Farriery Characteristics and Treatment of 20 Horses Presenting With Chronic Medial Heel Foot Pain.

W. Preece. AWCF.

The Farriery Department
Myerscough College,
Myerscough Hall,
Billsborrow,
Preston,
Lancashire,
PR3 0RY

Key words: Farriery, medial heel foot pain, conformation, shoe wear, foot-fall, foot balance, hoof capsule pathology.

Word count includes numeracy and all figures.

Acknowledgments

The author would like to thank the following people for their help and inspiration during this study. I would also like to pay special thanks to all the horses and their owners for their co-operation.

M. N. Caldwell FWCF; N. Madden FWCF,
The Farriery Department, Myerscough College, Myerscough Hall, St. Michaels Road, Billsborrow, Preston, Lancashire, PR3 0RY.

J. D. Reilly, BSc (Hons), BVSc, PhD, MRCVS.
Wolfson School of Mechanical and Manufacturing Engineering, Loughborough University, LE11 3TU.

Daniel Bennett AWCF, Beaver hall Therapy Centre, Bradnop Nr. Leek, Staffordshire.

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Introduction.

Reasons for performing the study

When horses present with chronic medial heel pain it is a diagnostic and treatment challenge. Little published information is available about the presenting characteristics of these horses. From a farriery and research perspective, knowledge about these characteristics is of interest in its own right because it can help unravel aetiological questions, but it is also of practical significance because it can affect treatment outcomes. Thus, a retrospective of these characteristics was undertaken. This paper deals with quantifying the presenting farriery signs of these horses and not with the treatment outcomes.

Objectives

The objectives of this work were:

To conduct a retrospective study of 20 cases of foot lameness involving chronic medial heel pain in order to:

1) Categorise the conformation groups that these horses represented
2) Assess foot-fall and contact (bearing border) force and pressure patterns (and to demonstrate the usefulness of new technologies such as high speed video cameras and pressure mats in this exercise)
3) Assess shoe wear
4) Assess foot balance
5) Assess hoof capsule pathology
6) To study the effectiveness of the half bar shoeing technique and associated variants.
7) Assess the impact of the imposition of static foot balance theories on dynamic foot balance on horses with gross morphological changes. Evaluate trimming and shoe fitting methodologies designed to impose the parameters of static foot balance.
8) To study the medium term prognosis of 20 cases of chronic medial heel pain presented for farriery treatment.

MATERIALS AND METHODS.

A mixed population of 20 performance horses (Appendix Table 1) were referred by different veterinary practices for corrective farriery treatment to the farriery departments at Myerscough College the Equine Therapy Centre at Beaver Hall, between March 2005 and March 2007. Referring veterinary practices confirmed all lameness cases were associated with poor medio-lateral hoof balance and palmar medial heel pain.

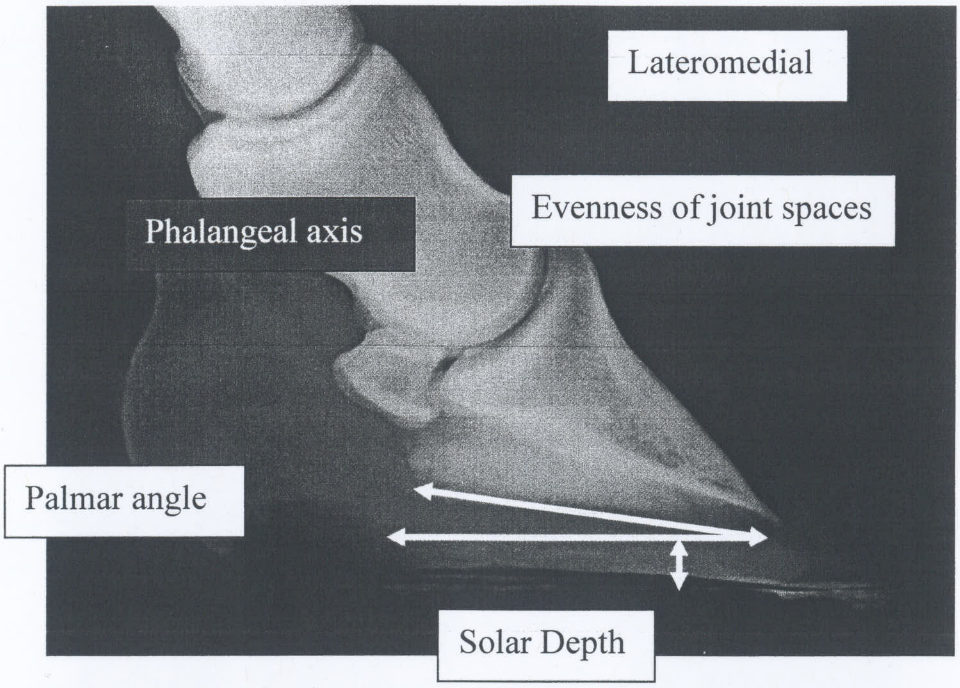
All horses were referred following second opinion lameness investigation by specialist Equine Veterinary Hospitals. All lameness investigations included clinical lameness evaluation at walk, trot straight line and 10metre circle. Lameness was graded in straight lines and in circles on both soft and hard surfaces on a scale of 0 - 10 (0 = sound; 2 = mild; 4 = moderate; 6 = severe; 8 = extremely severe, 10 = non-weight bearing). All cases in this study were reported as suffering mild to moderate lameness (grades 1 – 4).

All horses were examined radiographically using Lateromedial (LM), weight-bearing Dorsopalmar (DPa), Dorsoproximal-palmarodistal (Fig.1) (DPr-PaDiO), and palmaroproximal-palmarodistal oblique (PaPr-PaDiO) views of the foot of the lame limb.

Referring veterinary practices reported that all cases were diagnosed with lameness's isolated to the medial palmar third of the foot. Lameness was abolished by diagnostic local anaesthesia, by palmar digital block in 5 cases (cases 5, 7, 9, 10 and 15 in Table 1). Lameness was abolished in 11 cases (cases 1,2,3,4,8,11,12,14,15,16,17,18,19 and 20 in Table 1) by isolating the medial heel, and in 3 cases by a four point block (cases 6,11 & 13 in Table 1). In 2 cases (6 and 13) cases diagnostic local anaesthesia proved inconclusive (Appendix Table 1). Case 1, (Fig.2)

Cases 1, 3, 4,5,10 & 14 were diagnosed with collateral ligament desmitis of the Distal Interphalangeal Joint (DIP). Cases 2, 6 and 7 were reported to have medial quarter crack. Case 11 was diagnosed with a medial bar crack. Cases 8, 12, 13, 16 and 17 were all diagnosed as having chronic sheared heels. The remaining 6 cases were classified as having non-specific chronic medial heel pain (Appendix Table 1). In all cases no other significant pathological findings were confirmed by diagnostic imagery.

Figure 1



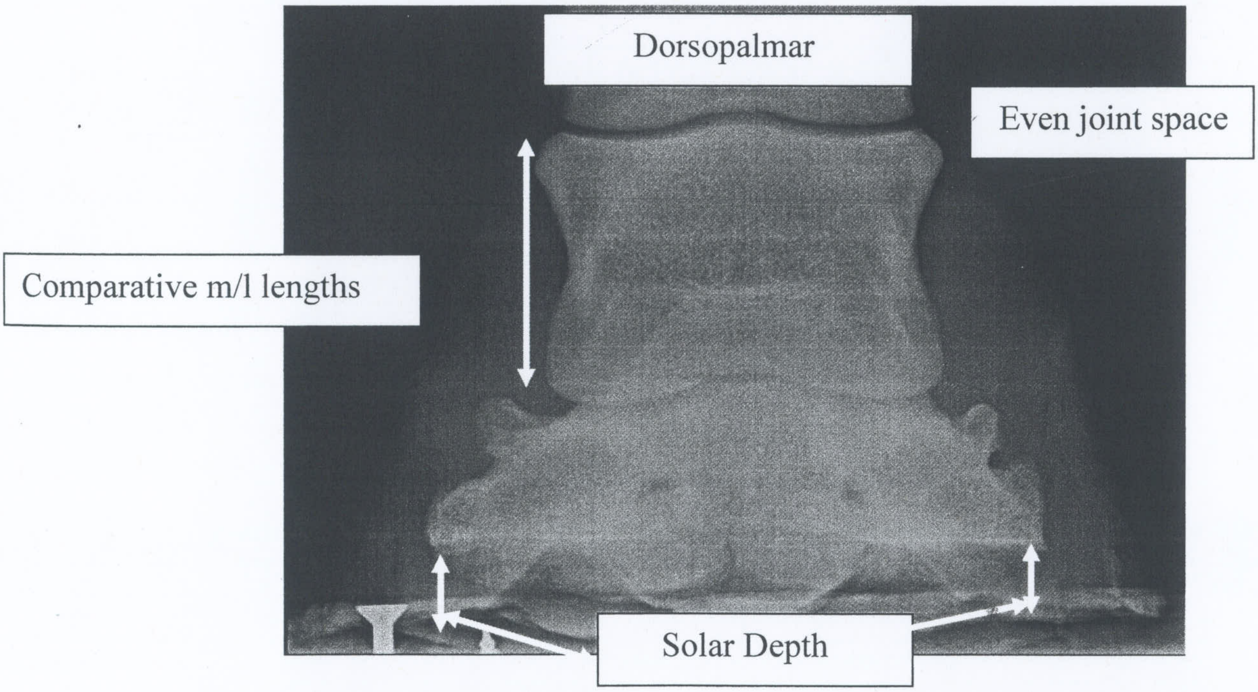


Fig. 1 High quality radiographs are an essential prerequisite for remedial / corrective farriery. Whilst farriers will not diagnose from x-rays they will draw essential information relating to the horses biomechanical composition. The vast majority of farriery manipulations are based on the restoration of biomechanical function within the digit.

Figure 2

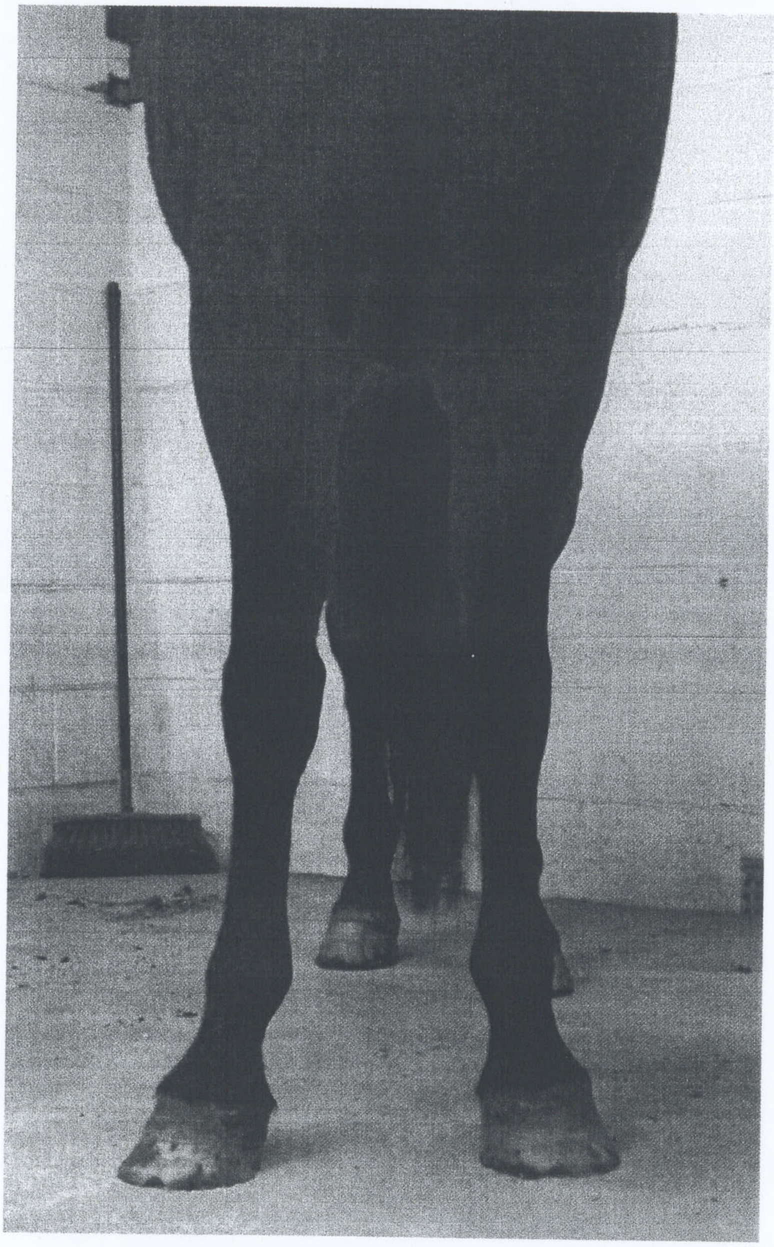


Fig.2. Typical conformation of horses presented in group A of the study. Narrow Chest Toe Out. The hoof capsule is asymmetric as a result of some overriding conformation abnormality.

