THE ASSESSMENT OF THE EFFECT OF FROG SUPPORT PADS AND PACKING UPON THE PALMAR ANGLE OF THE DISTAL PHALANX

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Dissertation

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ABSTRACT

Some of the most challenging feet that farriers deal with are those with under run/collapsed heels. These are usually combined with long toes, thin soles and weak walls. These terms describe some of the common external abnormalities of the hoof capsule. With this type of conformation, there is strong evidence to suggest the distal phalanx has repositioned so that the palmar processes are lower and may lie below the horizontal plane.

Aim: To investigate that frog support pads, when applied with medicated packing, are likely to help restore a foot towards its natural conformation by helping to improve the palmar angle, and improve the sole and heel depth.

Trial Methodology: A sample size of 18 horses of mixed breeds, age, height and work load were chosen: the treatment group (nine), were shod with frog support pads and medicated packing; the control group (nine) were without. All horses were re-shod at 35 days and the front feet were radiographed pre-trim. This produced five sets of measurements during an 11 month period. Measurements taken from the radiographs were: palmar angle, heel depth, navicular depth and solar depth.

Results: The palmar angle was significantly greater within the control group than the treatment group (p=0.016). There was no statistically significant change in palmar angle across the five occasions for either treatment or control group.

Conclusion: Although not statistically significant, there was an improvement in palmar angle, heel depth, sole depth and navicular depth within the treatment group. There was no improvement in palmar angle within the control group and the improvement within the treatment group of sole, heel and navicular depth was approximately double those seen in the control group. The improvements within the treatment group could be attributed to use of support pads and medicated packing.

DECLARATION BY AUTHOR

This thesis is composed of my original work, and contains no material previously published or written by another person except where due reference has been made in the text. The content of my thesis is the result of work I have carried out since the commencement of my research for the Worshipful Company of Farriers fellowship award and does not include a substantial part of work that has been submitted to qualify for the award of any other degree or diploma.

Signed……………………………………

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ABBREVIATIONS

DDFT	Deep Digital Flexor Tendon
DP	Distal Phalanx
FSP	Frog Support Pads
HH	Heel Height
HD	Heel Depth
NPA	Negative Palmar/Planter Angle
NB	Navicular Bone
PA	Palmar Angle
SD	Sole Depth
SB	Solar Border
WBB	Weight Bearing Border
StD	Standard Deviation
IQR	Interquartile range

CONTENTS

Word Count: 4091

INTRODUCTION

There is now substantial evidence in the veterinary and farriery profession to support the fact that pathology within the palmar half of the foot is one of the most common causes of lameness (Turner, 1986; Eliashar, McGuigan and Wilson, 2004; O'Grady, 2006).

The palmar aspect of the foot plays a significant role not only in soundness, but also in the condition and maintenance of the equine foot. It is subject to the most complex external and internal biomechanical forces. Conformational differences are common and are not always associated with lameness (Hunt, 2012). Most palmar foot lameness' are caused by some form of hoof capsule distortion (Moyer and Anderson, 1975; Turner, 1986), as these distortions are believed to subject the foot to secondary complications, which may lead to injury or lameness (Turner and Stork, 1988).

Distortion may be displayed as: under-run, collapsed heels, long toes, over developed frogs, thin convex soles, and a broken back hoof pastern axis (Colles, 1983; O'Grady and Poupard, 2010). Malalignment of the foot and pastern is seen in 72.8% of horses with forelimb lameness (Kummer *et al.*, 2006).

Correcting these cases can be some of the most challenging and problematic experiences that farriers encounter. Some farriers may find themselves under pressure to influence these feet with the rasp to 're balance' them before strength and mass has been achieved (Lungwitz, 1897; O'Grady, 2006).

Low heels are categorised as being less than a 3:1 ratio with the toe from the coronary band to the Weight Bearing Border (WBB) (Turner, 1992). When the heels are not maintained and become low, the angle of the coronary band in relation to the ground becomes steeper and the distal interphalangeal joint (DIPJ) extends. The orientation of the distal phalanx (DP) also changes; its solar border (SB) moves closer to the ground and the angle between the sole and DP may be closer to the solar surface compared to the toe region (Eliashar, McGuigan and Wilson, 2004).

The normal angle of the solar border of the DP with the horizontal, otherwise referred to as the palmar angle (PA), has been reported to be between two and ten degrees (Parks, Ovnicek and Sigafoos, 2003). Baxter, Shashak and Hill (2011) suggested the PA should ideally be between three and five degrees. Comprehensive evaluation connecting to soft tissue areas prone to damage and injury are now possible. With the help of standing magnetic resonance imaging (MRI) it has, for example, been shown that the angle and position of the DP can be related to lameness (Holroyd *et al.*, 2013). A one degree change in PA can lead to a 4% increase in pressure exerted by the deep digital flexor tendon (DDFT) on the navicular bone (NB) and a low or negative PA can have significant influences on associated lameness including distal sesamoid as well as DDFT lesions (Eliashar, McGuigan and Wilson, 2004; Holroyd *et al.*, 2013). It has been demonstrated that a steeper PA will decrease the force in the DDFT, and it was proposed that, as a result, horses with a flatter PA would be predisposed to lesions of the DDFT and NB (Eliashar, McGuigan and Wilson, 2004).

