Remedial farriery Part 5: Principles of foot balance

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ABSTRACT: Foot imbalance is an important cause of foot related lameness and should be assessed and addressed early on in the lameness investigation. Full assessment of the feet should involve inspection from lateral, dorsal and solar aspects with particular attention to foot and shoe balance, conformation and horn quality. Radiographs can be used as adjuncts to assessment. Trimming and shoeing protocols should aim to restore proper balance, where possible. This article provides an overview of assessment of foot balance, using clinical examples and principles behind the approach to improving these imbalances.

INTRODUCTION

The importance of foot balance cannot be overstated with regard to equine orthopaedics since, particularly in the forelimb, a high number of poor performance and lameness issues can be traced back to foot related problems. Unfortunately the 'ideal' foot is rarely encountered in practice and therefore it is a case of addressing what problems are present to the best of the farrier's and veterinary surgeon's abilities. The identification and management of foot balance issues should never be ignored in preference to further, more detailed, diagnostic investigations, as it is often easy to lose sight of basic principles when dealing with the equine foot. Obviously a number of cases will require these further investigations, including diagnostic anaesthesia, radiography and, more recently magnetic resonance imaging, but failure to address fundamental foot related issues can result in a poor outcome for these cases.

OVERALL CONFORMATION

It is important when examining and addressing foot related issues not to forget the rest of the horse. Conformational assessment of the horse should begin every examination since, although there is no direct link proven, many horses with conformational problems will have lameness/performance issues during their lifetime. Common abnormalities particularly occur in relation to the carpus and fetlock and some of these (for example, valgus or varus and/or rotational aspects) will have influence on foot development and growth (Fig. 1). Some of these cannot be rectified, particularly in the skeletally mature horse, but if identified earlier as a foal, may be responsive to conservative or surgical intervention.

It must be appreciated that the ability to correct the foot related problem in the face of moderate to severe conformational issues will be limited and the owner may have to accept that the horse will remain with some degree of foot imbalance that cannot be fully resolved with farriery.

Fig. 1: *The right forelimb of this horse shows an 'out-at-the-knee' conformation and is toe-in with inward rotation of the limb distal to the carpus which is likely to lead to abnormal loading and forces through the digit. The white line should bisect the forelimb equally, when viewed from the front.*

After overall assessment of the horse a more detailed examination of the foot can begin, or alternatively, some farriers and veterinary surgeons will next look at the horse during movement. Either way, both aspects should always be undertaken.

STATIC ASSESSMENT OF THE FOOT

The horse should be evaluated on firm level ground in good light from all aspects with the horse standing as square as is possible. From this approach, the dorsopalmar/plantar and lateromedial balance can be assessed. Examination of the foot when held up will

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also allow assessment of the sole/horn quality, shoe type/fitting and assessment of foot balance through the heels/frog. When assessing the foot held up, it is important to hold the limb in the mid cannon so that the long axis of the limb is parallel to the long axis of the horse and directly under the horse. In this respect a true assessment of the foot can be made.

Viewed from the side, the hoof-pastern axis can be evaluated. This is the angle of the dorsal hoof wall and the pastern. In the forelimb is it usually 45-55° to the ground whereas in the hindlimb it is usually slightly steeper (50-55°). The relationship of the dorsal hoof wall can be described as 'broken forward' or 'broken back' (Figs. 2a and 2b). The position of the shoe can be inferred when examining from the side, particularly in relation to the amount of caudal support of the foot it is providing. Often the bars of the shoe may not extend enough caudally and leave the heels unsupported. This can be due to incorrect fitting or too small a shoe. The heels are then subject to abnormal stresses, particularly at the junction with the end of the shoe and this can result in stress cracks at the heels and collapsing/instability. The dorsal hoof wall and heels should be parallel and the heel should be approximately one third of the length of the dorsal hoof wall.

Figs. 2a and 2b: *Examples of broken forward (a) and broken back (b) hoof-pastern axis, as shown by the white lines.*

Fig 2b.

From the dorsal aspect of the foot, assessment of the medial and lateral balance can be made. In a number of horses the medial wall is commonly straighter or more upright than the lateral. The coronary band should be parallel to the floor and inspection of the perioplar region should also be undertaken. Examination with the foot off the ground will provide additional information on the mediolateral balance, particularly at the heels and their relationship to the distal limb (Fig. 3). A T square can be used to assess this. When assessing mediolateral balance from the palmar aspect with the limb non weight-bearing, care should be taken to allow the foot to hang freely. Shoe size and type and position can be appreciated from the solar view as well as the shape and position of the frog. The sole should have some concavity and the frog should be positioned centrally, and occupy approximately half to two-thirds the length of the foot.