Figure 3

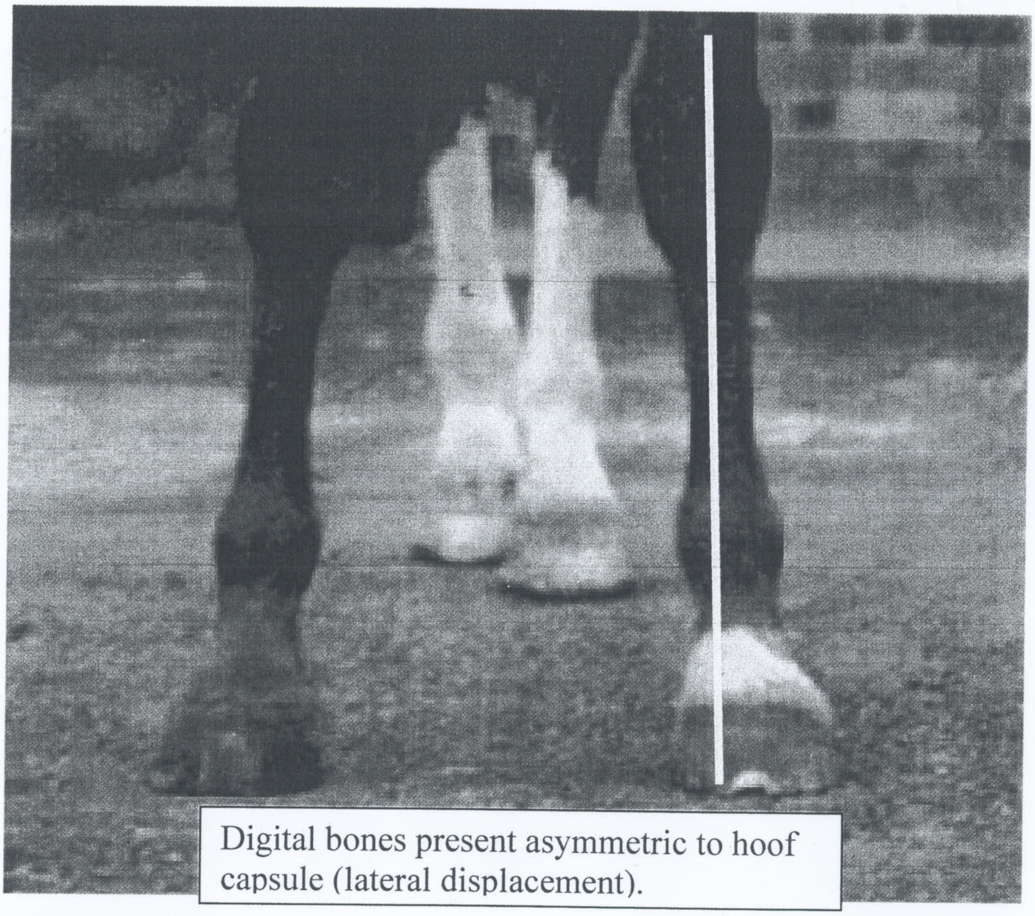


Fig. 3 Case 19 presented with the appearance of bilateral lateral displacement of the hoof capsule (left fore highlighted) with apart normal limb alignment. Full assessment revealed fetlock varus toe-in indicating that base wide carpal valgus appearance may well be a compensatory stance adopted to relieve pressure.

On presentation for remedial farriery, horses in the study were assessed for:

1. Hoof and limb conformation
2. Shoe wear
3. Foot-fall and contact pressure pattern
4. Foot balance
5. Hoof capsule pathology

Farriery Evaluation

1. Conformation assessment:

All cases were statically assessed with the horse stood squarely on a flat surface and given a conformation category. (Appendix Tables, 2a and 2b). Suspected axial deviations were confirmed or discounted when viewed with the limb suspended from the carpus, free from tension and viewed cranio- disto- dorsally ('eye line' view) (Fig.4).

2. Foot-fall assessment and contact pressure pattern

All horses were visually examined in a straight line on a flat level tarmacadam or concrete surface for soundness and foot-fall (point of first hoof-strike with the ground) and limb flight at the walk and trot were recorded. Changes in lameness score, lead and direction were noted for comparison. 5 horses from each group were selected for video foot fall analysis (Appendix Tables 3 and 4) and were lead at the walk and trot by the same assistant (farriery apprentice) in a straight line in both directions on a flat level tar macadam or concrete surface over a 6 metre distance ensuring straightness of motion (4 metres ensures capture of 2 full strides at the trot). Two Cannon DM-MV600i (25 Hz VI) video cameras placed on tripods and used to film records of lower limb movement. In addition 4 horses were also filmed in a straight line at walk and trot using high speed videography via a Photron FastCam-Ultima 512 at 250 frames per second (FPS). Footage was edited, converted to AVI format in the bespoke FastCam viewer software.

Video footage was downloaded onto a laptop computer and transferred to the (Ontrack Equine[2]) analysis software package using the software's 50Hz capture ability.

Figure 4

FIG.4. Static foot balance assessment used to confirm the presence of distal angular limb deformities. Illustrated above is typical of the conformation in horses presented in group B of the study. Base-wide toe-in with moderate angular limb deformity (ALD) distal to the metacarpophalangeal articulation.

Force and ground pressure measurements were also acquired. The subjects were walked and trotted across a composite force measuring system (MatScan® Tekscan[3]) until a valid measurement was obtained. A measurement was deemed valid when the subject moved freely without resistance at a constant speed over 5 metres and when the feet struck the mat with both a fore foot and ipsilateral hind foot simultaneously.

Force vs. time and ground pressure vs. time data was automatically stored by the system software (Fig.5). Two and three-dimensional videography of peak force contours were synchronised to simultaneous video footage at 50hz to give real time peak force and pressure data at specific stages of ground contact and loading. (Fig.6)

The MatScan® System (Tekscan[3]) measuring surface was 17 in x 14.5 in (432 mm x 368 mm) laminated floor mat 0.2 in (5 mm) thick with a pressure range 1-150pscm. The mat contains 2,288 conductive sensels with a spatial resolution 9.2 sensels/in2 (1.4 sensels/cm2) with a sampling rate 240 .Hz.

3. Shoe Wear Assessment:

Lateral shoe wear was recorded (Tables 5a and 5b) using a 'clock' method (Fig.7) and it was classified as occurring in one of four specific sites according to its occurrence on left or right forefeet :see Fig.7.

4. Foot Balance Assessment.

All horses were referred for corrective farriery with the aim of restoring static foot balance. Static foot balance refers to a geometric equilibrium of the hoof and limb in the square standing position (van Heel. 2004). ***See Figs, 8, 9, 10.***

5. Hoof Capsule Morphology Assessment

A visual assessment of hoof capsule morphology was compared against the hoof balance guidelines for the "normal" balanced foot (See Figs 8, 9 & 10). Digital photographs from the Latero/Medial, Dorso/Palmar and bearing border projections were taken and loaded on to the [2]Ontrack system for digital measurements. Each image was calibrated using measurements taken from two known reference points e.g. toe to heel length (Fig.10) Deviations in hoof symmetry from the static foot balance model at the bearing and coronary borders through the longitudinal axis of the limb were noted and measurements recorded via the digitised measuring tools within the software package (Fig.11)

Figure 5

<table>
<tr>
<td>Case 1. Pre treatment.</td>
<td>Peak Force digitised plots from 1st strike to mid stance.</td>
<td>Peak forces along the time line to mid stance</td>
</tr>
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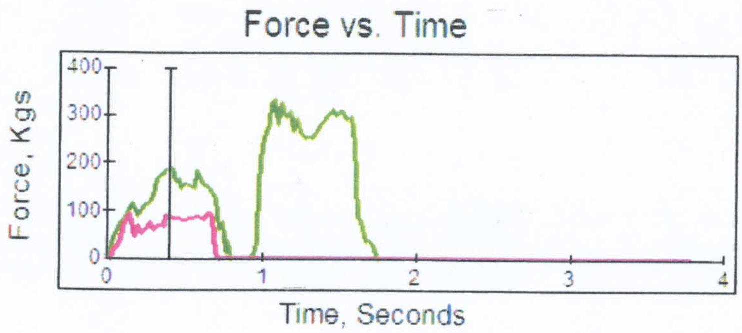
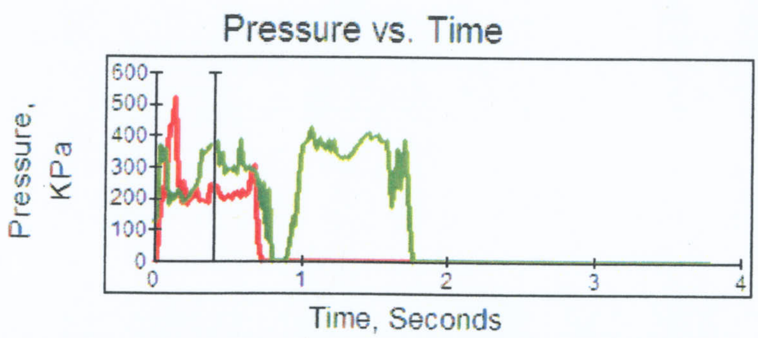
<td rowspan="3">



Graph 1. Force vs. Time @ mid stance. Green = Dorsal, Red = Palmar



Graph 2. Pressure vs. Time @ mid stance. Green = Dorsal, Red = Palmar

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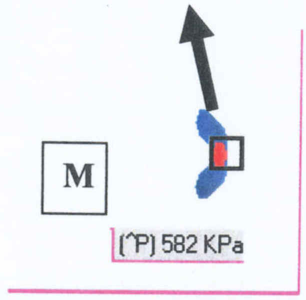

1st Strike Lateral Quarter

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Time = 0.04 sec

F = 64.76 kg

L

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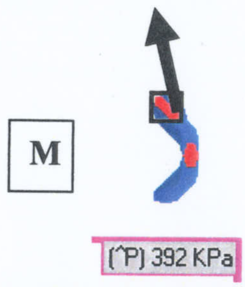

Avg; peak force lateral toe

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Time = 0.08 sec

F = 113.59 kg

L

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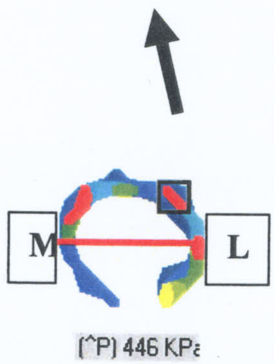

Mid Stance peak force lateral toe & medial toe quarter

</td>
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Time = 0.4 sec

F = 272.20 kg

P = 245 KPa

P = 370 KPa

</td>
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</table>

Fig.5. Peak Force and Pressure vs. Time graphs and bearing border pressure map for case 1.