A thin-soled foot will often have thin 'shelly' walls, with multiple old nail holes making new nail placement difficult (Williams and Deacon, 1999). When the shoe is removed the solar surface of the shoe will show deep creases in the heel area; this high friction area erodes an already weakened thin and collapsed heel (Figure 1).

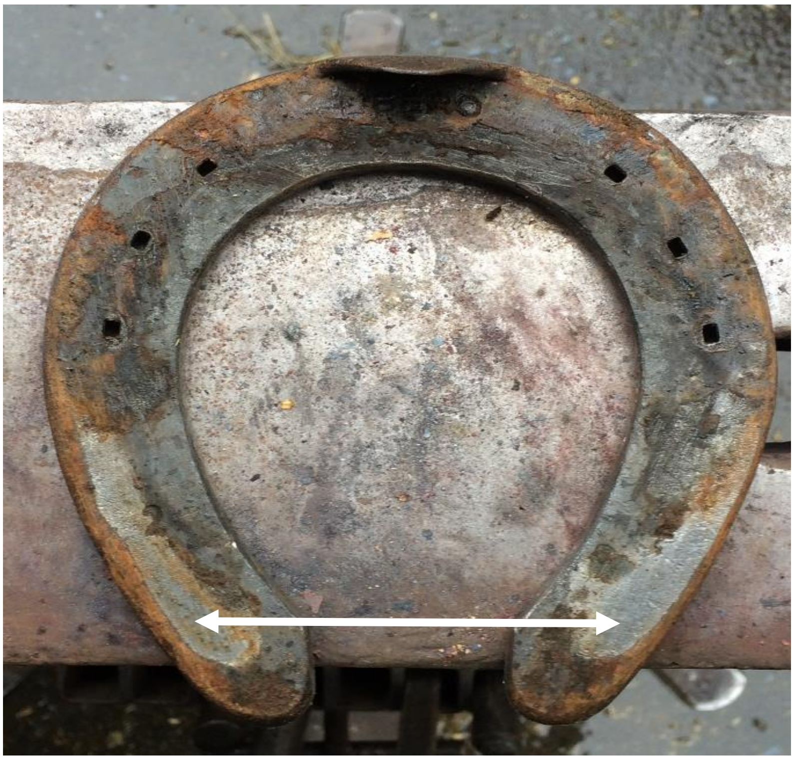

Figure 1: The arrows point to the deep creases at the heels, caused by hoof movement.

Savoldi (2007) linked hoof morphology to the orientation and function of the internal structures. Savoldi (2007) utilised the uniformity of sole thickness to the horizontal plane on the bearing border to analyse solar morphology. He believed that this indicates abnormal orientation of the DP which may lead to localised areas of pathology around the distal margin of the DP and associated structures of the navicular bone (NB).

The most difficult foot conformation for the farrier to deal with is the low heel/long toe, thin walled, flat soled individual (Figure 2). A compromised blood supply and soft tissue damage could result in an inadequate amount of sole growth and depth. Such feet are continuously exposed to multitude of deleterious factors (Moyer and Anderson, 1975). In some horses with these abnormalities, they could have a low or negative PA, where the DP has repositioned so that the palmar processes are lower than the horizontal plane. These measurements could be influenced by prolonged trimming intervals (Kummer *et al.*, 2006).

Different conformations require different trimming and shoeing protocols in order to achieve 'correct' conformation. A more 'correct' conformation should theoretically allow for minimal detrimental forces to be exerted through the internal structures of the foot (Figures 2 and 3).

Figure 2: A front foot examined at the end of a 5 week shoeing cycle demonstrating poor conformation. Note the long toes, broken back HPA, underrun heels, horn tubules running dorsodistally an overly acute angle, coronary band displacement and little hoof mass.

Figure 3: A front foot examined at the end of a 5 week shoeing cycle. The foot has a correct HPA, a near parallel heel and dorsal wall angle.

Correcting abnormal hoof conformation will always be part of a farriers goal. By re-distributing some of the peripheral loading away from the hoof wall, the compressive forces placed on the heels, frog, sole, and bars may be reduced (O'Grady, 2006).

Despite developments in knowledge that have occurred in recent times, there is still a great deal of controversy among farriers and veterinarians surrounding both maintenance and treatment of these and other palmar foot abnormalities and disorders. There are many variations in treatment; for example, the author has been requested to 'cut the toe back' and fit angled heel wedges to assist with management of navicular syndrome.

Open heel shoes that transfer the weight of the horse onto a narrow compressive band of material and that do not support the frog and sole, suspend the horse only on the dorsal hoof wall. If the horse is standing on a flat, unyielding surface, most of the pressure is distributed around the perimeter of the foot at the interface of the ground and wall (Parks, 2012). This may pull the epidermal and dermal laminae away from each other, allowing the bony column to descend further down into the hoof capsule, thereby flattening or pushing out the sole. The entire hoof, including the wall, bars, digital cushion, frog, and sole are all intended to work together to maintain optimum function during weight-bearing.