Fig. 3: *Using a T-square can assist in the assessment of foot balance.*

DYNAMIC ASSESSMENT OF THE FOOT

Examination is most useful at the walk and trot in a straight line, particularly when the horse is moving away, so that its footfall can be observed. Conformation may play a role in how the horse moves, since horses that are toe-out often wing in, whereas horses that are toe-in tend to wing out ('paddle'). Where the horse breaks over and lands can also be determined. Horses with pain at the dorsal toe (for example, laminitis) tend to land heel first whereas some horses with caudal heel pain will land toe first. Additionally, many horses land lateral first, particularly if they are toe-out. Landing lateral to medial may result in abnormal stresses across the foot and may particularly stress the collateral ligaments of the distal interphalangeal joint, particularly where there are rotational forces occurring as well.

COMMON FOOT IMBALANCES

Dorsopalmar imbalance

Dorsopalmar imbalance is a common finding in horses, particularly in Thorough-bred types (Fig. 4). A long toe/low heel conformation is most commonly encountered and may be due to the horse's conformation but can be exacerbated by poor trimming and shoeing where the toes are left too long and the heels cut too short. Placement of the shoe that does not extend caudally enough or a shoe size that is too small will lead to poor heel support and potentially collapse. A long toe/low heel will increase the strain in the deep digital flexor tendon (DDFT) and its accessory ligament (ALDDFT) and increases the moment force required through the distal interphalangeal joint during the transition from stance phase to breakover phase. This increased strain from the DDFT will compress the navicular bone and stresses are transferred through to this structure. The navicular bone will adapt to this abnormal loading and in some cases, lead to pain and therefore lameness.

Reducing the moment arm (trimming the toe) and/or elevating the heels will decrease the strain in the DDFT and ALDDFT and hence decrease strain on the navicular bone (although raising the heels can increase strain through the superficial digital flexor tendon and suspensory ligament). Additionally placing the shoe further caudally will provide support for the heels but also move the centre of rotation of the distal interphalangeal joint caudally, again reducing the moment force required for motion through this structure (Fig. 5). Using wedges to raise the heels may have a negative effect as increased pressure will further slow hoof growth at the heel and these have to be placed with caution where collapsed heels are present. In such cases, wedges may not be appropriate and placement of a bar shoe may achieve some of the aims whilst protecting the heels to allow further growth.

Fig. 4: *Dorsopalmar foot imbalance is commonly seen in Thoroughbred type horses. In this case, the toe is excessively long with low heels and there is little heel support afforded by the shoe.*

Figs. 5a and 5b: *An example of a horse with dorsopalmar foot imbalance before (a) and after (b) trimming and shoeing. Note the caudal position of the shoe and presence of heel wedges to improve the dorsopalmar angulation and heel support.*

Fig. 5b:

Mediolateral imbalance

Mediolateral imbalance again may be caused by poor conformation or can be as a result of poor trimming. Examination from the dorsal and palmar/plantar aspects of the hoof will reveal this imbalance. Additionally, incorrect or poor shoe placement may result in different stresses encountered on different parts of the hoof wall and result in mediolateral stress. Rotational abnormalities involving the feet may also lead to or exacerbate mediolateral imbalance but resolution of this underlying cause can be difficult to achieve.

Commonly, mediolateral imbalance is a seen as a taller, steeper medial wall and a flared-out lateral wall, resulting in a sloping of the coronary band from medial to lateral. Under-running of the narrower, more upright wall may also occur and in some cases shearing of the heels occurs, where the medial heel is 'shunted' upwards as the horse often lands heavily on the medial quarter resulting in pain (Fig. 6). As well as the effect on the heels, mediolateral imbalance will also result in differential forces across the distal and middle phalanges and on the horn tubules as they grow from proximal to distal. This can ultimately result in abnormal hoof growth and a distorted hoof capsule. Radiographs can be useful to appreciate the effects of mediolateral imbalance on the joints. With a horizontal dorsopalmar/plantar

Fig. 6: *An example of mediolateral foot imbalance of the right fore of a horse, as viewed from the heel region. The white lines illustrate the degree of imbalance in this case.*

Fig. 7: *A dorsopalmar radiograph of a horse with mediolateral imbalance demonstrating the effects of imbalance on joint loading when compared to the solar surface (white lines). Lateral is to the right.*

projection, sloping and abnormal loading of the joints can be seen (Fig. 7) and this will result in abnormal stresses through the joint cartilage/ subchondral bone and associated structures (such as the collateral ligaments).

Trimming to balance the foot is essential with mediolateral imbalance to try to re-establish the correct proportions of the foot. Trimming the longer wall (commonly lateral) is the first line of treatment or if there is insufficient wall, then lengthening the shorter wall (using a wedge) can be used. Additionally, thinning the shoe of the lateral wall and setting the shoe slightly out at the shorter wall can help redress the imbalance. In cases where shearing of the medial heel bulb has occurred, floating of the medial quarter may be required (Fig. 8). These alterations may take several visits to implement since major alterations in one shoeing may not be tolerated by the horse. Indeed it can be detrimental to aim to restore normal foot balance too rapidly and can, in some cases, lead to worsening of the lameness.