Denotes direction of travel

Fig. 6A Time = 0.04 sec F = 64.76 kg

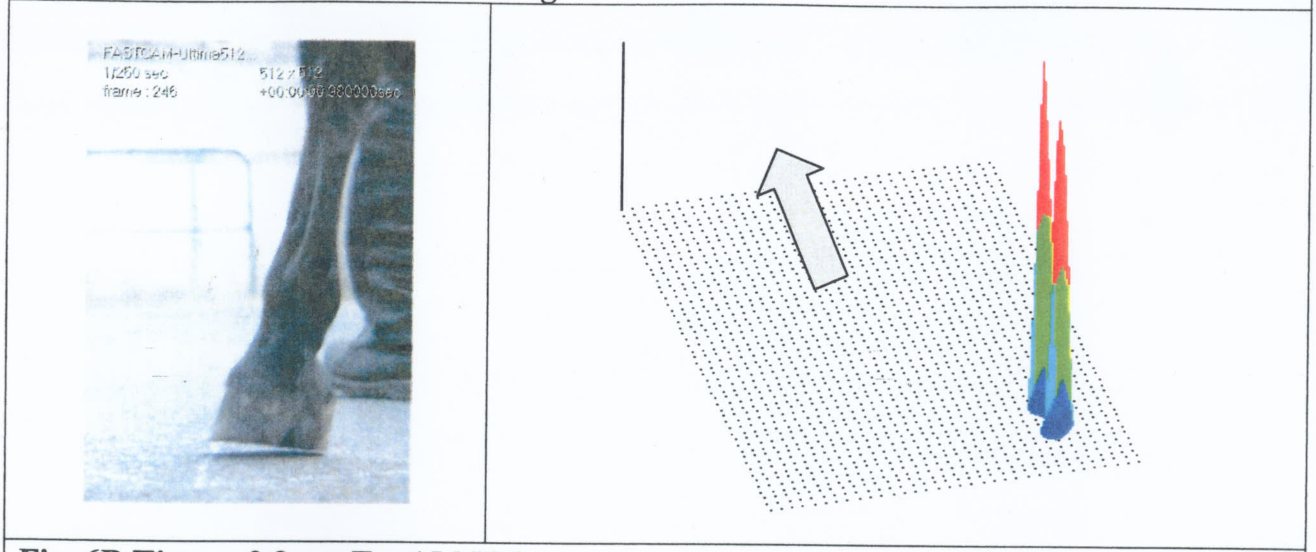


Fig. 6B Time = 0.2 sec F = 156.73 kg

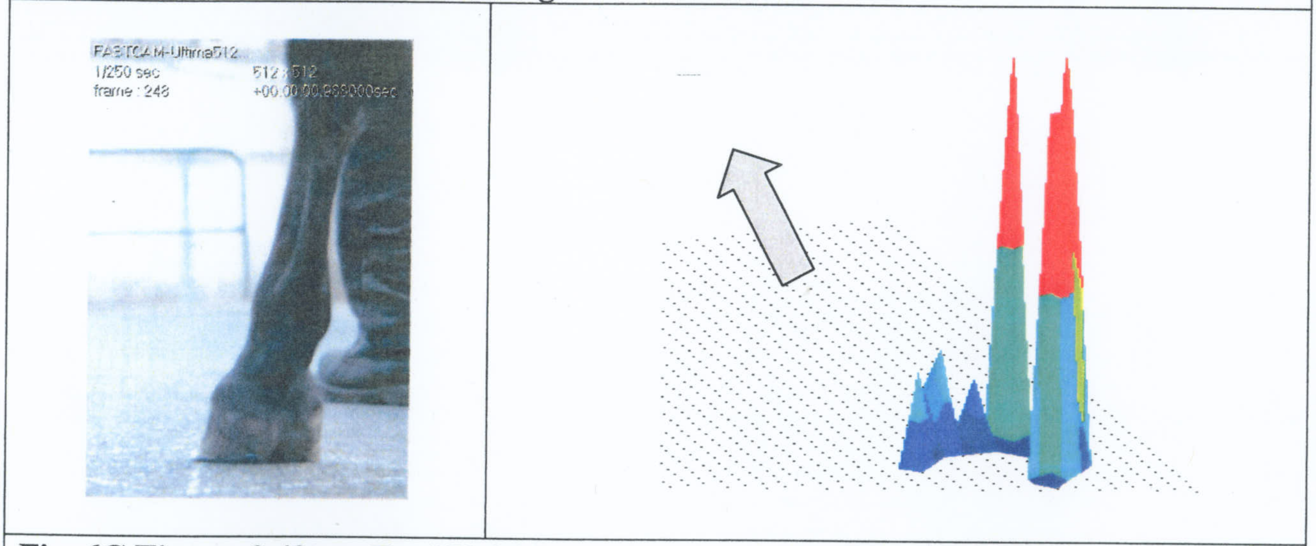


Fig. 6C Time = 0.42 sec F = 273.06 kg

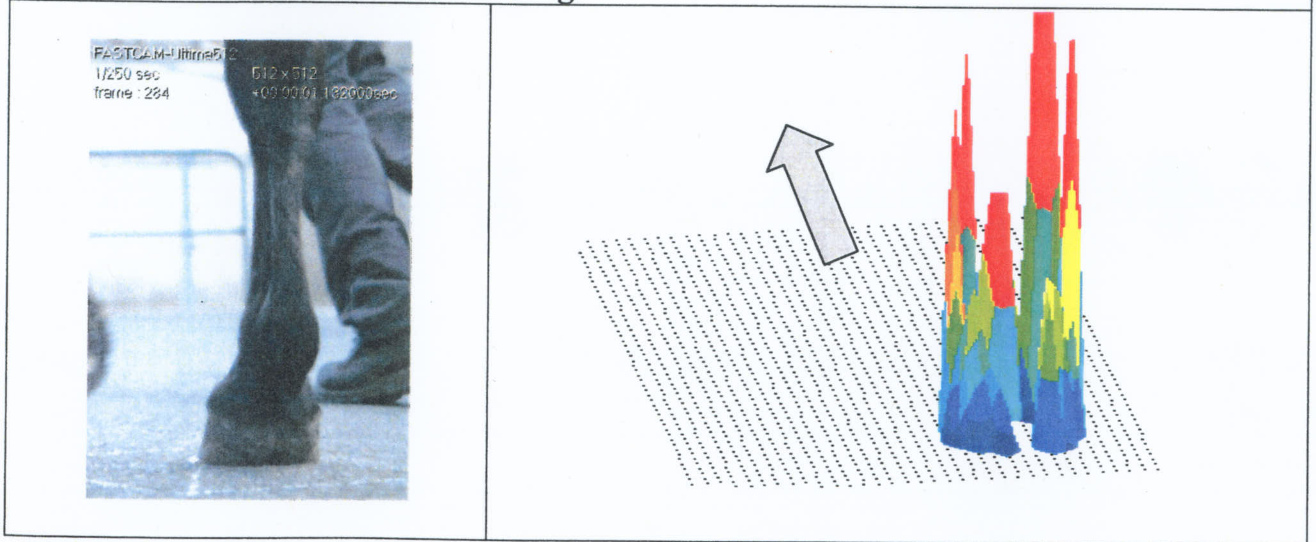
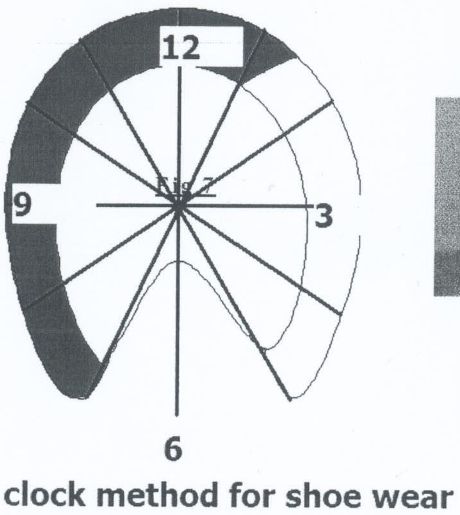


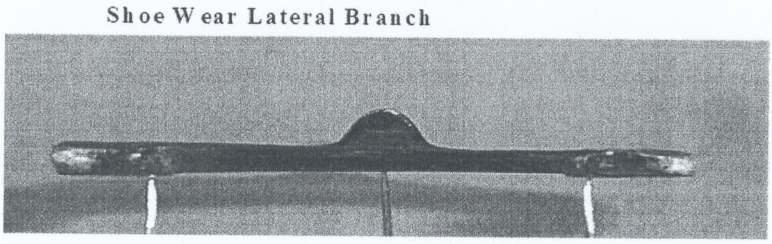
FIGURE. 6.

Fig. 6. **3 dimensional peak force contours for case 1 synchronised with high speed video footage. Illustrated above, 6A = 1st strike, 6B = peak load toe quarter as the hoof flipping over to the medial toe and 6C = mid stance with peak forces at medial and lateral toe quarter. Contrary to expectations the medial did not experience peak forces of the magnitude illustrated at the medial toe (the arrow indicates the direction of travel).**

- Toe: 11-1 o'clock
- Lateral toe 10-11 o' clock or 1-2 o'clock
- Lateral quarter 8-10 o'clock or 2-4 o'clock
- Lateral heel 7-8 o'clock or 4-5 o'clock

Figure 7





Medial

Fig. 7. Contact shoe wear was recorded (Appendix Table 3 & 4)

Figure 8

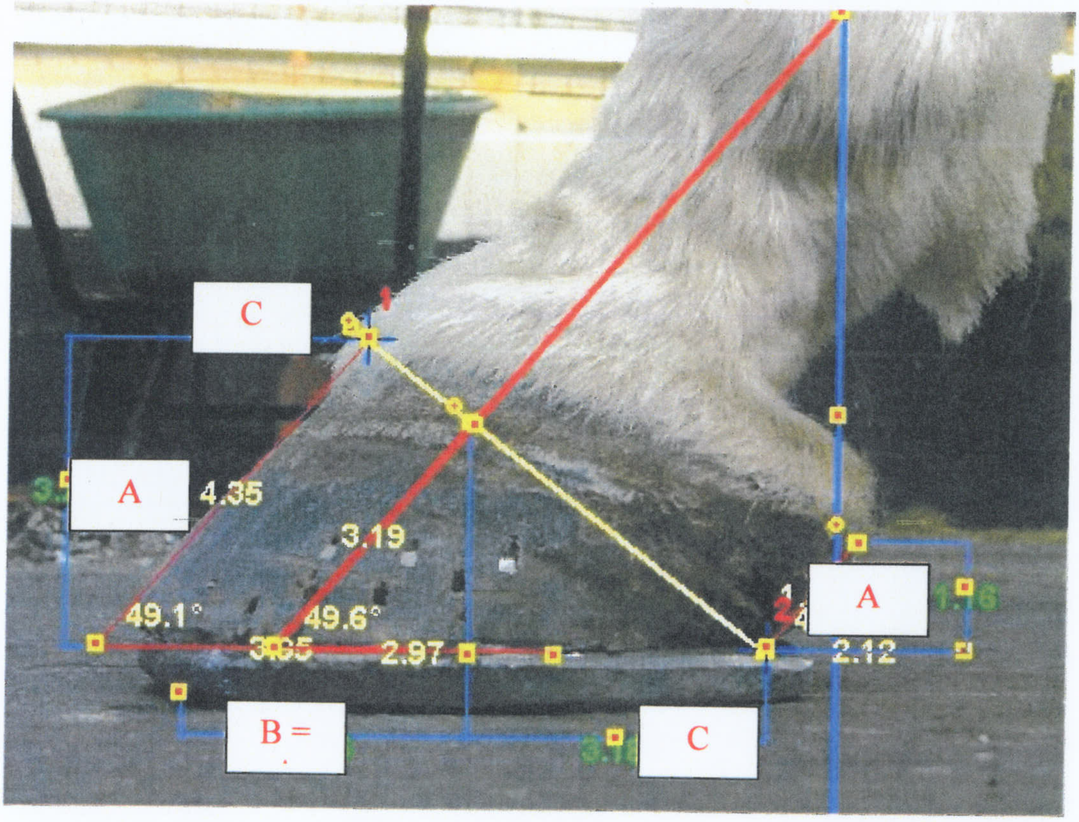


Fig. 8

The dorsal hoof wall should form a corresponding angle with both the mid line of the phalanges and the heel of the foot.

a. The toe heel height ratio is approximately 3:1 toe to heel.

b. The distance from the dorsodistal tip of the dorsal hoof wall to the centre of rotation of DIP joint is approximately that of the vertical toe height.

c. An imaginary line projected cranio palmer distally from the coronary hair line should intersect the C.O.R. and terminate at the last weight bearing point of the heel buttress.