The author’s approach to flat foot conformation was to try and improve these dysfunctional feet through a shoeing cycle rather than doing a ‘quick fix’, such as applying heel wedges for horses with navicular syndrome or rasping the toe back for cosmetic purposes. The author had limited success with bar shoes; whether Heart Bar, Egg Bar, or Straight Bar varieties nor wide-web sections, however had greater success through giving a period of rest, convalescence and going barefoot. This resulted in a foot which was improved to a healthier state in terms of greater hoof mass, heel and solar depth.

In applying frog support pads (FSP) and packing material (into the frog sulci and void created between the pad and shoe, to ensure uniform contact surface over the sole) peripheral loading may be reduced. It was theorised that the FSP and material help support the bony column by creating a greater surface area; recruiting the frog, sole and bars to share some of the weight bearing responsibilities that would normally be borne on the hoof wall. A load applied to the foot with a small surface area will produce higher stress in the underlying tissues than an identical load applied to the foot with a greater surface area (Bowker 2003).

AIM

The purpose of the paper was to investigate the effects of shoeing with frog support pads and medicated packing. The aim was to assess their potential to improve biomechanical conformation, by helping to increase the PA, sole and heel depth.

OBJECTIVES

The objectives of the study were to measure the effects of the inclusion of a frog support pad with medicated packing on feet with a negative PA, minimal sole depth and low heels.

To record the effects of a frog support pad with medicated packing upon the equine foot, namely: 1) sole depth, 2) heel height, 3) palmar angle of the DP.

METHOD AND MATERIALS

To achieve the aim and objectives, the following data was gathered using lateromedial radiographic images:

- Sole depth (SD)
- Heel depth (HD)
- Navicular depth (ND)
- Palmar angles (PA)

The study was conducted with horses selected from a private livery yard. The subjects consisted of a variety of breeds with a range in weight from 300-800kg. The subjects were in regular ridden work, with daily turn out.

To conduct this study:

1. Control and treatment groups were selected at a private livery yard. Each group contained 9 horses.

2. The horses' breeds, age, height, weight and work load were not uniform.

3. Horses were re-shod at intervals of 5 weeks. Data was collected on all 5 trimming occasions included in the study.

4. The horses selected for the pads displayed some signs of hoof capsule distortion (low heels and long toes) and none of the sample animals were clinically lame (see veterinary declaration in appendix 1). No horses within the control group had signs of conformational abnormalities.

5. Nine selected for pads were each fitted with a 2mm elastomeric chevron style frog support pad[1], which was filled with a leather medicated matrix[22] (Figure 4), and hemp[3] which acts as a bind (Figure 4). This group were defined as the treatment group and the remainder as the control group. Horses within the control group had no signs of conformational abnormalities.

6. The matrix consisted of shredded leather soaked in natural medicated substances. This was the author's preferred packing as it fills all negative space created by the placing of the pads over the solar surface, offering support and stability, whilst theoretically allowing the foot to function.

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[3] Handmade Shoes UK Ltd., Unit 3-4 Williams Court, Pitstone Green Business park, Tunnell Way, Leighton Buzzard, LU7 9GY.

7. Lateromedial radiographs were taken of each foot pre-trimming on each of the 5 occasions. These images would be used to collect measurements of sole, heel and navicular depth and PA.

8. All horses were prepared for radiographs by: removal of shoes, debridement of foreign material (by picking out of feet, wire brushing and trimming with a knife) and stood on equal height wooden blocks with rubber, anti-slip surfacing. The radiographs were calibrated with a 1p coin (20mm diameter) located at the same point for each image.

9. The navicular depth measurement was taken as it was potentially a more repeatable method of determining the heel depth.

10. Trimming protocol was based on an individual approach, aiming to achieve solar symmetry, dressing heel buttresses to sit at the highest and widest part of the frog (O'Grady and Poupard, 2010; Caldwell *et al.*, 2016), aiming to achieve appropriate medial/lateral balance (as close to 90 degrees as feasible) to the long axis (Curtis, 2002) and correct alignment of the HPA. All horses were shod with handmade open heel shoes, toe clips and upright heels fitted to the highest and widest point of the frog.

11. All horses were shod (by the author) with handmade fullered concave shoes, so as not to compromise nailing different wall angles.


d

Figure 4: Elasometric cheveron style foot pad and leather medicated packing material and hemp.

MEASUREMENTS

The radiographs were performed by a veterinary surgeon. The measurements from these radiographs were made by an independent veterinary student and the data was recorded on a data spreadsheet (Excel) for analysis. The SD measurement was taken from the dorsal tip of the DP to the weight bearing border (WBB) at 90 degrees; navicular depth (ND) was taken from the distal point of NB to the WBB at 90 degrees; HD was taken from the most palmar point of the external heel bulb at 90 degrees (Figure 5).