Figs. 8a and 8b: *An example of mediolateral imbalance before (a) and after (b) trimming. Note in this case the presence of 'shunting' upwards of the lateral heel bulb. In (b), the lateral quarter has been floated to try to unload this region.*

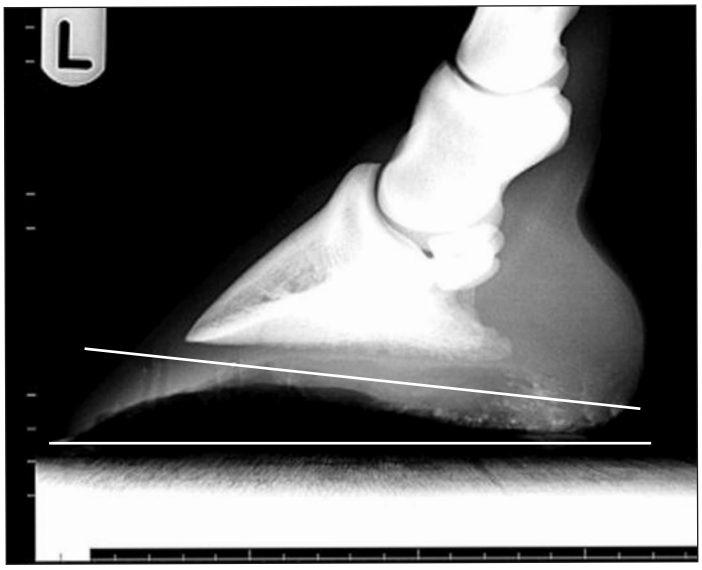
Figs. 8b.

Reverse rotation

Reverse rotation describes the negative angulation of the distal phalanx to the solar margin. The normal 5-10° angulation forwards of the solar margin of the distal phalanx is no longer present in these horses and is often reversed (i.e. the caudal aspect of the distal phalanx solar margin is lower than the dorsal margin). This is often seen in the hind feet of the horse (Fig. 9a) and can lead to altered biomechanical forces through the caudal structures of the foot and potentially increased extension (hyperextension) of the metacarpo/ tarsophalangeal joint. A number of these cases will have concomitant injuries to the suspensory apparatus, particularly involving the suspensory ligament/annular ligament where desmitis of one or more of these structure is also diagnosed.

The caudal aspect of the foot is often poorly supported with deformation and occasionally collapsing of the heels. Radiography again (particularly lateromedial radiographs) is important in assessing dorsopalmar/plantar foot imbalance (Fig. 9b). The centre of rotation of the distal interphalangeal joint is often over two-thirds of the way caudal from the dorsal to caudal margins, in

Figs 9a and 9b: *An example of reverse rotation in the hind feet of a horse. Photograph (a) showing the long-toe/low-heel in this example, with poorly supported heel. Lateromedial radiograph (b) demonstrating the reverse angulation (white lines) of the solar margin of the distal phalanx with the sole.*



Figs. 9b:

relation to the shoe, with the breakover point similarly too far forward. Addressing dorsopalmar/plantar foot imbalance is a priority (and any mediolateral imbalance, if present) in these cases. Often there is little heel growth present but trimming the toe and bringing the breakover point further caudally and using heel wedges will significantly improve the balance.

ADDITIONAL COMMENTS

As mentioned at the beginning of this article, poor foot balance is a common cause of foot-related problems in the horse and it is fundamental to aim to address these imbalances as best as possible early on in the lameness investigation. Although the underlying issues may not be resolved straight away, it is far better to aim to resolve the problems before embarking on a lengthy and potentially expensive lameness work-up. The longer term effects of poor foot balance however, are likely to lead to secondary changes within the foot that will require veterinary attention and investigation (for example, navicular bone pathology, collateral ligament desmitis), but addressing the instigators of these secondary problems before they arise will be better for the horse in the long-run.

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These multiple choice questions are based on the above text. Answers appear on page ??.

1. **The angle of the dorsal hoof wall and pastern to the ground in the fore and hindlimb is usually what:**
   a. Forelimb (45–55°) and hindlimb (40–45°)
   b. Forelimb (40–45°) and hindlimb (50–55°)
   c. Forelimb (45–55°) and hindlimb (50–55°)
   d. Forelimb (45–55°) and hindlimb (45–55°)

2. **Reducing the moment arm by trimming the toe and/or elevating the heels does what:**
   a. Decreases the strain on the SDFT and DDFT
   b. Decreases the strain on the DDFT and ALSDFT
   c. Decreases the strain on the SDFT and SL
   d. Decreases the strain on the DDFT and ALDDFT

3. **In a case where there is mediolateral imbalance characterised by a longer lateral and shorter medial hoof wall, what procedure(s) would assist in improving the balancing in this foot:**
   a. Shortening the lateral wall (by trimming) and lengthening the medial wall (using a wedge)
   b. Shortening the medial wall (by trimming) and lengthening the lateral wall (using a wedge)
   c. Shortening the dorsal toe and using a 3° heel wedge
   d. Placing an acrylic toe extension at the dorsodistal margin of the hoof wall