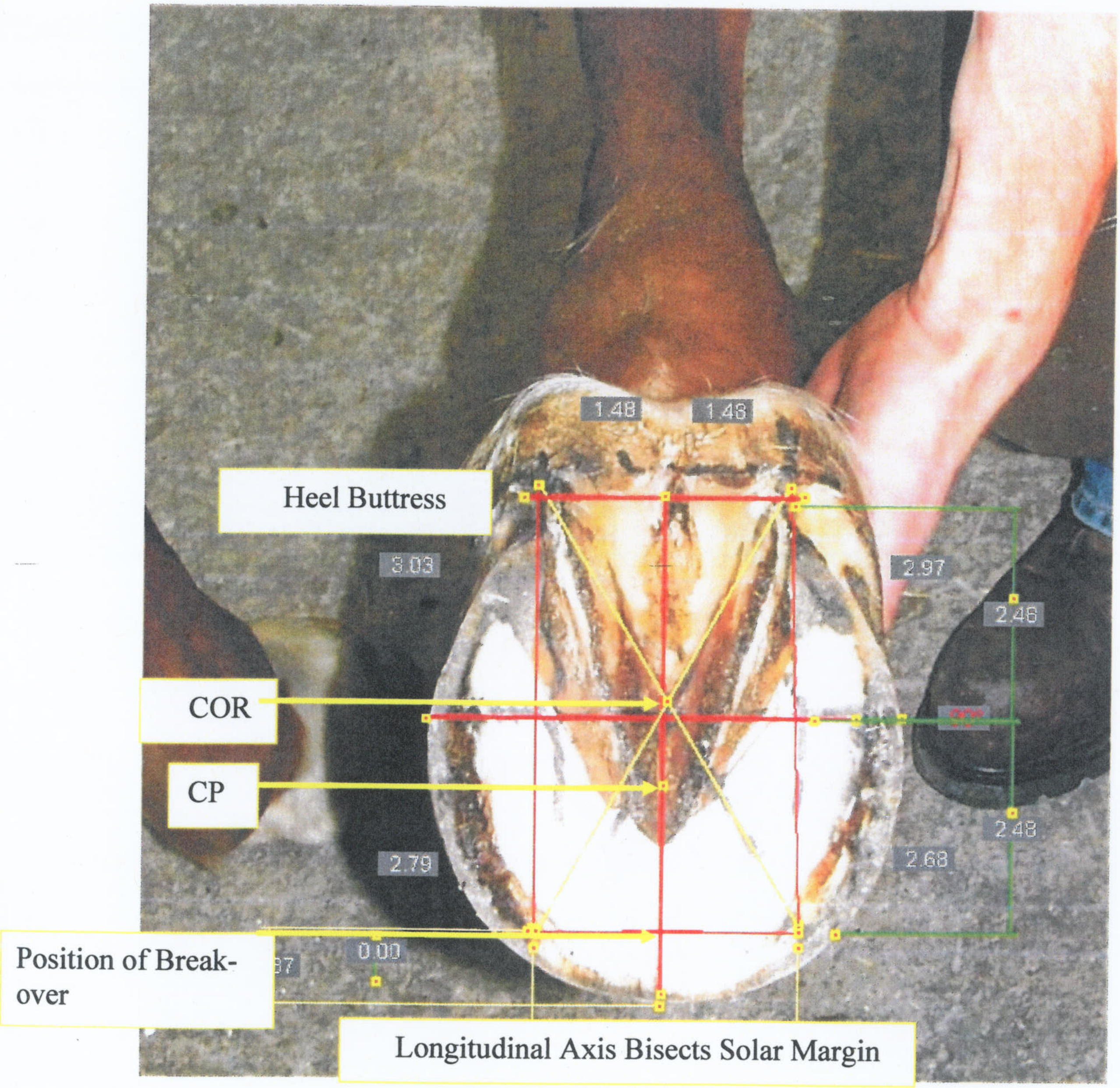


FIG. 9 Medial lateral / dorsal-palmer foot balance solar aspect.

a. Break-over to heel buttress is bisected by a line from C.O.R. which is the widest part of the foot.

Note: In this example the heels have under run (under run heels are defined as the heel angle having more than minus 5° differential to the angle of the dorsal hoof wall) (Balch et. Al. 1997) and are not adjacent to the widest point of the frog (Caldwell 1987).

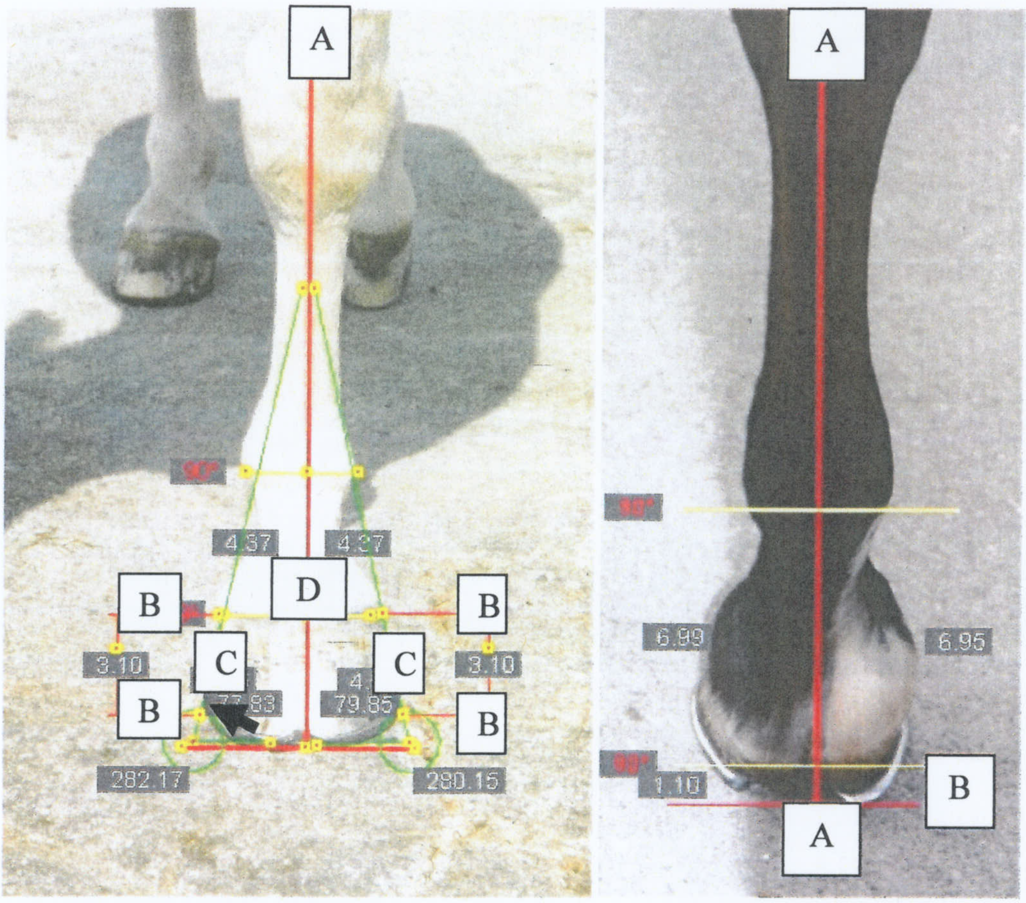


FIG 10 Dorso/palmar views static foot balance

a. A perpendicular line dropped from the point of the shoulder bisects the column of bones equally, falling to the ground at the mid-line of the bearing border of the hoof capsule; this is the medio-lateral hoof axis.

b. Both the ground surface and the hair line of the coronary band should present perpendicular at 90° to the medial-lateral axis (long axis).

c. Both the lateral and medial hoof-wall should form the same angle with the ground surface

d. The coronet should ideally be equidistant from the ground at all points around its circumference...

Figure 11

Fig.11. The On screen display of the Ontrack digital measuring software used for foot balance and hoof capsule morphology assessment. Each image is calibrated from a known measurement between two points. A range of measuring tools (top left corner) provides accurate digitised measurement data to within 1 pixel.

Deviations in outline shape and vertical and horizontal measurements to the longitudinal and central axis of the foot were classified as morphologies where there was no visible compromise to the structural integrity of horn structure. Where structural breakdown was evident e.g. collapsed, under-run or sheared heels, this was characterised as pathology.

6. **Corrective Trimming Methodology**

We used a geometric proportions model for foot trimming aimed at restoring theoretical static balance (Russell 1908, Duckett 1990). Fig. 12,

Dorsopalmar proportions are verified by the use of measurements at key external anatomical land marks e.g., the vertical length of DHW should be equal to the distance of the dorsodistal aspect of DHW to the widest part of the foot along, centre of phalangeal articulation (COR), its solar margin and from the widest point of the frog, at its visible proximal aspect, to the theoretical point of force (POF) located 10mm palmer to the true apex of frog (Chapman 1987) (see fig. 12). Anatomically we visualise the POF as being located between the insertion of the DDFT at the semi lunar crest and the insertion of CDET on the extensor process of P3.

Horses in Group A whose conformation was classified as being chest narrow toe-out or with rotational deviations and that exhibited no angular limb deformities cases were trimmed by reducing the lateral wall at the bearing border as perpendicular to the longitudinal axis of the limb as practical.(Fig.13)

Those horses in Group B with conformation exhibiting a base wide broken-in stance were trimmed with the bearing border perpendicular to the longitudinal axis of last deviation (short axis) as viewed from the farrier position see fig. 14.

7. Shoe Selection and Modification.

All cases were initially shod with a "half – bar" shoe. Variants and modifications to the shoe prior to application were based on the clinical signs and hoof capsule pathology, conformation scoring and assessment including video analysis and or the clinical and radiographic details of the individual case. (Caldwell et al 2007 submitted)

All horses were shod with handmade mild steel horseshoes (fullered concave) of an appropriate wide section and fitted to the hoof bearing border with symmetrical medial and lateral branches.

Level foot fall in those cases with an outward rotational deviation (1, 4,7,8,11,13 and 15) was attained by the creation of an artificial ground bearing border perpendicular to the longitudinal axis of the limb. (Spiralling medial lift) (Medial wedge). (Fig.15.) to avoid weight of shoe related changes in gait in cases, 1, 7 & 11, elevation of the medial branch of the foot was achieved by the application of a polymer wedge (Super Fast®) directly to hoof bearing border of the shoe (Ford, J. personal communication 2005).

In those cases exhibiting a base wide broken-in stance with moderate varus angular limb deformity (2,3,5,6,9,10,12,14,16,) level foot fall was achieved by manipulating an artificial ground bearing border perpendicular to the axis of last deviation of the distal limb. This was again achieved by reducing the thickness of the horseshoe however in these cases the reduction in thickness of the shoe was confined to diagonally across the shoe through to the point of first impact or by directly mimicking contact friction wear (Fig.16).

8. Shoe Fitting.

We apply the theoretical geometric proportion model used in foot trimming to impose a symmetrical weight bearing platform at the ground bearing border concentric to the longitudinal limb axis that Provides support to contracted, compressed or vulnerable epidermal structures such as the heel buttress.

The half bar is fitted so that it does not extend beyond the limits of the trimmed frog and follows the trajectory of the collateral sulci and bar which it replaces (Chapman and Platt 1984). The point of the half bar is placed palmer to COR. In those cases where the affected medial heel is both under-run and contracted in addition to having been subjected to coronary shunting (Caldwell et al 2007 submitted). The direction of the frog piece and the position of the heel of the shoe mimic the heel buttress / bar interface. Fig.17

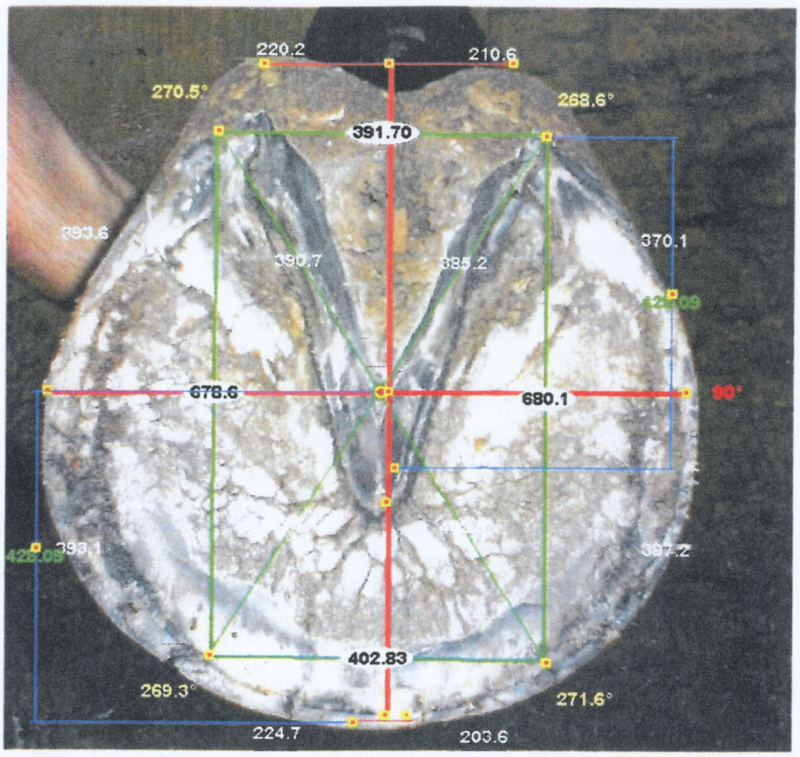


Figure 12

Fig 12.