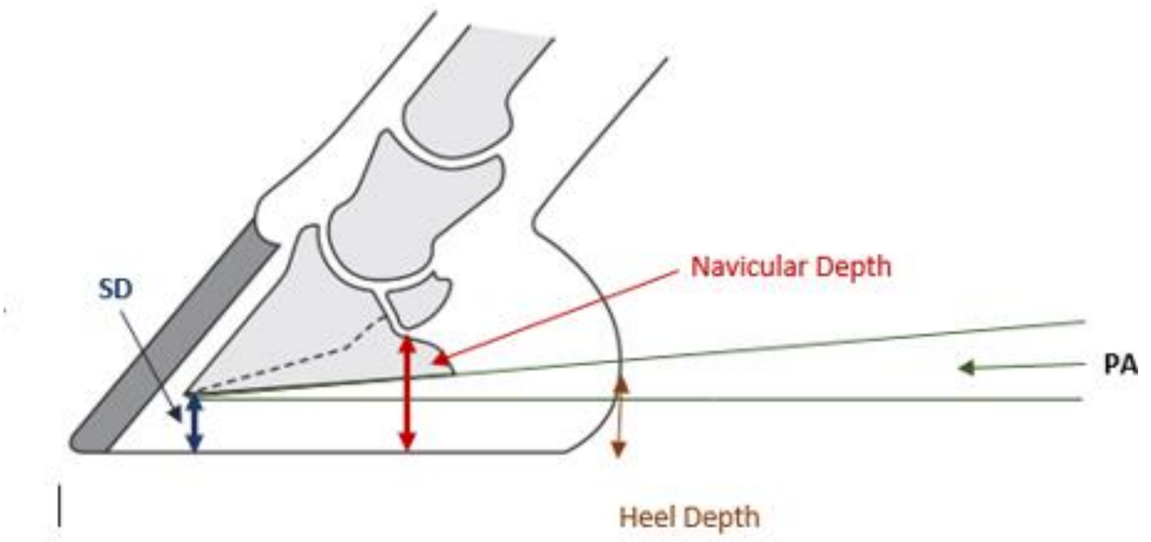


Figure 5: Schematic diagram showing method for obtaining measurements. Courtesy of J Tovey FWCF.

STATISTICAL ANALYSIS

A mixed model analysis was used to assess the variation and difference between horses considering the individual patient's variability, the different time points, the group (treatment or control) and the limb (left or right). Fixed factors were: treatment group, occasion and left or right limb. The significance value was set at $P < 0.05$.

For each dependent variable, the forelimb model was run twice. Left and right forelimbs were combined for the calculation of summary statistics as 'limb' did not have significant effect on the dependent variables.

A Kolmogorov-Smirnov statistic for normality and analysis of histograms showed that the results were normally distributed. Means and standard deviations (StD) are reported for sole depth, heel height and navicular depth however, due to the presence of some negative values for PA, these are reported as medians and interquartile range (IQR).

