (*D*) The measured distance on the shoe from the shoe point of breakover to the front of the shoe.

7. The heels should not be trimmed to a sharp point; instead, they should be rasped flat on top so that a large bearing area is left.
8. Never trim into the live structures of the sole at the toe or heel.

Summary of foot preparation for shoe application

1. The sole callus gives you a clear view of the location of the coffin bone (P-3).
2. When applying a shoe, the hoof wall is prepared to a flat plane rather than relieved in the quarters as you do when you leave the foot bare.
3. The caudal aspect of the foot is trimmed so that a gap of 1/8 to 1/16 inch is left (present) between the exfoliated functional sole and the ground surface of the finished hoof wall, behind the widest part of the foot. In cases of curved, underrun heels, trimming to the level of the exfoliated functional sole may be necessary for one or two shoeing cycles.
4. Be conservative, and do not invade any sensitive tissue.
5. Natural breakover occurs at the inside (back) edge of the sole callus (approximately 1–1.5 inch ahead of the true tip of the frog).
6. The back of the shoe should line up with the back of the frog buttress.
7. When the hoof wall extends beyond the shoe once it is applied, remove it by undercutting with your rasp at about 45°. Do not rasp the hoof wall back to the shoe from the coronary band.

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References

[1] Ovnicek G, Erfle J, Peters D. Wild horse hoof patterns offer a formula for preventing and treating lameness. Proc Am Assoc Equine Pract 1995;41:258–60.
[2] Bowker RM, Breuer AM, Vex KB, et al. Sensory receptors in the equine foot. Am J Vet Res 1993;54:1840–4.
[3] Bowker RM, Linder KE, Sonea IM, et al. Sensory nerve fibers and receptors in the equine distal forelimbs and their potential role in locomotion. Equine Vet J 1995;18:141–6.
[4] Page BT. Breakover of the hoof and its effects on structures and forces within the foot. J Eq Vet Sc 2002;22:258–63.
[5] Bowker RM, Van Wulfen KK, Springer SE, Linder KE. Functional anatomy of the cartilage of the distal phalanx and digital cushion in the equine foot and a hemodynamic flow hypothesis of energy dissipation. Am J Vet Res 1998;59:961–8.
[6] Page BT. How to mark the foot for radiography. Proc Am Assoc Equine Pract 1999; 45:148–9.