Dorsopalmar proportions are verified by the use of measurements at key external anatomical land marks e.g., the vertical length of DHW should be equal to the distance of the dorsodistal aspect of DHW to the widest part of the foot along, centre of phalangeal articulation (COR), its solar margin and from the widest point of the frog, at its visible proximal aspect, to the theoretical point of force (POF) located 10mm palmer to the true apex of frog (Chapman 1987) (see fig. 12). Anatomically we visualise the POF as being located between the insertion of the DDFT at the semi lunar crest and the insertion of CDET on the extensor process of P3.

Figure 13

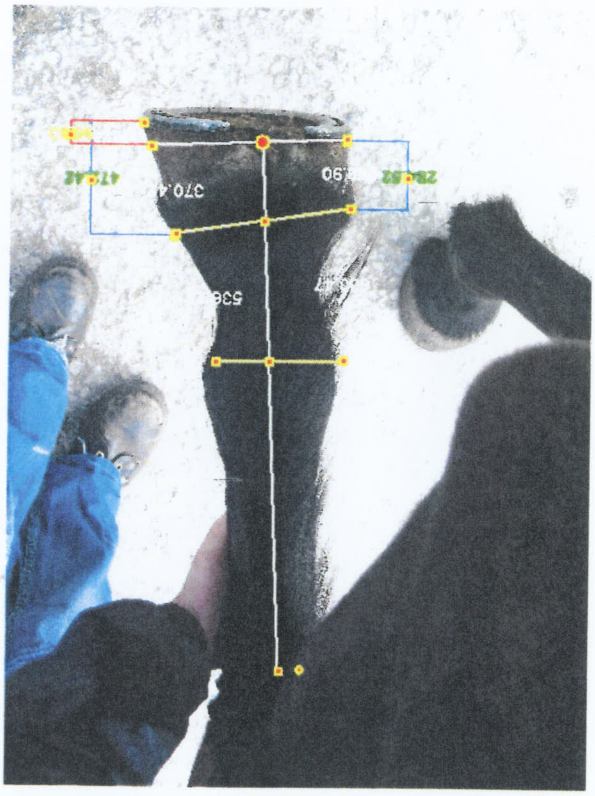


Fig.13. Assessment. The bearing border of the foot is compared to the long axis of the limb.

Figure. 14.

Fig.14. Farrier view from the short axis due to predisposing ALD.

Fig.15. Medial wedge half bar.

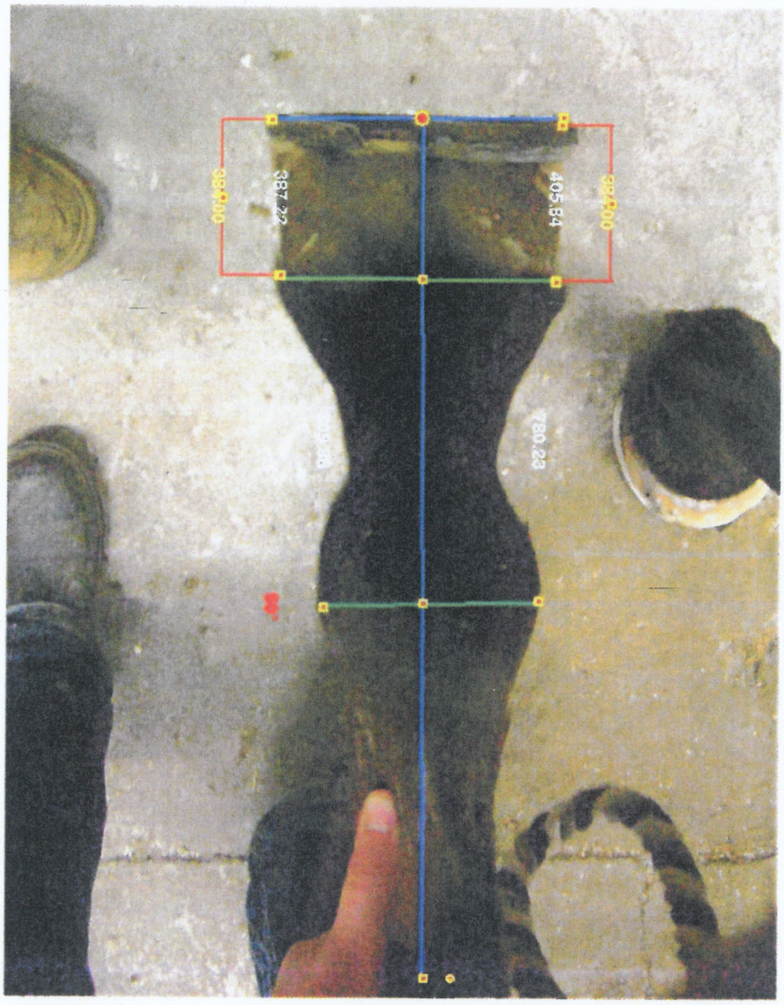
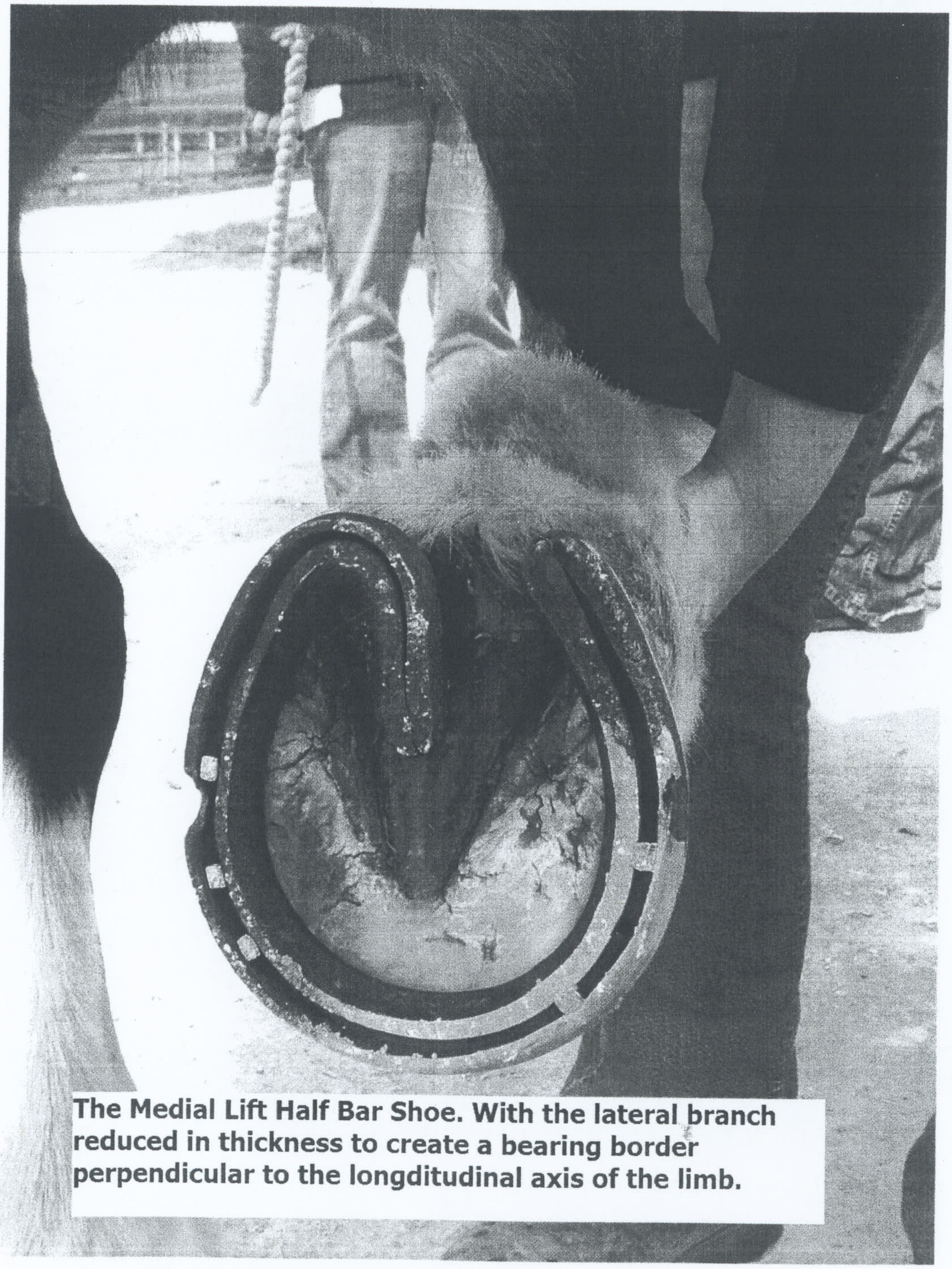


Fig.15. View of limb after application of medial wedge half bar with lift created with polymer (superfast®) J.Ford. Personal communication.

Figure.16.



The Medial Lift Half Bar Shoe. With the lateral branch reduced in thickness to create a bearing border perpendicular to the longditudinal axis of the limb.

Fig.16.

The bearing border of the shoe reduced on the Lateral branch mimicking contact shoe wear.

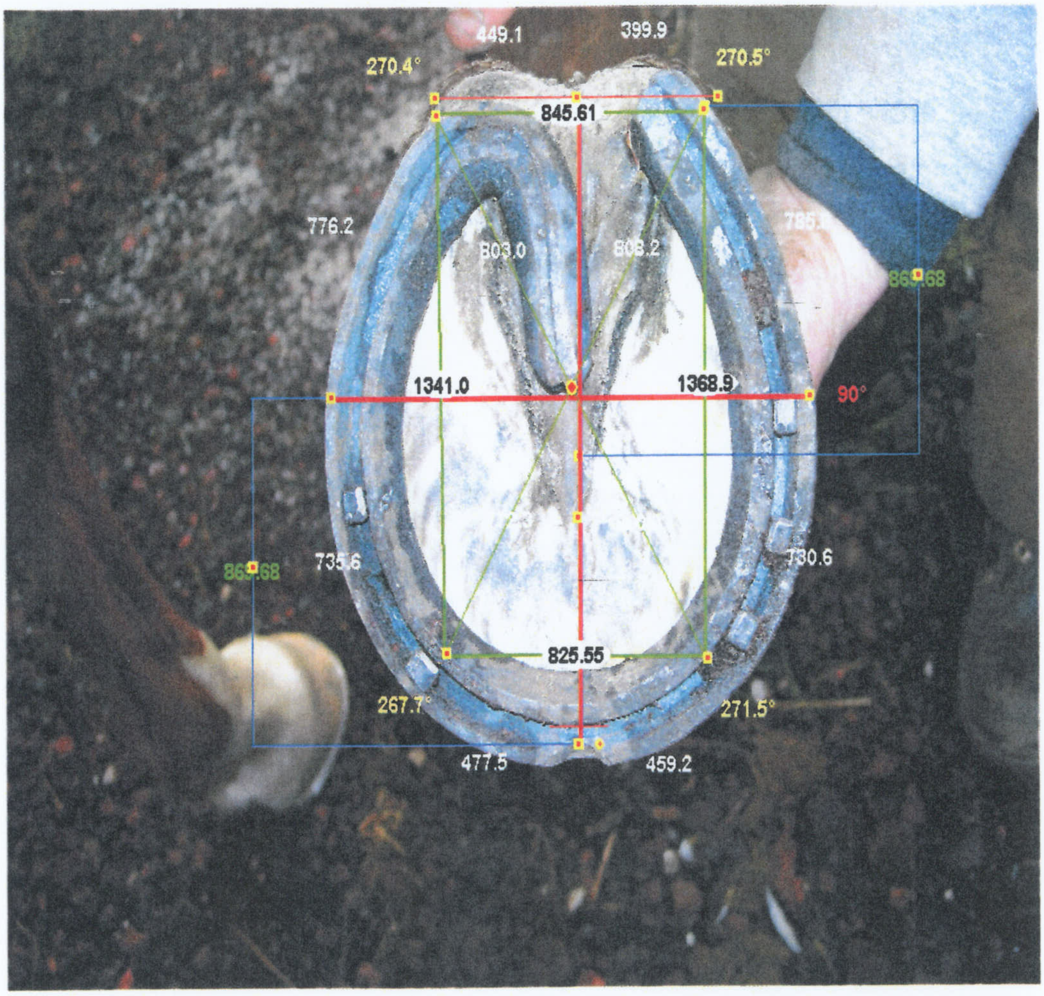


Figure.17.

Fig.17.Half bar Shoe.