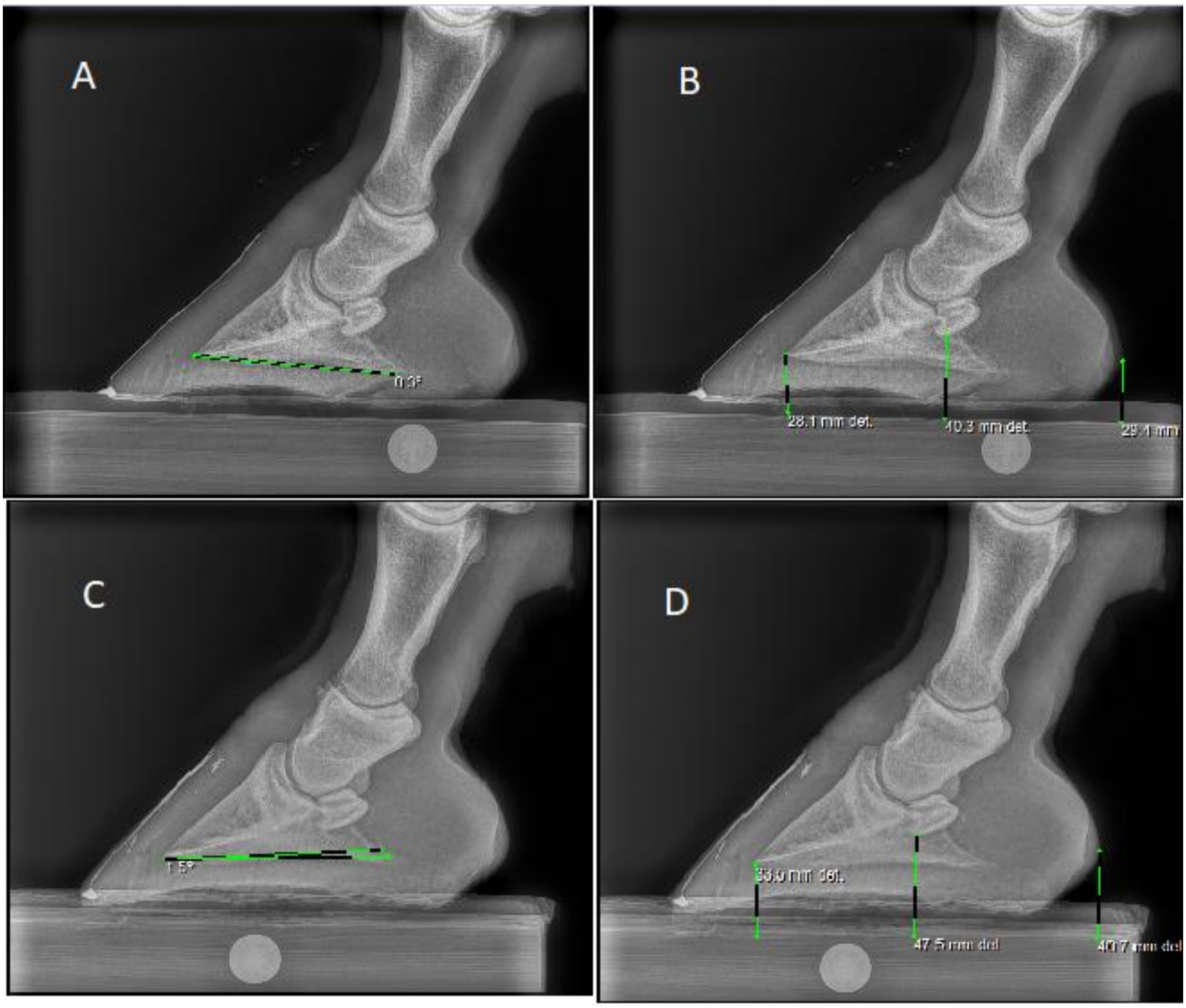


Figure 6: Examples of radiographs obtained throughout the study.
A = Radiograph of a treatment group subject on pre-trim occasion 1 (March 1st).
Demonstrating PA.
B = Radiograph of treatment group pre-trim occasion 1 (March 1st) demonstrating heel depth, sole depth, navicular depth.

C = Radiograph of treatment group pre-trim occasion 5 (December 1st) demonstrating PA*.*

D = Radiograph of treatment group pre-trim occasion 5 (December 1st) demonstrating heel depth, sole depth, navicular depth.

RESULTS

Table 1a: Sole depth of treatment group versus control group over 5 occasions.

	Mean (±StD) sole depth (mm)	
Occasion	Treatment	Control
1	19.33 (4.33)	20.56(3.41)
2	21.61 (3.77)	20.96 (4.55)
3	22.93 (3.8)	22.24(3.53)
4	23.52 (3.5)	22.4(3.03)
5	23.97 (3.86)	23.00(3.4)
Mean change in sole depth occasion 1-5	4.64	2.44

Table 1b: Navicular depth of treatment group versus control group over 5 occasions.

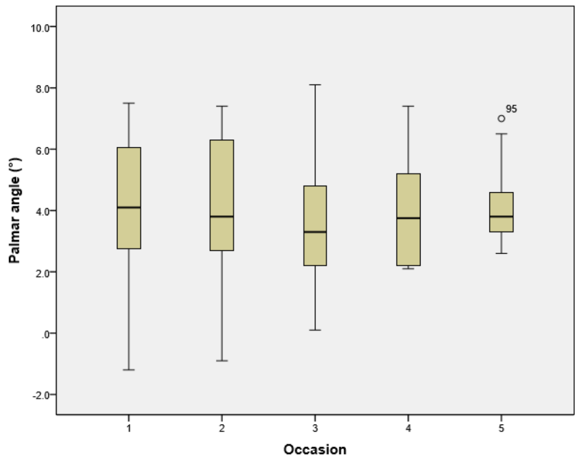
	Mean Navicular (±StD) depth (mm)	
Occasion	Treatment	Control
1	38.97(4.68)	44.11(6.27)
2	41.24(4.00)	44.76(6.63)
3	41.72(4.70	45.38(7.28)
4	42.52(5.47	46.22(4.35)
5	43.71(4.54)	46.82(5.4)
Mean change in navicular depth occasion 1-5	4.74	2.71

Table 1c: Palmar angle of treatment group versus control group over 5 occasions.

	Median (IQR) Palmar angle (Degrees)	
Occasion	Treatment	Control
1	1.15(3.6)	4.1(3.4)
2	0.8 (4.4)	3.8(3.9)
3	0.1 (5.2)	3.3(3.1)
4	0.8 (4.1)	3.75(3.1)
5	2.5 (3.7)	3.8(1.4)
Median change palmar angle between occasion 1-5	1.35	-0.3

Table 1d: Heel height of treatment group versus control group over 5 occasions.

	Mean (±StD) Heel height (mm)	
Occasion	Treatment	Control
1	26.37(5.28	30.3(6.05)
2	27.09(4.87)	30.18(6.34)
3	28.41(5.39	31.69(6.47)
4	29.31(5.39)	32.91(5.63)
5	31.21(6.25)	32.43(5.4)
Mean change in heel height between occasion 1-5	4.84	2.13



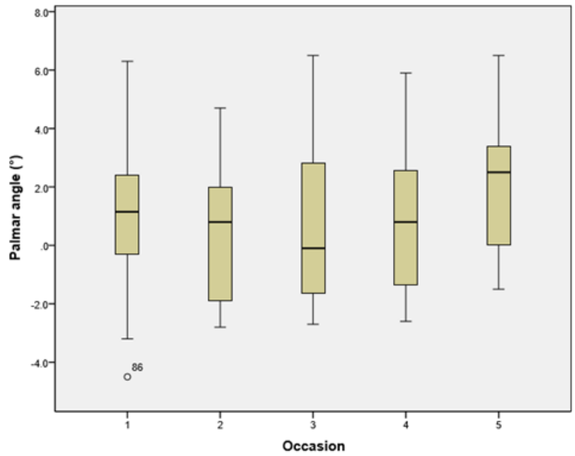


Figure 7a: Box and whisker plot showing median PA of control group (o= Outlier)