Shoe fitted concentric to the point of force following the geometric proportion model.

9. Heel Floating.

Direct pressure to the medial heel was alleviated through two complementary methods.
The transfer of weight from the heel area through to the frog was achieved by the application of a "Half-bar Shoe" (Fig.17). The frog support piece is positioned along the border of the frog closely following the angle of the collateral sulci of the affected side of the foot. (Fig.17). Frog pressure is said to be "Negative" when the bar has even contact without the application of direct pressure (in a non weight bearing position) to the frog along its length. Pressure is only applied to the frog via the bar during the load bearing and stance phases of a stride.

Direct pressure relief over the affected heel area is achieved by eliminating all contact between the shoe and the bearing border of the hoof where shunting and contracture have occurred. The technique of relieving wall contact from a shoe during loading is commonly referred to as "floating" (Moyer & Anderson 1975) (Fig. 18).
Floating was only performed immediately prior to application of the shoe so as not risk compression of the heel whilst stood bare foot. An area of bearing border is relieved by cutting a gap along the length hoof that has been shunted up into the coronary corium. This gap was never greater than 6mm and normally extended from the quarter palmer to the heel buttress. No nails or clips were placed in an area of hoof wall that had been floated at its bearing border.

10. Shoeing Protocol.

All horses were initially examined and shod by the primary author with the assistance of one co-worker. Follow up treatments post third evaluation and shoeing session was conducted by the primary author with assistance of one co-worker. Follow up treatment was based on a 28 – 35 day shoeing period and treatment was monitored throughout the period of the study. Final follow up data was collected by co-workers to whom routine farriery treatment had been referred.

Figure.18.

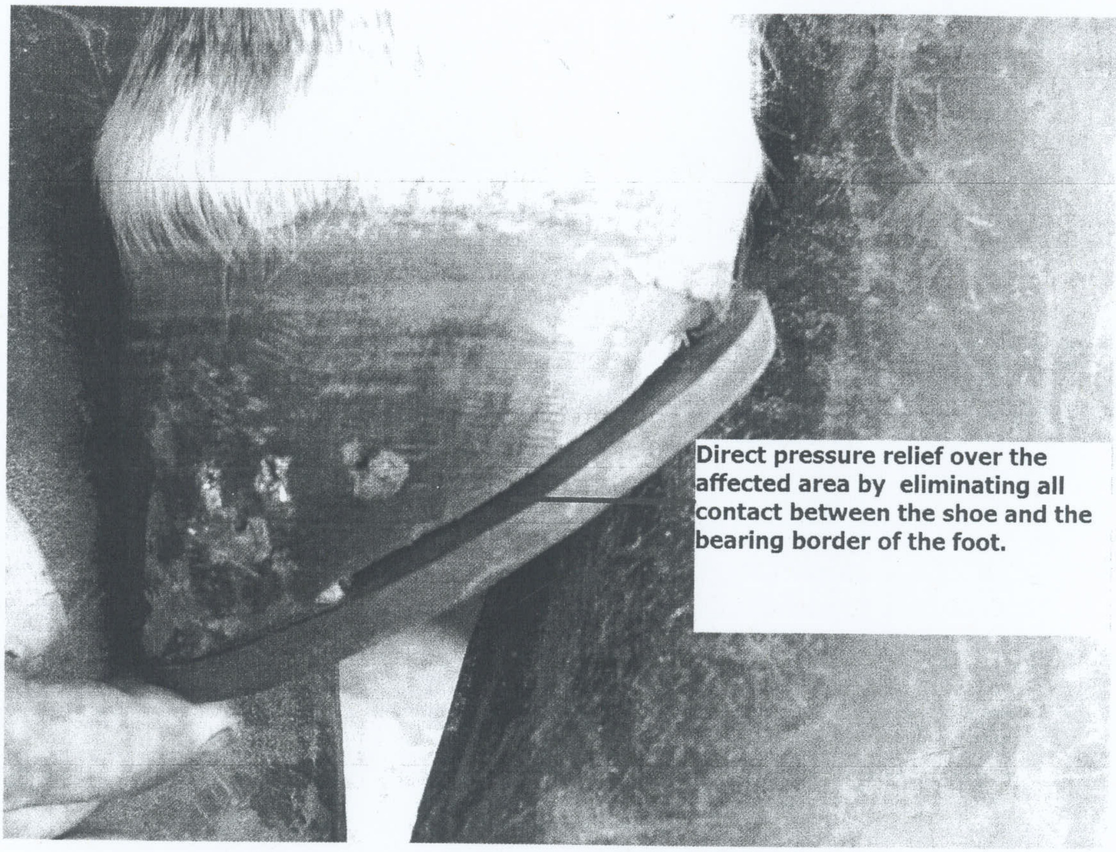


Fig. 18. Direct pressure relief over the affected area is achieved by eliminating all contact between the shoe and the bearing border of the foot. A technique commonly referred to as "floating". Immediately prior to application of the shoe wall is removed from the bearing border from the widest point of the foot through to the heel buttress creating a 3 – 4mm gap between shoe and hoof

Post Shoeing Results all horses:

The results and follow up data is summarised in tables7a and 7b but post shoeing evaluation in a straight line at the walk and trot revealed an immediate cessation of lameness in 12 cases. 7 from group A cases no's 1,7,11,13,15,17 & 18 (87.5%) and 5 group B cases 3, 4,6,12, & 16 (50%). Of these 12 cases 2 group A cases (11 &17) showed mild 1/10th lameness at the trot in a 10 metre circle on a good to firm fibre sand surface. The owners verbally reported, 14 days post initial shoeing, that lameness was abolished in these 2 cases.

The remaining cases received additional NSAID over periods ranging between 7 and 14 days post initial treatment. During this period 2 additional cases (2 & 9) reported a cessation in lameness. A total of 14 (70%) of horses were returned to full work within the period 14 days post shoeing. The level of lameness in the remaining 6 cases was reduced by 1 – 2/10 immediately post shoeing. Initial re shoeing was scheduled at either 28 or 35 days based on clinical judgement of foot pathology, work regime and general health criteria.

At the 1st follow up treatment examination showed that in three cases initially reported sound, two from group A (7 & 17) and one from group B (16) lameness had returned to a level of 2/10th.

1. Case 7 reported a medial heel quarter crack had appeared
2. Case 16 a lost shoe resulted in glue-on technology being required.
3. Case 17, lameness had resumed at day 28 and gradually deteriorated over the 7 days to the subsequent shoeing.

Over the three month period post initial shoeing lameness returned in four cases (1, 7, 8 & 17) from group A (50%) and five cases (3,5,6,10 & 16) from group B (50%) within the week prior to the next scheduled treatment. As lameness was mostly abolished immediately post re-shoeing for a variety of reasons associated with foot balance or shoe change. The time line was used to justify reducing the shoeing cycle from 35 to 28 days during follow up treatment for these cases.

Groups A & B:

At the end of the follow up period of between 12 and 20 months, 6 group A horses (1, 7, 13, 15, 17 & 18) have been returned to soundness and full work (75%) within 3 treatments and remained sound through the follow up period. 4 of these group A cases with an ORD conformation (1, 13, 15 & 17) only remain sound when shod with a half bar and medial lift variant. Case 8 has remained intermittently mildly lame throughout the follow up period. Case 9 mild 2/10th lameness returned after 9mths, the cause of which has yet to be determined, and has remained constant through the remainder of the follow up period (see table 7b).

At the end of the follow up period 7 group B horses (2, 4, 6, 9, 10, 14 & 16) remain sound in full work (70%). 2 of those cases (2 & 9) classified ALD remain sound shod with a bar shoe and extension variant. Case 16 remains sound with shoes applied using acrylic glue technology at this time due to catastrophic shoe loss. No follow up data is available for 2 cases (10%) sold during the trial (3 & 5). One case (12) remained sound for 12 months post initial treatment and has subsequently returned a moderate lameness associated with chip fractures of the metacarpophalangeal joint.

2 unclassified cases (19 & 20) presented with severe foot imbalance have remained sound during the entire follow up period and are currently shod to the National Standard (Caldwell in FTA 2007) with open heel riding horse style shoes.

Foot-fall and contact pressure / Force patterns.

Figure.19. Pre-shoeing graphs show force vs. time and pressure vs. time graphs at mid stance and two-dimensional bearing border peak force maps for case 1 during the stride time line from contact to mid stance.

The recorded point of first lateral strike (0.004 sec into stance gave a peak force of 64.76Kg. At first visible loading (0.008 sec into the stance) a peak force of 113.59Kg was recorded at the lateral toe with the lateral quarter experiencing a similar load. At mid stance (0.4 sec into the stance) peak force had increased to 272.2Kg.

Post shoeing graphs show that the peak force at first lateral strike (0.004 sec into stance) was recorded as 51.90Kg. At first visible loading (0.008 sec into stance) was recorded as 78.92Kg. At mid stance (0.4 sec into stance) a peak force of 115.15Kg was recorded. It can be seen that at mid stance the peak force is reduced by 67.7% with peak pressure reduced by 74.5% around the toe region and 45% through the heel region.

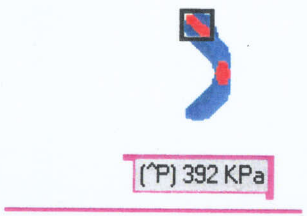
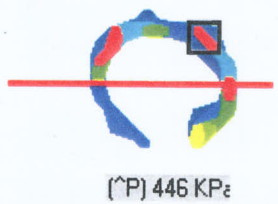
Peak Force digitised plots from 1st strike to mid stance pre shoe.	Peak forces along the time line to mid stance pre shoe	Peak Force digitised plots from 1st strike to mid stance post shoe.	Peak forces along the time line to mid stance post shoe
 **1st Strike Lateral Quarter**	**Time = 0.04 sec** **F = 64.76 kg**		**Time = 0.04 sec** **F = 51.90 kg**
 **Avg; peak force lateral toe**	**Time = 0.08 sec** **F = 113.59 kg**		**Time = 0.08 sec** **F = 78.92 kg**
 **Mid Stance peak force lateral toe & medial toe quarter**	**Time = 0.4 sec** **F = 272.20 kg** P = 245 KPa P = 370 KPa		**Time = 0.4 sec** **F = 115.15 kg** P = 135 KPa P = 135 KPa

Fig. 19 Case 1. Pre and Post Treatment peak force Vs time line 2 dimensional contour graphs. Peak force is calculated at point on the time line 0.04, 0.08 and 0.4 seconds representative of 1st load through mid stance. At mid stance peak force is reduced 67.7% with peak pressure reduced by 74.5% around the toe region and 45% through the heel region

Shoe wear

6 group A horses (1, 7, 13, 15, 17 & 18) have been returned to normal shoe wear characteristics (Madden 2001, Caldwell et al 2007 submitted) of graduated to flat friction wear to both medial and lateral shoe branches and centralised toe region acceleration (break-over) wear (75%) within 3 treatments. 4 of these group A cases remain shod with medial lift variant to maintain perpendicular bearing border alignment to the limb axis.

Case 9 mild 2/10th exhibits excessive heel wear (see fig. 9) (Madden 2001) consistent with characteristics more normally associated with Arthrodesis of the distal interphalangeal joint (Hickman 1981) or chronic founder type1 (Eustace & Cripps 1991) the cause of which has yet to be determined.

7 group B horses (2, 4, 6, 9, 10, 14 & 16) exhibit level friction wear and lateral toe acceleration wear (see fig. 9). 2 of those cases classified ALD shod with a bar shoe and lateral toe extension variant demonstrate normal toe acceleration wear (2 & 9). No follow up data is available for 2 cases (10%) sold during the trial (3 & 5). 2 unclassified cases (19 & 20) exhibit level friction wear and lateral toe acceleration wear (Madden 2001, Caldwell et al 2007 submitted).

Hoof balance:

At six months post initial treatment overall foot balance and hoof capsule symmetry had improved in those cases (2, 9, 12,15,18,19 and 20) that had remained sound throughout the period. Notably medial quarters had moved palmer and with an improvement in orientation and strength of the medial bar. These cases (35%) were returned to normal shoes and trimmed for dynamic foot balance with the shoeing cycle extended to 35 days. A further 7 additional cases (35%) remained sound without significant improvement in hoof pathology if shod with half bar shoes and variants as required (table 3).

DISCUSSION

From the results of this study, it would appear that there are differences in presentations for different conformational types. A study involving a larger number of horses would be required to make these associations clear and it is not possible from a study of this type to elucidate whether this association is causal.

Slow motion videography indicates that the mass travelling forward over a hoof, which presents with asymmetric foot-fall and lateral-first hoof strike, 'flips' the hoof capsule bearing border diagonally from lateral to medial as it bears weight. It has been traditionally thought, as a consequence of this, that the medial heel is then eventually obliged to take the entire load for that limb.

Diagonal force loading appeared to increase radially the further towards lateral heel- quarter initial ground contact was made. This may be significant as the initial level of lameness was greater in those cases exhibiting toe out posture.

Force and pressure measurements shown for one horse in the study (case 1) give results which clearly illustrate the pattern of increased force loading during the stance phase. The results do not comply with traditional thinking and further studies are warranted to investigate this biomechanical force and pressure transfer at the bearing border of the horse's foot. Such studies could then be used to improve farriery treatments to reduce load bearing induced lameness.

Further comparison for the type of foot fall seen in both study groups and other study populations may also prove useful in predictive models. The exact point of first strike may be a significant factor in the distortion of other structures such as the bars, the heel bulbs and frog given that the GRFVs from first strike are directed diagonally across the bearing border. Rotation of the foot onto the opposite heel during the stance phases of the stride appears to increase the force applied to that area by virtue of acceleration during the loading phase of the stride. With the forces of impact and load concentrated on opposing diagonal areas of the bearing border over time it seems likely that shear forces are concentrated at the weakest point: the frog sulci. The resultant ground pressure from force loading would appear to shunt the loaded structure vertically into the medial heel bulb whilst the lateral heel is non weight bearing.

The material properties and moisture contents of the hoof wall and other structures that make up the hoof capsule are often overlooked in this regard. (Reilly 2001) The stiffness, strength, elasticity and yield points of these materials under loading will dictate the way the hoof capsule behaves and distorts. Further studies are warranted to explore the way in which heel, quarter, bar and sole material distort under loading. It may be the case that the biological yield points of these structures are irreversibly exceeded (Reilly 2001) that is until farriery treatment is implemented.

The site of uneven shoe wear has long been noted by farriers as an indicator of digital pathology or foot imbalance. The Farrier assesses the symmetry of shoe wear and the degree of hoof capsule distortion when dressing and balancing the foot for the application of a shoe in order to promote even weight bearing across the bearing border of the foot. Clear definitions of shoe wear patterns and their relationship to conformation defects and hoof capsule distortion have been established (Madden 2001).

Contact deceleration friction wear from first impact and acceleration friction wear from breakover are clearly definable on horseshoes shortly after application, even on those horses whose work is confined to arenas. Contact shoe wear is created by resistance of ground reaction forces experienced at 1st strike whilst acceleration wear is created by friction during enrolment (van Heel. 2005a). Further work is required to ascertain whether objective measures of shoe wear, as well as the location of shoe wear, can be used as an objective diagnostic tool.

The results for farriery findings that affect hoof balance measurements and proportions such as contracture, compression, shunting and flaring of the hoof capsule are given in Tables 6a and 6b and show the range of presenting signs that the farrier uses to make an assessment of the foot, the mechanical traumas to which it has been subjected to.

In Group A, all cases presented with an under-run medial heel, were complicated by coronary shunting to that area. Interestingly, of these, 6 (75%) also presented with gross pathology of the medial bar indicating excessive collateral motion of the DIPJ as (Châteaux 2001) has suggested.

In Group B, 7 cases (70%) also presented with an under run medial heel and 8 cases (2, 4, 5, 6,8,12, 14 and16) were complicated by coronary shunting to the medial heel area. It was noticeable that whilst there was coronary shunting to the medial heel although this was less pronounced than in Group A cases. It was also evident that where shunting was less prominent contracture and dorsal migration of the heel buttress were more pronounced.

Conclusion.

The employment of modern technological methods (using high speed videography and force/pressure mats) has proven to be beneficial in assessing the site of first hoof strike and for quantifying the forces and pressures that occur at the bearing border of the foot. These methods have proved to be useful for investigating heel pain cases but they will undoubtedly also prove useful for other clinical presentations. The force/pressure mats served to demonstrate that not as much load as expected is taken by the medial bearing border of the hoof capsule during the interval when load is transferred radially and latero-medially around the bearing border after initial lateral-first hoof impact with the ground.

It is therefore possible that in these cases more energy is, instead, dissipated in the increased movement of more proximal digital joints (Châteaux. ET. al.. 2001) which, in turn, puts their collateral ligaments under increased strain leading to simultaneous presentations of collateral ligament desmitis in these cases (Dyson and Marks. 2003). Further studies should investigate the association between these conditions.

Corrective farriery methods for them (and other conditions) could then be assessed in the light of using more objective data gained from new technologies and from a paradigm shift in the way further "evidence based" data is gained from a scientific approach to farriery studies.

Appendix:

Table 1.

case	Age yrs	Height hands	Sex	Breed	Discipline	Duration mths	Limb	Score	Block	Diagnosis	Conformation
1	14	15.2HH	G	APPOL	DRESSAGE	12	R.F	3/10	M/H	COLLATERAL DESMITIS	O/ROT
2	7	16HH	M	T/BX	SHOW JUMP	4	L.F.	1/5	M/H	MEDIAL QUARTER CRACK	BROKEN IN
3	11	16.2HH	G	W/B	DRESSAGE	3	R.F.	3/10	M/H	COLLATERAL DESMITIS	BROKEN IN
4	13	15HH	M	T/BX	RIDING	15	L.F	3/10	M/H	COLLATERAL DESMITIS	BROKEN IN
5	11	16.3HH	G	IRISHX	EVENTING	6	RF	3/10	P/D	COLLATERAL DESMITIS	BROKEN IN
6	14	16.2HH	G	STD	RIDING	12 INT	LF	1/5	4/P	MEDIAL QUARTER CRACK	BROKEN IN
7	15	15HH	G	CONX	DRESSAGE	4	LF	1/5	P/D	MEDIAL QUARTER CRACK	O/ROT
8	12	14.2HH	M	T/BX	DRESSAGE	6	LF	3/10	4/P	FT IMBALANCE	O/ROT
9	16	16.2HH	G	T/BX	WORK HUNTER	6	RF	2/5	P/D	FT IMBALANCE	BROKEN IN
10	–	15.2HH	M	X/B	RIDING	9 INT	RF	3/10	P/D	COLLATERAL DESMITIS	BROKEN IN
11	15	16.3HH	M	W/BX	DRESSAGE	6 INT	LF	3/10	4/P	MED HEEL PAIN	O/ROT
12	18	16.2HH	M	W/B	DRESSAGE	4	LF	3/10	M/H	MED HEEL PAIN	BROKEN IN
13	10	16.2HH	G	T/BX	EVENT	2			4/P	SHEARED HEEL	O/ROT
14	12	15.2HH	G	COB	RIDING CLUB	12 INT	LF	2/5	M/H	COLLATERAL DESMITIS	BROKEN IN
15	13	16HH	G	T/B	EVENT	4	LF	3/10	P/D	MED HEEL PAIN	O/ROT
16	12	16.1HH	G	T/B	EVENT	3	RF	3/10	M/H	SHEARED HEEL	BROKEN IN
17	9	15.2HH	G	T/BX	DRESSAGE	12	RF	3/10	M/H	MED HEEL PAIN	O/ROT
18	14	15.3HH	G	ARAB	DRESSAGE	6	LF	1/5	M/H	MED HEEL PAIN	O/ROT
19	9	16HH	G	IRISH	HUNT	2	LF	1/5	M/H	MED HEEL PAIN	NORM
20	5	15.3HH	G	IRISH	RIDING	3	RF	3/10	M/H	MED HEEL PAIN	NORM

Table 1. Characteristics of the mixed group of 20 horses in the retrospective study.

Key to tables 2, 3 & 4

Description of deviation	Recorded as	Abbreviation
Deviation towards the mid line	Contracture	Con
Dense compact stratum medium convex shape	Compression	Com
Upward displacement of coronary hair line around the area of 1st strike	Coronary Shunting	Shunt
Severe proximal displacement of 1 heel bulb	Shearing	Shear
Non Level Bearing Border	High	L or M clock
Stretching of the white line and excess concave dorsal wall	flair	flair
Horn crushed and folding at the heel buttress / bar junction	Under - run	U/R
Lack of heel buttress depth	Collapsed	Col
Non centralised hoof capsule, appears to have shifted to one side	Lateral / Medial Displacement	L/M Dis
Crack in the bar to depth of lateral sulci	Bar crack	B/Crack
Horizontal crack through heel buttress	Heel crack	H/crack
Horizontal crack distal to coronary border in the area of shunting or shearing	Transverse heel crack	TH/Crack
Fissure in dorsal hoof wall palmer to positional markers 3 and 9	Quarter crack	Q/crack
Complete fissure through central sulci excessive independent medial lateral heel bulb movement	Split Frog	S/F
Non ground contacting frog (un shod)	Frog Atrophy	A/F
Dry, wet or suppurating corns unilateral or bilateral	*Corns	C1, 2 or 3 L, M or Bi

Key to tables 2, 3 & 4

Table 2a and b: the twenty horses split into 2 conformation groups

	Duration	Limb	**Score	Conformation	Radiographs	Block	Diagnosis
case	mths						
1	12	R.F	3/10	O/ROT	LM. DP	M/H	COLLATERAL DESMITIS
7	4	LF	1/5	O/ROT	LAT,DP,DDPO,PDDO	P/D	MEDIAL QUARTER CRACK
8	6	LF	3/10	O/ROT	—	P/D	SHEARED HEEL
11	6 INT	LF	3/10	O/ROT	LAT, DP	4/P	SHEARED HEEL
13	2			O/ROT	—	—	SHEARED HEEL
15	4	LF	3/10	O/ROT	LAT,DP,DDPO,PDDO	P/D	MED HEEL PAIN
17	12	RF	3/10	O/ROT	LAT, DP	M/H	MED HEEL PAIN
18	6	LF	1/5	O/ROT	LAT, DP	M/H	SHEARED HEEL

Table 2a Group A cases 1, 4, 7, 8, 11, 13, 15, 17 and 18 presented narrow chest toe-out, no angular limb deformities (ORD) cases 19 and 20 listed below presented with no distinguishable conformation defect.

	Duration	Limb	Score	Conformation	Radiographs	Block	Diagnosis
case							
19	2	L.F.	1/5	—	LM. DP	M/H	POOR FOOT BALANCE
20	3	R.F.	3/10	—	LM. DP	M/H	POOR FOOT BALANCE

Table 2b

	Duration	Limb	Score	Conformation	Radiographs	Block	Diagnosis
case							
2	4	L.F.	1/5	BROKEN IN	LM. DP	M/H	MEDIAL QUARTER CRACK
3	3	R.F.	3/10	BROKEN IN	–	M/H	COLLATERAL DESMITIS
4	15	L.F	3/10	BROKEN IN	LAT,DP,DDPO,PDDO	M/H	COLLATERAL DESMITIS
5	6	RF	3/10	BROKEN IN	LAT, DP	P/D	COLLATERAL DESMITIS
6	12 INT	LF	1/5	BROKEN IN	LAT,DP,DDPO,PDDO	–	MEDIAL QUARTER CRACK
9	6	RF	2/5	BROKEN IN	LAT,DP	P/D	FT IMBALANCE
10	9 INT	RF	3/10	BROKEN IN	LAT, DP	P/D	COLLATERAL DESMITIS
12	4	LF	3/10	BROKEN IN	DP	M/H	MED HEEL PAIN
14	12 INT	LF	2/5	BROKEN IN	LAT,DP,DDPO,PDDO	M/H	COLLATERAL DESMITIS
16	3	RF	3/10	BROKEN IN	LAT, DP	M/H	SHEARED HEEL

Table 2b Group B cases 2, 3, 5, 6, 9, 10, 12, 14 and 16 exhibited a base wide toe-in stance with moderate varus angular limb deformity at either the metacarpal phalangeal or middle inter phalangeal articulations (ALD).