Figure 7b: Box and whisker plot showing median PA of treatment group

The mean sole depth in the treatment group increased by 4.64mm and in the control by 2.44mm between occasion 1 and 5 (see table 1a). There was no significant difference in sole depth between the treatment group and the control group (p=0.898). There was a significant difference in sole depth across the five occasions, regardless of group (p<0.01) (see 'Pairwise Comparisons' table in appendix 2).

The mean navicular depth in the treatment group increased by 4.74mm and 2.71mm in the control group between occasion 1 and 5 (see table 1b). There was no significant difference in navicular depth between treatment and control group (p=0.123). There was a significant difference in navicular depth between occasions regardless of group (p<0.01) (see 'Pairwise Comparisons' table in appendix 2).

The mean heel depth in the treatment group increased by 4.84mm and 2.13mm in the control group between occasion 1 and 5 (see table 1d). There was no significant difference in heel depth between treatment and control group (p=0.169). There was a significant difference in heel depth between occasions regardless of group (p<0.01) (see 'Pairwise Comparisons' table in appendix).

The median PA increased over the course of 5 occasions within the treatment group (1.35). Whereas the median PA decreased in the control group over 5 occasions by (0.3) (see Table 1c and Fig 7b). There was no statistically significant change in PA across the 5 occasions for either the control or treatment group. The PA was significantly greater within the control group than the treatment group (p=0.016).

VISUAL RESULTS

Figure 8: Pre-shoeing after a 35-day shoeing cycle. Shod with a conventional opened heel steel shoe, note heel collapse, long toe, and coronary band displacement.

Figure 9: The same foot as figure 8 The image was taken pre-shoeing, after having FSP and packing in place for 35 days. Note the foot starting to show improvement in toe alignment, coronary band angles and heel angle.

DISCUSSION

The reason for performing this study arose from the author experiencing a lack of success in trying to keep flat thin soles, low/under run heels, in a functional and structural form. Generally, when these horses started showing signs of intermittent lameness and lateral radiographs were taken the same observations of low or negative PA, long toes, under run/low heels, thin soles were made.

When the heels collapse, the angle of the coronary band in relation to the ground becomes steeper and the DIP joint extends. The orientation of the DP also changes, its palmar border moves closer to the ground and the angle between the sole and the distal aspect of the bone becomes smaller. In severe collapse, the palmar aspect of the DP may be closer to the solar surface compared to the toe region (Parks, Ovnicek and Sigafoos, 2003; Eliashar, McGuigan and Wilson, 2004).

When a horse is shod, friction occurs between the expanding heels of the hoof capsule and the metal shoe (Figure 1), which results in greater wear at the heel compared to the toe. Over time this will change the conformation of the foot (Moleman *et al.*, 2010). Anecdotally, the author observed less erosion, through the interface of a plastic pad placed between the shoe and hoof; this is possibly in part due to the load sharing created by the pad. A load applied to a foot with a small surface area will produce higher stress in the underlying tissues than an identical load over a greater surface area (Bowker, 2003).

Although heel wear was not directly measured in this study, heel depth improved over occasions in the treatment group to a greater degree than within the control group and this may be due to the pad providing protection from friction. It was hypothesised that sole depth and health would be improved by application of pads and packing material, however, objective evaluation of health, without samples for histological analysis, is difficult. Therefore, only a correlation between sole depth and pad placement can be made within this study.

Long toes can be influenced with the rasp; pulling the toe back to ease break over does not reduce the DIP joint moment, the forces exerted on the DIP or peak force exerted by the DDFT on the navicular bone (Eliashar, McGuigan and Wilson, 2004). A steeper PA will decrease the force in the DDFT, and it was proposed that, as a result, horses with a flatter palmar angle would be predisposed to lesions of the DDFT or NB moment (Eliashar, McGuigan and Wilson, 2004). This means that even minor changes in palmar angle during a shoeing interval can have a significant effect on the internal structures of the foot, especially the DDFT and the navicular area (Moleman *et al.*, 2010). Wedged pads/shoes can have immediate results in realigning HPA with a 6-degree wedge pad reducing the forces on the navicular bone by 24% in sound Warmblood horses during the end stance (Parks, Ovnicek and Sigafoos, 2003). However, heel wedges tend to concentrate the forces applied on the heels (Moyer and Anderson, 1975), exacerbating the degree of collapse.