** Lameness scored on lunge in a 10 metre circle at the trot.

Case	*1 RF	*7 LF	8 LF	*11 LF	*13 LF	15 LF	17 RF	18 LF
Pathology								
**Lateral / Medial High (clock score)	7 - 1	5 - 11	5 - 1	5 - 11	5 - 12	5 - 1	7 - 12	5 - 10
Con	MH	MHQ	MHQ	MHQ	MHQ	MH	MH	MHQ
Com	LTQ	LT	LT		LTQ	LHQ	LHQ	LTQ
Shunt	LTQ	LT	LT		LTQ	LHQ	LHQ	LTQ
Shear	MH	MH	MH	MH	MH		MH	MH
Flair	M T	M T	M T	L T	L T	MT	—	MT
U/R	MH	MH	MH	MH	MH	MH	MH	MH
Col	MH	MH	MH	MH	MH	BI	MH	MH
L/M Dis								
B/Crack	M			M				
H/crack		M						
TH/Crack	MHQ		MHQ				MHQ	
Q/crack		MHQ						
S/F					√	√		
A/F			√					√
C1, 2 or 3 L, M or Bi			C1M	C1M				

Table 3. Hoof capsule pathologies and significant signs recorded for Group A cases 1, 4, 7, 8, 11, 13, 15, 17 and 18

** Lateral / Medial high may also denote wall depth to the opposite diagonal is below the level of the live sole (non exfoliating viable solar horn) and was assessed as whether or not the bearing border of the foot was perpendicular to the longitudinal axis of the limb.

Case	**2 RF**	***3 LF**	**5 RF**	***6 LF**	***9 RF**	**10 RF**	**12 LF**	***14 LF**	***16 LF**
Pathology									
**Lateral / Medial High (clock score)	1 - 5	11 - 7	1 - 5		1 - 5	1 - 5	11 - 7	1 - 7	1 - 5
Con	MHQ	MHQ	MHQ	MHQ	MH	MHQ	MH	MHQ	MH
Com	LTQ	LTQ	LT	LT	LT	MQ	LTQ	LHQ	LTQ
Shunt	LTQ	LT	LT	LT	LT	LTQ	LTQ	LHQ	LTQ
Shear		MH	MH	MH			MH	MH	MH
Flair		MT	MT LHQ	MT	MT		MT	MT	
U/R		M	M	M		M	M	M	M
Col	M	M	M		M	M	M		
L/M Dis									
Bar Dis		L		L				L	
B/Crack		M		M				M	
H/crack									
TH/Crack				MHQ					
Q/crack				M					
S/F	√	√		√					√
A/F									
C1, 2 or 3 L, M or Bi	C2M	C1M	C1M	C1M					

Table 4 Hoof capsule pathologies and significant signs recorded for Group B cases 2, 3, 5, 6, 9, 10, 12, 14 and 16

** Lateral / Medial high may also denote wall depth to the opposite diagonal is below the level of the live sole (non exfoliating viable solar horn) and was assessed as whether or not the bearing border of the foot was perpendicular to the longitudinal axis of the limb.

Case	*1 RF	*7 LF	8 LF	*11 LF	*13 LF	15 LF	*17 RF	18 LF
1st Strike	LQ	LQ	LHQ	LQ	LTQ	LHQ	LHQ	LTQ
Contact Shoe Wear (clock score)	9 - 11	3 - 1	4 - 1	3 - 1	2 - 1	1 - 5	11 - 8	2 - 1
Acceleration Wear (clock score)	12 - 11	12 - 1	1 - 11	12 - 1	12 - 1	12 - 2	12 - 10	12 - 1
Bearing Border Wear	MH	MH	MH	MH	MH	BI	MH	MH
**Lateral / Medial High (clock score)	7 - 1	5 - 11	5 - 1	5 - 11	5 - 12	5 - 1	7 - 12	5 - 10

Table 5A. Shoe wear patterns recorded for Group A

- Cases numbers marked * were videoed for foot fall analysis.

Case	2 RF	*3 LF	5 RF	*6 LF	*9 RF	10 RF	12 LF	*14 LF	*16 LF
1st Strike	LTQ	LT	LT	LT	LT	LTQ	LTQ	LHQ	LTQ
Contact Shoe Wear (clock score)	1 - 4	12 - 1	11-12	11-9	1-3	1-4	11-8	11-7	1-4
Acceleration Wear (clock score)	11-12	12-1	11-12	N/A	11-12	11-12	12-1	12-1	11-12
Bearing Border Wear	MH	MH	MH	MH	MH	MH	MH	NA	MH
**Lateral / Medial High (clock score)	1 - 5	11 - 7	1 - 5		1 - 5	1 - 5	11 - 7	1 - 7	1 - 5

Table 5B Shoe wear patterns recorded for Group B

* Cases numbers marked * were videoed for foot fall analysis.

Case	***1 RF**	***7 LF**	**8 LF**	***11 LF**	***13 LF**	**15 LF**	**17 RF**	**18 LF**
Morphology								
**Lateral / Medial High (clock score)	7 - 1	5 - 11	5 - 1	5 - 11	5 - 12	5 - 1	7 - 12	5 - 10
Con	MH	MHQ	MHQ	MHQ	MHQ	MH	MH	MHQ
Com	LTQ	LT	LT		LTQ	LHQ	LHQ	LTQ
Shunt	LTQ	LT	LT		LTQ	LHQ	LHQ	LTQ
Flair	M T	M T	M T	L T	L T	MT	—	MT
U/R	MH	MH	MH	MH	MH	MH	MH	MH
L/M Dis								

Table 6A. Hoof balance morphological changes recorded for Group A

Case	**2 RF**	***3 LF**	**5 RF**	***6 LF**	***9 RF**	**10 RF**	**12 LF**	***14 LF**	***16 LF**
Morphology									
**Lateral / Medial High (clock score)	1 - 5	11 - 7	1 - 5		1 - 5	1 - 5	11 - 7	1 - 7	1 - 5
Con	MHQ	MHQ	MHQ	MHQ	MH	MHQ	MH	MHQ	MH
Com	LTQ	LTQ	LT	LT	LT	MQ	LTQ	LHQ	LTQ
Shunt	LTQ	LT	LT	LT	LT	LTQ	LTQ	LHQ	LTQ
Flair		MT	MT LHQ	MT	MT		MT	MT	
U/R		M	M	M		M	M	M	M
L/M Dis									

Table 6B Hoof balance morphological changes recorded for Group B

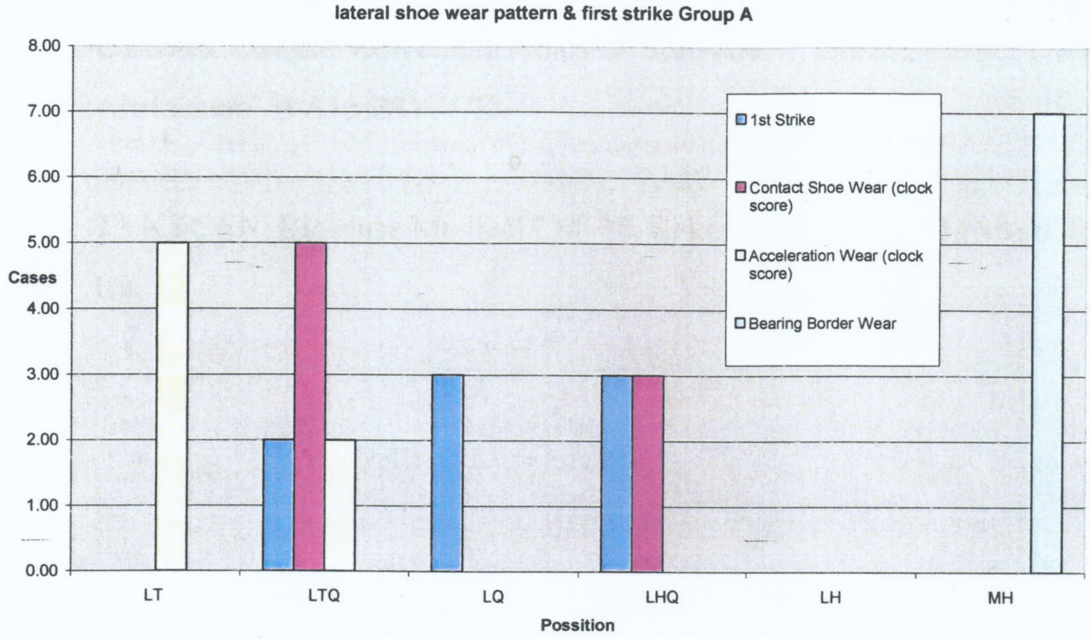
se	Lame	Limb	Score	0	1	3	6	9	12	03/07	Comment
1	12	R.F	3	0	0	2	0	0	0	0	Remains 0/10th in ½ bar
7	4	LF	1	0	2	0	1	0	0	0	Bar shoes
8	6	LF	3	1	2	1	0	1	1	1	0/10th only 21days post shoe
11	6 INT	LF	3	0	0	0	0	2	2	2	Remains 2/10th
13	2			0	0	0	0	0	0	0	Remains 0/10th med lift
15	4	LF	3	0	0	0	0	0	0	0	Remains 0/10th in ½ bar
17	12	RF	3	0	2	0	0	0	0	0	Remains 0/10th 28day shoeing cycle
18	6	LF	2	0	0	0	0	0	0	0	Remains 0/10th

(Table 7a). The results from horses characterised in group A. Lameness score is ex 10.

:ise	Lame	Limb	Score	0	1	3	6	9	12	03/07	Comment
2	4	L.F.	2	2	0	0	0	0	2	0	Remains 0/10 in bar shoes
3	3	R.F.	3	0	0	2	0	0			No follow up data. Sold
4	15	L.F	3	0	0	0	0	0	3	0	0/10th i/2 bar medial lift added 11/06
5	6	RF	3	1	1	1	0	0	0		No follow up data. Sold
6	12 INT	LF	1	0	0	1	0	1	0	0	Remains 0/10th med lift
9	6	RF	4	2	0	0	0				Remains 2/10
10	9 INT	RF	3	2	2	0	0	0	0	0	Remains 0/10th
12	4	LF	3	0	0	0	0	0	4	2	Chip fracture fetlock joint
14	12 INT	LF	4	2	2	0	0	0	2	0	Remains 0/10th med lift
16	3	RF	3	0	2	0	0	0	n/a	n/a	Remains 0/10th glue-on

(Table 7b). The results from horses characterised in group B. Lameness score is ex 10

22A.



22B

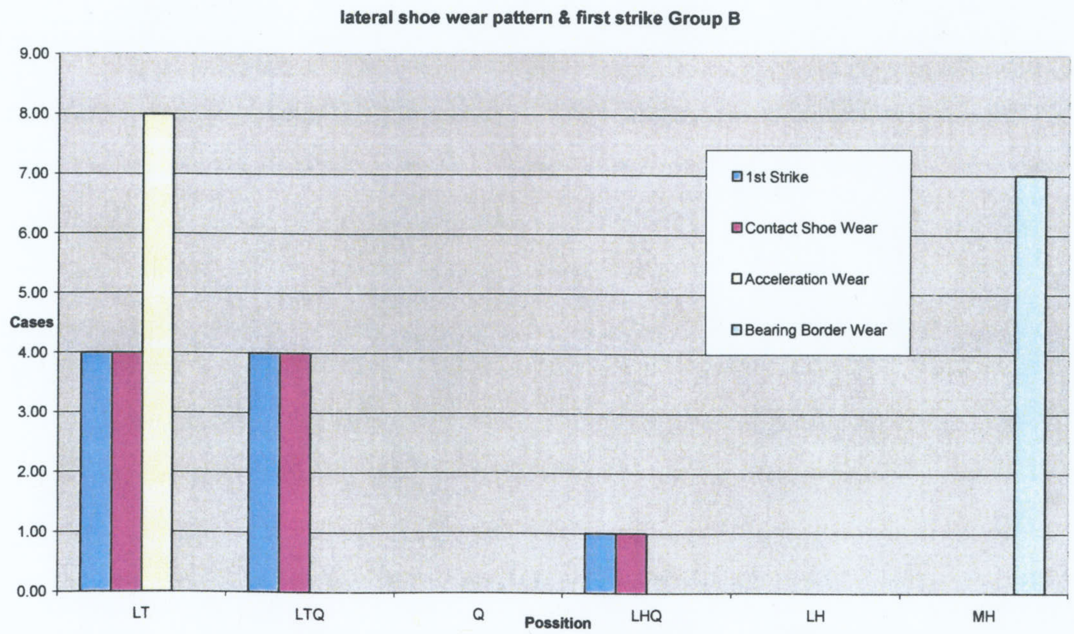


Fig 22a and b Histograms illustrating the range of lateral shoe wear patterns and the number of cases recorded in each area of the bearing border at 1st contact.

Manufactures Addresses.

1. **Ontrack Equine.** Movement Analysis Software. 4, Curzon Drive, Timperley, Altrincham. WA15 7SY. UK.

2. **TEKSCAN**. Biosense Medical Ltd. 18, Eckersley Road, Chelmsford. Essex. CM1 1SL. UK

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