As with any study, there are variables that will have influences on the results obtained. This study investigated whether the PA, heel, and sole depth could be improved by applying a frog support pad and medicated packing. The investigation was a live longitudinal study on the authors' client's horses, so for ethical reasons the horses selected for the treatment group were not selected at random, but for their poor foot conformation. They were chosen based on showing signs of low/underrun heels, flat soles and broken back HPA. This selection bias resulted in the PA being significantly greater within the control group, than the treatment group across all occasions. It was theorised by the author, that using pads and packing to reduce the forces on the dorsal hoof wall, by recruiting a greater surface area, the chance of the DP repositioning into a negative angle would be decreased. The PA is not significantly increased using pads and packing over time. There is however, a greater increase in angle in the treatment group across the five occasions, which could be attributed to pads, as the angle of the control group decreased. It is possible that the control group, with a good PA to start with, were unlikely to increase much. However, it is equally possible that the treatment group were the hardest horses to shoe, given their poorer foot conformation, in which case making any significant difference to their feet should be viewed as an achievement. The lack of statistical significance could be attributed to the small variation in angle. To confirm significance, a larger sample size would be required. A way to remove the bias in the future would be to randomly select the horses before looking at them.

This study found that over time, all depths (sole, navicular and heel) significantly increased in both treatment and control groups. There may be multiple factors involved in this result, including good general farriery and the natural progression of the foot during the seasonal cycle. Therefore, the changing of spring to summer may play a part in the alteration of the foot, as the ground hardens and changes in nutrition occur, for example, improved grass quality (Curtis, 2006). The study was started in early spring and finished mid-winter so it encountered all the seasonal environmental and nutritional changes that can affect foot growth such as variations in surface moisture, texture, solidity, grazing and dietary alterations. Environment has been said to be an equal or perhaps even greater influence in determining the “degree of goodness or badness” in the foot, and thus the relative incidence of chronic foot pain (Bowker, 2003). The external environment was not a factor that could be controlled within the study, however, through selecting candidates for both groups from the same livery yard, the environmental effects on the study were reduced as all candidates were subject to the same variations.

There was a greater increase in all ‘depth’ measurements in the treatment group compared to the control. As both groups underwent individualised trimming to the same standard throughout the entire duration of the study, with the only controlled variable altered between groups being the presence of foot pads and medicated packing, it could therefore be inferred that there is a positive correlation between the use of frog support pads, improved heel height, navicular and sole depth compared to standardised trimming.

It was discussed whether using the left fore as a treatment and the right fore as a control would reduce more of the variables within the study, however this was considered unethical as the horses may have ended up unbalanced and more likely to injure themselves. It is also common to find that the front feet of a horse are asymmetrical (Watson, Stitson and Davies, 2003; Curtis, 2012) and therefore may have vastly different angle and depths. Further limitations of the study include a large variety of breeds, ages and workloads. It is inevitable that human factors may have influenced irregularities in measurements, for example the calibration spot for radiography may not have always been central/at the same level, radiographs and measurements were not obtained for every horse on every occasion. However, every patient was radiographed on occasion 1 and occasion 5.

Radiography is not always available to the farrier therefore, these types of conformations require a great deal of skill, experience, and intuition to manage. Some of the alternative methods to shoeing for this poor conformation are pour in polymer packing and bar shoes (Heart Bar, Egg Bar, or Straight Bar). These shoeing techniques could facilitate sharing of the loading responsibilities of the dorsal hoof wall with the frog and sole, preventing vertical distal displacement of the DP. However, the rigid Heart Bar Shoe creates positive pressure for the duration of the shoeing cycle and the polymers, being a non-breathable product can compromise the health of the foot producing necrosis and thrush.

Further studies should be conducted with treatment and control groups comprising of horses of more similar ages and weights, with the same work load, plane of nutrition and competition discipline. To avoid selection bias, horses should be randomly allocated into treatment and control groups prior to commencement of the study.

CONCLUSION

Although not statistically significant, it has been shown that there was an improvement in PA, heel depth, sole depth and navicular depth across the five data collection occasions within the treatment group. There was however no improvement in PA within the control group and the magnitude of improvement within the treatment group of sole, heel and navicular depth was approximately double that was seen in the control group. The improvements within the treatment group could be attributed to use of support pads and medicated packing, as this was the only controlled variable difference between the two groups. Additionally, since conducting this study, the author believes that seasonal changes may have attributed to the amount and quality of hoof growth, which may explain the results in Table 1C.

To add support to these findings, it could be suggested that further studies would be required with larger population numbers to reduce the influence of external variables and candidates randomly selected for treatment to eliminate the effect of selection bias. Furthermore, a study conducted over a longer period of time such as 24 months or longer, may also provide the opportunity to compare and correlate results seasonally.

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APPENDIX 1
Letter of declaration

PRIORS FARM
Equine Veterinary Excellence

Priory Road, Forest Row, East Sussex RH18 5JD T: 01342 823011 F: 01342 824342 E: vets@priorsfarm.co.uk W: www.priorsfarm.co.uk
Directors: **Ben J N Chilvers** BVMS CertEM(IntMed) MRCVS. **Duncan D Harrison** BVSc CertEM(IntMed) MRCVS.
Associate Directors: **James A Hopkins** BVSc CertAVP(ESO) MRCVS. **Ian T Bellis** BVM&S CertAVP(ESO) MRCVS.

I can confirm that all of the horses in this study were checked at the beginning and found to be in acceptable heath and soundness to carry out the study on them.

Ian Bellis BVM&S CertAVP(ES) MRCVS

RCVS ACCREDITED PRACTICE
OUTSTANDING CLIENT SERVICE RCVS

Registered company address as above. Company registration number: 6578383 Company VAT number: 933 808803

Londonderry Farm

Crowborough Road

Nutley

East Sussex

I hereby give my consent for Andrew Casserly to conduct a study using frog support pads and packing on the horses at Londonderry Farm and that the data collected will be confidential.

Phyllida Kirby

APPENDIX 2

Pairwise Comparison Tables

Sole Depth

(I) Occasion	(J) Occasion	Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c]	
						Lower Bound	Upper Bound
1	2	-.682	.648	129.791	1.000	-2.531	1.167
	3	-2.298*	.617	129.380	.003	-4.061	-.536
	4	-3.584*	.647	129.656	.000	-5.432	-1.735
	5	-3.606*	.593	128.966	.000	-5.298	-1.914
2	1	.682	.648	129.791	1.000	-1.167	2.531
	3	-1.616	.666	129.791	.167	-3.519	.287
	4	-2.901*	.697	130.269	.001	-4.893	-.910
	5	-2.924*	.648	129.791	.000	-4.773	-1.075
3	1	2.298*	.617	129.380	.003	.536	4.061
	2	1.616	.666	129.791	.167	-.287	3.519
	4	-1.285	.673	130.268	.584	-3.208	.637
	5	-1.308	.617	129.380	.360	-3.070	.455
4	1	3.584*	.647	129.656	.000	1.735	5.432
	2	2.901*	.697	130.269	.001	.910	4.893
	3	1.285	.673	130.268	.584	-.637	3.208
	5	-.022	.647	129.656	1.000	-1.870	1.826
5	1	3.606*	.593	128.966	.000	1.914	5.298
	2	2.924*	.648	129.791	.000	1.075	4.773
	3	1.308	.617	129.380	.360	-.455	3.070
	4	.022	.647	129.656	1.000	-1.826	1.870

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Dependent Variable: Sole depth (mm).

c. Adjustment for multiple comparisons: Bonferroni.

Heel Depth

(I) Occasion	(J) Occasion	Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c]	
						Lower Bound	Upper Bound
1	2	-.521	.950	129.884	1.000	-3.234	2.193
	3	-1.516	.905	129.494	.964	-4.102	1.069
	4	-3.943*	.950	129.756	.001	-6.655	-1.231
	5	-3.568*	.869	129.101	.001	-6.051	-1.085
2	1	.521	.950	129.884	1.000	-2.193	3.234
	3	-.996	.978	129.885	1.000	-3.788	1.797
	4	-3.423*	1.023	130.339	.011	-6.345	-.500
	5	-3.047*	.950	129.884	.017	-5.760	-.334
3	1	1.516	.905	129.494	.964	-1.069	4.102
	2	.996	.978	129.885	1.000	-1.797	3.788
	4	-2.427	.988	130.339	.153	-5.248	.394
	5	-2.051	.905	129.494	.251	-4.637	.534
4	1	3.943*	.950	129.756	.001	1.231	6.655
	2	3.423*	1.023	130.339	.011	.500	6.345
	3	2.427	.988	130.339	.153	-.394	5.248
	5	.375	.950	129.756	1.000	-2.336	3.087
5	1	3.568*	.869	129.101	.001	1.085	6.051
	2	3.047*	.950	129.884	.017	.334	5.760
	3	2.051	.905	129.494	.251	-.534	4.637
	4	-.375	.950	129.756	1.000	-3.087	2.336

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

Navicular Depth

(I) Occasion	(J) Occasion	Mean Difference (I-J)	Std. Error	df	Sig.[c]	95% Confidence Interval for Difference[c]	
						Lower Bound	Upper Bound
1	2	-.567	.759	129.448	1.000	-2.735	1.601
	3	-1.878	.723	129.214	.105	-3.943	.187
	4	-3.946*	.759	129.370	.000	-6.113	-1.780
	5	-3.782*	.694	128.977	.000	-5.765	-1.800
2	1	.567	.759	129.448	1.000	-1.601	2.735
	3	-1.311	.781	129.447	.958	-3.542	.920
	4	-3.379*	.818	129.722	.001	-5.715	-1.043
	5	-3.215*	.759	129.448	.000	-5.383	-1.047
3	1	1.878	.723	129.214	.105	-.187	3.943
	2	1.311	.781	129.447	.958	-.920	3.542
	4	-2.069	.790	129.724	.098	-4.323	.186
	5	-1.905	.723	129.214	.095	-3.970	.161
4	1	3.946*	.759	129.370	.000	1.780	6.113
	2	3.379*	.818	129.722	.001	1.043	5.715
	3	2.069	.790	129.724	.098	-.186	4.323
	5	.164	.759	129.370	1.000	-2.002	2.331
5	1	3.782*	.694	128.977	.000	1.800	5.765
	2	3.215*	.759	129.448	.000	1.047	5.383
	3	1.905	.723	129.214	.095	-.161	3.970
	4	-.164	.759	129.370	1.000	-2.331	2.002

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Dependent Variable: Navicular Depth (mm).